Utrecht University

An Alternative Approach to the Assessment of Carbon Leakage Risk in the European Emission Trading Scheme

MSc Thesis

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Stefano De Clara – 3776271

Student address: Van Alphenplein 2A, 3581 JE Utrecht

Telephone: NL - 0031 (0)615208132

E-mail: s.declara@students.uu.nl

Programme: Sustainable Development

Track: Energy and Resources

Supervisor: Dr. Robert Harmsen

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Executive Summary

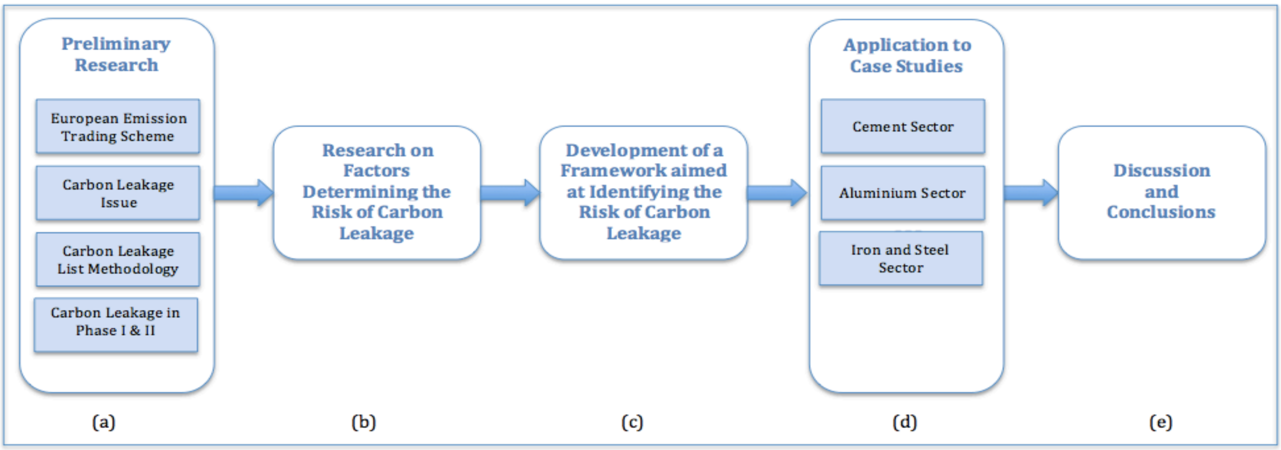
The present work focuses on the carbon leakage issue in the European emission trading scheme (ETS). Carbon leakage is one of the major threats to the functionality and effectiveness of the ETS and happens when, as a consequence of the additional costs deriving from the compliance to the ETS Directive, it is more convenient for an industry to relocate its production to non-compliant countries, or when the price of an industry's product increases so significantly that the market shifts its preference towards products coming from non-ETS countries. Thus, in both cases, GHG emission reductions in countries belonging to the ETS are counterbalanced by an increase in emissions in third countries, coupled with a loss of competitiveness and profitability of EU industries. Phase III of the ETS (starting in 2013) introduced, among several improvements to the scheme, the carbon leakage list, which is a list of sectors deemed to be exposed to significant risk of carbon leakage that therefore will receive allowances free of charge up to a benchmark level. Nevertheless, the carbon leakage list has the effect of cancelling out the peculiarity of the new auctioning regime, envisaged as one of the most ambitious and challenging changes introduced in Phase III.

The Commission's methodology to include sectors in the list relies on two indicators: the carbon cost indicator, which quantifies the additional costs a sector has to face, and the trade intensity indicator, which quantifies a sector's trade exposure. Ever since the methodology for the carbon leakage list has been established, there has been an on-going debate on whether or not the two indicators can adequately reflect the actual risk of carbon leakage. Critics focus mainly on two aspects: first, the appropriateness of threshold levels has been questioned and, second, it has been pointed out that the two metrics are rather broad indicators and could thus be not fully representative. This implies that, even when the criteria are met, the 'real' risk of carbon leakage is influenced by a number of different factors and conditions.

The goal of the present research is therefore to move beyond the Commission's approach and develop a new method to identify sectors at risk of carbon leakage, answering the following research question:

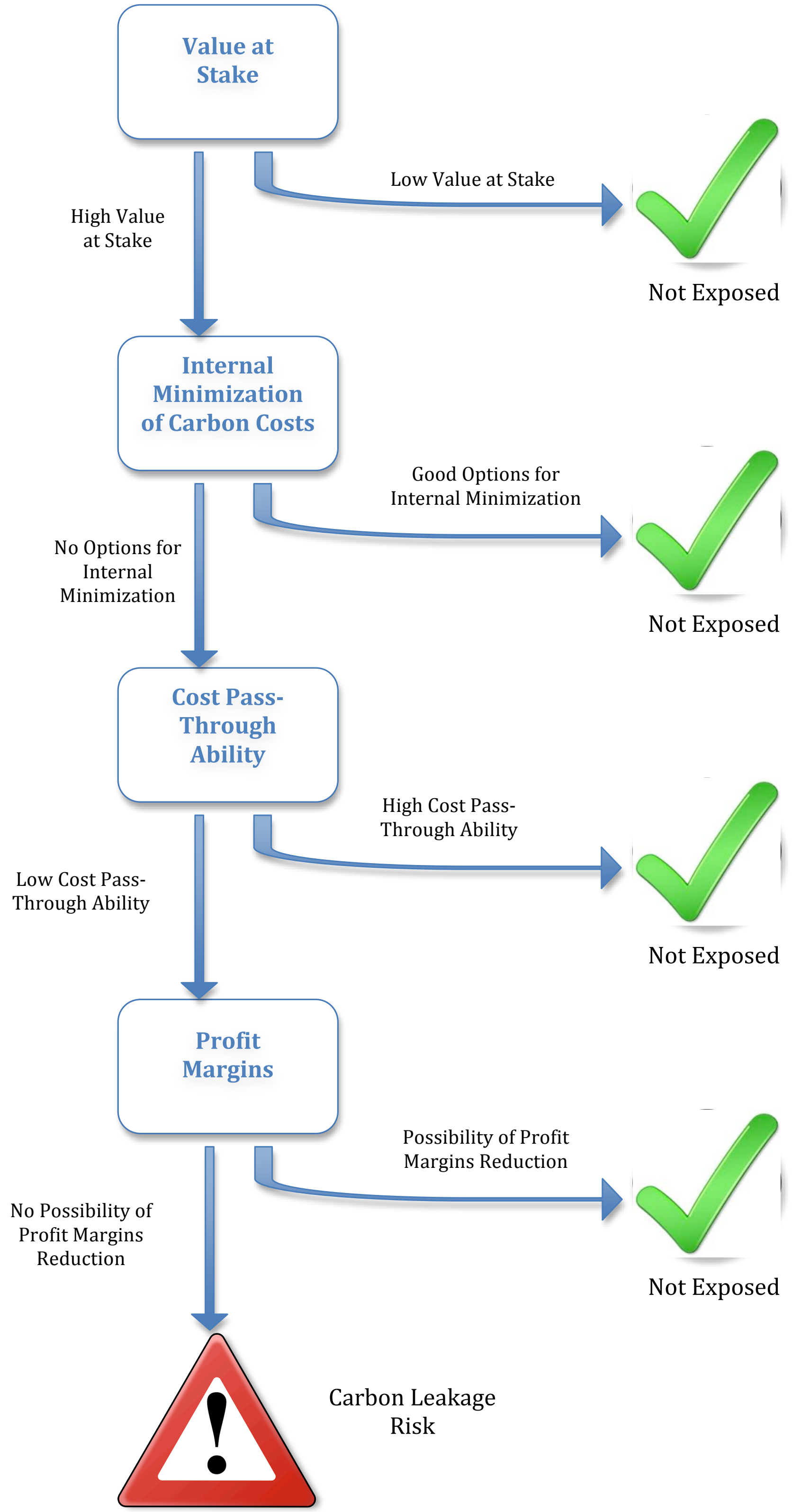
> *What indicators, other than the two metrics used by the Commission, can be used to identify sectors at risk of carbon leakage and what are their advantages and disadvantages?*

To this end, the research has been structured as shown in the figure below.



The first step of the project consisted in an extensive preliminary research on the key elements involved in the study, i.e. the EU ETS, the carbon leakage issue, the Commission's approach to the carbon leakage list with special attention to its weaknesses and shortcomings and carbon leakage in Phase I & II of the ETS. The preliminary research was needed in order to become acquainted with the main elements involved in the research and, most importantly, has been crucial in developing an adequate know-how to structure the alternative approach. For example, among other findings, the preliminary research revealed that the two indicators do not necessarily reflect the real carbon leakage risk, that the Commission's carbon price assumption is well above recent forecasts, that it is possible for industries to pass on carbon costs even to a large extent and that a conspicuous surplus of allowances has formed. The second step was a research on factors determining the risk of carbon leakage. Such a research was aimed at drafting a list of carbon leakage determinants and relative indicators. These two first steps of the research directly fed into the third step: the development of a framework aimed at identifying the risk of carbon leakage.

First, insights gathered in the preliminary research have been organized in a flowchart depicting carbon leakage dynamics and representing the backbone of the framework. The flowchart is meant to investigate, in a stepwise manner, the risk of carbon leakage. The first step assesses what the value at stake for a certain sector is. If this turns out to be marginal, the analysis can stop with the conclusion that the sector is not exposed to a significant risk, otherwise the analysis moves on. The second step of the framework assesses whether a sector has viable options for internal minimization of compliance costs. If this is the case, the sector can be considered not exposed to a significant carbon leakage risk, otherwise the analysis moves on. The third step of the framework consists in analysing the cost pass-through ability of a sector. If the latter turns out to be good the sector is not exposed to a significant risk, otherwise the analysis moves on. In the last step, the consequences of a profit margin reduction are taken into account. This reasoning is depicted in the following flowchart.


Value at Stake
Low Value at Stake
Not Exposed
High Value at Stake
Internal Minimization of Carbon Costs
Good Options for Internal Minimization
Not Exposed
No Options for Internal Minimization
Cost Pass-Through Ability
High Cost Pass-Through Ability
Not Exposed
Low Cost Pass-Through Ability
Profit Margins
Possibility of Profit Margins Reduction
Not Exposed
No Possibility of Profit Margins Reduction
Carbon Leakage Risk

The flowchart structure has been chosen in order to reflect the peculiar nature of carbon leakage, i.e. a phenomenon that happens in consequential steps or stages as a result of a causal chain of implications. This methodology allows analysing one carbon leakage determinant at a time, when it is more relevant, without applying all the indicators at once as it is often done in studies on carbon leakage.

As a further step, the carbon leakage determinants and indicators have been used to operationalize the flowchart by linking them to the different steps of the framework, according to their relevance to depict particular aspects of carbon leakage. Indicators have been selected based on their recurrence in the reviewed studies, their relevance and significance with respect to the characteristics of the carbon leakage phenomenon, their usability in the flowchart and data availability. The final framework structure and indicators list have been validated via expert consultation. The table below shows the framework structure, consisting of 4 steps and 9 determinants and indicators.

Flowchart Step	Determinant	Indicator
Value at Stake	Carbon costs	Commission's CCI (Corrected for the Carbon Price)
Internal Minimization of Carbon Costs	CO_2 Emission abatement and electricity consumption reduction potential	MACCs BATNEECs
	Surplus of Allowances	Number of Unused Allowances
Cost Pass-Through Ability	Price Elasticity	Price Elasticity
	Market Concentration	Herfindahl-Hirschman Index
	Product Differentiation and Substitutability	Armington Elasticities Product's Characteristics
	Transportation Costs and Transportability	Transportation Costs Product's Transportability
	Trade Exposure	Commission's TII
Profit Margins	Profit Margins	Profit Margins

As a further step of the analysis, the framework has been applied to three sectors covered by the ETS and currently included in the carbon leakage list, namely Cement, Aluminium and Iron and Steel, in order to assess whether it could provide meaningful insights on the actual risk of carbon leakage. The three sectors have been chosen because of their diverse classification according to the carbon cost indicator and trade intensity indicator that, as it turned out, could provide a basis for an interesting discussion of results. The three sectors in fact have different values with respect to the Commission's metrics and are therefore impacted differently by the compliance to the ETS and by carbon leakage. Cement has very high compliance cost but is rather isolated from international trade, aluminium has moderately high compliance costs, virtually all being indirect costs, and it is very intensely traded at a global level and iron and steel is in a similar situation as aluminium but, differently from the latter, the major part of its compliance costs derive from direct emissions.

The framework indeed proved to be able to deliver extremely meaningful results, enlightening aspects that the Commission's approach is not able to depict. Cement sector, for instance, has significant compliance costs but is hardly exposed to international trade; therefore the risk of carbon leakage is low. The sector also holds a significant surplus of allowances. Clinker, a cement sub-product, has been spotted as a possible issue, due to its better transportability, but blended cement, i.e. a cement mix with low clinker content, could reduce leakage concerns and CO_2 emissions at the same time. Aluminium sector is indeed highly exposed to international trade and historical trends show that European producers are progressively losing competitiveness. Nevertheless, the sector would not benefit from being on the carbon leakage list because virtually all its compliance costs are indirect carbon costs from electricity prices and the list only compensates for direct emissions, which are very marginal. Iron and steel sector, despite being and energy-intensive and highly traded sector, seems to be currently shielded from compliance costs by low carbon prices and a significant surplus of allowances. Nevertheless the sector could be exposed in the future, if the situation changes.

Concluding, the present work showed that an alternative approach is possible. The framework, through its set of determinants, proved to be able to deliver meaningful insights on the risk of carbon leakage. The flowchart-like approach seems to better depict and capture the real nature and dynamics of carbon leakage, thus being more appropriate than the Commission's two indicators and three criteria. Moreover, the proposed stepwise approach allowed applying the different indicators when more relevant in relation to a sector's situation. The analysis indeed shed light on several aspects and complexities that would have remained unaddressed by the Commission's approach.

The formulation of the framework directly addresses the main research question, showing which indicators should be considered in developing an alternative approach to carbon leakage and what are their strengths and weaknesses. This research showed that a more accurate approach is possible and identified a new methodology, consisting in a flowchart-like four-step framework, its determinants and relative indicators. This constitutes a sound basis for the development of a new quantitative methodology for the assessment of the carbon leakage risk.

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List of Abbreviations

EAF	Electric Arc Furnace
BATNEEC	Best Available Technology Not Entailing Excessive Costs
BOF	Blast Furnace/Basic Oxygen Furnace
CCI	Carbon Cost Indicator
CL	Carbon Leakage
CLL	Carbon Leakage List
ETS	Emission Trading Scheme
EUA	European Union Emission Allowance
EU	European Union
GHG	Greenhouse Gases
GVA	Gross Value Added
J	Joule
k	Kilo (10^3)
LME	London Metal Exchange
M	Mega (10^6)
MACC	Marginal Abatement Cost Curve
NAP	National Allocation Plan
t	Tonne
T	Tera (10^{12})
TII	Trade Intensity Indicator
US	United States
Wh	Watt Hour

1 Introduction

1.1 Background

Acknowledging the climate change issue and willing to be a frontrunner in reducing anthropogenic impact on the environment, the European Union (hereafter EU) signed the Kyoto protocol, making the commitment of reducing its greenhouse gases (hereafter GHG) emissions by 20% compared to 1990 levels by 2020. At the EU level, the Kyoto commitment has been translated into a climate and energy package, known as 20-20-20 objective, which is a set of binding legislations setting three goals to be met by 2020: 20% GHG emissions reduction compared to 1990 levels, 20% share of renewable sources in the energy mix, and 20% energy efficiency improvements. The emission trading scheme (hereafter ETS) represents a cornerstone for the EU's 20-20-20 objective (European Commission, 2013).

An ETS is a market-based policy tool aimed at reducing a certain kind of emissions in a cost-effective way. It generally consists of an overall emissions cap, rights, or allowances, to emit certain quantities and a market where to trade these emission rights (Jegou and Rubini, 2011). The main rationale behind an ETS is to put a cost on emission rights and to "generate a price signal, through the CO_2 price, strong enough to drive production and investment decisions towards a low carbon economy" (European Commission, 2012b p. 9). In other words, the carbon price should stimulate actors to implement emission abatement measures as a way to avoid having to buy emission allowances. This happens, theoretically, if certain abatement options are cheaper than the price of allowances. By allowing players in the market to trade allowances, emission rights can be used where they are of most value, e.g. in industries with few abatement options, and emission reductions can happen where they are cheaper (Brunner et al., 2008). Therefore the ETS is considered a cost-effective oriented policy because it lets emission reduction to take place where it is more economically feasible, e.g. via the most cost-effective abatement measures. Firms with low-cost abatement opportunities will likely implement such measures and sell the unused allowances to firms that cannot reduce emissions in a cost-effective way, and therefore are eager to pay the price of allowances. This stems from the idea that emission allowances carry an opportunity cost, meaning that a firm has the choice to either use a given allowance to account for its emissions or to sell it on the market for a profit. Therefore there is an incentive for firms to implement emission reduction measures if it is more profitable for them to do so and sell allowances (Jegou and Rubini, 2011).

The cost-effectiveness of the ETS is clearly illustrated by Brunner et al. (2008) in Figure 1, which represents the marginal abatement cost curves (hereafter MACC) of two companies. Company A has a less steep MACC than B, meaning that it can abate more emissions at a lower cost. Given an emission limit, represented by the left-dotted line, and without an ETS the two companies would have to comply with their individual target; entailing to relatively low costs for company A and relatively high costs for company

B. According to economic theory, under an ETS, company A can benefit from a further reduction of its emissions by selling the extra allowances to company B, until their MACCs converge to P. By doing so, the overall emission reduction remains the same, but it is obtained in a more cost-effective way. Area "a" represents the profits of company A from the allowances sold to B and area "b" represents the saved abatement costs for B thanks to the possibility of buying allowances from A (Brunner et al., 2008).

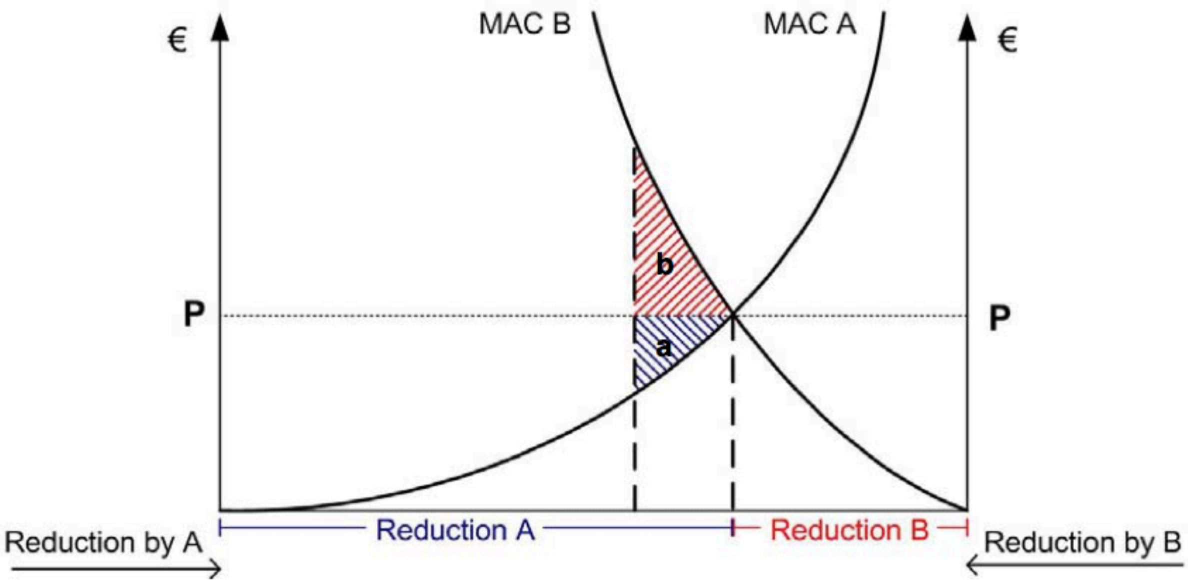

Figure 1. Rationale behind an emission trading scheme (Brunner et al., 2008)

The European ETS, launched in 2003, currently includes nearly 12,000 installations across the EU, covering around 45% of the total EU-27 CO_2 emissions. Installations in sectors covered by the ETS, mainly energy-intensive industries such as combustion plants, oil refineries, coke ovens, iron and steel plants, cement-producing facilities, are obliged to comply with the scheme. As of 2012 also the aviation sector has been included.

Allowances are defined as an "allowance to emit one tonne of carbon dioxide equivalent during a specified period, which shall be valid only for the purposes of meeting the requirements of the revised ETS Directive and shall be transferable in accordance with the provisions of the revised ETS Directive" and are usually referred to as European Union emission allowance (hereafter EUA) (European Parliament & Council, 2003 p. 34). Similarly to any market, the key to high prices is scarcity and therefore the maximum number of available allowances is crucial. The experience made in Phase I & II has revealed that setting the right cap, and consequently obtaining an optimal carbon price, is rather difficult. If the cap is too generous there is no scarcity to stimulate prices but, on the other hand, if the cap is too strict actors would be so economically endangered that their compliance to the scheme would be at risk. Moreover, as it has been witnessed, the system is very sensitive to external influences, such as the international financial crisis (Jegou and Rubini, 2011).

Phase I of the ETS ran from 2005 to 2007 and was designed to be a learning-by-doing period with the main goal of putting the system in place. Therefore no ambitious mechanisms were implemented. Phase II started in 2008 and ran for a four year period until 2012. In these two periods most of the allowances, respectively 95% and 90%, have been allocated to industries for free (European Commission, 2013). The first ETS Directive has been amended in 2009 (European Parliament & Council, 2009). The new Directive introduced significant changes to the system for the period 2013 – 2020, known as Phase III. Drawing from the experience made in Phase I & II the main changes applied to the ETS in Phase III were (European Commission, 2012b):

- The shift towards a more centralized system with the replacement of 27 national electronic emission and allocation registries with a single Union registry;
- The introduction of an EU-wide cap on allowances, replacing the 27 individual Member State caps in place before. The allowances cap will decrease by 1.74% annually, up to and beyond 2020, providing much greater regulatory predictability and stability;
- The introduction of auctioning of allowances as the default system of allocation;
- Free allocation of allowances based on EU-wide harmonised rules and on performance benchmarks.

1.2 Problem Definition

One of the major threats to the functionality and effectiveness of the ETS is carbon leakage (hereafter CL). CL happens when, as a consequence of the additional costs deriving from the compliance to the ETS Directive, it is more convenient for an industry to relocate its production in non-compliant countries, or when an industry’s product prices increase so significantly that the market shifts its preference towards products coming from non-ETS countries. Thus, in both cases, GHG emission reductions in ETS countries are counterbalanced by an increase in emissions in third countries, coupled with a loss of competitiveness and profitability of EU industries. In order to address the risk of CL, the 2009 Directive foresees that the Community should allocate allowances free of charge at 100% of a benchmark to sectors or sub-sectors meeting certain criteria (European Parliament & Council, 2009). The Commission Decision determining a list of sectors deemed to be exposed to a significant risk of CL, the so-called “carbon leakage list” (hereafter CLL), was approved by the Member States in 2009 and new ones will be determined every five years thereafter. The first CLL identified 164 sectors as deemed to be at risk and applies until 2014 (European Commission, 2011a).

The CLL will play an important role in Phase III of the ETS. As sectors included in the list receive allowances free of charge at 100% of a benchmark level, the more sectors in the list the more Phase III will be similar to Phase I & II. In fact the CLL has the effect of cancelling out the peculiarity of the new auctioning regime, envisaged as one of the most ambitious and challenging changes introduced with Phase III. Auctioning instead of free allocation was indeed thought as a way to strengthen the efficiency of the Directive and to renew the ambitions of the scheme. According to Parker (2008 p. 14), the main arguments in favour of auctioning are:

- Purest embodiment of the 'polluter pays' principle;
- Reduces distributional distortions that free allocation (and accompanying 'windfall profits') can create;
- Creates a 'level playing field' for existing and new covered entities;
- Gives the potential for reducing the impact of compliance on the economy as a whole if auction revenues are used to reduce more distorting taxes on investment (i.e., 'double dividend'); and
- Can improve emission market liquidity and transparency.

Also, in the Commission's words, auctioning "best ensures the efficiency, transparency and simplicity of the system and creates the greatest incentive for investment in a low-carbon economy. Auctioning will also eliminate windfall profits, which arise when operators charge their customers the cost of allowances they have received for free" (European Commission, 2013). According to Hepburn et al. (2006 p. 3) auctioning:

- Is likely to increase the macroeconomic efficiency of the EU ETS and offers scope to partially address its distributional impacts;
- Will have negligible competitiveness impacts;
- Reduces the distortions associated with free allocation and is correspondingly more compatible with EU State Aid legislation;
- Will have a smaller impact on EU ETS prices than allocation cutbacks without auctioning;
- Will increase management attention and thus market efficiency.

A broad CLL would set back the ETS implementation to a situation very much similar to Phase I & II and thus not as challenging as Phase III is meant to be. Experts also argue that free allocation of allowances could be seen as a subsidy, meaning that firms receiving them will be in a stronger financial position than firms that have to auction, entailing all the controversies peculiar to this policy instrument (Jegou and Rubini, 2011). On the contrary, auctioning is strongly indicated as the most straightforward way of implementing the 'polluter pays' principle and as a good strategy to reduce all the distortions and windfall profits related to free allocation (Jegou and Rubini, 2011; European Commission, 2013). Since the CLL has the effect of maintaining sectors under the free allocation regime, the importance of the list itself and of its underlying methodology is clear.

Article 10 of the amended ETS Directive lays down the guidelines to identify sectors deemed to be exposed to the risk of CL, which have consequently to be included in the CLL. Two metrics are applied to identify sectors exposed to the risk of CL: the Carbon Cost Indicator (hereafter CCI) and the Trade Intensity Indicator (hereafter TII) (European Parliament & Council, 2009). The CCI quantifies the additional costs sectors are facing due to the introduction of the Directive, taking into account the sum of direct costs stemming from the value of allowances to be purchased to cover the direct emissions and indirect costs of emission rights included in the electricity purchases of the sector in relation to the gross value added (GVA) of a certain sector.

According to Article 10 of the amended ETS Directive a sector or subsector is deemed to be at a significant risk of CL if the CCI exceeds 5% and the TII exceeds 10%, or if either one exceeds 30% (European Parliament & Council, 2009). The assessment is based on NACE codes of sectors, subsectors and products. NACE codes used to classify which specific sector an installation belongs to, based on the activities carried out. The codes are taken from the Classification of Economic Activities in the European Community (European Parliament & Council, 2010).

A number of factors are involved in the calculations of the two indicators and a number of assumptions are associated with those factors. The factors relying on the most sensitive assumptions are: carbon price, share of allowances allocated free of charge and electricity emission factor. A high carbon price would result in more sectors deemed to be at risk and, on the contrary, a lower price would lead to a shorter list. In a similar way, also the emission factor for electricity and the share of free allowances influence the calculation's outcome, with a higher emission factor and a lower share of free allowances resulting in more sectors meeting the metrics as a consequence of higher direct and indirect carbon costs. Article 10a (14) of the Directive states the assessment should be based on an average carbon price according to the Commission's impact assessment accompanying the package (European Parliament & Council, 2009). A price of € 30 per tonne of CO_2 has been used to draw the first CLL, as also indicated on the Commission Decision itself and in the *Impact Assessment accompanying the Commission Decision on the first Carbon Leakage List* (European Commission, 2009). In the same impact assessment, conflicting positions have been expressed concerning the assumption on the level of free allocation of allowances and on the electricity emission factor when the impact assessment on the first CLL was carried out. Nevertheless, the price associated with the purchase and trade of emission allowances is arguably the most sensitive assumption that has to be made. Carbon prices proved to be quite fluctuating in the past and very sensitive to external influences, as witnessed when the financial crisis caused the carbon price to plunge to extremely low levels (Jegou and Rubini, 2011). It should also be noted that carbon prices influence both the direct and indirect cost parameters. It is therefore clear that the CLL is strongly dependent on the assumption on the carbon price.

Moreover, not only the two metrics rely on some very sensitive assumptions, it is also important to question their appropriateness. Ever since the methodology for the CLL has been established, there has been an on-going debate on whether or not the two metrics can adequately reflect the actual risk of CL, especially in sectors close to the threshold values. Critics focus mainly on two aspects: first, the appropriateness of threshold levels has been questioned and, second, it has been pointed out that the two metrics are rather broad indicators and could thus be not fully representative, implying that, even when the criteria are met, the ‘real’ risk of CL is influenced by a number of different factors and conditions (Cambridge Econometrics, 2010; Martin et al., 2010). A study carried out by the Grantham Institute of the London School of Economics covers both the aforementioned discussion points concluding that most of the sectors currently included in the list do not actually face a significant CL risk and that there is a need for rethinking the two metrics. The CLL has also significant financial implications. The study estimated that improving the design of the CLL indicators could raise additional incomes from the scheme up to € 7 billion annually (Martin et al., 2010). The revised Directive acknowledges the existence and importance of other factors in determining CL and groups them into three main areas that can be referred to as: technological assessment, market conditions and profit margins (European Parliament & Council, 2009). A study carried out by Cambridge Econometrics (2010) was focused on identifying criteria that could provide indications on the risk of CL. The study identified nearly 100 factors in total, grouped in 4 categories: cost structure, pass-through ability, abatement potential and regulatory conditions. Therefore there is evidence that not only two indicators, but also a large number of factors and determinants should be taken into account. Despite providing a sound research on CL determinants, which represents a basis of this study, when it came to assess the CL risk for sectors the work of Cambridge Econometrics selected only three indicators, beside the two already used by the Commission. The current research will use the research on CL determinants and indicators carried out by Cambridge Econometrics as one of the most important starting points, but aims at moving further and developing a new approach to the assessment of the CL risk.

Concluding, CL is a complicated and articulated phenomenon and therefore it is very difficult to frame it using just two metrics. A large number of factors are involved in determining CL and could thus help in identifying sectors at risk. Therefore, even if the Commission’s metrics picture some of the key elements determining the risk of CL, many more factors are thought to influence this phenomenon (Cambridge Econometrics, 2010). Given the importance of the CLL and its central role in Phase III of the ETS, it is highly relevant to question the appropriateness and reliability of two metrics employed by the Commission and to investigate what other indicators might be employed to assess the risk of CL.

1.3 Research Goal and Research Question

In line with the problem definition, this research therefore aims at looking beyond the current approach in order to develop a new approach to identify sectors at risk of CL. This proposed approach, building upon useful insights on what factors determine the CL risk and how these factors can be used to build indicators aimed at assessing the risk for a certain sector, will consist in a set of CL determinants and relative indicators organized in a framework. The framework will then be applied to three case studies to test whether it could serve its purpose.

Bearing in mind the aforementioned goal, the following research question will be answered:

> *What indicators, other than the two metrics used by the Commission, can be used to identify sectors at risk of carbon leakage and what are their advantages and disadvantages?*

1.4 Research Sub-Questions

In order to understand the appropriateness and reliability of the two metrics currently used by the Commission to identify sectors deemed to be at risk of CL, to investigate what other factors could contribute to identify the actual CL risk, to structure the research process and to be able to answer the main research question, a set of sub-questions is needed:

I. What is the EU ETS and how does it function?
II. What is the CL issue and how does it affect the EU ETS?
III. What is the approach currently used to identify sectors exposed to the risk of CL?
IV. What are the factors involved in the current approach and what are the underlying assumptions?
V. What are the strengths and weaknesses of the current approach?
VI. How did CL affect the EU ETS thus far?
VII. What are the important factors determining the risk of CL?
VIII. What are the determinants taken into account in studies on the CL issue?
IX. What framework can be built on those determinants?
X. What indicators can be used to operationalize the framework?
XI. What does result from an application of this set of indicators on a number of sectors?
XII. What are the advantages and disadvantages of these indicators?
XIII. Which indicators seem to lead to most significant results?

1.5 Research Structure

Consequently, following the structure imposed by the sub-questions, this research is organized as follow:

1. An overview of the EU ETS will be offered to understand the system's development and functioning;
2. A research on the CL issue will be carried out in order to gain insights on the phenomenon and on its dynamics;
3. The Commission's approach used to determine sectors at risk of CL will be analysed and discussed, enlightening its strengths and weaknesses;
4. A research on CL in Phase I & II will be undertaken in order to understand to what extent the EU ETS is threatened.

5. Keeping in mind the results of this first part of the research, this study will then look at what factors concur to determine the risk of CL and thus at what other indicators, beside the two metrics already used by the Commission, could be used to identify sectors at risk of CL.
6. Building upon the results of the first 5 steps, a framework based on these determinants will be developed.
7. Consequently, the framework will be applied to three case studies in order to investigate whether it can provide meaningful insights to assess the CL risk.
8. Lastly, the application of the framework will be discussed, conclusions will be drawn and the main research question will be answered.

2 Methods

In line with the problem definition, research goal research question and sub-questions, the research will follow the structure depicted in Figure 1.

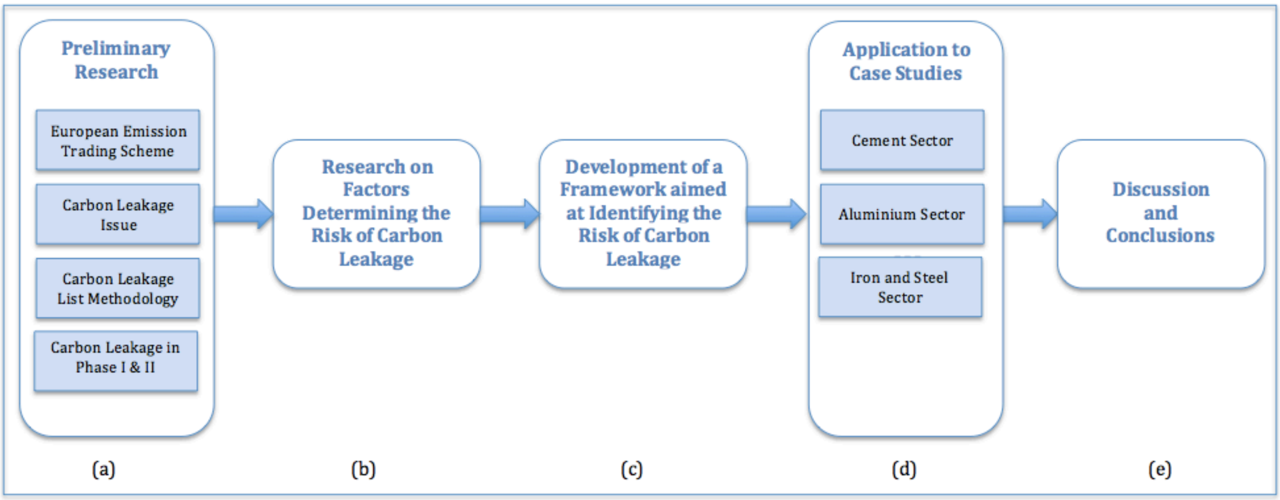

Figure 2. Research Framework

2.1 Preliminary Research

As depicted in section (a) of Figure 2, the first step of the current research consists in a preliminary research on the EU ETS, CL issue, CLL's methodology and CL in Phase I & II of the ETS. This preliminary research aims at addressing steps 1 to 4 of the aforementioned research structure and at answering sub-questions I to VI. First, an overview on how the European ETS functions will help to contextualize the research and will contribute to a better understanding of the project. To this end, the birth and development of the system, from the first Directive to the most recent documents, will be illustrated, focusing in particular on the important and deep changes introduced in Phase III. Such changes led to the development of the CLL and thus their understanding is fundamental for the whole research project. Second, a research on the CL issue will be carried out in order to gain insights on the phenomenon and on its dynamics. An adequate understanding is crucial for a proper formulation of the framework of indicators. Third, the current approach to identify sectors at risk of CL will be reviewed. The methodology behind the CLL will be illustrated along with the underlying assumptions. The main goal of this part of the preliminary research is to enlighten strengths and weaknesses of the current approach. This work will be based on an extensive literature review of publicly available documentation on the EU ETS, including European Commission's Directives, Decisions, Impact Assessments studies and documents in general as well as scientific studies and reports.

As a last step of the preliminary research, reports and scientific papers will be scanned to understand the impact of CL in Phase I & II of the ETS. The goal of this brief investigation is to understand if CL has taken place and to what extent, in order to determine if this phenomenon is a significant threat for the ETS and whether the first CLL is over- or under-estimating it.

The overall goal of the preliminary research is to gain useful insights on the European ETS, on CL, on the CLL and on some key points of the topic. These insights have to be kept in mind throughout the whole process and are crucial for the correct development of the proposed approach.

2.2 Research on Carbon Leakage Determinants

This section, corresponding to step (b) of Figure 2, aims at investigating which are the factors that concur in causing CL, therefore addressing step 5 of the research structure and answering sub-questions VII and VIII. Some of these factors are already outlined in European Commission’s Directives, Decisions, Impact Assessments and other documentation. Moreover, relevant studies, reports and academic articles on this topic will be scanned to complement the study with other insights. The goal is to gain a deeper understanding on this phenomenon and to draw a list of the main determinants of the CL risk. This research step will directly feed into the development of the proposed approach, as determinants and relative indicators will be used to operationalize the framework.

2.3 Development of a Framework Aimed at Identifying the Risk of Carbon Leakage

Drawing from the results of section (b) and from the insights gained in section (a), section (c) of Figure 2 aims at building a framework of indicators based on the previously identified factors addressing step 6 of the research structure and answering sub-questions IX and X. First of all, information gathered in the literature review will be organized in the form of an analytical framework aimed at targeting the main characteristics and dynamics of the CL phenomenon. Secondly, determinants and relative indicators will be linked to the framework in order to operationalize it. Indicators need to be representative of the determinants identified in step (b) (see section 2.2) and will be included in the framework if there is evidence that it will be possible to evaluate them with the publicly available data. It should be kept in mind that the main goal of the current research is to understand whether an alternative approach is possible and to show which indicators should be included in such approach. To this end, the selected indicators and the framework are meant to be employed in a qualitative analysis of sectors. When data allows it, the research will be complemented by more quantitative insights, meaning that it might be possible to calculate and quantify outcomes for some indicators. Prior to its application the framework’s accuracy, reliability and completeness will be verified via consultation of experts in the field.

The main goal of section (c) is therefore to build this framework of indicators based on factors determining the risk of CL.

2.4 Application to Case Studies

In this section the aforementioned framework will be applied to three sectors covered by the ETS in order to assess whether the proposed approach could provide meaningful insights on the actual risk of CL. Therefore this section addresses step 7 of the research structure and answers sub-question XI and XIII. The framework, through its indicators, in fact aims at showing which other factors, other than the two metrics used by the European Commission in the quantitative evaluation, could be helpful to identify sectors at risk of CL. Sectors will be chosen based two main characteristics. First, in order for them to provide a good basis for the discussion of results, they will be chosen different values of CCI and TII. Second, sectors will be selected according to data quality and availability. Data and data sources used in this analysis depends on the specific indicator and sector, but they will involve: databases, sectoral reports, sectoral studies, European Commission documents, academic articles and other publicly accessible sources. The sector analysis will go as in-depth as data will allow it.

The main goal of section (d) is to assess the risk of CL and, based on the results of the framework application, understand strengths and weaknesses of the proposed approach.

2.5 Discussion and Conclusion

Lastly, section (e) will offer a discussion on the robustness of both research method and results, on whether the framework provides meaningful insights on factors determining the risk of CL and if it could be effectively employed to assess the exposure of a given sector to the risk of CL. This reflection will be especially focused on quality, reliability and consistency of the data gathered and will take into account the problems encountered in the research. Nevertheless, strengths and weaknesses of the proposed approach will be carefully analysed. The research will then be finalized by the conclusions, addressing step 8 of the research structure and answering the main research question.

3 Preliminary Research

The preliminary research has two main objectives: first, to get the reader acquainted with the elements, concepts and issues constituting the background of the current research and, second, to build up the knowledge base on which the main part of the research will be developed. As a first step, in Chapter 3.1 the EU ETS is analysed, focusing on its functioning and development, which allow understanding why CL became such a big concern. Chapter 3.2 offers an overview on the CL issue, useful both to understand the main phenomenon addressed by the current research and to structure the proposed approach. Chapter 3.3 analyses the current Commission's approach, in order to understand how the issue is being addressed. Chapter 3.4 analyses strengths and weaknesses of the Commission's approach, with the aim of understanding how it can be improved. Lastly, Chapter 3.5 offers a literature review on CL in the past ETS phases, in order to understand to what extent and how this issue threatens the scheme.

3.1 The European Emission Trading Scheme

This first chapter of the preliminary research aims at gaining an understanding on how the EU ETS was born and on how it developed. Beside becoming familiar with the scheme and its functioning, the main aim of the chapter is to understand why CL became such a big concern in Phase III. The understanding and insights gained in the current analysis will be particularly useful when structuring the proposed approach to CL.

The EU ETS is by far the largest "cap and trade" scheme in the world. It covers the EU-27 Member States, Iceland, Norway, Liechtenstein and Croatia with a total of nearly 12.000 installations. Sectors included in the ETS account for around 45% of the total GHG emissions in Europe (European Commission, 2013). The first step towards the development of the EU ETS has been made in 2000 with the European Commission's *Green Paper on greenhouse gas emissions trading within the European Union* (European Commission, 2000). The Green Paper was meant to pave the road towards the development and implementation of an European "cap and trade" system, in light of the Kyoto commitment. In 2005 the Kyoto Protocol, signed in 1997, entered into force. According to the document, the EU is committed to reduce its GHG emissions by 8% during the period 2008 – 2012 compared to the 1990 levels. The institution of a cap and trade system is envisaged to play a central role in meeting this commitment (European Commission, 2000). Moreover the ETS is a cornerstone of the EU's 20-20-20 objective, i.e. obtaining 20% reduction in GHG emissions compared to 1990 by 2020 (European Commission, 2013). The green paper wished for the establishment of a EU ETS by 2005, in order to gain the necessary experience before the start of the international emission trading system in 2008 (European Commission, 2000).

3.1.1 Establishment of the Emission Trading Scheme and Phase I

The *Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council*

Directive 96/61/EC launched the scheme and provided guidelines for the period from 2005 to 2012 (European Parliament & Council, 2003). The basic rationale behind the ETS is:

- An overall emission cap is set, determining the maximum quantity of available emission allowances;
- Allowances are allocated to participants, which are allowed to trade them among each other;
- On the 30th of April of each year, participants have to surrender allowances for the past calendar year, in a quantity equal to their verified emissions in the same year;
- Non-complying participants have to pay a penalty of 40€/t in Phase I and of 100€/t in later Phases for each tonne of CO_2 emissions not covered by the surrendered allowances. They are also required to surrender allowances for the non-complied emission in the next year (Sijm, 2009).

Figure 3 shows the main steps in the ETS trading year.

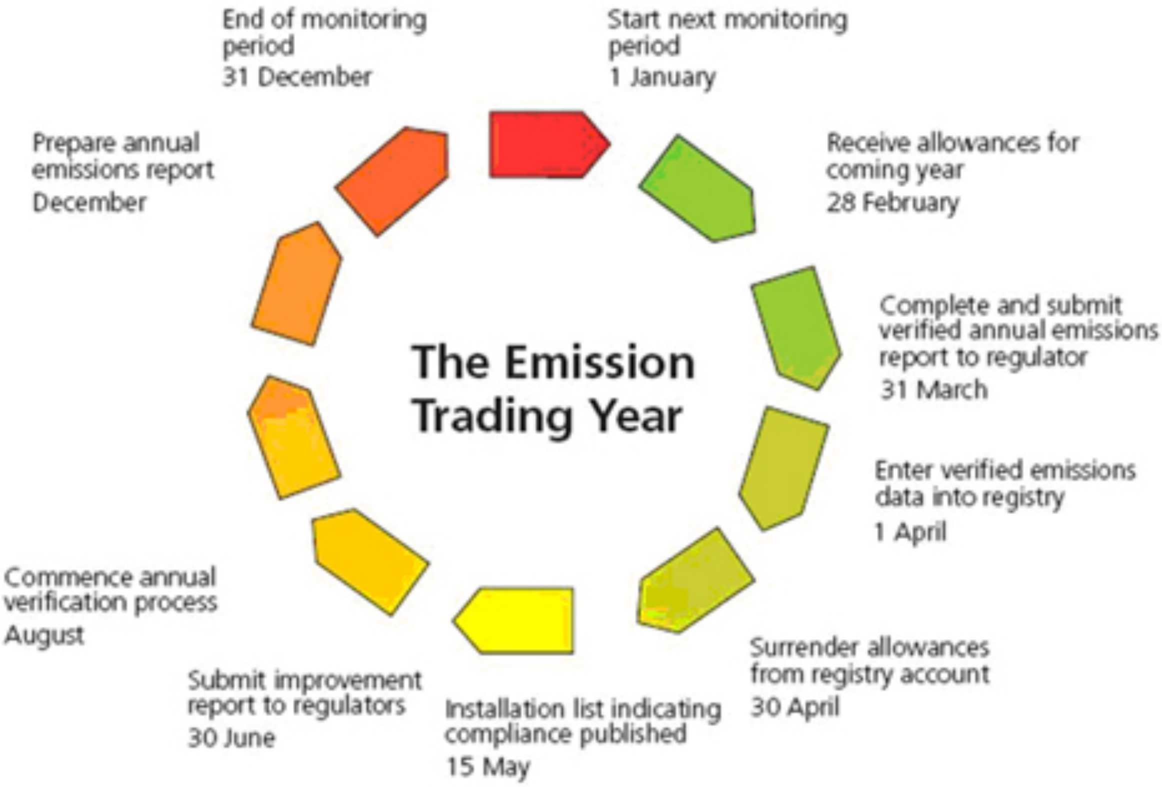

Figure 3. Main steps of the trading year (European commission, 2012a)

Phase I of the ETS ran from 2005 to 2007 and was designed to be a learning-by-doing period with the main goal of putting the system in place. Therefore no ambitious mechanisms were implemented. Allowances have been distributed for free based on a grandfathering allocation system and each Member State was required to develop its own National Allocation Plan (hereafter NAP) that determined the number of allowances to be given to each installation (Venmans, 2012). Grandfathering is an allocation method based on past levels of emissions and thus the amount of allowances given to a certain industry reflects its average emission levels over a specified period of time. In absence of major changes in production, it grants installations virtually all the permits they need. Grandfathering has been employed with the specific purpose of introducing the ETS to installations but had the major drawback of not stimulating emission reductions, as installations expected to receive future allowances based on their current emission levels (Jegou and Rubini, 2011). Moreover, as there was a significant lack of data and industries overstated their needs, allocation has been rather generous.

As a result, Phase I witnessed an over-allocation of allowances, meaning that sectors received more allowances than they needed and that, by the end of the Phase, a surplus of allowances had formed. Allowances banking from Phase I to Phase II was not permitted. Although grandfathering was the dominant allocation method, Member States were allowed to auction up to 5% of their allowances. Only Denmark auctioned the full 5% and only three other countries made use of auctioning to allocate some of their allowances (Jegou and Rubini, 2011). In total, 0.13% of the total allowances have been auctioned in Phase I (Brunner et al., 2008).

Although Phase I was only meant to be a trial, prices of allowances were initially unexpectedly high, averaging at around 20 €/tCO$_2$ with peaks of 30 €/tCO$_2$. This situation suddenly changed when in the spring of 2006, first, data on actual emissions level in 2005 were released revealing that allowances allocation had been rather generous and, second, the Commission announced that leftover permits could not be banked and transferred to Phase II. As a consequence, carbon prices collapsed dramatically for the first time, plunging from 29 €/tCO$_2$ to 13 €/tCO$_2$ in a week and further decreasing to 0.8 €/tCO$_2$ by the end of 2007 (Jegou and Rubini, 2011; Venmans, 2012). Another major effect of grandfathering has been the occurrence of windfall profits as industries passed on to consumers the price of allowances they received for free. This especially happened in sectors with no extra-European competition, such as power generation (Venmans, 2012). Evidence shows that in liberalized energy markets, such as the Dutch and the German ones, energy producers have been able to pass on between 60% and 100% of their opportunity costs, with windfall profits amounting to billions of euros (Jegou and Rubini, 2011; Venmans, 2012; Grubb et al., 2012). Egenhofer et al. (2011) reviewed some studies and concluded that windfall profits could be estimated to be more than € 19 billion in Phase I alone and will stand somewhere between € 23 and € 71 billion in Phase II (Reyes, 2011).

During Phase I emissions rose slightly from 2,012 billion tonnes in 2005 to nearly 2,050 billion tonnes in 2007, thus by less than 2%. This is consistent with the fact that Phase I was not meant to deliver emission reductions, but simply to put the system in place (Jegou and Rubini, 2011).

3.1.2 Phase II

Phase II started in 2008 and ran for a four year period until 2012. Learning from the experience in Phase I and willing to avoid situations similar to the 2006 price crash, the Commission turned down the Member

States' demands for allocation quantities in favour of a more stringent cap. The proposed NAPs would have in fact lead to a 5% increase of emissions compared to 2005 levels. Instead, the Commission rejected the NAPs and lowered the total amount of allowances by 245 million, determining a 6.5% decrease (Jegou and Rubini, 2011; Venmans, 2012). Consequently prices rose again at around the pre-crash levels. In Phase II Member States were allowed to auction 10% of their allowances and, in order to reduce price volatility, allowances banking from Phase II to Phase III was permitted (Venmans, 2012). Moreover, starting from Phase II the project-based offset mechanisms created under the Kyoto Protocol, namely the Clean Development Mechanisms (CDM) and the Joint Implementations (JI), are accepted, within certain limits, for compliance in the ETS market (Perdan and Azapagic, 2011).

Although the situation seemed to be finally under control, a second dramatic price collapse occurred in 2008, as a consequence of the financial crisis that struck in the autumn of that year. Prices declined in few months from a peak of 29 €/tCO_2 in July 2008 to a low of 8 €/tCO_2 in February 2009 (Jegou and Rubini, 2011). This mainly happened because the reduced industrial production caused by the crisis determined a smaller need for emission permits, depreciating their value. Between April 2010 and April 2011 the carbon price remained stable at around 15 €/tCO_2 (Venmans, 2012). In the second half of 2011 prices started to further decline as it became evident that a conspicuous surplus of allowances was forming again, mainly because allocation quantities have been determined on pre-crisis emission levels. There is evidence that this surplus could be well over 1.5 billion allowances at the beginning of Phase III (European Commission, 2012d). Fears of a continued recession in 2012 and uncertainty in global climate negotiations have also contributed in reducing the carbon price (Grubb et al., 2012). Figure 4 shows the evolution of the carbon price in Phase I and II.

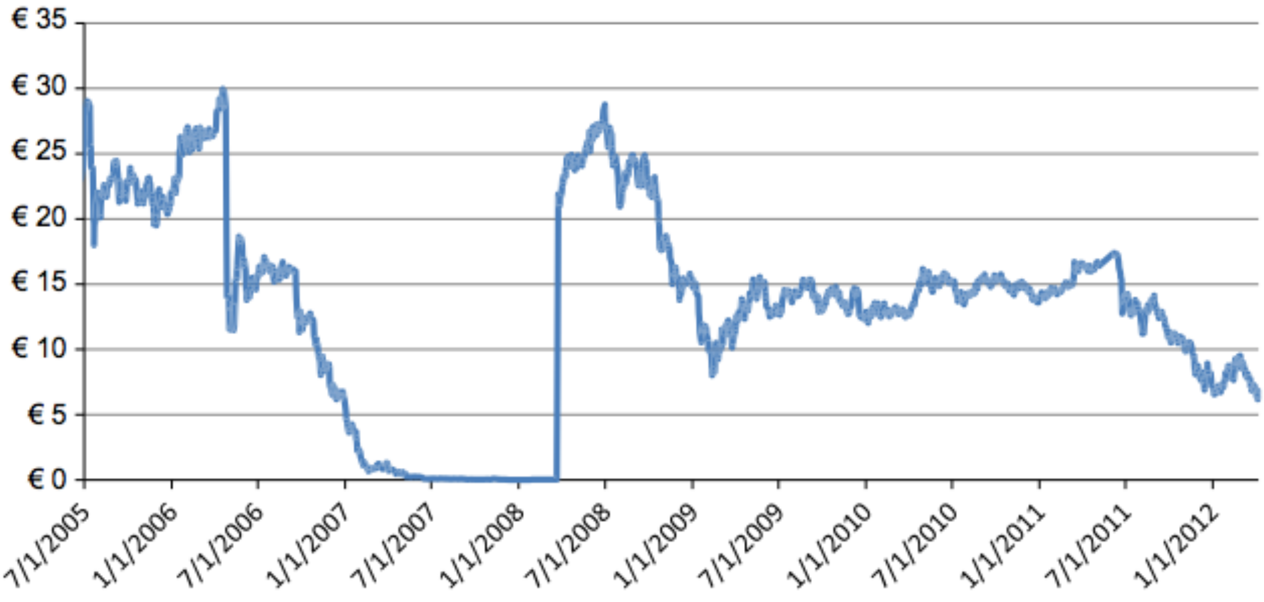

Figure 4. Evolution of carbon prices in Phase I & II (Venmans, 2012)

Table 1 shows the quantities of issued allowances and actual emission in Phase II. It is clear that a conspicuous surplus has been progressively formed.

Table 1. Issued Allowances and Reported Emissions from 2008 to 2011 (based on European Commission, 2012d)

(in Mt)	2008	2009	2010	2011	Total
Issued allowances and used international credits	2076	2105	2204	2336	8721
Reported Emissions	2100	1860	1919	1886	7765
Cumulative Surplus of Allowances	-24	245	285	450	956

As of 2012 also the aviation sector is covered by the ETS, meaning that all the airlines landing in European airports have to comply with the scheme (Venmans, 2012).

3.1.3 Significant Changes and Phase III

The amendment to the first Directive on the EU ETS was published on 5 June 2009 with the document *Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community* (European Parliament & Council, 2009). The document introduced significant changes to the system for the period 2013 – 2020, known as Phase III. The main changes applied to the ETS were:

- The shift towards a more centralized system with the replacement of 27 national electronic emission and allocation registries by a single Union registry;
- The introduction of an EU-wide cap on allowances, replacing 27 individual Member State caps that were in place before. The allowances cap will decrease by 1.74% annually, up to and beyond 2020, providing much greater regulatory predictability and stability;
- The introduction of auctioning of allowances as the default system of allocation;
- Free allocation of allowances based on EU-wide harmonised rules and on performance benchmarks established prior to Phase III (European Commission, 2012a).

The first novelty in Phase III is that the emission cap is set at a EU level, replacing the 27 national caps in place before. Moreover the cap decreases by 1.74% annually leading ETS sectors to 21% emissions reduction in 2020 compared to 2005 levels (European Commission, 2011b). With the *Commission Decision of 9 July 2010 on the Community-wide quantity of allowances to be issued under the EU Emission Trading Scheme for 2013 (2010/384/EU)* the Commission decided that, given that the average annual total quantity of allowances issued by Member States in the period from 2008 to 2012 amounts to 2,032,998,912 and that the total quantity of allowances to be issued from 2013 onwards has to decrease annually by a linear factor of 1.74%, the absolute Community-wide quantity of allowances to be issued for 2013 amounts to 1,926,876,368 (European Parliament & Council, 2010b). The quantity has been later raised to

2,039,152,882 by the *Commission Decision of 22 October 2010 adjusting the Union-wide quantity of allowances to be issued under the Union Scheme for 2013 and repealing Decision 2010/384/EU*. The allowances issued in 2020 are, in absence of changes, consequently forecasted to be 1,791,533,615 implying that the figure represents, in tonnes, also the overall cap level (European Parliament & Council, 2010c).

Moreover the 2009 Directive, and more specifically the *Commission Decision of 27 April 2011 determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council* states that "auctioning should be the basic principle for allocation, as it is the simplest and generally considered to be the most economically efficient system" (European Parliament & Council, 2011a; European Parliament & Council, 2009 p. 65). Therefore in Phase III the Community-wide harmonised allocation method aims at replacing the free allocation of allowances with a transitional, benchmark-based auctioning system. Transitional means that the free allocation is initially 80% of a certain benchmark and decreases each year by an equal amount resulting in 30% free allocation in 2020, with a view to reach 0%, and thus no free allocation, in 2027 (European Parliament & Council, 2009). The power sector will have to auction 100% of its emission allowances right from the beginning of Phase III as the 2009 Directive states "No free allocation shall be made in respect of any electricity production by new entrants" (European Parliament & Council, 2009 p.73).

The quantity of allowances still allocated free of charge is determined by product benchmarks or, when the latter are not available, by following fallback approaches. A product benchmark is defined as the average of the 10% most greenhouse gas efficient installations, in terms of tonnes of CO_2 emitted per tonne of product produced at European level in the years 2007 - 2008. Therefore the most efficient installations will have to auction a smaller quantity of allowances compared to less efficient installations. Product benchmarks are not differentiated by technology, fuel mix, size, age, climatic circumstances or raw material quality of the installations producing the product. Product benchmarks, listed in Annex I of the aforementioned Commission Decision, include fifty-two products covering around 80% of the emissions of those sectors where benchmarking applies (European Commission, 2011a; European Parliament & Council, 2011a). Figure 5 shows graphically how product benchmarks are established.

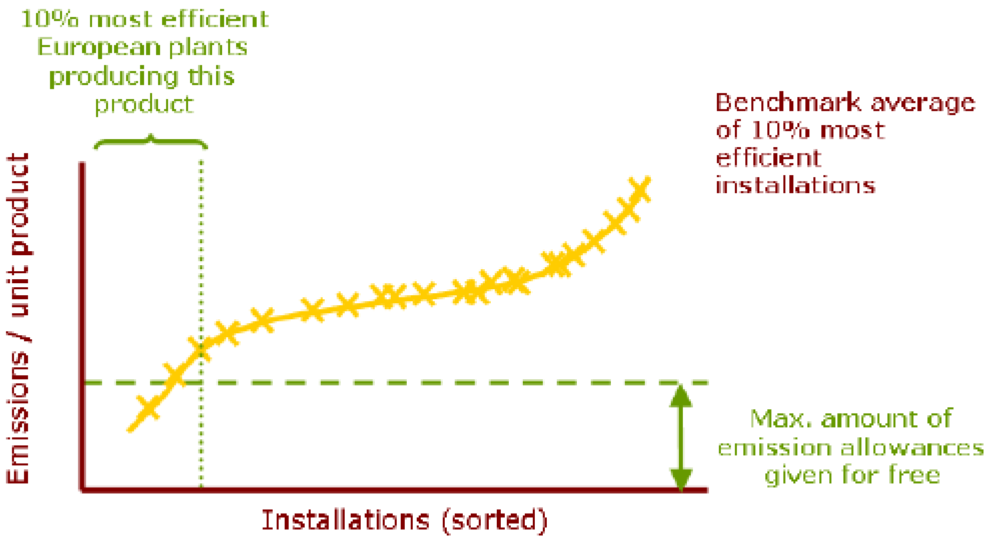

Figure 5. Graphical representation of benchmark setting (European Commission, 2011b)

Fallback approaches apply to installation eligible for free allocation but not covered by product benchmarks. To these installations alternative benchmarks are applied in the following order:

- Heat benchmark (62.3 tonnes of CO_2 per TJ of heat consumed);
- Fuel benchmark (56.1 tonnes of CO_2 per TJ of fuel consumed);
- Grandfathering process emissions (97% of historical emissions).

Following these benchmarks, the calculation of the quantity of allowances to be allocated for free to installations consists in multiplying the benchmark value with the relevant historical activity level, based on the median value over the baseline period (European Parliament & Council, 2011a).

Exceptions are made for installations in sectors exposed to significant risk of CL. CL and the Commission's approach will be addressed more in depth in the coming chapters. Those installations will receive free allowances at 100% of the aforementioned benchmark. The Commission Decision determining the list of sectors exposed to a significant risk of CL, the so-called "Carbon Leakage List", was approved by the Member States in 2009 (European Parliament & Council, 2010a). The Commission determined the first CLL in 2009 and will determine new ones every five years thereafter. The first list identified 164 sectors as deemed to be at risk and applies until 2014 (European Commission, 2011b). In light of the possible exposure of certain sectors to the risk of CL, the calculation of the quantity of free allowances to be allocated to a specific installation is thus completed by a last step: the multiplication with the exposure factor. The latter is 1, meaning 100% free allocation of the benchmark level, in the period 2013 – 2020 for installation in sectors exposed to the risk of CL and will vary from 0.8 in 2013 to 0.3 in 2020 for installations in sectors not exposed to CL, reflecting the transitional system aimed at progressively introducing auctioning (European Commission, 2011a). Table 2 shows the exposure factors for CL and non-CL sectors.

Table 2. Exposure factor for Carbon Leakage and non-Carbon Leakage Sectors (based on European Parliament & Council, 2009)

Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Exposure factor for significant carbon leakage risk	1	1	1	1	1	1	1	1
Exposure factor for no significant carbon leakage risk	0.8	0.7286	0.6571	0.5857	0.5143	0.4429	0.3714	0.3

The EU ETS has indeed stimulated emissions abatement. In a survey conducted by Point Carbon (2012), a consultancy which tracks and analyses the carbon markets, the majority of respondents said that the EU ETS has caused emission reductions in their company. Grubb et al. (2012) reviewed a number of studies estimating the ETS's emission abatement and concluded that it could be in the order of 40 – 80 Mt of CO_2 per year in the first 4 years of the ETS. A study carried out by the World Bank came to similar conclusions (Perdan and Azapagic, 2012). It should also be mentioned that, being the first large scale ETS in the world, the EU ETS has provided extremely useful opportunities for institutional learning, development of market infrastructure and a valuable experience that can be used, and it is being used, in establishing ETS in other world regions (Wrake et al., 2012).

Concluding this overview, the EU ETS has shown that it is possible to design and implement a large scale trading system and that it can function. The system has revealed to have strengths and weaknesses. There is evidence that windfall profits occurred in Phase I and II, mainly in the power generation sector but also in other sectors, totalling several billions of euros per year (Jegou and Rubini, 2011; Venmans, 2012; Grubb et al., 2012). Phase III aims at eliminating these windfall profits with the introduction of the auctioning regime. As shown by Figure 4 above, carbon prices proved to be quite fluctuating and vulnerable to external factors, as in the case of the financial crisis. Carbon price instability is a limiting factor for long term investment in energy efficiency and emission reductions, and thus only by ensuring a better stability the ETS effectiveness can be enhanced. Moreover, with regard to the development of the proposed approach, two insights gained in this chapter are of particular interest. First of all it has been important to understand which changes introduced in Phase III determined CL concerns and, second, it is important to keep in mind that Phase II witnessed the formation of a significant surplus of allowances that will be banked to Phase III. Both elements will be crucial for a correct formulation of the proposed approach.

3.2 The Carbon Leakage Issue

In order to understand which indicators could be used to identify sectors at risk of CL we should analyse which are the factors causing the phenomenon. This chapter therefore gives a deeper look at the CL issue, at its dynamics and characteristics. This chapter has the twofold objective of getting the reader acquainted with the topic and gather information to structure the later parts of the research. Obviously, it is fundamental to have a full understanding of the nature and dynamics of CL in order to develop a correct approach.

With regard to the EU ETS, CL is mentioned for the first time in an official document in the 2009 Directive. CL is defined as “an increase in greenhouse gas emissions in third countries where industry would not be subjected to comparable carbon constraints” which “at the same time could put certain energy-intensive sectors and sub-sectors in the Community which are subject to international competition at an economic disadvantage” (European Parliament & Council, 2009 p.66).

CL is a rather complex and articulated phenomenon that can be defined, in its broadest meaning, as a change in GHG emissions in one world region as a result of the implementation of a strict climate policy in another region. The change can either be positive or negative, according to which aspect of the phenomenon is being considered. Most studies agree on identifying three main channels through which CL takes place and which are helpful to understand how climate policies and carbon pricing affect global emissions. These three channels are:

- Global energy markets;
- Industrial operations and investment effects; and
- Technology and policy spill-over effects (Dröge, 2009).

CL happens through the first channel, global energy market, following a chain of causal effects. First of all, the introduction of a carbon price in a world region causes a local increase in fuel prices. Increased prices determine a reduction in fuel demand in that world region, which in turn, following a simple supply-demand effect, would lead to a decrease in prices on the global market. Consequently demand for fossil fuels, and thus GHG emissions, would increase in other world regions, triggered by lower prices (Dröge & Cooper, 2010; Jegou and Rubini, 2011).

The second channel refers to the effect of a climate policy at an industry level. Industries in a region with a strict climate policy face competitiveness constraints due to the unilateral carbon pricing compared to their foreign competitors. This leakage channel can be divided into two main sub-channels: first, CL can result from a loss of market shares to more carbon-intensive foreign competitors and second, it can arise from new investments of domestic industries taking place on foreign markets (Jegou and Rubini, 2011). In both cases CL occurs because carbon prices impact direct and indirect costs of an industry and consequently its competitiveness and profits. Carbon pricing entails to an increase in production costs that can result in a profit margin reduction or in a loss of market shares. If a price on carbon emissions is imposed, firms can react by increasing their product prices, reducing their profit margins, investing in cleaner technologies or relocating their production to areas with a weaker environmental regulation (Dröge & Cooper, 2010; Grubb et al., 2012). Leakage should not be confused with the market shift from carbon intensive products to greener substitutes, which is part of the desired result of a climate policy (Venmans, 2012). Nevertheless, while stimulating investments in cleaner technologies is the goal of imposing a carbon price, all the other reactions listed above lead to a possible risk of CL.

If a firm decides to increase product prices, it will likely face the risk of losing market shares. As a consequence a region regulated by a strict climate policy will witness an increase in imports of carbon-intensive products from non-regulated regions, as they become more competitive than the domestic ones, coupled with a reduction of its exports to foreign markets. Emissions are therefore simply being shifted from one world region, i.e. the regulated one, to another (Dröge, 2009). On the other hand, if a firm does not pass on costs to consumers by increasing its product prices it will suffer a reduction of its profit margin. Decreasing profits affect also the investment decision of domestic industries (Reinaud, 2008b; Dröge, 2009). An industry would then be stimulated to redirect its investments towards a foreign market, and eventually relocate its production, if a weaker environmental regulation in the latter constitutes a cost advantage to heavy emitters and carbon-intensive installations (Dröge & Cooper, 2010). It has to be underlined that competitiveness impacts do not automatically lead to carbon emissions being shifted abroad, but the likelihood is high if cost impact and trade intensity are significant (Dröge, 2009).

Summing up, CL happens through the second channel when, as a consequence of the additional costs deriving from the compliance to the ETS Directive, it is more convenient for an industry to relocate its production in non-compliant countries, or when an industry’s product prices increase so significantly that the market shifts its preference towards products coming from non-ETS countries. Thus, in both cases, GHG emission reductions in countries belonging to the ETS are counterbalanced by an increase in emissions in third countries, coupled with a loss of competitiveness for EU industries.

Further studies on the nature of the impact on industries of climate policies revealed that CL occurs in stages. Typically, the first effect is the so-called production leakage that, as described before, happens as a consequence of a shift in market preference. Consumers’ preference, driven by lower prices of non-CO_2 priced foreign products, causes a decrease in domestic demand and an increase in imports from non-ETS countries, coupled by a similar trend for GHG emissions. In a second stage, the loss of profitability in ETS countries stimulates firms to redirect investments towards non-ETS countries. This investment leakage could evolve, in a third stage, in the relocation of exposed industrial activities in non-ETS countries (Reinaud, 2008b; European Commission, 2012b). Nevertheless, it has to be underlined that both stakeholders involved in consultations and a number of studies agree that the third stage of leakage is highly unlikely (European Commission, 2012b).

The third channel of leakage refers to the impact of carbon pricing on investment in technology innovation and policy diffusion. Carbon pricing favours clean and more efficient technologies, thus stimulating their development and implementation. For example, a long-term carbon price signal offers incentives to introduce new technologies so that installations can reduce their carbon costs (Dröge & Cooper, 2010). Gradually, R&D will lower the costs of low-carbon technologies making them able to compete with current production practices. There is therefore the possibility for a positive global effect because clean technologies are eventually transferred and used in countries outside of carbon pricing regions. A similar reasoning holds also for the development and implementation of climate policies. If ambitious climate policies prove to be successful and effective, the experience gained in early adopting countries will pave the road for their worldwide diffusion (Dröge & Cooper, 2010).

It is clear that the three CL channels operate differently and differ also in their effects. The first two channels determine a net increase of global emissions and an economic loss for the regulated region as a result of a unilateral climate action. The last channel results in a global reduction of emissions and in an economic gain for the region that undertakes early climate measures. It is still under discussion which of the three channels has the biggest impact as well as what the final net effect is (Venmans, 2012). Figure 6 below represents the three different channels, enlightening the second one, which is address by the CLL and thus the main subject of this thesis.

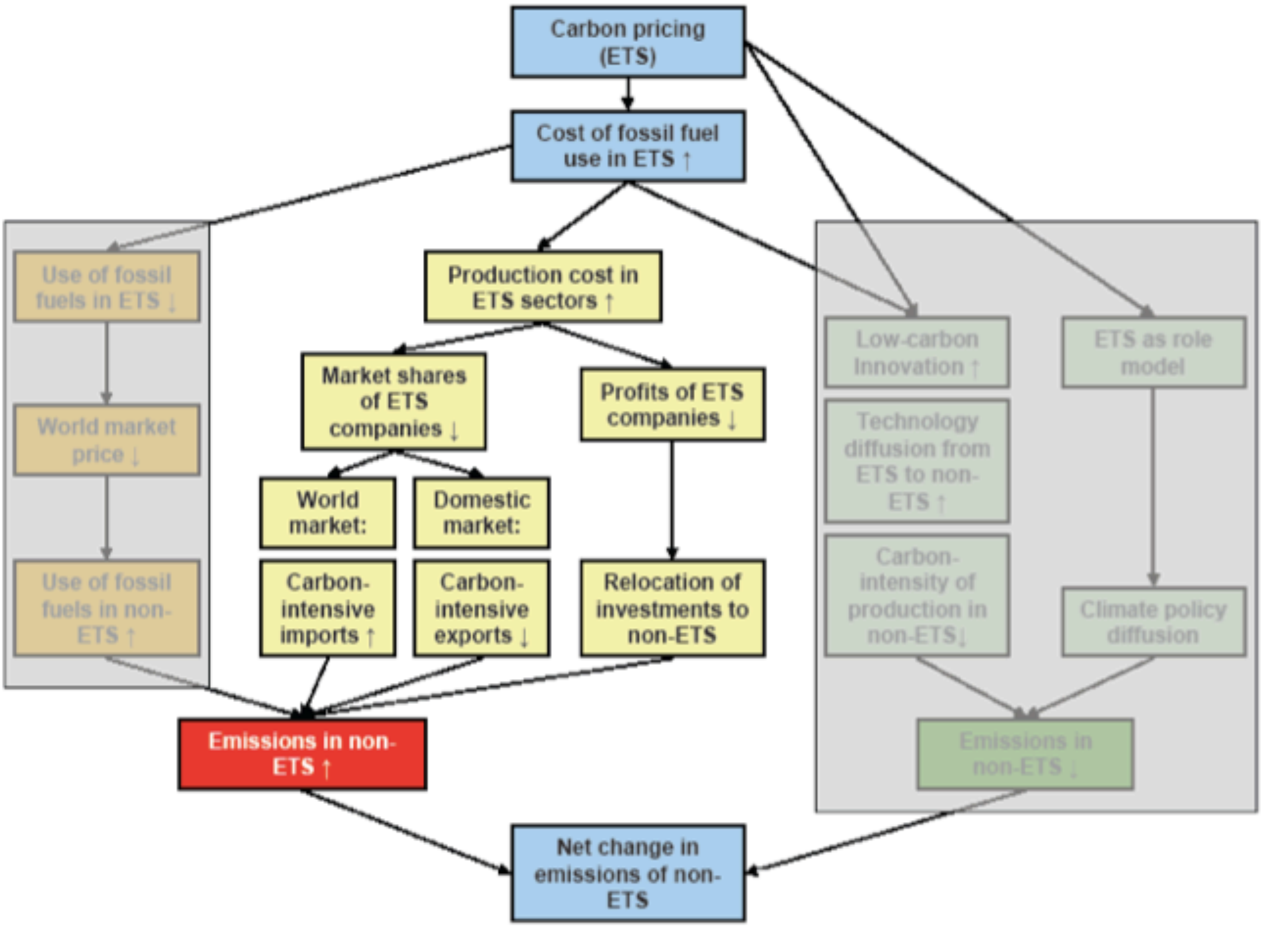

Figure 6. Carbon Leakage Channels (Dröge, 2009)

Focusing on the second CL channel, it is clear that all the causal implications are triggered in a first place by the additional costs for industries in regulated regions compared to their foreign competitors. The increase in production costs is the key determinant of CL. Therefore a region implementing a strict unilateral climate policy, such as the EU, has to adopt measures to avoid CL by intervening on this price differential. According to economic theory, policy makers have three options to address the negative impacts from carbon pricing:

- Levelling down carbon costs for EU producers;
- Levelling up carbon costs in other world regions;
- Levelling carbon costs at the border (Dröge & Cooper, 2010).

These three options are visually represented in Figure 7.

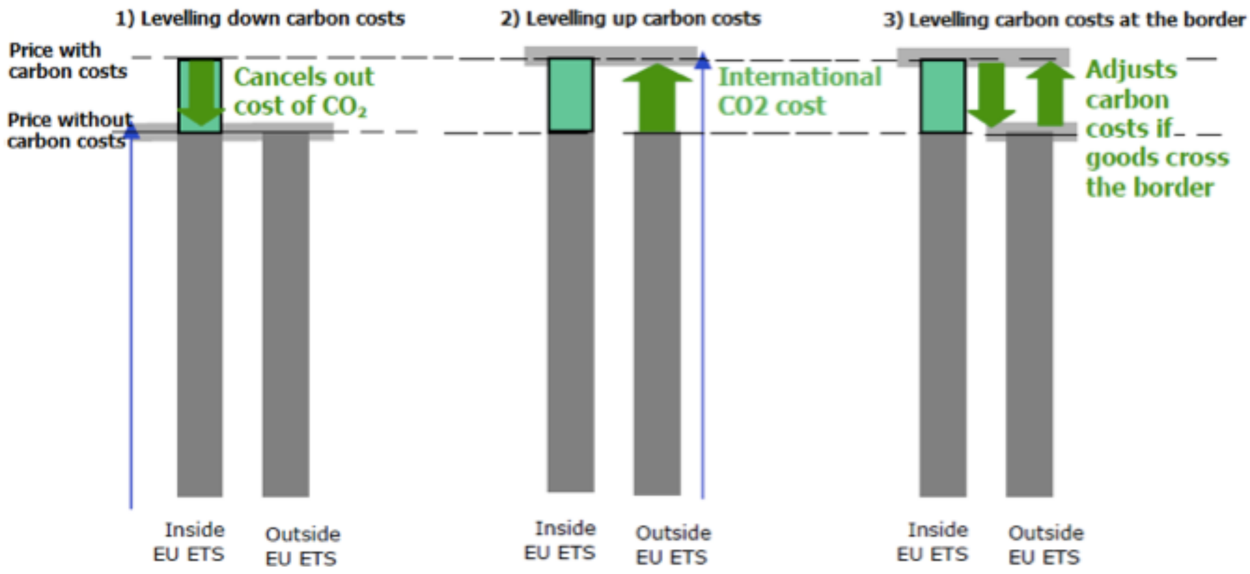

Figure 7. Carbon Leakage mitigation options (Dröge & Cooper, 2010)

Levelling costs down is the mitigation option chosen by the European Commission with the implementation of the CLL. This strategy, explained in more details in the next chapter, consists in exempting the most CL exposed EU industries from full compliance to the ETS, i.e. by granting them free allocation to reduce their compliance costs. In this way their competitiveness is less affected by the ETS, as the additional carbon costs are minimized (Dröge & Cooper, 2010).

Levelling costs up in other world regions is what the EU hopes for in the long run. This happens when other world regions decide to put a price on their GHG emissions as well, therefore aligning production costs for their industries to the EU's. Levelling costs up could be realized through worldwide emissions reduction commitments, through international sectoral agreements or by including importers in the scheme (Dröge & Cooper, 2010).

The last option is to level costs at the border, also referred to as border adjustment measures. It consists in applying measures to adjust the price of EU products to the price of extra-EU products either by levelling up the price of imported products or levelling down the one of exports. There are a number of options to do so, such as an import tax for imported goods or an export rebate for products leaving the ETS region. Border adjustment measures are generally opposed by the World Trade Organization and therefore are not easily implementable (Dröge & Cooper, 2010).

Concluding, the current chapter shed light on the nature and dynamics of the CL phenomenon. CL, with regard to the second channel addressed by this work, is a process that happens in stages through two main dynamics: a short-term production leakage and a long-term investment leakage. The first type of leakage is mainly a consequence of prices raising due to carbon costs, while the second type of leakage happens when an industry witnesses a loss of profitability and seeks better profits by relocating. An adequate understanding of CL will be fundamental in structuring the proposed approach and in shaping the framework.

3.3 Commission’s Approach to Carbon Leakage

The present chapter aims at reviewing the Commission’s approach to CL. Shedding light on the Commission’s methodology is useful in order to understand how the issue is currently being addressed.

One of the biggest changes in Phase III of the EU ETS is the introduction of the so-called CLL in order to protect sectors deemed to be exposed to such a risk. CL became a major threat for the effectiveness of the EU ETS as a consequence of the additional compliance costs deriving from the auctioning regime. The 2009 Directive states: “to address the risk of CL, the Community should allocate 100 % of allowances free of charge to sectors or subsectors meeting the relevant criteria” meaning that, instead of going through the transitional allocation system, sectors deemed to be exposed to a risk of CL will continue to receive allowances free of charge up to a benchmark level in the period 2013 – 2020 (European Parliament & Council, 2009 p.66).

The assessment of sectors to determine whether they are exposed to the risk of CL has to be based on specific criteria and, in this regard, the Directive states: “in order to determine the sectors or subsectors referred to in paragraph 12, the Commission shall assess, at Community level, 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” (European Parliament & Council, 2009 p.74). Paragraph 15 and 16 of Article 10a of the revised Directive lay down the two criteria to identify sectors at risk of CL (European Parliament & Council, 2009 p.75):

15. A sector or subsector shall be deemed to be exposed to a significant risk of CL if:

a) The sum of direct and indirect additional costs induced by the implementation of this Directive would lead to a substantial increase of production costs, calculated as a proportion of the GVA, of at least 5 %; and
b) The intensity of trade with third countries, defined as the ratio between the total value of exports to third countries plus the value of imports from third countries and the total market size for the Community (annual turnover plus total imports from third countries), is above 10 %.

16. Notwithstanding paragraph 15, a sector or subsector is also deemed to be exposed to a significant risk of CL if:

a) The sum of direct and indirect additional costs induced by the implementation of this Directive would lead to a particularly high increase of production costs, calculated as a proportion of the GVA, of at least 30 %; or

b) The intensity of trade with third countries, defined as the ratio between the total value of exports to third countries plus the value of imports from third countries and the total market size for the Community (annual turnover plus total imports from third countries), is above 30 %

Moreover, Paragraph 17 lays down the guidelines for the qualitative assessment, analysed later in the chapter (European Parliament & Council, 2009).

3.3.1 The First Carbon Leakage List

According to these criteria, the *Commission Decision determining a list of sectors and sub-sectors deemed to be exposed to a significant risk of CL*, the so-called "Carbon Leakage List", was approved by the Member States in 2009 in the form of the *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 CL* (European Parliament & Council, 2010a). The document identified 164 sectors as deemed to be at risk applies for the years 2013 and 2014. The Commission will determine a new CLL every five years thereafter (European Commission, 2011a). The first CLL has been amended twice, by the documents *Commission Decision of 11 November 2011 amending Decisions 2010/2/EU and 2011/278/EU as regards the sectors and subsectors which are deemed to be exposed to a significant risk of CL* and *Commission Decision of 17.8.2012 amending Decisions 2010/2/EU and 2011/278/EU as regards the sectors and subsectors which are deemed to be exposed to a significant risk of CL* each one of the two added few sectors to the original list, bringing the total number of sectors included in the list to 170 (European Parliament & Council, 2011b; European Parliament & Council, 2012). Sectors included in the CLL represents 60% of the 258 ETS sectors and account for 95% of the industrial emissions (de Bruyn et al., 2013).

3.3.1.1 Quantitative approach

The revised Directive establishes two main methods to identify sectors at risk of CL: a quantitative assessment, drafted in paragraph 15 and 16, and a qualitative assessment, drafted in paragraph 17. The quantitative assessment is the main tool used to draw the CLL but, as stated in the Directive, the final list could be completed by the qualitative assessment. The quantitative approach consists of two indicators: the CCI and the TII (European Parliament & Council, 2009). The CCI quantifies the additional costs that sectors face due to the introduction of the Directive. It is the sum of direct costs stemming from the value of allowances to be purchased to cover the direct emissions and indirect costs of emission rights included in the electricity purchases of the sector in relation to GVA (GVA). It is represented by the formula:

$$CarbonCost = \frac{DirectCosts + IndirectCosts}{GVA}$$

Direct costs induced by the EU ETS to industrial sectors can be quantified as direct emissions minus free allocation multiplied by the carbon price, i.e. the price of allowances. Direct costs are represented by the formula:

$$DirectCosts = (DirectEmissions - FreeAllocation) * Carbon\,\mathrm{Pr}\,ice$$

With the introduction of the EU ETS, carbon costs related to GHG emissions from electricity generation are reflected in the electricity prices and are assumed to be passed on to consumers. In order to reflect these additional costs, indirect costs have been included in the CCI. They are calculated by multiplying the amount of electricity purchased for own consumption with an electricity emission factor and the carbon price (European Commission, 2011a). Indirect costs are represented by the formula:

$$IndirectCosts = (ElectricityConsumption * EmissionFactor) * Carbon\,\mathrm{Pr}\,ice$$

The second indicator to assess the risk of CL is the trade intensity of an industry, which is defined as the ratio of imports and exports in relation with the domestic market, expressed as EU turnover plus imports.

$$TradeIntensity = \frac{Imports + Exports}{Turnover + Imports}$$

According to the Commission's approach, sectors are deemed to be exposed to the risk of CL if they meet certain thresholds for the two indicators. Paragraph 15 and 16 identify three different cases; sectors are included in the list if:

- The CCI exceeds 5% and the Trade Intensity exceeds 10%, hereafter referred to as first criterion, or;
- The CCI exceeds 30%, hereafter referred to as second criterion, or;
- The TII exceeds 30%, hereafter referred to as third criterion (European Parliament & Council, 2009).

The assessment is based on NACE codes of sectors, subsectors and products. NACE codes are used to classify which specific sector an installation belongs to, based on the activities carried out. The codes are taken from the Classification of Economic Activities in the European Community (European Parliament & Council, 2010a). Figure 8 graphically represents the threshold levels for the two indicators in the quantitative assessment.

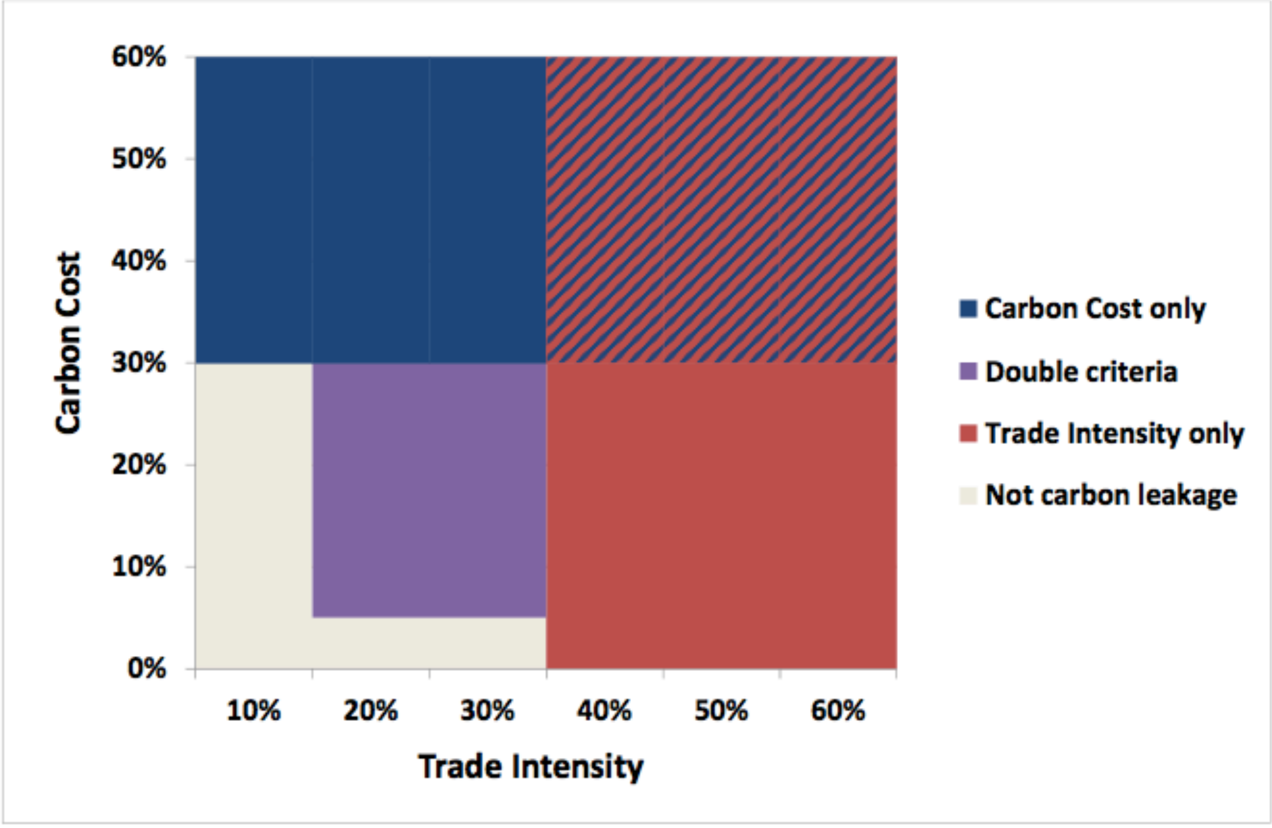

Figure 8. Differentiation of sectors according to Carbon Cost and Trade Intensity (Graichen et al., 2013)

The table below shows how many sectors along with their emissions have been included in the CLL due to the specific criteria.

Table 3. Sectors and relative emissions included in the carbon leakage list (Based on de Bruyn et al., 2013)

Criterion	N° of Sectors	Verified Emissions	In % of industrial emissions
Carbon Cost >5% and Trade Intensity >10%	13	219,302,751	36%
Carbon Cost >30%	2	177,572,917	29%
Trade Intensity >30%	133	157,233,891	26%
Qualitative Assessment	6	14,435,748	2%

Figure 9 below combines the previous Figure 8 and Table 3 showing where the sectors included in the CLL lie with respect to the CCI and TII.

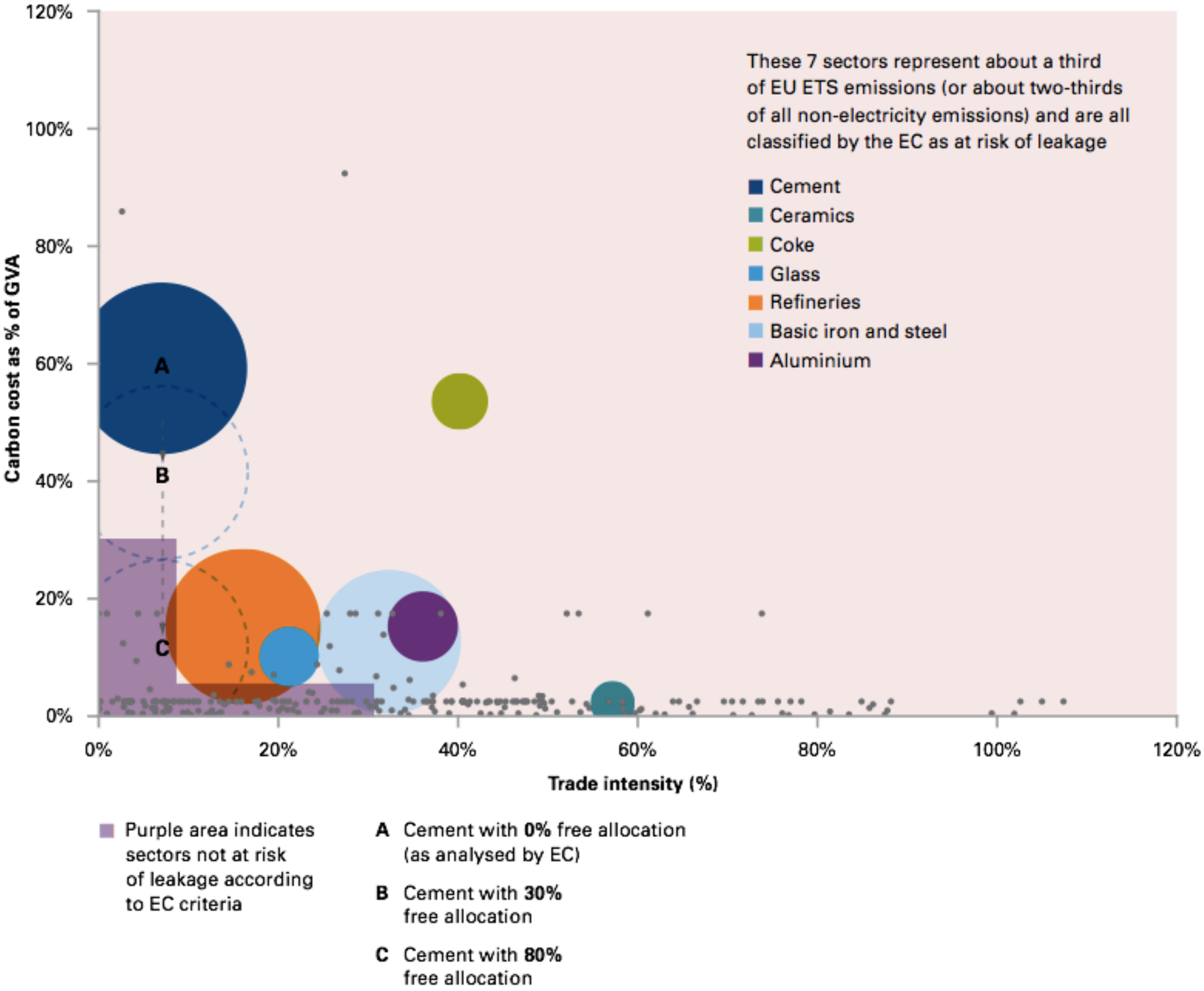

Figure 9. Distribution of ETS sectors with respect to the CCI and TII (Carbon Trust, 2010)

3.3.1.2 Qualitative Approach

According to paragraph 17 of article 10a sectors the list may be supplemented after completion by a qualitative assessment. This assessment is carried out to: better analyse sectors not sufficiently represented by the quantitative assessment, sectors considered to be borderline cases (i.e. with values close to the threshold levels indicated in paragraph 15 and 16), sectors for which there was a significant lack of data needed in the quantitative assessment and sectors for which Member States or sectors' representatives requested a deeper analysis, based on reasonable request (European Parliament & Council, 2009). Following the guidance of paragraph 17 the qualitative assessment focuses on three main aspects:

- The ease with which a specific sector can abate its GHG emissions or reduce its electricity consumption by implementing the most efficient techniques at a reasonable cost, referred to as the "technological assessment";
- Current and projected market characteristics typical of a specific sectors, referred to as "market characteristics";

- Profit margins of a specific sector and the potential consequences on long-term investment decisions and activity relocation, referred to as “profit margins” (European Parliament & Council, 2009).

Eight indicators fall in these three categories and are listed, along with a brief explanation, in Annex 1. The value added of the qualitative approach is that it can provide insights on sector specific characteristics and peculiarities that the quantitative approach is not able to capture. In the context of the first CLL a qualitative assessment has been carried out on 5 sectors and resulted in all 5 sectors being included in the list (European Parliament & Council, 2010a).

Concluding, the present chapter reviewed how the current Commission’s approach works. Sectors are mainly chosen via a quantitative assessment following three criteria based on two indicators, i.e. CCI and TII. Occasionally sectors can be added based on a qualitative assessment, which takes into considerations three main aspects. The Commission’s approach, as well as the indicators considered, will be taken into account when formulating the proposed approach.

3.4 Analysis of the Commission’s Approach and Critics

The present chapter is of fundamental importance for this research. The aim is to analyse the current Commission’s approach with regard to its strengths and weaknesses. Moreover the main critics moved to the approach are reviewed. Such analysis will be very valuable when drafting the proposed new approach and the framework. Particular attention is given to the current approach’s weaknesses and shortcomings, in order to understand how to develop a stronger approach.

3.4.1 Assumptions

Having in mind the aforementioned methodology for the quantitative approach, it is clear that a number of factors are involved in the calculation. Some of these factors rely on sensitive assumptions. Looking back at the mathematical formulation of the CCI, the first CLL relies on three main assumptions, clearly listed in the Commission Decision (European Parliament & Council, 2010a):

- A carbon price of € 30 per tonne of CO_2 equivalent (paragraph 10);
- An auctioning level of 75% of the allowances in non-exposed sectors for the years 2013 and 2014 (paragraph 12);
- An emission factor for electricity of 0.465 tonne of CO_2 per megawatt (paragraph 13).

3.4.1.1 Carbon Price

Article 10a (14) of the Directive states that the assessment should be based on an average carbon price according to the Commission's impact assessment accompanying the package (European Parliament & Council, 2009). A price of € 30 per tonne of CO_2 has been used to draw the first CLL and in the *Impact Assessment accompanying the Commission Decision on the first CLL* (European Commission, 2009), as also indicated on the Commission Decision itself. This is a rather weak assumption as evidence on recent carbon prices has shown that they have been stable at around 15 €/tCO_2 in the period 2009 – 2011 and have been progressively declining ever since, as shown in Figure 10.

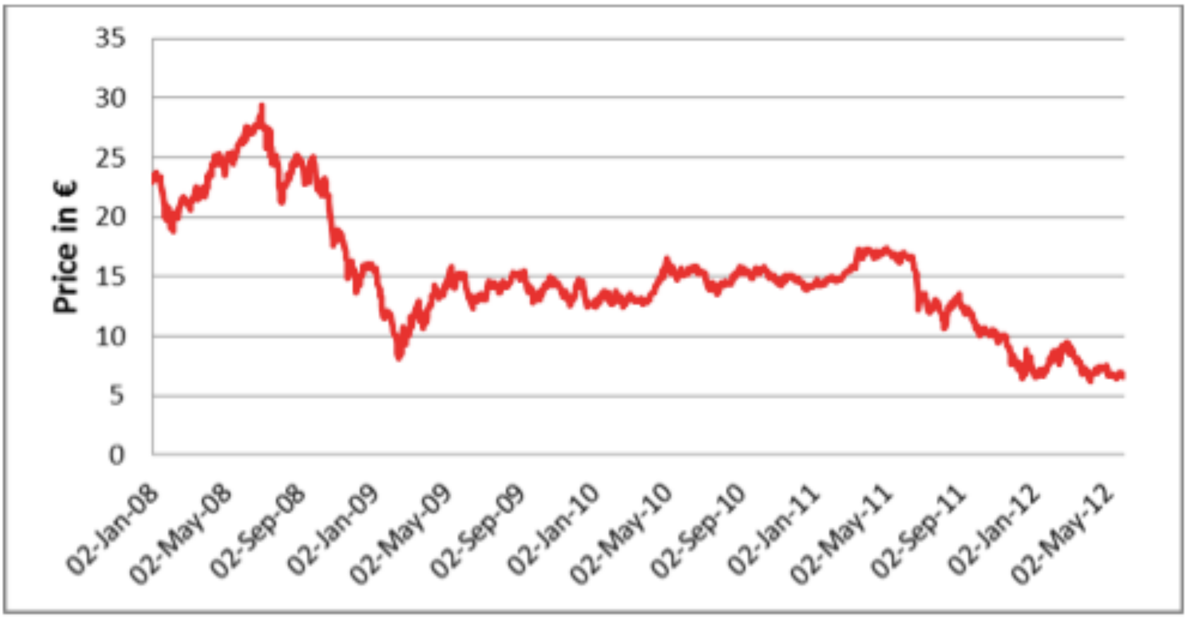

Figure 10. Price of ETS Allowances (European Commission, 2012d)

This trend is confirmed by several carbon price forecast studies. The main reason behind the low prices is the evidence of an existing surplus of allowances that will likely persist through Phase III (European Commission, 2012d). Point Carbon (2012) reports an average EUA price of 8 €/tCO_2 in 2012 and forecasts an average price of 9 €/tCO_2 for the period 2012 – 2014. Moreover, the Commission's document *Proportionate Impact Assessment on Auctioning* (European Commission, 2012c) reviewed some carbon price projections for the period 2012 – 2015 in absence of backloading[1] and found them to be ranging from a minimum of 4 €/tCO_2 to a maximum of 8 €/tCO_2. Carbon prices are forecasted to be well below the Commission's value also in 2020, with most of the projections averaging around 10 – 12 €/tCO_2 and with only the highest one being 29.2 €/tCO_2. Even a significant backloading is not expected to bring carbon prices anywhere close to the Commission's 30 €/tCO_2, at least in the short term.

3.4.1.2 Free Allowances

An important element involved in the calculation of the direct carbon costs is the number of allowances that a sector would need to buy in order to comply with the ETS. The first CLL has been published before benchmarks were established, and therefore the amount of allowances to be auctioned had to be estimated. The decision on the first CLL assumed 75% auctioning for the years 2013 – 2014 (European Parliament & Council, 2010a). This assumption has been made taking into account that benchmarks were expected to be very restrictive and that the linear reduction factor would further reduce the quantity of free allowances. The other proposed auctioning levels were 100% and 24%. 100% auctioning was meant to represent the long-term additional costs for sectors, as the view of the Commission is to reduce to zero the quantity of free allowances by 2027. 24% auctioning is solely based on the share of free allocation up to

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[1] Backloading is a proposed measure to avoid the persistence of low carbon prices. It consists in postponing the auctioning of a certain quantity of allowances in order to induce allowances scarcity and it is currently under discussion.

benchmark levels, which are 80% for 2013 and 72% for 2014 thus entailing to 24% auctioning on average in the two years (European Commission, 2009). The Impact Assessment Report accompanying the first CLL states that conflicting positions have been expressed concerning the assumptions on the level of free allocation of allowances, with the industry representatives insisting that 100% auctioning should be the reference level and with the NGOs representatives arguing that the approach should be based on a lower auctioning figure (European Commission, 2009). A review of the Commission's approach carried out by de Bruyn et al. (2013) concluded that the assumption of 75% auctioning was clearly overshooting the real impact of the benchmarks, with the result of overestimating the impact of auctioning on sectors.

3.4.1.3 Electricity Emission Factor

In the Decision on the first CLL the assessment of indirect costs was based on the Union average emission factor for electricity of 0.465 tonnes of CO_2 per MWh according to the Model-based Analysis of the 2008 EU Policy Package on Climate Change and Renewables (European Parliament & Council, 2010a). As in the previous case, this assumption has been topic of debate. Industry representatives argued that a marginal electricity emission factor should be used instead of the EU average electricity emission factor in the calculation of indirect carbon costs. This marginal value would have been higher (0.75 tonnes of CO_2 per MWh) thus potentially entailing to more sectors being included in the list. Marginal values are generally higher because they reflect the specific CO_2 emissions of the last kWh of electricity produced, i.e. the peak load, which is often produced by combustion of fossil fuels (European Commission, 2009). On the other hand, it can be argued that the CO_2 emission factor for electricity is expected to decrease in the future in line with the EU's 20-20-20 objective and therefore it is more reasonable to base the indirect costs calculation on the expected emission factor in the period for which the CLL applies, rather than on a past value. Doing so would generally imply lower indirect costs for industries (European Commission, 2012b).

3.4.2 Sensitivity of the Assumptions

From this overview it is clear that the Commission's quantitative approach employed in the first CLL relied on some sensitive assumptions. The most sensitive assumption is undoubtedly the carbon price as it shows the biggest range of uncertainty. It should also be noted that carbon prices influence both the direct and indirect cost parameters, and thus have an even broader impact on CCI. It is therefore evident that the CLL is strongly dependent on the carbon price assumption, where a high price would result in more sectors deemed to be at risk and, on the contrary, a low price would lead to a shorter list. Similarly, also the emission factor for electricity and the share of free allowances influence the calculation's outcome, with a higher emission factor and a lower share of free allowances resulting in more sectors meeting the metrics as a consequence of higher direct and indirect carbon costs. Additionally, the entire approach relies on a fundamental assumption that has been proven wrong by different ex-post analyses: the impossibility of costs pass-through for sectors lying outside the non-leakage area of Figure 8 and Figure 9. Instead, there is evidence that during the first two phases several sectors have been able to pass on additional carbon costs to consumers, often to a large extent, even if thought to be at risk according to the Commission's indicators (Martin et al., 2012; de Bruyn, Markowska, de Jong and Bles, 2010; Alexeeva-Talebi, 2011; Oberndorfer et al., 2010).

The aforementioned assumptions characterized the first CLL, but the same concerns hold also for the second CLL, which will be approved by the 31st December 2014 and will apply from 2015 to 2019. The only difference is that no assumption needs to be made with regard to the quantity of free allowances as benchmarks have been established. Therefore the level of free allocation, and consequently the amount of allowances that have to be bought, can be calculated. Nevertheless assumptions are needed with regard to carbon price and electricity CO_2 emission factor. These two assumptions are even more delicate for the second CLL because the time span to which they apply is twice as long as the previous one. Carbon price projections show a large variability, depending on a number of factors such as the size of the allowances surplus and whether backloading will be implemented and to what extent. Also the CO_2 emission factor for electricity is likely to show some changes, especially as the second CLL applies until 2019, which is very close the end year of the 20-20-20 objective that, if met, is likely to lower the carbon intensity of power production (European Commission, 2012b; European Commission, 2012c).

3.4.3 Critics to the Commission's Approach

Not only the two metrics rely on some very sensitive assumptions, it is also important to question their appropriateness. Ever since the methodology for the CLL has been established, there has been an on-going debate on whether or not the two indicators can adequately reflect the actual risk of CL, especially for sectors close to the threshold values. Critics focus mainly on two aspects: first, the appropriateness of threshold levels and, second, the appropriateness of the two indicators themselves. It has been pointed out that the two metrics are rather broad indicators and, thus, could be not fully representative, implying that, even when a given sector meets the criteria, the 'real' risk of CL is influenced by a number of different factors and conditions. The TII has been by far the most criticized, especially in regard with its use in the third criterion, i.e. TII >30% (Cambridge Econometrics, 2010; Martin et al., 2010). Dröge & Cooper (2010) argue that although the risk of leakage is the result of a complicated interaction of factors, the Commission chose only two indicators and did not elaborate on why the specific threshold were picked. A study carried out by the Grantham Institute of the London School of Economics covers both the aforementioned discussion points concluding that most of the sectors currently included in the list do not actually face a significant CL risk and that there is a need for rethinking the two metrics. The study, based on more than 800 interviews with managers in manufacturing plants in six EU countries, revealed that none of the sampled industry is at risk of relocation or closure. Moreover it revealed that there is a correlation between high CCI values and risk of downsizing, but such a correlation seems to be non-existent with respect to the TII (Martin et al., 2010).

Martin et al. (2010) also argue that, as it sums together exports and imports, the TII could be high for several, often conflicting, reasons. One reason could be a strong non-EU competition, which increases the CL risk. On the other hand, another reason could be that location specific advantages enable EU firms to export more which, according to the authors, would reduce the risk of CL. They further argue that the more strongly a firm benefits from factors that are specific to the EU such as skilled workforce, agglomeration economies, institution stability, etc., the less likely it is to relocate abroad. More importantly, the third criterion, i.e. TII >30%, leads to the inclusion of several sectors in the CLL solely as a consequence of the high trade exposure, even if a significant cost increase is not present. Therefore, the use of the TII will potentially lead to the inclusion of firms that are not at risk of downsizing or CL. The authors of the study suggest that sectors meeting only the 30% TII should not be exempted from auctioning (Martin et al., 2010). The same opinion is also shared by Dröge & Cooper (2010) that underline how, in the first CLL, 118 sectors out of the 164 sectors present in the list have been included only because they met the third criterion, even if they did not have a high CCI. A study by the Carbon Trust (2010) enlightens that many of the sectors included due to the TII alone are minor emitters with specialised products. Trade intensity in these sectors is often driven by such specialisation and facilitated by low transport costs relative to the product's value. A study by Cambridge Econometrics (2010) also came to the conclusion that sectors with low carbon costs and varying trade intensity levels are at equally low risk of CL, supporting the idea that the TII is not indicative of the risk of CL. The same study by Martin et al. (2010) also estimates that improving the design of the CLL indicators could raise additional incomes from the scheme up to € 7 billion annually. As will be shown in the next chapter, also ex-post studies suggest that the actual CL rate is significantly lower than what estimated by ex-ante studies. Hourcade et al. (2007) argue that anti-leakage measures should be focused on few sectors, i.e. the most exposed to carbon pricing, rather than cover a large number of sectors as they currently do.

The wrong estimation of the CLL for sectors is a consequence of the fact that it is rather difficult to frame and assess an articulated phenomenon such as CL under two indicators. Therefore, basing the second CLL largely on the current quantitative approach could lead to an inaccurate decision-making. In this regard, it is meaningful to underline that, according to Dröge & Cooper (2010), the number of sectors identified to be at risk by the Commission's approach is significantly higher than that identified by any other study. They also point out that, although the qualitative approach has sometimes been used to add sectors to the list, it has never been employed to assess whether sectors meeting the quantitative criteria actually face the risk of CL. Dröge & Cooper (2010) further argue that a qualitative approach is the key to the understanding of the real nature of the risk that sectors face.

Concluding, the present chapter underlined that not only the Commission's approach relies on a number of sensitive assumptions, but also its setting is topic of debate. The carbon cost is the most sensitive assumption as the Commission's estimated 30 €/tCO_2 has been proven wrong by the latest allowances prices. Moreover, given that CL is a complicated phenomenon, the current approach has been criticised because of its use of two broad indicators only, that are thought not be able to capture the real CL risk properly. Lastly, the third criterion, i.e. TII >30%, has been pointed out by many studies as particularly inadequate. These insights helped understanding which elements of the current approach could still be employed and which elements should be improved when developing the new approach.

3.5 Carbon Leakage in Phase I & II

In order to understand whether the risk of CL is real and to what extent it can affect EU's industries it is important to carry out a literature review on CL in the past phases of the ETS. The results of this research are useful to structure the framework of indicators and can also provide further indications to assess the appropriateness of the Commission's approach.

First of all, Venmans (2012) reviewed a number of ex-post studies on the effect of the ETS on competitiveness, employment, revenues, demand, imports and more generally on CL. The general conclusion was that most of them did not reveal significant impacts (Anger & Oberndorfer, 2008; Ellerman et al., 2010; Reinaud, 2008b). An explanation of the fact that, although it has been dramatically feared, leakage did not take place significantly can be that additional costs deriving from carbon pricing were relatively small compared to other factors taken into account in the industries' strategic decisions. Grubb and Neuhoff (2006) underline that for most industries the value at stake due to additional carbon costs is lower than 1.5% of the sector's GVA. They also point out that the most affected industries, for example cement, have rather low import intensity and therefore are not significantly exposed to foreign competition. The impact assessment carried out by the Commission points out that several studies on the competitiveness impact of the ETS came to the conclusion that for most sectors extra costs deriving from carbon prices are relatively small and their effects are therefore largely outweighed by other factors (European Commission, 2012b). Reinaud (2008b) similarly argues that carbon cost affects investment decisions only marginally and that other factors play a bigger role. These factors are: currency exchange rate variations, cost and qualification of labour, cost of capital, infrastructure technological clusters and cost of other inputs (Reinaud, 2008b; European Commission, 2012b).

Moreover, there is also evidence that industries generally managed to pass-through at least part of the carbon costs (Martin et al., 2012). de Bruyn, Markowska, de Jong and Bles (2010) analysed data about EU and US industry prices in relation with carbon prices and found out that energy intensive industries had the possibility to pass on to consumers large shares of the additional production costs. A number of other studies has been carried out on specific sectors and came to the same conclusion. The sectors covered by these studies were: iron, steel, refineries, UK industries in general, glass, ceramics and chemical products. The cost pass-through rates were as big as 75% for some sectors (Alexeeva-Talebi, 2011; Oberndorfer et al., 2010; Martin et al., 2012). Grubb & Sato (2009) also reviewed a number of studies showing that a correlation between carbon costs and product prices was observable in the electricity, cement, refineries, chemicals, and steel sectors, indicating an evidence of costs pass-through.

As a consequence, impacts of compliance costs were significantly smaller than what was feared in a first place or even non-existent. A study by Martin et al. (2012) carried out interviews with almost 800 managers of European firms in order to know what are the real effects of carbon pricing at the industry level. The study revealed that none of the sampled industries faces the risk of relocation or closure. A study by Kenber et al. (2009) was based on interviews with managers of six manufacturing firms and found out that the ETS did not cause a significant increase in costs and did not result in changes in firms' strategy. Another study based on interviews by Lacombe (2008) came to similar conclusions.

This brief literature review shows that CL did not raise significant concerns thus far. Although we should not forget that the aforementioned considerations hold only with regard to Phase I & II, when the vast majority of allowances has been handed out free of charge. As previously seen, carbon price is not the only determinant taken into account in the industries' strategic decisions, but other factors outweigh the latter. Low carbon prices undoubtedly contributed to a large extent in determining the scarce attention given to ETS compliance costs. This represents a further proof that the CCI is built upon a weak assumption. Additionally, there is also evidence that firms have managed to pass on costs more successfully and to a larger extent than estimated, a situation that the Commission's approach failed to depict.

3.6 Final Remarks on the Preliminary Research

Having reviewed the Commission's approach and its shortcomings, having gained insights on the CL issue and having gained a sense of what the real situation is, we can conclude that the development of a better approach to CL is desirable. These first chapters provided good insights and suggestions, constituting a basis for the development of the main part of the current thesis.

Summing up the main findings of Chapter 3.1 to 3.5, it is worth underlying which aspects are particularly important for the forthcoming development of the proposed approach. Chapter 3.1 revealed that carbon prices proved to be quite fluctuating and vulnerable to external factors and nevertheless, turned out to be well below the Commission's assumption of 30 €/tCO_2 and are not forecasted to be around that value in the period 2013 - 2020. Moreover it is important to keep in mind that Phase II witnessed the formation of a significant surplus of allowances that will be banked to Phase III. Both elements will be crucial for a correct formulation of the proposed approach.

Chapter 3.2 helped understanding the mechanisms and dynamics of CL, distinguishing between short-term production leakage and long-term investment leakage. An adequate understanding of CL will be fundamental in structuring the proposed approach and in shaping the framework.

Chapter 3.3 reviewed the Commission's approach, showing that sectors are mainly chosen via a quantitative assessment following three criteria based on two indicators, i.e. CCI and TII.

Chapter 3.4 analysed shortcomings and pitfalls for the Commission's approach underlining that not only the approach relies on a number of sensitive assumptions, but also its setting is topic of debate. As CL is a complicated phenomenon, the current approach has been criticised because of its use of two broad indicators only, that are thought not be able to capture the real CL risk properly. Lastly, the third criterion, i.e. TII >30%, has been pointed out by many studies as particularly inadequate. These insights helped understanding which elements of the current approach could still be employed and which elements should be improved when developing the new approach.

Chapter 3.5 showed that CL did not raise significant concerns thus far. Keeping in mind that the studies reviewed were focused on Phase I & II, when the vast majority of allowances has been handed out free of charge, it can be argued that a CLL that includes about two-thirds of the ETS sectors is likely to be an overestimation. Additionally, there is also evidence that firms have managed to pass on costs more successfully and to a larger extent than estimated, a situation that the Commission's approach failed to depict. In the coming chapter, all these insights will be combined with further research on CL determinants in order to develop an alternative approach to CL.

4 Development of an Alternative Approach to the Assessment of Carbon Leakage Risk

The aim of the present chapter, in line with the main goal of the thesis, is to develop an alternative approach to identify sectors at risk of CL. To this end, the first step in this process is to re-elaborate information gathered through literature review in the form of an analytical framework that captures the main steps of the CL phenomenon. Based on the information gathered in the preliminary research a carbon leakage flowchart is developed. The flowchart depicts the main dynamics of CL and represents the backbone of the framework. As a second step, a research on CL determinants and relative indicators is carried out. A shortlist of indicators is then drafted based on their recurrence in the reviewed studies, their relevance and significance with respect to the characteristics of the CL phenomenon, their usability in the flowchart and data availability. In order to operationalize the flowchart, determinants and relative indicators are linked to the different steps of the framework, according to their relevance to depict particular aspects of CL. The final framework structure and indicators list is verified via expert consultation.

4.1 Carbon Leakage Flowchart

In order to develop an alternative approach to identify sectors at risk of CL it is useful to briefly sum up what the crucial steps and dynamics of the phenomenon are. It is also important to underline that, as suggested by the literature review, CL happens in stages and as a gradual process. Consequently, it has been chosen to structure the approach in the form of a stepwise flowchart depicting the main characteristics and dynamics of CL and representing the backbone of the framework. The stepwise approach pursued by this proposed framework aims at better reflecting the very nature of the phenomenon. Consequently, the main elements, causal links and connections have been drawn from the preliminary research and have been organised in the flowchart framework discussed below.

First of all, CL takes place as a consequence of the additional costs imposed to an industry by the compliance to a climate policy, such as the EU ETS. Consequently, the first step of the analysis should consist in assessing what is the value at stake for a certain sector. If this turns out to be marginal, the analysis can stop with the conclusion that the sector is not exposed to a significant risk. If, on the other hand, these costs prove to be significant the analysis should move on to assess how an industry can deal with the additional burden.

When faced with carbon pricing, an industry can either minimize costs internally or pass them on to consumers. Costs could be minimized, for example, if an industry has the possibility to implement abatement measures at a cost lower than the carbon price or if it possesses a significant number of unused allowances from the previous trading years to cover for its emissions. Consequently the second step of the framework should assess whether a sector has viable options for internal minimization of compliance costs.

If this is the case, the sector can be considered not exposed to a significant CL risk. If, on the other hand, an industry cannot minimize compliance costs, the analysis should move on to check whether it has the possibility to pass-through costs to consumers safely.

Increasing product prices to reflect the additional production cost could cause CL, but some sectors, thanks to certain circumstances discussed later, have a good costs pass-through ability, meaning that are able to pass on costs without losing market shares and consequently without triggering CL. The third step of the framework thus consists in analysing the cost pass-through ability of a sector. If the latter turns out to be good we can come to the conclusion that the sector is not exposed to a significant risk.

If, on the other hand, also this is option is not viable, the industry has to face a reduction of its profit margins. The latter could result in CL if it triggers changes in investment flows or production relocation. As a last step the framework therefore analyses what are the likely impacts of a profit margin reduction. This reasoning is depicted in the following flowchart that represents also the backbone of the framework.

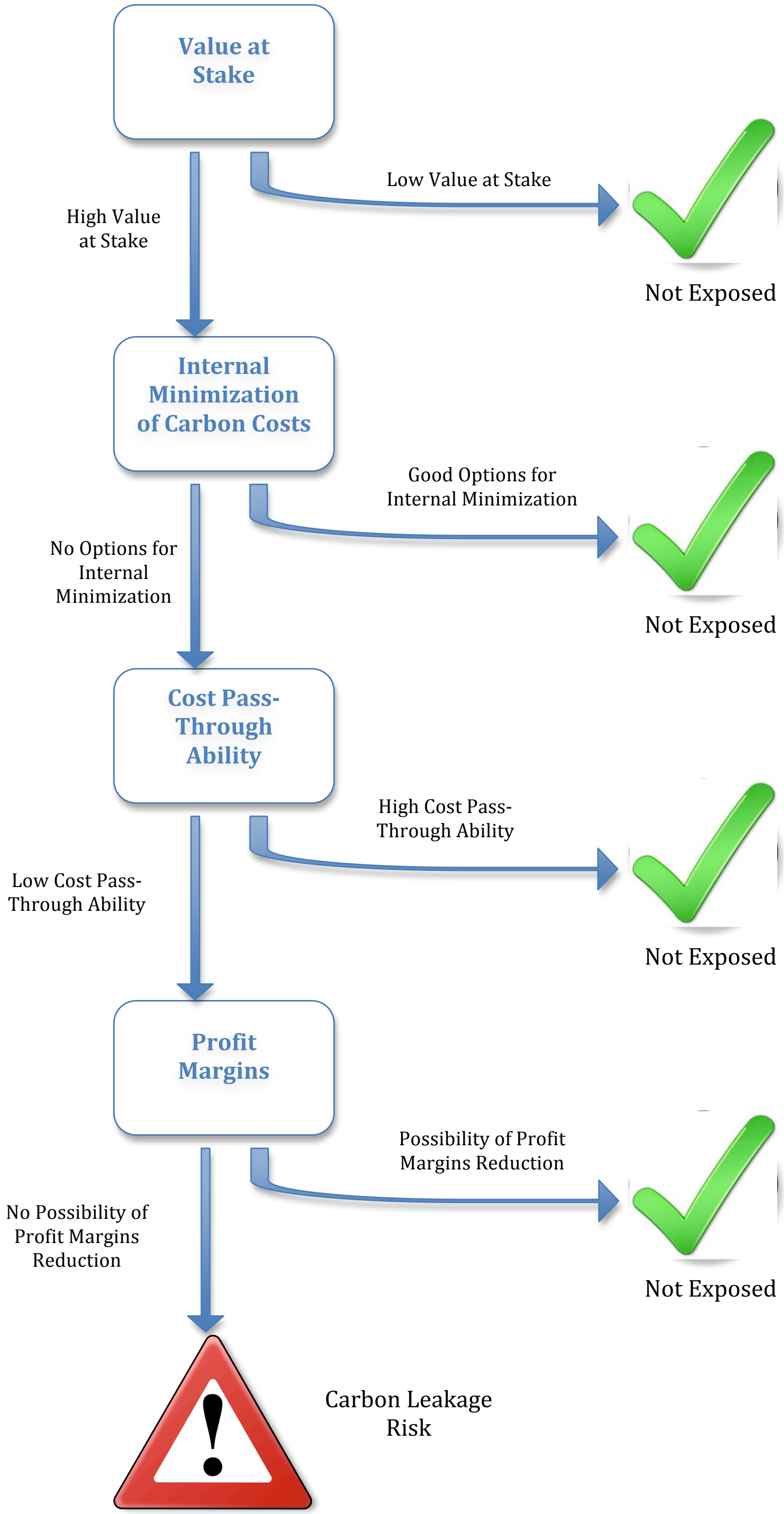

Figure 11. Carbon Leakage Flowchart

The flowchart represents the structure of the analytical framework that is being set up by this study. It has been obtained as a result of the preliminary research and will be used as a backbone for the framework. As mentioned before, the flowchart structure has been chosen in order to reflect the peculiar nature of CL, i.e. a phenomenon that happens in consequential steps or stages as a result of a causal chain of implications. This methodology also allows analysing one CL determinant at a time, when it is more relevant, without applying all the indicators at once as it is often done in studies on CL.

4.2 Literature Review on Carbon Leakage Determinants and Indicators

As a next step of the analysis, an extensive literature review has been carried out to identify indicators that can be linked to different steps of the flowchart in order to operationalize it. First of all, it is important to consider the indicators used by the Commission in the qualitative assessment of sectors, outlined in paragraph 17 of the revised Directive. They are organized in three categories:

- "Technological Assessment", which is the ease with which a specific sector can abate its GHG emissions or reduce its electricity consumption by implementing the most efficient techniques at a reasonable cost;
- "Market Characteristics", which are current and projected market characteristics typical of a specific sectors;
- "Profit Margins", which are the profit margins of a specific sector and the potential consequences on long-term investment decisions and activity relocation (European Parliament & Council, 2009).

The Impact Assessment on the first CLL lists a total of eight indicators falling in these categories. The complete list of indicators, along with a brief description, can be found in Annex 1.

The study by Cambridge Econometrics (2010) is one of the most complete studies on factors determining CL. It carried out an extensive literature review to identify criteria that could be used to assess the risk of CL. The study identified nearly 100 factors in total, organized in 4 categories:

- Cost Structures;
- Pass-Through Ability;
- Abatement Potential;
- Regulatory Conditions.

Cost structures give an idea of a sector's carbon costs relative to the overall sector's financial balance, both in terms of production costs and GVA. This category helps to understand the extent to which a sector's production and investments are impacted by carbon costs. As mentioned before a crucial determinant of the CL risk is whether or not a sector can pass on its carbon costs by increasing product prices, without losing a significant market share, as an alternative to reduction of profit margins or relocation of production. A sector's pass-through ability is dependent on a number of both local and international factors and can be measured by its cost pass-through rates. When faced with carbon costs, a sector has the option to implement abatement measures to reduce its emissions. Abatement options assess, according to the relative prices of abatement and carbon, the sector-specific opportunities to reduce emissions. Regulatory conditions is another important factor to understand the real risk of CL. Taxes, subsidies and standards need to also be taken into account when evaluating firm's production location decision. Moreover certain kinds of regulations, such as international sectoral agreements, can significantly reduce the risk of CL (Cambridge Econometrics, 2010).

In the analysis of Cambridge Econometrics (2010), criteria under "Regulatory Conditions" were not taken forward predominantly due to a lack of standardisation in the variables chosen to represent them in the literature and a lack of data allowing comparability between sectors. The extensive list of factors has been synthesized by grouping raw factors into a set that represents the range of factors in literature but avoids repetition. This set contained thirty-six factors that can be found in Annex 2.

It is important to underline that the main categories identified by the Commission and by Cambridge Econometrics can be linked to the steps of the flowchart. The Cambridge Econometrics' Cost Structure reflects what is captured in the first step of the framework: Value at Stake. The Commission's Technological Assessment and the Cambridge Econometrics' Abatement potential can be linked to the second step: Internal Minimization of Carbon Costs. The Commission's Market Characteristics and the Cambridge Econometrics' pass-through ability reflect the third step: Cost Pass-Through Ability. The Commission's Profit Margins is in line with the last step of the flowchart.

A number of other studies that tried to identify the sectors at risk of competitiveness loss or CL, based on an assessment of the major determinants of this risk, have been reviewed, namely: Sijm (2009), Dröge (2009), Dröge & Cooper (2010), Venmans (2012), Grubb et al. (2012), Reinaud (2008b), Grubb & Neuhoff (2006), Carbon Trust (2004), McKinsey and Ecofys (2006), Hourcade et al. (2007), de Bruyn et al. (2008). The most recurrent determinants of the risk of CL were generally in line with the findings of Cambridge Econometrics (2010).

The results of the literature review have been compared and the different studies have been used to come up with the final list of CL determinants and indicators. Indicators have been chosen based on their recurrence in the reviewed studies, their relevance and significance with respect to the characteristics of the CL phenomenon, their usability in the flowchart and data availability. Lastly, determinants and relative indicators have been linked to the different steps of the framework, according to their relevance to depict particular aspects of CL. The final list has been verified via expert consultation.

4.3 Framework of Indicators

In the following section CL determinants identified through literature review are used to operationalize the flowchart. In order to do so, each step of the flowchart is related to a number of determinants and relative indicators that are relevant with respect to the specific step.

4.3.1 Value at Stake

As a first step, it is important to quantify extra costs deriving from the EU ETS. The Commission's Carbon Cost, despite its shortcomings, can provide a first insight on the additional costs that a sector has to face. As seen in Chapter 3.2, the indicator calculates a sector's production costs increase relatively to its GVA. It is calculated as the sum of direct costs stemming from the value of allowances to be purchased to cover the direct emissions and indirect costs of emission rights included in the electricity purchases of the sector in relation to GVA (European Commission, 2009). The exact formulation has already been analysed in the Commission's approach chapter. Moreover the indicator has been chosen because of data availability. Data on direct, indirect and total carbon costs are publicly available for all of the sectors covered by the ETS. Nevertheless we should keep in mind that the calculation of this indicator relies on an assumed carbon price of 30 €/tCO_2. Therefore, when using the Commission's values, a correction factor should be applied in order to account for the most recent carbon price projections. A study by de Bruyn et al. (2013) reviewed several allowances price projections and suggested to use a carbon price of 12 €/tCO_2 as an average up to 2020. Therefore a correction factor of 2/5 will be applied in order to convert the carbon price used in the calculation from 30 €/tCO_2 to the forecasted 12 €/tCO_2.

4.3.2 Internal Minimization of Carbon Costs

If a sector has to face significant carbon costs its first choice, before risking to pass-through costs or reducing profit margins, will likely consist in trying to minimize these additional costs. This can be done mainly by reducing the carbon costs at their origins, i.e. the carbon-intensive parts of the production process (European Commission, 2009; Cambridge Econometrics, 2010; Dröge & Cooper, 2010). Alternatively, a sector can reduce its compliance costs by using the surplus of allowances from the previous trading periods.

4.3.2.1 CO_2 Emission abatement and electricity consumption reduction potential

If a sector has the possibility to reduce the carbon intensity of its production process in a cost-effective way, compliance costs can be reduced. This can mainly be done by implementing CO_2 emissions and electricity consumption abatement measures. The reduction of the carbon intensity of production processes through the implementation of greener technologies is the final aim of the EU ETS. Analysing the emission abatement and electricity consumption reduction potential is particularly meaningful because, as pointed out by Venmans (2011) and Brunner et al. (2008), it is reasonable to assume that many of the abatement options, even if cost-effective, have not been implemented yet because allowance allocation, at least in the early phases, was expected to be correlated to past emission levels, thus creating an incentive to postpone abatement.

In theory, it is convenient for companies to implement mitigation measures until these investments cost as much as the market price of CO_2 (Reinaud, 2008b). Therefore MACCs will be consulted in order to investigate what share of an industry's emissions can be abated at a cost lower than the allowances price. MACCs are also used to derive references for the best available technology not entailing excessive costs (hereafter BATNEEC), which will also be taken into account. The main measures contributing in minimizing the compliance costs are: substitutability of inputs or fuels with less carbon intensive ones, availability of electricity consumption reduction measures, availability of emissions abatement measures (Cambridge Econometrics, 2010; Dröge & Cooper, 2010).

4.3.2.2 Surplus of Allowances

Although in none of the studies considered in the literature review this factor has been taken into account, recent developments in the EU ETS, i.e. the formation of an allowances surplus, suggest that the number of unused allowances from previous trading periods can play an important role in reducing the risk of CL. A sector can effectively reduce its compliance costs by using the potential surplus from previous trading years. As shown before, evidence suggests that this surplus could be well over 1.5 billion allowances at the beginning of Phase III (European Commission, 2012d). If a sector has enough allowances to cover for a significant share of its need, CL will not take place, as compliance costs can be easily avoided by surrendering allowances.

A study carried out by Elsworth et al. (2011), based on analysis of CITL data, estimated that in the current Phase of the ETS the ten most benefiting companies hold a surplus of 240 million allowances, equivalent to the annual emissions of Austria, Denmark, Portugal and Latvia combined. These ten firms are iron and steel and cement companies, sectors that are usually considered as highly exposed to CL. This proves that the allowances surplus could be extremely consistent, especially in certain sectors. Therefore it is important to take this factor into account when determining the possibilities for an internal reduction of the carbon costs.

4.3.3 Cost Pass-Through Ability

If there are no possibilities for internal reduction of carbon costs, a sector could try to pass on the extra costs to consumers by increasing product prices. Under certain circumstances a sector is able to do so safely, meaning that the market can absorb the extra costs with no negative impacts. On the other hand, in some cases the market could shift its preference towards non carbon-compliant foreign products, therefore causing a loss of market shares loss the sector and triggering CL. The effect of an increase in product prices could be evaluated by the cost pass-through ability of a sector. The pass-through ability is thus a measure of the ability to recover the additional carbon costs without significantly undermining international competitiveness (Reinaud, 2008b; Dröge & Cooper, 2010). A high ability means that the sector is able to pass on a significant part of its compliance costs without losing market shares, while a low cost pass-through ability entails to a loss of market shares and production leakage if product prices are raised. The pass-through ability is therefore an indicator of CL risk, because the latter is a threat only if EU sectors cannot pass on carbon costs downstream without losing significant market share to third country competitors (European Commission, 2012b; Reinaud, 2008b). Consequently, understanding the cost pass-through ability of a sector is crucial for understanding the risk of leakage (Dröge & Cooper, 2010).

In the first place, pass-through ability is a function of the amount of production cost increase, analysed in step one of the flowchart. If the latter is small, it could be relatively easy for companies in certain sectors to increase product prices without affecting market shares. If the price increase is high, cost pass-through ability will depend on a number of factors (Reinaud, 2008a). These factors are mainly: price-responsiveness of demand for products, market structure and dynamics, product characteristics and international competition (Parker & Blodgett, 2008). The determinants selected after the literature review to represent the cost pass-through ability are:

- Price Elasticity;
- Market Concentration;
- Product Differentiation and Substitutability;
- Transportation Costs and Transportability;
- Trade Exposure.

4.3.3.1 Price Elasticity

Price elasticity is defined as the responsiveness of consumers to a change in product price. A high price elasticity indicates that consumers are highly responsive to a change in price and therefore the industry's market share will increase if prices fall and will decrease if prices rise. On the other hand, low price elasticity, also referred to as inelastic prices, means that the market preference is quite stable and does not depend on the product prices. In this condition firms can increase prices in response to increased costs without a substantial negative response by the market (Parker and Blodgett, 2008; Cambridge Econometrics, 2010). It is quite obvious that price elasticity is an important determinant when evaluating the cost pass-through ability of a sector. If the sector's market shows to have high price elasticity it will be hard to pass on costs without triggering production leakage. Price elasticity varies largely depending on sectors and on product characteristics. For example demand for electricity is usually relatively inelastic, while demand for other goods may be fairly elastic (Parker and Blodgett, 2008).

4.3.3.2 Market Concentration

Market characteristics play an important role in determining the costs pass-through ability of a firm. One of the most important characteristics is market concentration, which refers to the number and size of companies supplying the market. Intuitively, a firm is alone in the market it holds a monopolistic position and should be able to pass on costs easily to consumers, assuming that market access would not change as prices change (Reinaud, 2008b). Consequently, industries where few firms have the largest market share are more likely to be characterized by a high cost pass-through ability, as big players have the power to influence prices (Parker and Blodgett, 2008). The most popular indicator used to measure a sector's market concentration is the Herfindahl-Hirschman Index (HHI). The HHI is a statistical measure of concentration, used to characterize the size of firms in relation to an industry (European Commission, 2009).

4.3.3.3 Product Differentiation and Substitutability

Products with a high level of differentiation are less substitutable. The level of differentiation can be given by quality, marketing, branding or content, or it may be peculiar to the product. High differentiation increases the consumer's willingness to pay for a good independently from its price, as the latter is not directly comparable to the price of other products. Product differentiation therefore increases the cost pass-through ability of firms. On the other hand, if a product can be easily substituted, it is at risk of CL when its price rises. Therefore low substitutability indicated good cost pass-through ability (Cambridge Econometrics, 2010). It has to be underlined that CL would only take place if the product were substituted with non-carbon priced product. Instead, the substitution of current production with domestic, less carbon-intensive products is one of the goals of the ETS.

Keeping in mind that the aim of the analysis is to assess the potential loss of competitiveness to foreign industries, we toned to understand if the EU's carbon priced products are exposed to the risk of being substituted by non-ETS products. The product's specificity will be taken into account. The elasticity of substitution is estimated by the Armington Elasticities, which reveal the degree of consumer preferences for domestic goods over foreign imports. Armington Elasticities are indicative of the costs pass-through ability of a sector, in case domestic consumers do not see foreign products as substitutes for the internal ones (European Commission, 2009; Cambridge Econometrics, 2010). Armington elasticities are also based on the assumption that producers do not differ only for their product but also for their location (Armington, 1969). In other words, goods of the same kind produced by different countries are not perfect substitutes.

4.3.3.4 Transportation Costs and Transportability

Transportation costs and product transportability are two important determinants of the cost pass-through ability and, consequently, of the risk of CL. Transportation costs are not directly captured in the TII but can affect investment decisions and international competition, depending on their relevance compared to the carbon cost. Although it is often argued that in a competitive global market producers with the lowest costs will have the biggest market share and eventually rule out other competitors, transportation costs can make a big difference. High transportation costs can cancel out the foreign products' competitive advantage given by not having to comply with the ETS (Neuhoff, 2008). On the other hand, if domestic production costs are high, as a consequence of carbon pricing, and transportation costs are low, it is more likely that investments could be shifted outside the ETS region. Under the same circumstances, it is also more likely for non-ETS products to gain competitiveness in the EU market, if transport costs are low compared to EU production costs (European Commission, 2009). Nevertheless transportation costs are not the only determinant of the feasibility of international trade. Some products, characterized by very energy intensive processes and therefore possibly significantly exposed to non-ETS competition, could also have a low transportability due to the fact that they are hazardous substances, e.g. in the case of chlorine, or because of other characteristics, e.g. weight, size (Parker and Blodgett, 2008).

When assessing a sector's cost pass-through ability it is thus important to consider transportation costs and transportability of its products. Intuitively, by favouring foreign competition, low transportation costs and high transportability entails low cost pass-through ability.

4.3.3.5 Trade Exposure

A driver for CL is international competition. Sectors with significant volumes of imports from or exports to non-ETS countries might have a low costs pass-through ability as a consequence of the fierce competition and are therefore not able to pass on costs to consumers. On the other hand, obviously, sectors that are not internationally traded are exposed to a very limited CL risk (Dröge & Cooper, 2010). In order to assess the trade exposure of a sector, the Commission's TII will be used. As seen before, the Commission's indicator is defined as the ratio of imports and exports in relation to the domestic market, which is the EU turnover plus imports (European Parliament & Council, 2009). The TII has been criticized when used as the "only criteria", as some sectors have been included in the list only by meeting the third criteria, i.e. TII > 30%. Nevertheless the Commission's Trade Intensity is indeed a good indicator of a sector's trade exposure and can therefore be useful when used together with other indicators. The use of this indicator is based on the assumption that sectors with significant trade intensity are likely not to be able to pass on costs to consumers (Sijm, 2009).

4.3.4 Profit Margins

The analysis of profit margins gives an indication of the flexibility that a sector has to withstand the impact of additional cost burdens, assuming that it has no options to minimize it or to pass it on to consumers. An industry that operates with very small profit margins has usually less possibilities to absorb additional costs. If significant compliance costs are combined with a low costs pass-through ability the risk of CL as a consequence of relocation or closure might be significant (Cambridge Econometrics, 2010). Profit margins are also used in the Commission's qualitative assessment as an indicator of long-run investment and relocation decisions (European Commission, 2009). In the long term, a loss of profitability, in terms of profit margins reduction, could result in firms seeking to maximize profits by exploiting non-carbon priced markets. This happens when firms change investment flows, relocate part of the production or close

European installations. Relocation is an extreme form of CL and, given that it involves long-term decisions, determines dangerous locked-in situations (Cook, 2011).

4.4 Final Remarks on the Framework of Indicators

The following table sums up the steps of the framework with the relative determinants and indicators.

Table 4. Flowchart steps, carbon leakage determinants and indicators constituting the framework

Flowchart Step	Determinant	Indicator
Value at Stake	Carbon costs	Commission's CCI (Corrected for the C Price)
Internal Minimization of Carbon Costs	CO_2 Emission abatement and electricity consumption reduction potential	MACCs BATNEECs
	Surplus of Allowances	Number of Unused Allowances
Cost Pass-Through Ability	Price Elasticity	Price Elasticity
	Market Concentration	Herfindahl-Hirschman Index
	Product Differentiation and Substitutability	Armington Elasticities Product's Characteristics
	Transportation Costs and Transportability	Transportation Costs Product's Transportability
	Trade Exposure	Commission's TII
Profit Margins	Profit Margins	Profit Margins

The preliminary research has been useful to structure the CL flowchart, while the research carried out at the beginning of this chapter was aimed at operationalizing the framework by linking different steps to CL determinants. The first two steps of the framework are important to understand whether a sector is exposed to significant carbon costs and whether it can reduce the latter internally. If carbon costs turn out not to be negligible after these two steps, the two latest step of the flowchart are aimed at understanding to what extent and by which dynamics CL could take place.

The third step is mostly focused on short-term leakage, which consists in an increase in foreign production and decrease in domestic production. This type of CL, often referred to as production leakage, happens because, as domestic product prices rise, the market shifts its preference towards more competitive, non-carbon priced, foreign products. The second step of the framework thus aims at understanding whether a sector is able to increase its prices, i.e. pass on carbon costs, without losing significant market shares. It has to be underlined that, often, determinants might be slightly overlapping or simply depicting two sides of the same coin, as in the case of price elasticity and market concentration. Moreover, the five indicators can be grouped in two sub-groups according to their focus, with the first three depicting an industry's characteristics and market type and the last two focusing more on the sector's exposure to international trade. Indicators within the two sub-groups are deeply interwoven and when analysed together they contribute to give a general idea of a sector's cost pass-through ability. This aspect will be further elaborated in the discussion chapter.

The fourth step of the framework is instead focused on the long-term effect of CL, which consists in changes in investment flows, relocation of part of the European production or closure of European installations. This type of CL could happen if European firms witness a profitability reduction, i.e. reduction of profit margins, and consequently decide to seek new profits in non-carbon priced markets. It has to be underlined that transportation costs and transportability play a role also in this context, as they are important factors taken into account by firms when studying strategic decisions.

4.5 Expert Consultations

As mentioned before, upon its completion, the flowchart, the CL determinants and their description have been submitted to an expert consultation. This has been done in order to validate and ensure the soundness of the framework before its application. The experts have been selected among the professionals with expertise on the CL issue at the European level. Most of them are authors of several studies and publications used in this research and work for research institutes and consultancy firms. In total, six experts took part in the expert consultation. The following list reports their names and the institutions they work for:

- Peter Coenen (TNO),
- Matthew Smith (Ecofys Netherlands),
- Katja Schumacher (ÖKO-Institut),
- Paul Blinde (Ecofys Netherlands),
- Sander de Bruyn (CE Delft),
- Sean Healy (ÖKO-Institut).

Each expert involved received an earlier draft of the framework including a description of its contents and working mechanism and was asked the following questions:

- Do you think that the framework, in its setting, adequately reflects the nature of CL?

- Do you think that the set of determinants/indicators is complete?
- Do you think that the framework could lead to a valuable analysis, according to its purpose?
- Is there any comments/suggestions/critics that you would like to make?

The responses of the experts can be found in Annex 3. Generally, the expert consultation proved that the proposed approach is sound and can lead to an effective analysis of the risk of CL, as the experts agreed with the flowchart structure and choice of indicators, underlining that the systematic and linear approach is valuable and the general setting robust and logical. Especially the stepwise approach, the determinants and indicators employed as well as the angle of the approach were enlightened as strengths of the proposed framework. More specific comments have been used to refine some indicators and are further elaborated in the discussion chapter.

5 Application to Case Studies

The objective of this chapter is to test the framework by applying it to ETS sectors. This analysis is fundamental to understand whether the framework could be effectively and adequately employed to assess the risk of CL. The experience with the framework application to the case studies will be the basis for the last part of the research and, more importantly, will allow fully addressing the main research question. Only by employing the proposed framework to the case studies it will be possible to understand whether it can effectively lead to a valuable analysis, fulfilling its purpose.

Three sectors have been chosen for the framework application: cement, aluminium and iron and steel. First of all, sectors have been chosen because there was evidence that data availability could allow applying the framework. Among all the sectors that showed good data availability, the three sectors have been picked because of their diverse classification according to the CCI and TII that, as it turned out, could provide a basis for an interesting discussion of results. The three sectors in fact have different values with respect to the Commission's metrics and are therefore impacted differently by the compliance to the ETS and by CL. Cement has very high compliance cost but is rather isolated from international trade, aluminium has moderately high compliance costs, virtually all being indirect costs, and it is very intensely traded at a global level and iron and steel is in a similar situation as aluminium but, differently from the latter, the major part of its compliance costs derive from direct emissions. It could indeed have been interesting to include among the three case studies one sector showing low CCI and high TII, in order to test whether the studies (such as Cambridge Econometrics, 2010; Dröge & Cooper, 2010; Martin et al., 2010) arguing that there is no correlation between high TII and risk of CL, in absence of significant compliance costs, are right. Nevertheless, sectors with low CCI and high TII are mostly small and specialized industry segments, characterized by a lack of data that did not allow the inclusion among the selected case studies.

The framework has been formulated as a flowchart in order to allow stopping after each step if the analysis suggests "no risk". Nevertheless in the case studies the whole analysis will be entirely carried out to fully test the proposed approach. Lastly, the framework composition in Table 4 proposes an "ideal" set of indicators. The current case studies will apply the proposed indicators when possible, and will cover up for a possible lack of data via literature review in the other cases.

5.1 Cement

5.1.1 Introduction

The cement industry accounts for around 5% of the global anthropogenic CO_2 emissions and has a total annual output of 1.94 billon tonnes of cement. China is the world's biggest producer, accounting for 67% of the total production, followed by the EU with 10%. Cement is one of the most basic and important building materials worldwide, being mainly used for the production of concrete, a mixture of mineral aggregates and cement (Worrell et al., 2001; Reinaud, 2005; de Bruyn et al., 2008). It is thus extremely important in construction activities. Given its economic importance and thanks to the fact that raw materials required in the production process, mainly limestone, are globally widespread and abundant, cement is produced virtually in every country. Its widespread distribution is also a consequence of the relatively low price and high density of cement, which makes transport difficult and localized production more convenient (Worrell et al., 2001).

Cement production is an extremely energy intensive process. Globally, it accounts for about 2% of the primary energy consumption and about 5% of the total industrial energy consumption (Worrell et al., 2001). In the EU, cement production emits as much CO_2 as steel, accounting for about 3% of the total energy related CO_2 emissions (Reinaud, 2005; Grubb et al., 2009). Each tonne produced requires 60 to 130 kg of fuel oil and about 110 KWh of electricity. These figures vary according to the cement variety and the technologies used (Cembureau, 2013).

Cement production is a relatively simple process involving few steps. In an extremely simplified description, the limestone has to be baked into a particular furnace, called kiln, to obtain an intermediate product: nodules called clinker. The latter is then crushed and blended to obtain cement. The majority of the CO_2 produced in the process is emitted by the fuel used to heat up the furnace and by the decarburization of the limestone (Demailly et al., 2007; Grubb et al., 2009). It has to be underlined that clinker can be transported more easily than cement and therefore is more open to the possibility of international trade (Reinaud, 2008b).

Despite the fact that cement itself is a relatively homogeneous product, the carbon intensity of the production process can vary largely in different countries, mainly depending on the type of kiln. Vertical kilns are the most dated and inefficient type, while rotary kilns are more modern and require less energy (Demailly et al., 2007). Rotary kilns are further divided into dry, semi-dry and wet. The dry process is the most efficient and is dominant in the EU with an estimated 95% market share (de Bruyn et al., 2008). A cement plant usually requires an investment of more than € 150 million per Mt of annual capacity. This makes cement industry one of the most capital intensive, characterized by long-term dynamics (Cembureau, 2013). Although raw materials can be slightly different, cement can be considered a standardized product. There are only few classes of cement and within every class products from different producers are generally interchangeable. As a consequence price is a very important sale parameter (Cembureau, 2013).

Land transportation costs are significant compared to the product price and generally transporting cement further than 200 or 300 km is not economically feasible. Long distance road transportation could cost more than the product price. The situation is different for sea transportation. Freight ships can transport cement economically over long distances (Cembureau, 2013). Cement has been included in the first CLL, and thus receives 100% free allocation up to the benchmark level, thanks to the fact that it meets the second criterion, i.e. CCI >30%.

5.1.2 Value at Stake

According to a study by de Bruyn et al. (2008) production costs for a typical European cement production plant will increase by 36.5% due to CO_2 emissions pricing. The major part of this cost increase is due to direct emissions and only a very marginal part comes from higher electricity prices. A study by Neuhoff & Matthes (2008) based on the UK industry found that additional carbon costs have a higher impact on the cement sector than for almost any other activity.

The Commission's CCI confirms these previous findings reporting a value of 45.5% additional costs relative to the sector's GVA, with the direct cost being 41.1% and the indirect costs 4.4% (European Commission, 2009). This makes cement one of the most exposed sectors in the EU ETS. Nevertheless, if we correct for the current carbon price we obtain a value of 18.2%, which is significantly lower than the Commission's. It is interesting to underline that with such correction cement sector would no longer meet the Commission's thresholds and would therefore not be included in the CLL.

5.1.3 Internal minimization of Carbon Costs

5.1.3.1 CO_2 Emission Abatement and Electricity Consumption Reduction Potential

There are three main different ways to reduce emissions in the cement production process: improving the energy efficiency of the process, switching from high to low carbon fuels and reducing clinker content by using blended cement (Hourcade et al., 2007).

Energy efficiency improvements have been the largest contributors to CO_2 emissions reductions in the past, especially thanks to the shift to new processes such as dry kilns, to improvements of the heating process and to a better management of the whole production chain (Hourcade et al., 2007). Dry kilns consume 50% less energy than wet kilns, but as mentioned before 95% of EU cement is already being produced in dry kilns leaving only a small potential for further emission reductions by kiln improvements (de Beer et al., 2001).

Given that the largest share of emissions comes from combustion of fossil fuels in the heating step of the process, switching to low carbon fuels has a large emission reduction potential. One common measure is the shift from coal to gas or to non-fossil fuels (Worrell et al., 2001). For example the use of waste-derived fuels can reduce CO_2 emissions by 0.1 to 0.5 tCO_2/kg of cement produced (Hourcade et al., 2007). The potential of fuel substitution changes from country to country with the determinants being waste availability, legislation, infrastructures and public concern (de Beer et al., 2001). In 2000, 10 to 15% of the total fuel consumption in the cement sector came from alternative fuels. The percentage has been constantly increasing (de Beer et al., 2001).

Clinker production is responsible of most of the emissions in the cement production process. Generally, 60% comes from the decarbonisation of limestone and 40% from the fuel combustion. Clinker content of cement can be reduced by substituting clinker with other industrial by-products. The use of blended cement could thus reduce the clinker content and therefore the overall CO_2 emissions. Globally, the clinker to cement ratio has been constantly declining (Worrell et al., 2001; Hourcade et al., 2007).

According to Cook (2011), investments in the cement sectors over the past 5 – 10 years have been aimed at improving efficiency through production site rationalization, larger production lines and closure of smaller plants. Grubb et al. (2009) state that cement sector has been, second only to power production, the main source of emission reductions in the EU, mainly thanks to the shift towards blended cement.

5.1.3.2 Surplus of Allowances

There is evidence that in the past years allowances have been largely over-allocated to the cement sector. The graph below is based on the UE ETS data viewer and shows that every year the amount of freely allocated allowances has been larger that the verified emissions, except for 2007 when the two were equal. Ever since 2007 the gap has been progressively enlarging.

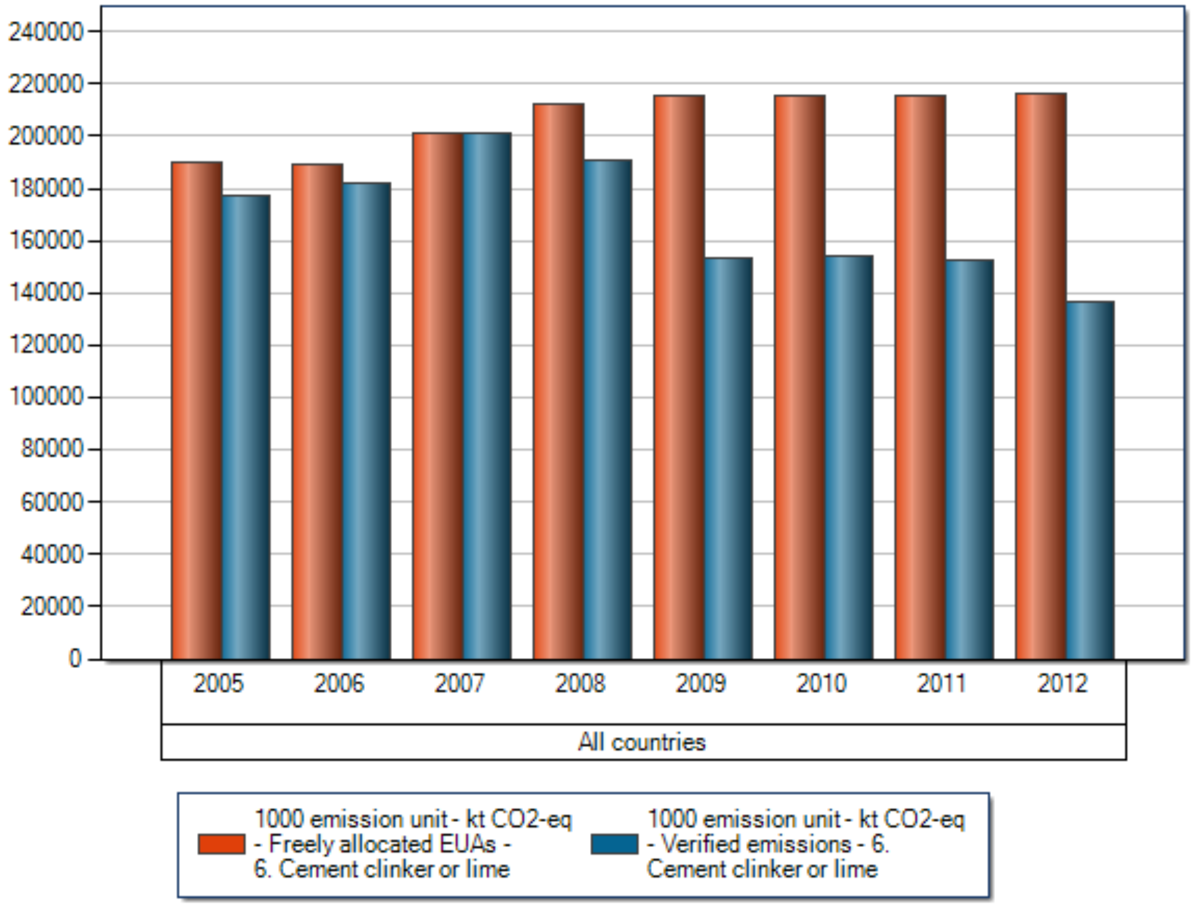

Figure 12. Allocated allowances and verified emission in the cement sector from 2005 to 2012 (European Environment Agency, 2013)

As the allocation was set in advance, most of the surplus is due to the combined effect of inflated growth projections and the economic crisis. As a consequence, many companies in the cement sector had little or no incentive to reduce their emissions. Moreover, as it is currently possible to bank allowances and use them in later years or phases, many companies have an extremely large surplus of allowances that they have been able to transfer from Phase II to Phase III. A report by Elsworth et al. (2011) shows that the biggest emitters and the biggest players in the cement sector are also the ones holding the biggest allowances surplus, with Lafarge having an impressive 27.1 million stored allowances. As shown by Figure 13, in total the top ten emitting companies have a surplus of 90 million allowances, with an estimated value of €1.5 billion.

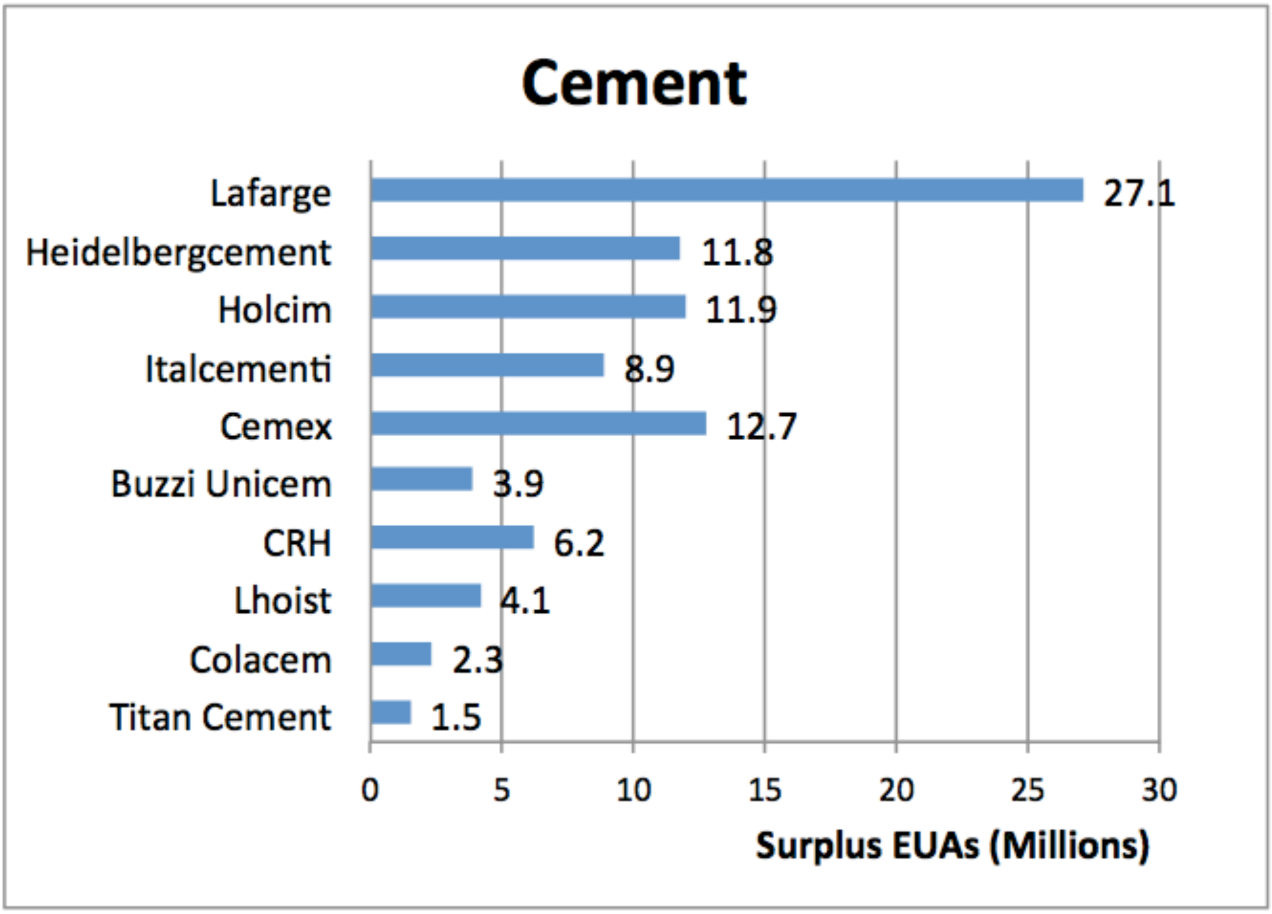

Figure 13. Allowances surplus of top ten emitting companies in the cement sector (Elsworth et al 2011)

5.1.4 Costs Pass-Through Ability

5.1.4.1 Price Elasticity

Cement is an extremely important product for the construction sector and for the economy in general as there are only few practical and economically attractive alternatives to its use. Therefore, given the fact that it is an essential good and is widely used in almost every construction activity it is reasonable to expect its price elasticity of demand to be quite inelastic. It has to be underlined that the same reasoning does not stand for clinker, as there are several opportunities to substitute it with other additives or to simply reduce its use (Cook, 2011).

When it comes to model price elasticity for the cement sector, most studies agree on using relatively low figures, therefore assuming inelastic market behaviour. La Cour and Mollgaard (2002) use a coefficient of -0.27 while Demailly and Quirion (2006) adopted an even lower value of -0.2. Price elasticity of demand is said to be inelastic, meaning that price variations have a small effect on the product’s demand, when the absolute value of the coefficient is smaller than 1. According to Cook (2011) a number of other studies use similar values (Smale et al., 2006; Reinaud, 2004). It is meaningful to underline that when studying the cost pass-through rates for the UK, Oxera Consulting (2004) employed a price of elasticity for cement of -0.27, extremely similar to the one they used for electricity, -0.25, which is notoriously a sectors characterized by one of the highest cost pass-through rates. This, by comparison, provides an indication of what the values used for cement entail.

5.1.4.2 Market Concentration

Although it was not possible to find data about the Herfindahl-Hirschman Index for the aluminium sector at the EU level, useful insights have been gained thanks to a literature review. Cement sector appears to be characterized by a high degree of market concentration both at the global and EU level (Cook, 2011). Often the biggest players occupy central positions in both markets. Five multinationals cement producers, namely Holcim, Lafarge, Cemex, HeidelbergCement and Italcementi, account for about 58% of the European and about 30% of the global market, while the top ten EU players have a market share of 76% (de Bruyn et al., 2008; Cook, 2011). The top three larger cement producers have a market share of 50% in countries such as Germany, Italy, Spain and Poland and a share of more than 80% in the UK and in France (Bergmann et al., 2007).

Moreover, there is evidence that the cement industry has been repeatedly characterized by a collusive behaviour in Western Europe that often lead to prosecutions by anti-trust authorities (Walker, 2006). A total of 16 cartels and anti-trust cases have been reported in the years between 1995 and 2005 (Bergmann et al., 2007). The high capital-intensity of the industry and its economies of scale favour the presence of large firms and discourage new entrants in the market. As a consequence the few incumbents present in the sector tend to own several production facilities across Member States and often also in non-EU countries. This large production net allows them optimizing production decisions and capacity availability (Cook, 2011). It is therefore clear that the cement industry is highly concentrated and that few incumbents govern the market. Most of the literature describes the European cement market as an oligopoly (Cook, 2011).

5.1.4.3 Product Differentiation and Substitutability

Although it was not possible to find data about the Armington Elasticities for the aluminium sector at the EU level, useful insights have been gained through literature review. Cement is considered to be a relatively homogenous product and production from extra-EU countries could in principle substitute domestic production relatively easily (Carbon Trust, 2008; Cook, 2011). Although raw materials might slightly differ, there are only few classes of cement and, within every class, products from different producers are generally interchangeable (Cembureau, 2013). Nevertheless, some authors point out that even in the cement sector differentiation could be an issue. First of all, Demailly et al. (2007) argue that European producers could lobby and push towards more stringent product standards. They further maintain that European firms could have an advantage in the eyes of clients in guaranteeing product quality, price stability and availability over time compared to foreign producers.

5.1.4.4 Transportation Costs and Transportability

Cement is a good characterized by having a significant weight in relation to its value. Therefore it has a low price and high transportation costs. Consequently it is generally not economically feasible to transport cement by land more than 200 or 300 km away from the production location (Cembureau, 2013). It costs € 10 to transport a tonne of cement over 100 km on land. These characteristics have lead to the creation of regional markets, relatively secured from external competition (Cook, 2011). Freight is the only economically feasible way of transporting cement, but even this mean of transportation is limited to short and medium distances. Shipping over the Atlantic is cheaper than transport cement 400 km by road. Shipping cement across the Mediterranean costs around 15 €/t while from China to Europe costs about 59 $/t (Bergmann et al., 2007; Demailly et al., 2007; de Bruyn et al. 2008). The latter price is comparable to cement prices in the EU (Demailly et al., 2007). Freight rates have been quite fluctuating in the past, following volatility in fuel prices and trade-related charges (Demailly et al., 2007). Nevertheless extra expenses, such as the rent of a storage facility in the destination port, have to be added to the freight shipping cost (Demailly et al., 2007). Due to these characteristics, cement is by far the sector with the lowest trade exposure among the energy intensive industries (Bergmann et al., 2007). Nevertheless the significant difference between transport costs by land and by sea implies that coastal regions, especially Mediterranean countries, are significantly more exposed to trade than inland regions (de Bruyn et al., 2008). It has also to be underlined that clinker is cheaper to transport than cement and therefore opens up possibility for international trade, especially by freight shipping (Demailly et al., 2007).

5.1.4.5 Trade Exposure

The volume of cement being traded globally is relatively low, accounting only for about 6 - 7% of the total production (Cook, 2011). The EU market reflects the global situation. The Commission's TII reports a value of 6.8%, which can be considered to be a rather low figure (European Commission, 2009). This can be easily explained by the high transportation costs described above. Figure 14, based on Eurostat data, shows that non-EU imports are only a marginal part of the traded cement, which in turn is a small share of the total cement production, implying that cement is mostly produced for local markets (Cook, 2011). Moreover the economic value of cement trade is way lower than many other goods (Carbon Trust, 2010).

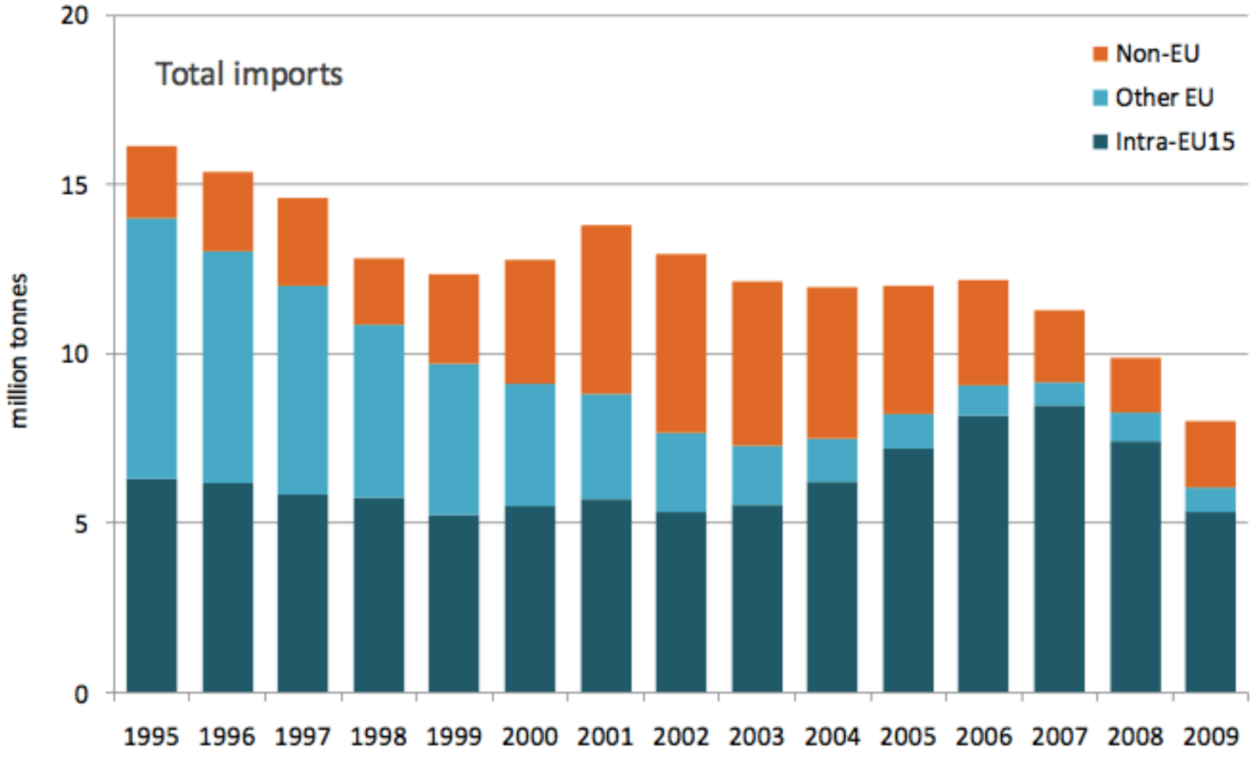

Figure 14. EU-15 Cement Imports from 1995 to 2009 (Cook, 2011).

Cement trade is rather volatile over time with fluctuations being driven by short-term determinants, such as supply-demand balances in the export countries and in the EU and fuel prices (Carbon Trust, 2010). Given that sea transportation is more convenient, coastal regions are the most exposed to trade. Generally, 75 - 80% of the traded cement is transported by freight ships (Cook, 2011). Exporters are generally low-cost producers located in North Africa, in the Middle East and, occasionally, in China. Changes in political situation, taxation and currency exchange rate in these countries also contribute to the high fluctuations in trade trend (Carbon Trust, 2008; Cook, 2011). Figure 15, based on Eurostat data, shows which European countries are more exposed to cement imports. It is clear that coastal Mediterranean countries are the most exposed.

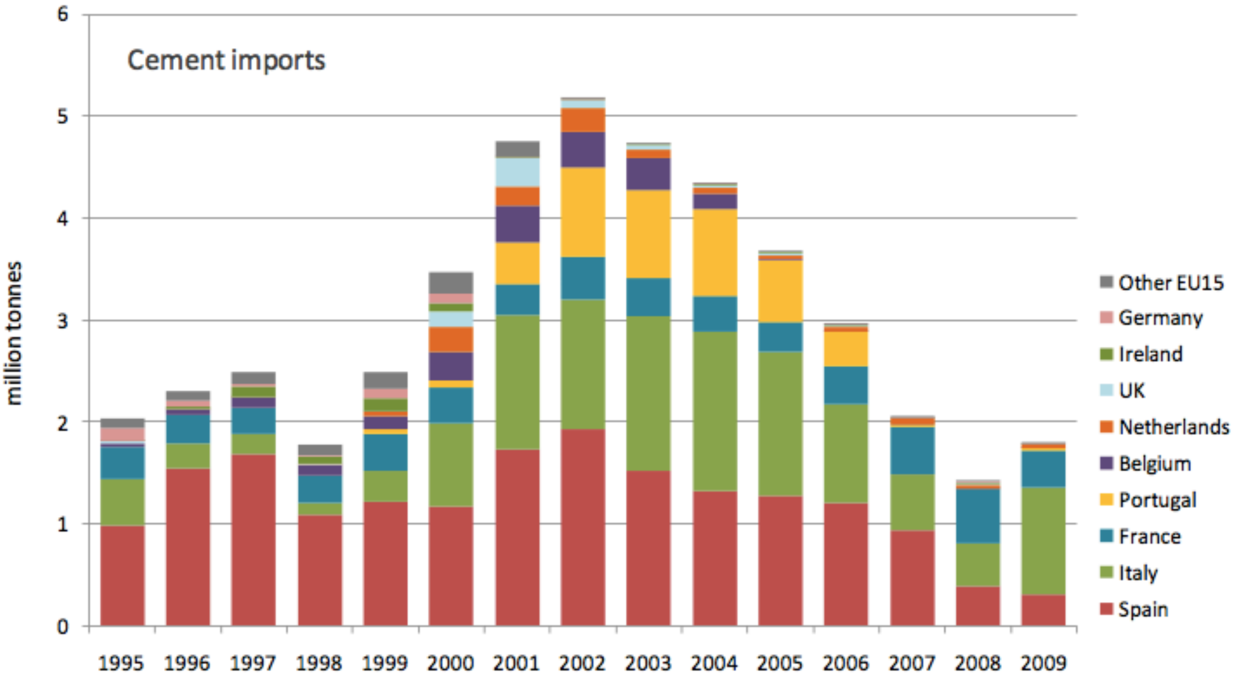

Figure 15. Cement imports from non-EU countries from 1995 to 2009 (Cook, 2011).

Particular attention should be given to clinker trade. Clinker is easier and more economical to transport than cement. Its production is also the most CO_2 intensive part of the cement production process and therefore is of central importance when studying CL. There is evidence that in the past years trade has been increasingly shifted from cement to clinker (Carbon Trust, 2008). This is also confirmed by the fact that rather than to new kiln capacity, new investments have been directed towards the development of new clinker grinding capacity, especially in coastal regions (Walker, 2008; Cook, 2011). This could indicate a growing tendency of the EU cement industry to rely on imported clinker and thus it could point the risk of CL due to imports from North Africa and the Middle East (Walker, 2008). Figure 16, based on Eurostat data, shows that non-EU imports progressively gained a big share of the traded clinker in the EU market, until the economic downturn in 2008.

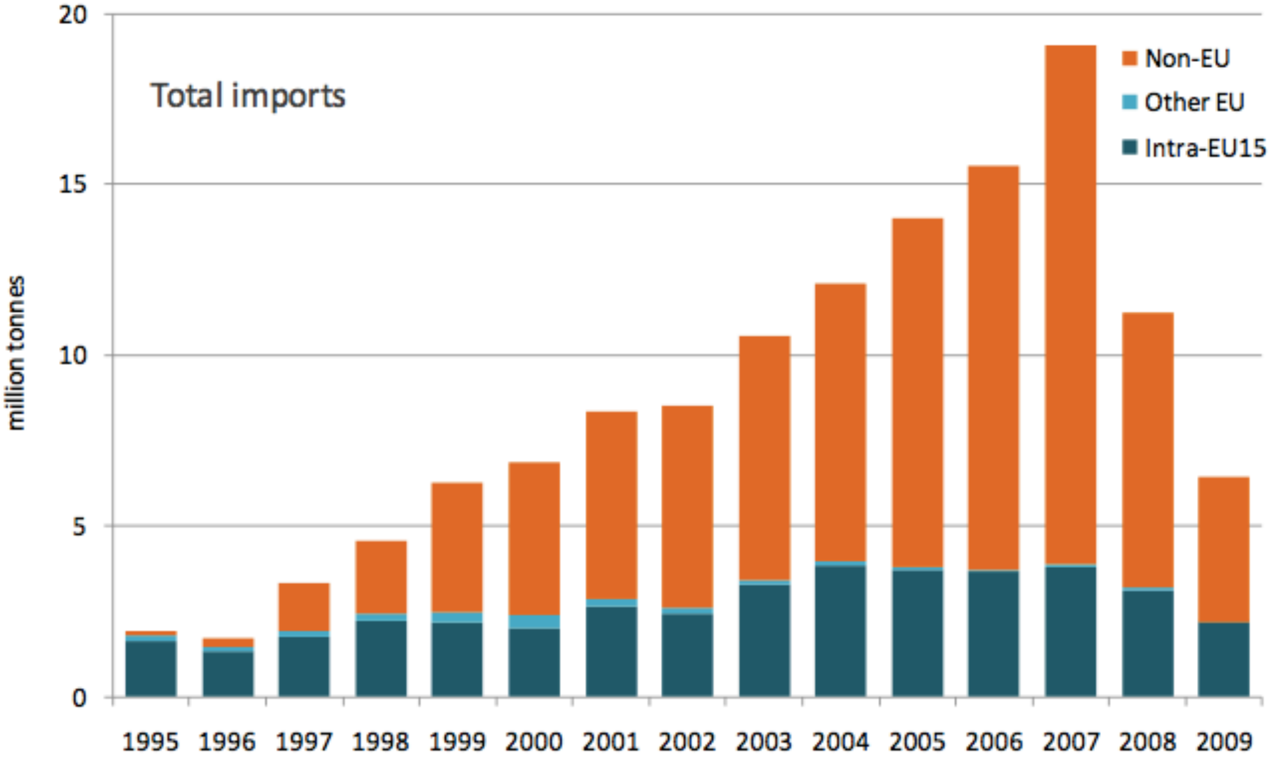

Figure 16. EU-15 Clinker Imports from 1995 to 2009 (Cook, 2011).

Similarly to cement, Figure 17, based on Eurostat data, shows that coastal Mediterranean countries are more exposed to extra-EU clinker trade.

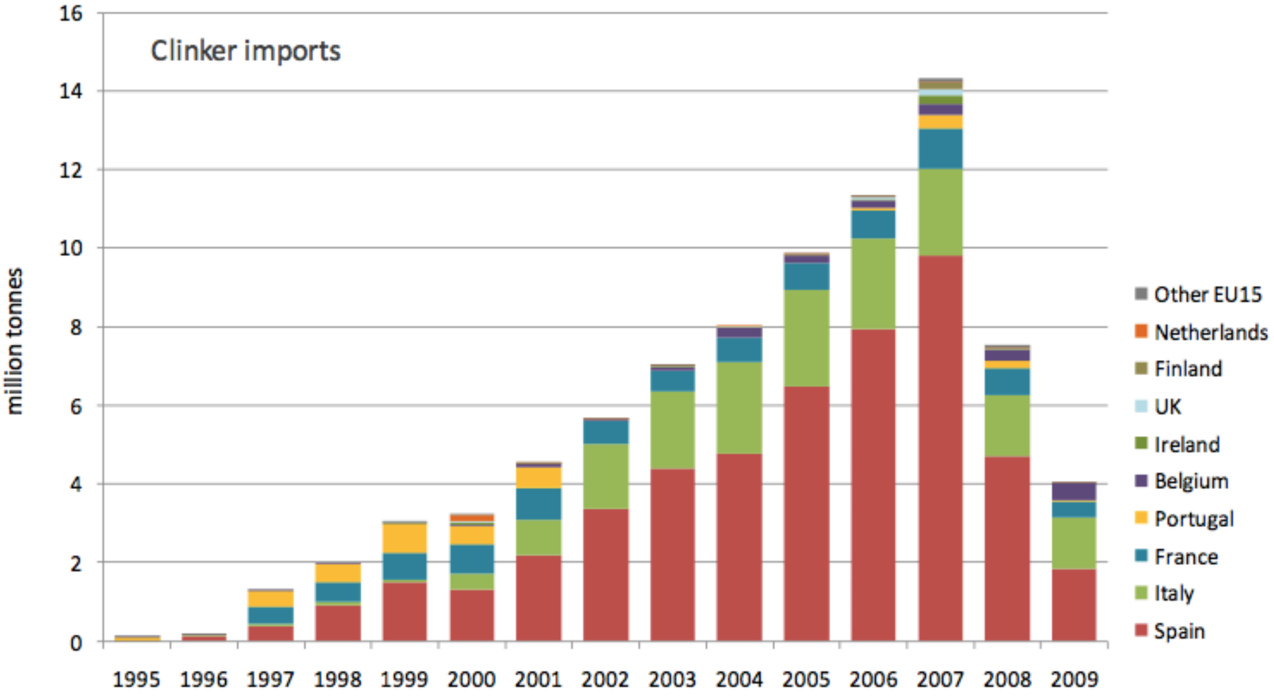

Figure 17. Clinker imports from non-EU countries from 1995 to 2009 (Cook, 2011).

High costs for inland transport result in the exclusion of inland regions from international cement trade. For instance Germany is hardly reached by non-EU cement imports (Cook, 2011).

5.1.5 Profit Margins

Operating margins in the European cement sector are usually relatively low, being somewhere between 11 and 15%, mainly as a consequence of low cement prices and high production costs (de Bruyn et al., 2008). Moreover, the continuous rise in costs of cement production in Europe in the recent years could not be absorbed because cement prices have been declining over the same period. In EU-25 on average, in the period 2007 – 2011, cement prices dropped by 13%, fuel costs rose by 26%, raw materials extraction by 10%, labour by 6% and electricity by 12% (Baeza et al., 2013).

The recent financial crisis seems to have further impacted profit margins of the cement industry. The sector is not obtaining acceptable returns, with an average return on capital over the last 4 years being somewhere between 5 – 6% below the cost of capital (Baeza et al., 2013). As a result there has been significant investment reductions in the cement sector. The historical rate of about 6.5% capital expenditure (CAPEX) over tangible assets declined by 3.5% in 2009 and 2010 (Baeza et al., 2013). The impact of the financial crisis is also evident from the previous graphs showing cement and clinker imports: the trade of both products witnessed a dramatic reduction from 2007 onwards. This could be mainly explained by the fact that the financial crisis largely halted construction activities, which are among the biggest consumers of cement. As a result, there have been capital expenditures reductions in the most impacted markets.

The crisis impact has been worsened by its occurrence in the middle of an investment phase, which usually entails to a period of financial gearing. This sensitivity is due to large regional difference in investment costs (Cook, 2011). The evidence that a number of cement plants are being built in the Middle East in the recent years supports these results. As their capacity seems to be in excess of domestic demand, it is possible that they have been developed mainly to satisfy foreign demand (Cook, 2011). These plants are mainly founded by local companies but there might be the risk that, following their example, also European firms could spill their investments in these regions.

5.1.6 Discussion

Summing up the insights gained using the framework of indicators, it is evident that the level of exposure of the European cement sector to the risk of CL is diverse and depends on the angle considered. First of all cement is an energy intensive sector and thus has potentially high compliance costs. Nevertheless we should not forget that the Commission’s value of 45.5% extra costs in relation with the GVA is based on the 30 €/tCO_2 carbon price assumption. If we adjust this value according to the most recent price projections we obtain a more modest 18.2%.

Moving to the second step of the framework, the sector seems to have some good options to reduce emissions. Cement blending and clinker substitution seem to be the most promising ways of reducing emissions, as clinker is responsible for most of the emissions in the cement production. Unfortunately, the lack of data did not allow quantifying the potential impact of these measures. With regard to the allowances surplus, cement producers seem to be holding a considerable amount of permits that, if surrendered to cover for emissions, could potentially shield them from compliance costs.

Moving to the third step of the framework, cost pass-through ability, requires a bit more of elaboration. Being a fundamental and hardly substitutable construction material, cement has an inelastic price elasticity of demand. Market concentration is high and cement industry is characterized by an oligopoly of few big incumbents dominating the majority of the market. Cement is not considered to be a very differentiated product, even if domestic producers might have some advantages, mainly due to costumer fidelity and trust. Transportation costs are high in relation with the product value and therefore cement does not travel long distances on land. Shipping by sea is more convenient but only on short and medium distances, e.g. crossing the Mediterranean. These characteristics are reflected in the sector's low trade exposure. Coastal regions are the only areas witnessing a significant level of trade, but even in the case of sea shipping cement transportation is confined in the area surrounding the import port and does not reach inland regions. Clinker is more transportable than cement and imports from North Africa and the Middle East have been growing in the last years. Nevertheless the trend has been quite steady from 1995 to 2007, so it appears not to be related with the ETS implementation.

All in all, we can conclude that cement producers are likely to have a good cost pass-through ability, especially thanks to high market concentration, inelastic demand and low trade exposure. Clearly, the possibility of passing on large shares of the extra costs is more feasible in inland regions and only limited in coastal areas. Producers located near the Mediterranean coast might be less free to pass on costs to consumers due to higher trade intensity and the presence of low-cost overseas producers. Looking at the historical evidence of cost pass-through, we see that Walker (2007), studying cement market prices, estimated cost pass-through in Phase I of 25-35%. Sijm et al. (2008) estimated a rate of 33-50%, Demailly and Quiron (2006) of 75% and Oxera (2004) of 83% (Cook, 2011). Even the lower estimates show that producers have been able to pass on a larger share of extra costs. Moreover the cement sector has been able to pass on to consumers extra costs from the latest electricity prices rise (de Bruyn et al., 2008).

The last step of the framework revealed that profit margins in the cement sector are low and therefore firms could significantly suffer if ETS compliance costs could not be minimized or passed on.

The Table below sums up the results obtained through the application of the framework.

Table 5. Results of the Framework Application

Flowchart Step	**Determinant**	**Conclusion**
Value at Stake	Carbon costs	Rather high
Internal Minimization of Carbon Costs	CO_2Emission Abatement and Electricity Consumption Reduction Potential	Some potential exists, mainly clinker substitution
	Surplus of Allowances	Extremely significant
Cost Pass-Through Ability	Price Elasticity	Inelastic
	Market Concentration	High
	Product Differentiation and Substitutability	Undifferentiated, domestic production can be substituted by imports
	Transportation Costs and Transportability	Land transportability is very limited, sea transportation of clinker is economically viable
	Trade Exposure	Generally low, limited to sea imports
Profit Margins	Profit Margins	Generally low

Looking at these results, it is clear that assessing the risk of CL for the cement sector is not clear-cut and straightforward because different determinants are in place. The sector seems to have a significant amount of unused allowances shielding it from compliance costs and also a good cost pass-through ability. These two factors alone should exclude a significant risk of CL. Given the limited impact, at least with the current carbon price, it is unlikely that the cement sector will significantly suffer or that production will relocate. The capital-intensive nature of the industry will further discourage investment and production relocation. However there is the risk that partial migration could take place, especially with regard to clinker production.

Due to high transport costs the level of risk exposure changes greatly according to the plant location. The inclusion in the CLL could result in huge windfall profits for inland producers while plants located in coastal areas would still be at risk. Nevertheless, coastal producers, even under free allocation, could leak a big part of the emissions importing clinker, obtaining windfall profits by selling the allowances surplus on the ETS market and causing CL at the same time. Following this reasoning, it seems natural that the best option would then be to compensate cement industry based on clinker production, or even consider finished cement and clinker as two different sectors. Nevertheless compensating for clinker would endanger incentives to improve the overall cement production efficiency by producing blended cement via clinker substitution, which is one of the biggest chances at hand to lower the CO_2 intensity of the process. One possible solution would be to push producers, possibly through the establishment of cement standards, towards a reduction of the clinker content of cement, which is the main responsible of CO_2 emissions in the production process and also the most exposed to CL.

5.2 Aluminium

5.2.1 Introduction

Aluminium is a very important material, being the world's second most used metal after steel (Healy & Schumacher, 2011). Aluminium and its alloys are easy to process and possess versatile characteristics: they are strong, durable, ductile, light-weighted, corrosion-resistant, recyclable and have good thermal and electrical conductivity. They therefore find applications in a broad range of sectors such as transportation industry, packaging and construction (Bergmann et al., 2007; Healy & Schumacher, 2011). Global demand has been increasing exponentially in the past decades and is expected to maintain the same trend in the future. World production grew, almost doubling, from 19 Mt in 1990 to 37 Mt in 2007 (Bergmann et al., 2007; Healy & Schumacher, 2011).

The production of aluminium is an energy intensive process and the sector accounts for 1% of the global GHG emissions (Dröge, 2012). Most of the emissions derive from electricity consumption, which usually accounts for 75% of the overall emissions in the process. Differences in emission intensity of plants are mostly a consequence of the different carbon intensities of the fuel sources (Dröge, 2012). Aluminium can be produced via two main processes: primary smelting and recycling of aluminium scrap, known as secondary smelting (Dröge, 2012).

Primary smelting is the process used to produce aluminium from its raw material: the aluminium oxide known as alumina. The process is based on electrolysis and involves passing large amounts of electricity in a bath of alumina and molten cryolite in order to dissolve molecular bonds (Sartor, 2012). Secondary smelting consists in recycling aluminium waste to obtain new aluminium and does not involve electrolysis. Primary smelting is extremely more energy intensive than secondary smelting as it uses 20 times more electricity: 15 MWh per tonne of primary aluminium against 0.7 MWh/t (McKinsey and Ecofys, 2006). Thanks to its profitability and to the fact that no difference exists between primary and secondary aluminium, secondary production has become progressively more and more important in the recent years (Dröge, 2009). European aluminium production is split in 50% primary smelting and 50% secondary smelting. At the end of the aluminium-making process, the product is casted in unwrought forms, such as slabs, billets or ingots, which can be made of pure aluminium or its alloys (Sartor, 2012).

Global aluminium prices are established by the London Metal Exchange (LME). Firms therefore are not free to adjust prices independently in order to compensate for an increase in production costs (Healy & Schumacher, 2011). Aluminium is also intensely traded at a global level, where the market domination witnessed significant changes over the last decades. The traditional largest producers, the EU and the USA, have been overtaken by China in the early 2000s (Bergmann et al., 2007). China's output accounted for 37% of the global production in 2009 and was characterized by a constant upward trend (Dröge, 2012).

Transporting aluminium is relatively cheap compared to its value. Producers in China can export to the European market at a cost 10% lower than for European production (McKinsey and Ecofys, 2006).

The competitiveness of the European aluminium industry is mainly endangered by the rising electricity costs (Healy & Schumacher, 2011). Electricity usually accounts for 35 – 50% of the total primary aluminium production cost (Sartor, 2012). Even if it was not covered by the ETS in Phase I & II aluminium sector seems to have suffered from the carbon costs passed on by electricity producers (Sartor, 2012). As a consequence, producers from countries with cheap electricity access or cheap fuels have been favoured in the last years (Dröge, 2012). Nevertheless, so far European aluminium industry has been shielded from the major part of the electricity price rise by the existence of long-term power supply contracts, which guaranteed a stable energy price. These agreements have allowed producers to be insulated from price fluctuation risks and to maintain competitiveness. A study by Reinaud (2008a) expected 65% of these contract to end by 2010 and forecasted that by 2016 no plant would benefit from contracts stipulated before the EU's reform of the energy market.

Long-term trends indicate that, as a consequence of rising electricity prices and opportunities for low-cost energy supply in other areas, most of the European smelting capacity is likely to be shut down in the coming 20 years (McKinsey and Ecofys, 2006). Investments in new plants in Europe are declining; several plants have been closed and only very few new ones have been opened (Sartor, 2012). Analyses indicate that such trends have been in place long before the establishment of the EU ETS. Nevertheless, increased electricity prices as a result of carbon pricing is expected to speed up these trends (McKinsey and Ecofys, 2006).

As mentioned before, aluminium production was not covered by the ETS in Phase I & II, but has entered the scheme from the beginning of Phase III. The sector has been included in the CLL because it meets the first criterion, i.e. CCI >5% and TII >10% (European Parliament & Council, 2009; European Parliament & Council, 2010a).

5.2.2 Value at Stake

Due to the large amount of electricity consumed in the production process, aluminium sector has been exposed to the effect of carbon pricing even if it was not directly covered by the ETS (Sartor, 2012). Power producers in fact raised prices to pass on large parts of their compliance costs to consumers, thus determining an increase in aluminium production costs. According to a study, a carbon price of 20 €/tCO_2 would determine a production cost increase of 11.4% for primary aluminium and 0.5% for secondary aluminium (McKinsey and Ecofys, 2006). The Commission estimated a direct cost of 1.7% of the sector's GVA and an indirect cost of 10.3%, with a total carbon cost of 14% (European Commission, 2009). The high indirect cost reflects the sector's electricity-intensive nature and the total carbon cost justifies the fact that it is usually classified among the energy intensive sectors. If we correct for the current carbon price we obtain a total carbon cost value of 5.6%, meaning that the sector would still meet the double criteria. It is interesting to underline that the sector has been included in the CLL because its high indirect costs but, being on the list, it is only compensated for its direct costs. This contradiction is further analysed in the discussion section.

5.2.3 Internal Minimization of Carbon Costs

5.2.3.1 CO_2 Emission Abatement and Electricity Consumption Reduction Potential)

Minimization of carbon costs measures should focus on electricity consumption reduction, as it contributes for the largest share of compliance costs. Few abatements measures exist but are generally rather expensive (Monjon & Quirion, 2011).

One option is to retrofit old plants. The conversion from an old to a new process could save up to 1 MWh/t, while rebuilding the whole plant upgrading it to state-of-the-art techniques could save 2 – 2.5 MWh/t. In the EU most of the smelting plants already operate with the most efficient processes and only about one third could be available for some degree of retrofitting (de Beer et al., 2001). It has to be underlined that the study reporting this information is quite outdated.

Alternatively, emissions can be abated by increasing recycling rates and secondary production of aluminium. Recycling rates are already quite high in the EU and in the USA but in countries such as Brazil, Norway and Japan are close to 90%. A study estimated that if all countries raised their recycling rates to this level, global emissions could be decreased by 5% (Dröge, 2009).

Lastly, the carbon-intensity of electricity also plays a big role. Chinese producers have the highest share of coal-based electricity, while some countries such as Norway and Iceland employ electricity with an extremely low carbon content, as a result of using hydropower and geothermal energy (Dröge, 2009).

5.2.3.2 Surplus of Allowances

Aluminium production has entered the ETS only in Phase III and therefore did not have the possibility to accumulate a surplus of allowances from the previous phase.

5.2.4 Costs Pass-Through Ability

5.2.4.1 Price Elasticity

In a modelling exercise, Smale et al. (2006) assumed a price elasticity of -1.1. Coefficient’s absolute values bigger than 1 generally correspond to rather elastic prices. Aluminium’s value is the highest among energy intensive industries. Such figure means that demand is quite responsive to changes in prices and therefore producers might not be able to adjust prices without losing market shares and profits.

5.2.4.2 Market Concentration

Although it was not possible to find data about the Herfindahl-Hirschman Index for the aluminium sector at the EU level, some useful insights have been gained through literature review. Aluminium is traded in the global market where few incumbents, present in several countries, hold the largest market share (McKinsey and Ecofys, 2006). For instance, Alcan accounts for 27% of the global production, Alcoa for 16% and Norsk Hydro for 10%. Access to raw materials, i.e. alumina, is in the hands of the same few largest players. At the EU level, the four biggest primary aluminium smelters account for 85% of the market (Parker & Blodgett, 2008). Aluminium sector tends to have also a high degree of vertical integration, with the same companies being present in all the different steps of the production process (McKinsey and Ecofys, 2006).

Moreover, aluminium production is concentrated in a limited number of countries: China, Russia, Canada, USA, Australia, New Zealand, Brazil, Norway and India account for 75% of the global production. Production is concentrated in countries that offer either access to raw materials or cheap electricity supply (Sartor, 2012).

5.2.4.3 Product Differentiation and Substitutability

Although it was not possible to find data about the Armington Elasticities for the aluminium sector at the EU level, some useful insights have been gained through literature review. Products of the aluminium sector are rather undifferentiated and homogeneous. Primary and secondary aluminium present no differences. Semi-finished products and speciality products can be obtained from any kind of alumina or scrap aluminium and do not differ in terms of quality (de Bruyn et al., 2008; Dröge, 2012). As a consequence, aluminium produced by different producers in different parts of the world is highly interchangeable.

5.2.4.4 Transportation Costs and Transportability

One of the most valuable aluminium’s characteristics is represented by its light weight. Aluminium has a very high value in relation with its weight. As a consequence, transportation costs have a little impact in the final product price. For example, producers in China can export to the European market at a cost 10% lower than for European production. Also alumina has low transportation costs compared to its value. Often smelting plants are therefore located in countries offering cheap electricity; alumina is shipped in from the mining locations and aluminium is shipped out to the global markets (McKinsey and Ecofys, 2006).

5.2.4.5 Trade Exposure

The EU is a net importer of aluminium. On average, the EU imports aluminium products for a total annual value of $ 18 billion and exports for $ 8 billion (Healy & Schumacher, 2011). In 2006 the volume of EU internal trade was only 60% of the import volume from outside the EU (Reinaud, 2008a). The Commission’s

TII, reflecting this situation, reports a value of 35.9%, which can be considered a relatively high figure (European Commission, 2009).

It is worth underlining that imports are predicted to increase in the future because, as a consequence of a lack of investments in new capacity in the EU, European smelters are currently running at full capacity. Any future increase in demand will therefore be met by an increase in imports (Reinaud, 2008a). As we can see from Figure 18 below, 9 countries, i.e. Norway, Iceland, Russia, Mozambique, Canada, UAE, Brazil, Bahrain and South Africa account for almost all the extra-EU imports. It has to be underlined that Norway and Iceland are currently covered by the EU ETS. China is not exporting significant quantities of primary aluminium to the EU at the moment because an export tax scheme is in place to favour internal demand (Reinaud, 2008a). Aluminium imports have been steadily increasing until 2008, when they halted as a consequence of the financial crisis. Between 1999 and 2006 consumption of primary aluminium grew by 40% (Reinaud, 2008a).

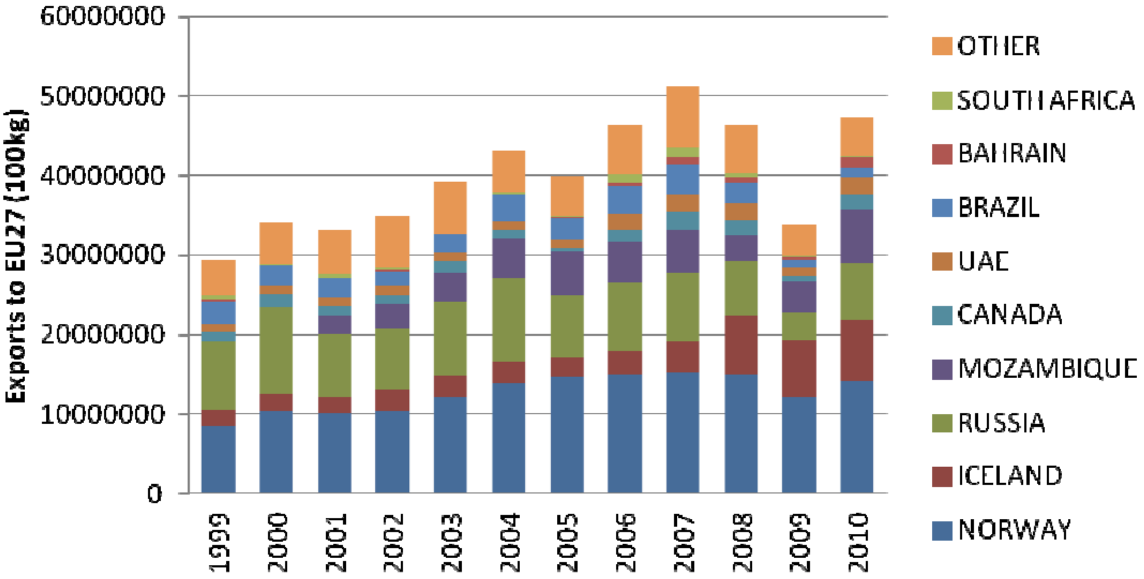

Figure 18. Major exporters of unwrought primary aluminium to the EU27 (Sartor, 2012)

Aluminium is so intensely traded because, as previously explained, smelting plants tend to be located in countries with cheap electricity supply, but not necessarily close to raw material sources nor to consumers. Consequently, the worldwide primary aluminium demand originates trade flows from few production countries to the global market, with 77% of the global primary aluminium output being traded internationally (Reinaud, 2008a). This pattern is also evident when analysing the trade value of individual products within the aluminium sector, as shown in Figure 19. Most of the value corresponds to products in the lower steps of the production chain, such as unwrought aluminium (Healy & Schumacher, 2011). This reflects the fact that the energy-intensive parts of the production chain, such as the processing of raw materials into basic aluminium forms, are located in countries with favourable conditions and then the semi-finished products are exported to other countries, including the EU, where they are further transformed with less energy-intensive processes. This explains why unwrought aluminium represents the biggest share of trade value in the EU-27 imports. On the other hand, exports from the EU are dominated by products of late steps of the production chain, such as aluminium plates and other elaborated forms (Healy & Schumacher, 2011).

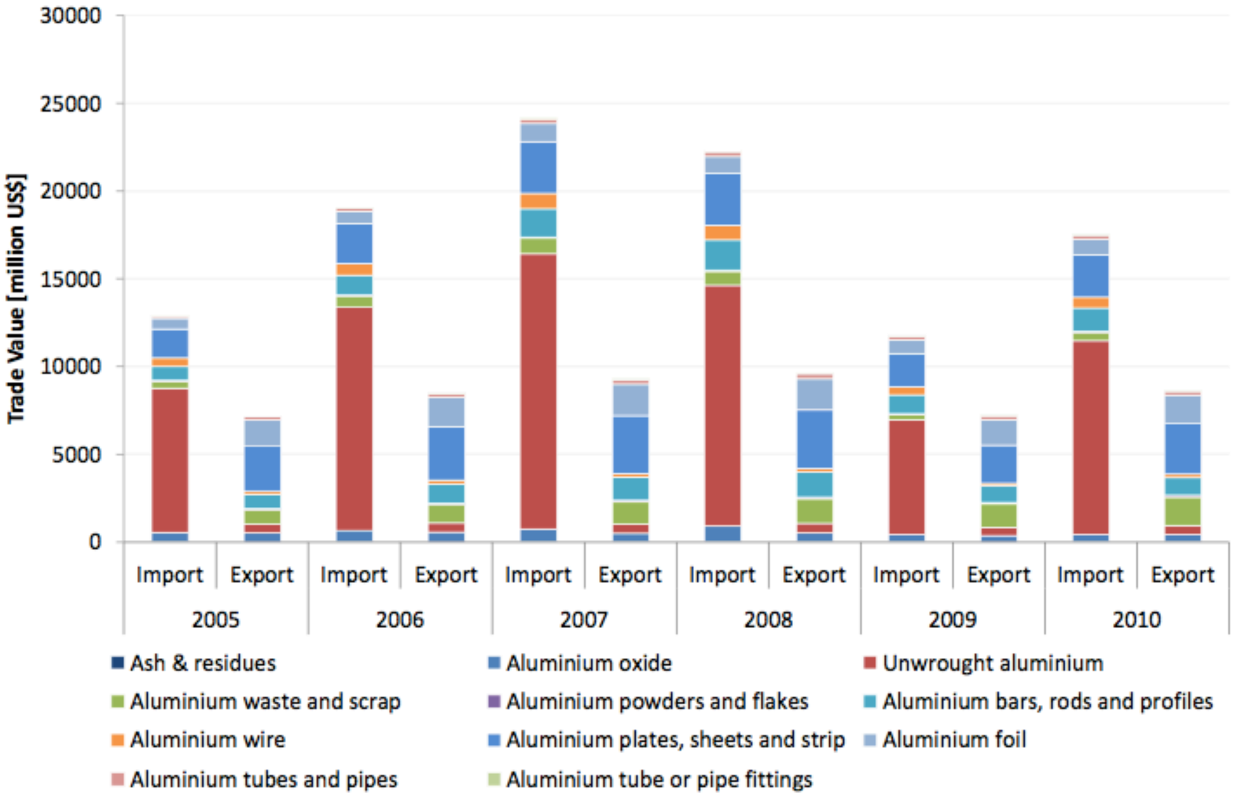

Figure 19. Trade value of aluminium imports to the EU-27 from 2005 to 2010 (Healy & Schumacher, 2011).

5.2.5 Profit Margins

There are three main categories of operational expenditures in the aluminium production: purchase of energy products (which includes electricity and fuels), personnel costs and all other purchase of goods and services. Their relative influence varies from country to country and determines the industry's profitability (Dröge, 2009). In the past years the European aluminium industry has been shielded from the rise in electricity price by the existence of long-term power supply contracts, which guaranteed a stable energy price. Moreover the rise in global aluminium prices, started in 2003, has overcompensated producers for any increase in production cost (Reinaud, 2008a). High prices granted European aluminium smelters operational margins of around 50%, compared to an average of 20% in the late 1990s (Reinaud, 2008a). The situation will differ when producers will no longer benefit from long-term energy contracts, as aluminium production is more expensive in Europe than in many other parts of the world. European plants that are already operating with no contracts saw their profit margins plunging to around 20 – 30% (Reinaud, 2008a). This is a consequence of the fact that global aluminium prices are established centrally by the LME and therefore producers have no chance to recover profits by passing extra costs on to consumers.

LME prices cover all the intermediate products from raw materials to finished products and apply at a world level. Single companies cannot influence prices and local premiums hardly exist (Reinaud, 2008a). Consequently investment flows have historically always favoured regions offering low operational expenditures, in order to maximize profit margins. Another important element to consider when analysing investment flows is that aluminium is priced in Dollars but EU producers' costs are in Euros. Therefore the latter are also exposed to the volatility of the exchange rate (Reinaud, 2008a).

As a consequence, in the past decades investments have been focused in areas outside the EU. In the period from 1989 to 2005, 21 smelting plants closed in Europe and only 2 new ones opened (Sartor, 2012). Long-term trends indicate that, as a result of better profit margins in other part of the world, most of the European smelting capacity is likely to be shut down in the coming 20 years (McKinsey and Ecofys, 2006). There is evidence that this tendency was in place long before the introduction of the ETS. Moreover the latter is responsible only for a marginal part of the total electricity price increase and thus it cannot be the primary cause of the decline in EU investments.

5.2.6 Discussion

Summing up the results of the analysis, we see that the aluminium sector has a fairly high value at stake, mainly as a consequence of the considerable indirect costs deriving from the high electricity consumption. Nevertheless carbon costs would fall slightly above the 5% threshold after the correction for the actual carbon price.

Regarding internal carbon cost minimization options, due to the sector's nature, abatement measures should be focused on electricity consumption reduction. To this end, the most promising possibilities seem to be the shift towards secondary aluminium production and the use of low-carbon electricity, for instance hydropower or geothermal. Nevertheless, both options are not easily and readily implementable. The former depends on long-term industry decisions and investment trends and the latter on local availability of such energy sources. Moreover the sector does not hold any allowance surplus from previous phases as it has entered in the ETS only in 2013.

Moving to the third step of the flowchart, the sector's cost pass-through ability seems to be extremely limited. Aluminium producers have to succeed in a concentrated market, characterized by an elastic demand, with aluminium being a highly traded, easily transportable and undifferentiated product. Furthermore, cost pass-through ability is particularly limited by the fact that global aluminium prices are determined by the LME. Therefore producers do not have the possibility of directly adjusting prices to compensate for increased costs unless their competitors also support such action, which is unlikely (Reinaud, 2008a). All the studies taken into consideration in this regard agreed on classifying the aluminium sector's cost pass-through ability as extremely limited (de Bruyn et al., 2008; Reinaud, 2008a; Dröge, 2012; Sartor, 2012).

Since there is no cost pass-through possibility, EU producers have no choice but to decrease their profit margins if an increase in production costs occurs. The effects of such move have been taken into consideration in the last section of the analysis. The sector's profit margins have been secured in the recent years thanks to a global increase in aluminium prices that has shadowed the electricity price rise. Moreover, another reason why the general increase in European electricity prices did not yet impact the aluminium sector is because most producers are still covered by favourable long-term contracts. It should also be kept in mind that, since prices are fixed, the sector's profitability entirely depends on local production costs. European producers have higher production costs than competitors in many other parts of the world and, consequently, a long-term trend of diminishing production in Europe is in place, while new capacity is being built up in other countries. This happens because producers fear that producing in Europe will no longer be profitable in the near future, especially in comparison with other world regions benefiting from cheaper electricity and workforce.

The Table below sums up the results obtained through the application of the framework.

Table 6. Results of the Framework Application

Flowchart Step	**Determinant**	**Conclusion**
Value at Stake	Carbon costs	Moderately high, mainly due to indirect costs.
Internal Minimization of Carbon Costs	CO_2 Emission Abatement and Electricity Consumption Reduction Potential	Potential exists, but its implementation is difficult
	Surplus of Allowances	Non-existent
Cost Pass-Through Ability	Price Elasticity	Rather elastic
	Market Concentration	High
	Product Differentiation and Substitutability	Rather undifferentiated, domestic production can be substituted by imports
	Transportation Costs and Transportability	Highly transportable
	Trade Exposure	High, the product is traded globally

Profit Margins	Profit Margins	Good, but likely to be endangered in the future

The analysis revealed that the aluminium sector, due to the extremely poor cost pass-through ability, is particularly endangered by production costs increase, especially if it concerns electricity prices. Since individual producers cannot adjust aluminium prices, they tend to locate production where costs are smaller, in order to maximize and secure profit margins. Europe is among the most expensive production locations in the world and therefore the last decades had witnessed an on-going trend of decreasing investments in the EU and increasing production capacity in other world regions. It has to be underlined that the increase in capacity outside Europe does not mean that direct relocation is happening. Nevertheless it might represent a risk in the future (de Bruyn et al., 2008). McKinsey and Ecofys (2006) forecasted that primary aluminium industry has no future in Europe and that the major part of the smelting capacity is expected to be shut down in the next decade or two. The only two countries in the EU ETS that offer favourable conditions for primary aluminium production are Norway and Iceland, thanks to their availability of cheap and low-carbon electricity (Carbon Trust, 2010).

Studies focusing on the effect of the ETS on the aluminium industry concluded that it did not have a significant impact on the sector, mainly because the scheme is not thought to be the major determinant of neither the rise in electricity prices nor the loss of profitability of European aluminium. However its incidence can worsen the sector’s situation and speed up its decline (Sartor, 2012; Venmans, 2010). Nevertheless, it is also interesting to notice that new capacity is often planned in areas that offer cleaner electricity, as in the case of hydropower in Russia, some parts of Africa and South-America and natural gas in the Middle East. If a hypothetical relocation took place from Europe to a country with a less carbon intensive electricity, global emissions would decrease (Sartor, 2012).

Concluding, CL concerns for the aluminium sector should be focused on long-term investment trends and relocation risk. Short-term production leakage and market shift towards foreign products are not the main issues because the sector is already highly traded and prices are globally standardized. Even if trends involving the lack of investments in Europe and increase in capacity elsewhere in the world were in place before the implementation of the ETS, the latter has the effect of worsening the sector’s profitability due to higher electricity prices. Although aluminium producers need to be protected from production cost increase, it is worth underlining that the inclusion of aluminium in the CLL is controversial. In fact the sector has been included because, besides being intensely traded, it is exposed to high carbon costs. Most of these costs are indirect costs deriving from electricity consumption and only a small share is a consequence of direct emissions. Being on the list, the sector receives 100% free allowances up to a benchmark level to cover for its emissions. The contradiction lies in the fact that the sector has been inserted in the list as a consequence of its indirect costs, but it is being compensated for its direct costs only, which are extremely marginal. The sector in fact seems to be mainly endangered by the rise in electricity prices, and not by the compliance to the ETS itself. Therefore the sector's compensation is no longer a matter of CLL, as the sector does not need to be compensated for its compliance costs.

Nevertheless, if the aim is to protect the sector from excessive competitiveness loss and to prevent its premature closure in Europe, other forms of compensation should be implemented focusing on indirect costs. One option would be to use the measures mentioned in Article 10b of the amended Directive "Measures to support certain energy-intensive industries in the event of CL" in order to cover for the share of electricity cost increase attributable to the ETS costs pass-through.

5.3 Iron and Steel

5.3.1 Introduction

Iron and steel are two extremely common and widely employed materials. They find application in a broad range of economic sectors, e.g. construction, machinery, heavy transport, automotive, household appliances and packaging (Bergmann et al., 2007).

Iron and steel account for about 19% of the total manufacturing energy consumption in the EU-25 and are responsible for about 7% of the global CO_2 emissions (Bergmann et al., 2007; Grubb et al., 2011). Consequently, it is usually considered one of the most exposed sectors to carbon pricing (Grubb et al., 2011). In 2007 the EU-25 steel output accounted for 17% of the total world production. In the EU, five countries account for 64% of the total production. Germany is the biggest European producer (23%), followed by Italy (15%), Spain (10%), France (9%) and the UK (7%) (Bergmann et al., 2007; Dröge, 2009; Linares & Santamaria, 2012). Steel is not a homogeneous product. There is a great variety of grades and qualities, differing in composition and application (Bergmann et al., 2007).

There are two main processes to produce steel: the classic blast furnace/basic oxygen furnace (BOF) route and the electric arc furnace (EAF). The first process, also referred to as primary steel making, is traditionally used to produce steel from raw materials while the second one, also referred to as secondary steel making, emerged more recently and is mainly employed to obtain steel by melting recycled scrap. In the primary steel making process the blast furnace produces pig iron that is further processed in the basic oxygen furnace to obtain steel products. The production chain determines also the type of output. The classic BOF is mainly used to produce "flat" iron and steel products, often specialties with a relatively high value used for example in the automotive industry, while the secondary steel making process is usually employed to obtain long products used in construction or in households appliances (de Bruyn et al., 2008; Carbon Trust, 2008). Generally, "long" products are mostly commodities, while "flat" products are specialties (McKinsey and Ecofys, 2006). The BOF route uses fossil fuels, most commonly coal, as energy input while the EAF mainly uses electricity (Dröge, 2009). CO_2 is also emitted by chemical reactions in the iron making process and therefore, as a result, primary steel production emits 2 tonnes of CO_2 per tonne of steel produces, of which 90% are direct emissions and 10% indirect, while secondary steel production emits only about 0.4 tonnes of CO_2 per tonne of steel produced, 100% as indirect emissions from electricity consumption (assuming an electricity production CO_2 emission factor of 0.41 tCO_2/MWh) (McKinsey and Ecofys, 2006; Demailly et al., 2007).

In the EU, primary steel making generally accounts for two-thirds of the industry's output, but the exact share differs from country to country (Bergmann et al., 2007). For instance in countries such as Greece, Luxemburg, Portugal and Slovenia EAF is the only steel making process. These three countries account only for 3% of the total iron and steel output (Linares & Santamaria, 2012). Secondary steel making has high shares also in Spain (78%) and Italy (63%), while the primary process is significantly more important in countries such as Germany (69%), the Netherlands (98%), Austria (92%) and the UK (80%) (Demailly et al., 2007; Dröge, 2009). The higher share of EAF in countries such as Italy and Spain can be explained by the availability of scrap and by easy access to the sea, which favours imports of this raw material. (Linares & Santamaria, 2012)

Iron and steel trade has become progressively more and more important over the last years in the EU, doubling from about € 114 million in 2003 to about € 259 million in 2007. Currently iron and steel are highly traded, with 40% of the global production being traded internationally (de Bruyn et al., 2010). The intra-EU trade share is around 77% of the total volume. The six biggest non-EU trade partners are China, Ukraine, Russia, the USA, Turkey and Switzerland, which together account for half of the extra-EU trade. The first three countries are the main sources of imports while the USA and Turkey are the main export destinations (Dröge, 2009). As in the case of aluminium, despite historically the EU and the USA have dominated the global market, in the last decades China has emerged both as producer and consumer becoming the largest world player (Bergmann et al., 2007).

Iron and steel is a capital-intensive industry (McKinsey and Ecofys, 2006). Production costs in Europe are 10 - 20% higher than the world average and up to 40% higher than low-cost producing countries such as Brazil, Ukraine and Russia, which have access to cheap energy and raw materials (Carbon Trust, 2008). Some iron and steel products have a relatively high value in relation to their weight and thus transport costs do not limit their international trade (Carbon Trust, 2008). Long products are generally less exposed to import pressure, as they are traded in regional-oriented market due to their considerable size, weight and rather low value. On the other hand, flat products are subject to stronger trade intensity (McKinsey and Ecofys, 2006). The iron and steel sector is included in the first CLL, and thus receives 100% free allocation up to the benchmark level, thanks to the fact that it meets the first criterion, i.e. CCI >5% and TII > 10% (European Parliament & Council, 2009; European Parliament & Council, 2010a).

5.3.2 Value at Stake

The BOF process, with its total emission of 2 tonnes of CO_2 per tonne of steel produced, is more exposed to carbon pricing that the EAF process, which emits only 0.4 tonnes of CO_2 per tonne of steel produced (assuming an electricity CO_2 emission factor of 0.41 tCO_2/MWh) (McKinsey and Ecofys, 2006). It has also to be underlined that in the BOF process emissions are 90% direct and 10% indirect while in the EAF process emissions are 100% indirect (McKinsey and Ecofys, 2006; Demailly et al., 2007). A study calculated that a CO_2 price of 20 €/tCO_2 would determine a short and mid-term cost increase of around 17.3% for primary iron and steel making and 2.9% for secondary steel making (McKinsey and Ecofys, 2006). Of the total European production, about two-thirds are primary steel and one-third secondary steel (Bergmann et al., 2007).

This situation is reflected by the Commission's CCI that reports a total carbon cost of 10.6% of the sector's GVA, split in 6.5% direct costs and 3.6% indirect costs. If we correct for the current carbon price we obtain a total carbon cost value of 4.2%, meaning that the sector would no longer meet the double criteria. Nevertheless it would still be included in the CLL as it meets the third criterion, i.e. TII >30%. It is interesting to notice that the total carbon cost figure is comparable to the one of the aluminium sector, but the influences of direct and indirect costs are inverted, with the direct costs being the most significant (European Commission, 2009).

5.3.3 Internal Minimization of Carbon Costs

5.3.3.1 CO_2 Emission Abatement and Electricity Consumption Reduction Potential

A variety of energy efficiency and emissions abatement measures applicable throughout the whole iron and steel production chain exists. The potential varies from country to country and from plant to plant, according to fuel mix, technologies and type of process employed (Demailly et al., 2007). The International Energy Agency (2007) quantified a technological potential for CO_2 emissions reduction of 220-270 Mt CO_2/yr at a global level. The largest contributors appear to be blast furnace improvements followed by increased basic oxygen furnace gas recovery. The study does not quantify a potential at the EU level nor it develops MACCs. Iron and steel production is already thought to be a relatively efficient process in Europe. Nevertheless a study shows that the technical energy saving potential per tonne of steel produced is 7% by 2020 and 13% by 2030. However, the study does not specify how these savings have been estimated, e.g. simply by increasing the share of EAF production or by improving the overall efficiency of the BOF process (Altmann et al., 2010).

5.3.3.2 Surplus of Allowances

There is evidence that in the past years allowances have been largely over-allocated to the iron and steel sector. Figure 20 is based on the UE ETS data viewer and shows that every year the amount of freely allocated allowances has been larger than the verified emissions. The gap has become extremely significant especially in Phase II.

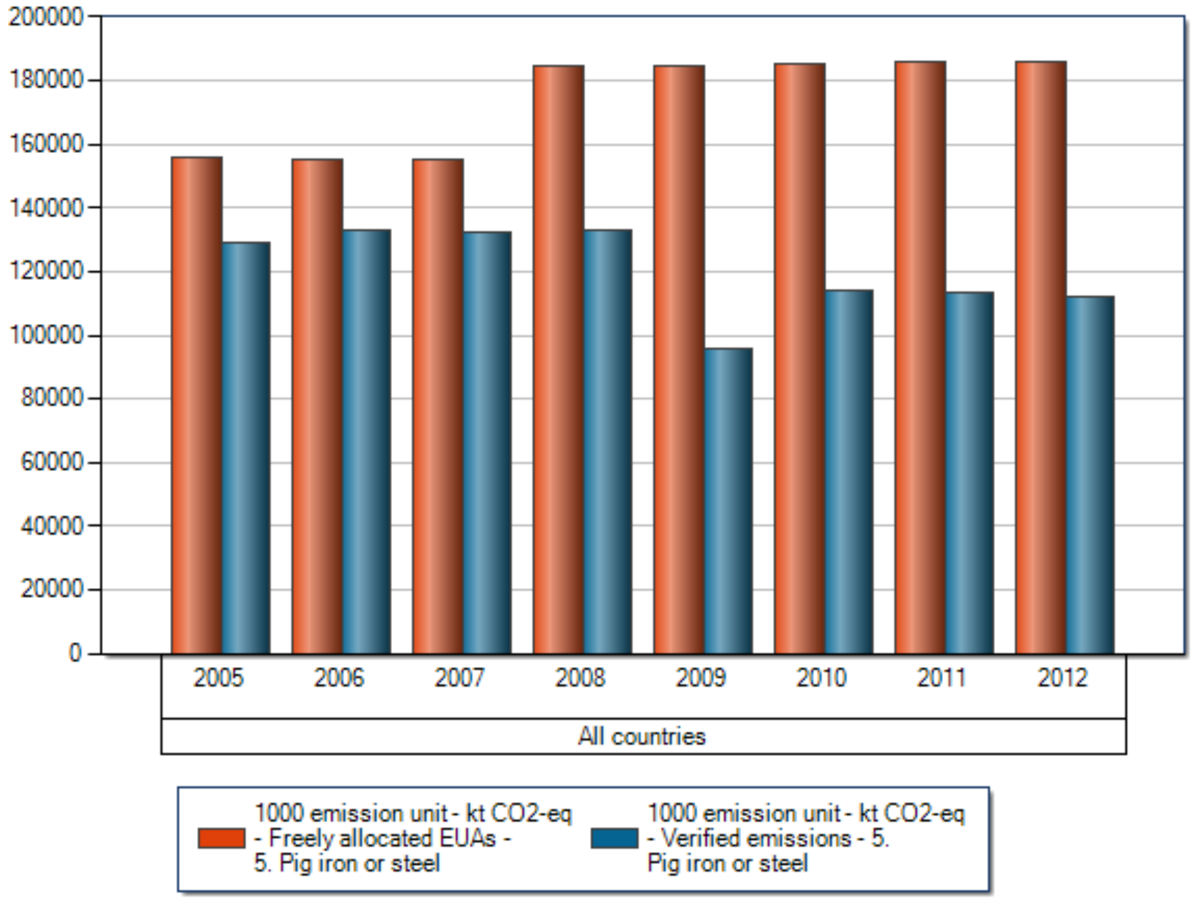

Figure 20. Allocated allowances and verified emission in the iron and steel sector from 2005 to 2012 (European Environment Agency, 2013)

As for the cement sector, the over allocation problem originates from the combined effect of inflated growth projections and the economic crisis. The generosity in the allocation is also a consequence of the sector being commonly seen as one of the most exposed to carbon pricing and of the effectiveness of the iron and steel lobby pressures (Elsworth et al., 2011). The possibility of banking allowances from Phase II to Phase III will give enormous benefits to the industry, especially considering the economic value of the allowances surplus.

A report by Elsworth et al (2011) shows that the top ten emitting firms in the sector hold a surplus of 172 million allowances, worth about € 2.9 billion. Data are shown in Figure 21. However the surplus is not equally distributed among companies: according to the data reported by the study, ArcelorMittal has a has a surplus of 66.3 million allowances while Moravia Steel falls short of 0.2 million. The difference is a consequence of the level of free allocation granted by NAPs and of the effectiveness of firm's individual lobbying actions.

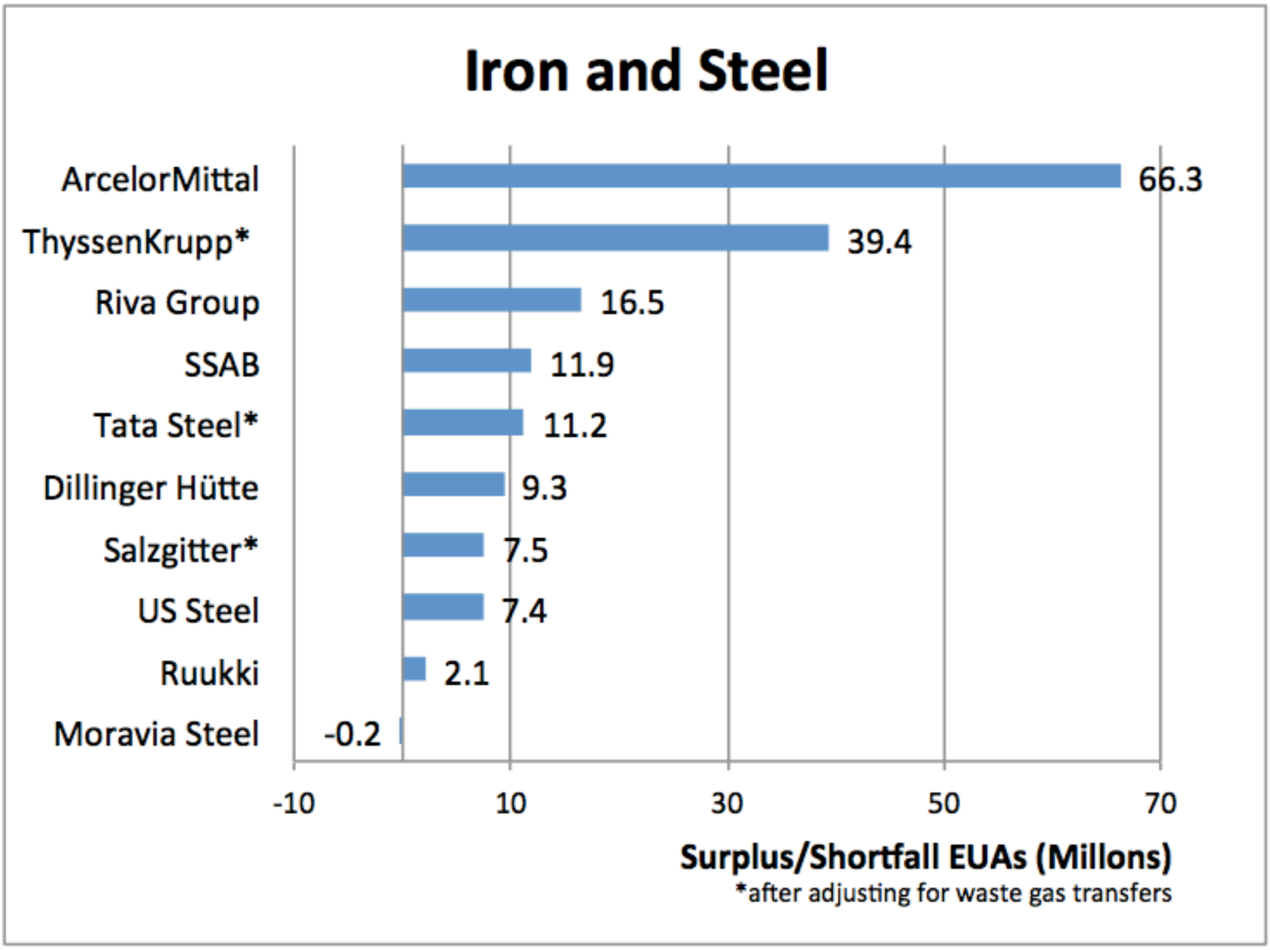

Figure 21. Allowances surplus of top ten emitting companies in the iron and steel sector (Elsworth et al., 2011).

5.3.4 Costs Pass-Through Ability

5.3.4.1 Price Elasticity

Iron and steel are very important materials for an extremely wide range of sectors and therefore it is reasonable to expect rather low price elasticity. Nevertheless some other products can substitute iron and steel: aluminium competes with “flat” products while concrete competes with “long” products (McKinsey and Ecofys, 2006).

When modelling the iron and steel sector, Demailly and Quirion (2008) used a price elasticity of -0.67 while Smale et al. (2006) employed a value of -0.62. Absolute values of the coefficient smaller than 1 usually entails to inelastic demand, but it is evident that iron and steel price elasticity is not as inelastic as cement’s and the sector therefore falls half way between the latter and aluminium. In line with these values, a study by Carbon Trust (2008) came to the conclusion that steel trade is significantly more sensitive to price changes than cement trade.

5.3.4.2 Market Concentration

Although it was not possible to find data about the HHI for the aluminium sector at the EU level, some useful insights have been gained through literature review. Similarly to many energy and capital-intensive industries, the iron and steel sector tends to be rather concentrated. In the EU-25 the top 5 producers hold 53% of the market shares and the top 10 account for 68%. The same incumbents are also present in most of the European countries (Demailly et al., 2007). Especially the company ArcelorMittal, which holds also the largest allowances surplus, is seen as a market leader (de Bruyn et al., 2008). In general the EU iron and steel market is thought to be an oligopoly where the incumbents are also price makers to some extent. The high market concentration is a consequence of the industry's consolidation over the past decades, its high entry barriers and its capital-intensive nature (de Bruyn et al., 2008). The market is also concentrated from a geographical point of view. In the EU, five countries account for 64% of the total production. Germany is the biggest European producer (23%), followed by Italy (15%), Spain (10%), France (9%) and the UK (7%) (Bergmann et al., 2007; Dröge, 2009; Linares & Santamaria, 2012).

5.3.4.3 Product Differentiation and Substitutability

Iron and steel are not homogeneous products. A lot of grades, qualities and varieties exist on the market, reflecting also the broad range of applications. Products for different applications are usually produces with different production routes, thus enlarging steel variety. Product differentiation and specialization usually allows EU producers to maintain market share and profits despite its production costs and prices are higher than the world average (Demailly et al., 2007). Usually "flat" products, obtained in the BOF process, are destined to global markets, while "long products", obtained in EAF processes, have a more regional distribution (McKinsey and Ecofys, 2006). Flat products, especially the ones used in the automotive industry, are generally highly specialized and differentiated (de Bruyn et al., 2010). Demailly et al. (2007) argue that steel consumers, which usually seek high-quality services, might prefer local producers. Consumers seem also to be willing to accept higher prices for high-quality products. This is especially true for flat products (de Bruyn et al., 2008).

5.3.4.4 Transportation Costs and Transportability

Transportation costs for iron and steel products are generally rather high. However there is a difference between long and flat products. The former are usually large heavy and have a low value, while flat products are often considered specialties and have a high value. Transportation costs compensate and cancel out to a certain extent the higher production costs in Europe, and so far have secured, to some extent, the market from imports (de Bruyn et al., 2008). Nevertheless 40% of the global production is being traded internationally, indicating that often transportation costs do not represent a major barrier to trade (de Bruyn et al., 2010).

5.3.4.5 Trade Exposure

The Commission's TII reports a value of 32.3%, which is a relatively high figure, very close to the one of aluminium (European Commission, 2009).

According to data reported by Demailly et al. (2007), the EU-25 imports around 4.2 Mt of long products (about 5% of the internal production) and exports 5.9 Mt (about 7% of the internal production). Flat products are slightly more traded; the EU-25 imports 10.1 Mt (about 11% of the internal production) and exports 11.9 Mt (about 13% of the internal production).

Globally, steel is a heavily traded product. As mentioned before 40% of the global production is traded. Nevertheless, trade tends to take place within regions (de Bruyn et al., 2008). Figure 22 shows the import-export shares of the main non-EU trading partners. It is clear that China, Russia and Ukraine are the main sources of imports, while the USA, Turkey and Switzerland are the main destinations of European exports.

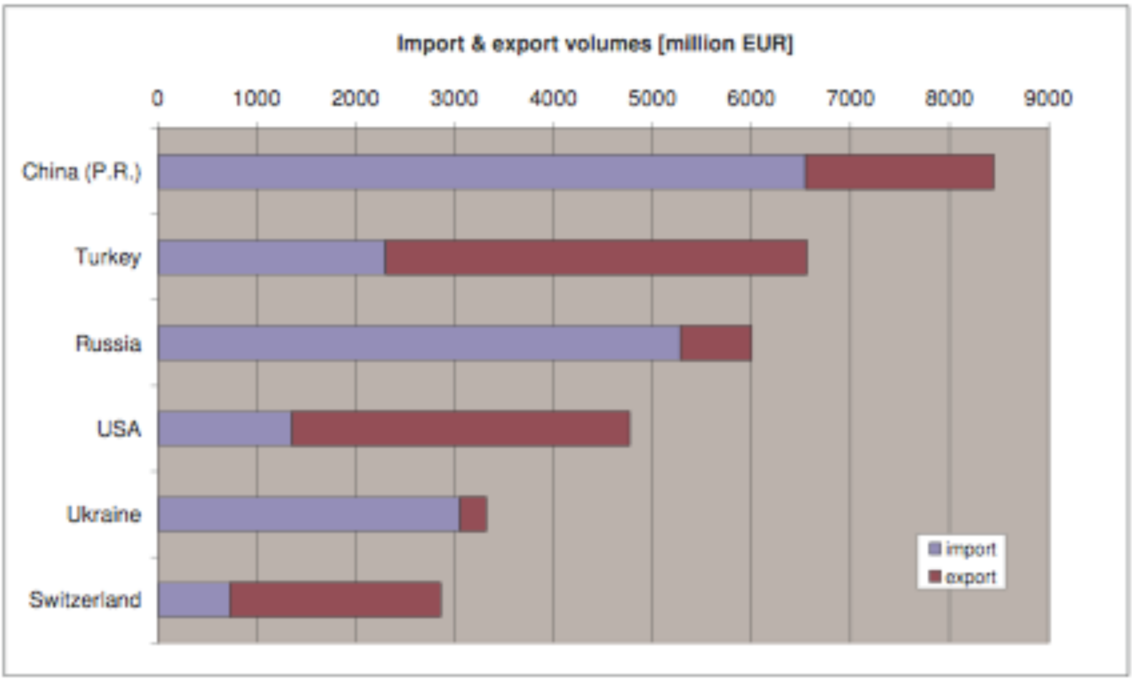

Figure 22. Import and export shares of the main non-EU trading partners in the iron and steel sector in 2007 (Mohr et al., 2009).

5.3.5 Profit Margins

As iron and steel is an energy-intensive industry, with potentially high direct and indirect carbon costs, its profit margins could be threatened by carbon pricing. A modelling study by Carbon Trust (2008), estimated that in a no free allocation scenario (100% auctioning) profit margins would decline by 5% from the initial value of 15% for each 15 €/tCO_2 added to the carbon price, thus approaching zero for a carbon price of 45 €/tCO_2. Nevertheless the same study estimated that the impact on profit margins would be moderate if only half of the costs are passed on to consumers (Carbon Trust, 2008). Therefore it seems that profit margins are threatened only by relatively high allowances prices.

5.3.6 Discussion

Summing up the results of the analysis, it appears that the iron and steel industry presents a rather articulated situation. First of all, the value at stake as calculated by the Commission is rather high, since iron and steel is an energy-intensive industry. Total carbon costs are made up for two-thirds by direct costs and for one-third by indirect costs, reflecting the shares of different production techniques across Europe. Nevertheless, the value at stake would fall below 5% if corrected for the most recent carbon price projections.

The second step of the framework revealed that, although iron and steel making is already an energy efficient process in Europe, a certain margin for efficiency improvements exists. Moreover, the iron and still industry holds an impressive surplus of allowances from Phase II that could potentially protect the sector from compliance costs to a large extent. The surplus appears not to be equally distributed among firms.

The third step of the framework is perhaps the most controversial. Models generally assume a rather inelastic price, with a figure in between the one of cement and aluminium. Similarly to most energy and capital-intensive industries, iron and steel is a concentrated sector in which few incumbents hold the majority of the market shares. A broad variety of iron and steel products exists, differing in quality and use. This generally shielded, to some extent, European producers from foreign competition. Transportation costs are generally rather high. However quality products and specialties have a high value to weight ratio. According to the Commission's TII, the sector is highly exposed to international trade. Therefore, if on one hand inelastic prices, concentrated market, differentiated products and high transportation costs could entail to a good cost pass-through ability, on the other hand the high trade intensity could indicate that the sector is exposed to foreign competition. A study by de Bruyn et al. (2010) reports that there is evidence that iron and steel producers have been able to pass on carbon costs, in some cases up to 100%, into the product price. The situation is likely to differ according to the specific product and production practice. McKinsey and Ecofys (2006) estimated a cost pass-through of 66% for EAF production and of 6% for BOF production. The difference arises because EAFs mainly produce "long" products, which usually compete in regional markets, while BOFs are employed to produce "flat" products, which generally are traded globally. Thus the latter are more exposed to international competition and producers are less free to pass on ETS costs to consumers. The last step of the framework reveals that profit margins are rather low and could be endangered by high carbon prices.

The Table below sums up the results obtained through the application of the framework.

Table 7. Results of the Framework Application

Flowchart Step	Determinant	Conclusion
Value at Stake	Carbon costs	Moderately high. 2/3 direct costs, 1/3 indirect costs
Internal Minimization of Carbon Costs	CO_2 Emission Abatement and Electricity Consumption Reduction Potential	Some potential exists
	Surplus of Allowances	Extremely significant, not equally distributed among firms
Cost Pass-Through Ability	Price Elasticity	Rather inelastic
	Market Concentration	High
	Product Differentiation and Substitutability	Very differentiated, generally Europe produces quality products and specialties
	Transportation Costs and Transportability	Generally high
	Trade Exposure	Rather high
Profit Margins	Profit Margins	Rather low, endangered by high carbon prices

Looking at the results, it is clear that assessing the risk of CL for the iron and steel sector is rather difficult, because several determinants are in place, often contrasting each other. The analysis revealed that the value at stake is significant, but only at high carbon prices. Compliance costs are moderate considering current allowance prices. The sector is further secured by the large surplus of allowances, although some companies are not in such a favourable condition. Cost pass-through ability is particularly controversial: high market concentration, low price elasticity, high product differentiation and high transport costs are counterbalanced by high trade intensity. The framework's results would thus not allow coming to a clear-cut conclusion on this aspect, but past evidence suggests that producers have been generally able to pass on costs into product prices. The situation seems to differ for EAF and BOF production, with the latter being more exposed to international competition and thus less free to pass on costs. In case of low cost-pass through ability and high carbon costs the already rather low profit margins would be endangered, therefore posing the risk of investment and long-term production leakage.

Summing up, currently the sector seems to be rather safe, mainly thanks to low carbon prices and a large surplus of allowances. Nevertheless, if backloading or other price adjustment measures were to be implemented, high carbon prices would pose a real threat to the sector. In this case its inclusion in the CLL would be legitimate. This is particularly true considering that the majority of the European production is obtained via BOF, which has a limited cost pass-through ability and is exposed to direct costs from fossil fuel use. EAF production, which is somehow comparable to aluminium production as virtually all the carbon costs are indirect costs from electricity consumption, would not benefit from the inclusion in the CLL, but accounts only for a minor share of the European output. Nevertheless EAF production seems to be less exposed to CL thanks to a higher cost pass-through ability.

It is interesting to notice that iron and steel and aluminium sectors are practically equal according to the Commission's indicators, having roughly the same carbon cost and trade intensity, but are in a radically different situation according to the framework analysis. This aspect, which is part of the insights gained using the framework application, will be further elaborated in the next chapter.

Concluding, even if the sector seems not to be exposed to the risk of CL in the current situation, the possibility that it will be endangered in the future exists. Its inclusion in the list would be legitimate if there is evidence that future allowance prices will be higher than current ones.

6 Discussion

The current chapter presents a discussion on the work carried out thus far. It is an occasion to reflect on strengths and weaknesses of the research and on its results. Let us start the discussion by looking back at the step-by-step framework application. In order to assess a sector's value at stake, the Commission's CCI appears to be a strong indicator, once its shortcomings are clear and taken into account. The main weaknesses related to the Commission's assumptions have been already addressed in Chapter 3.4. Nevertheless, further aspects emerged from the case studies. First of all, the Commission's approach assumes that, except for power production, there is no downstream cost pass-through. This assumption is reflected in the formulation of the CCI, representing a shortcoming. In fact, beside direct emissions, only indirect costs from electricity consumption are accounted for in the indicator's calculation, implicitly assuming that upstream suppliers do not pass on carbon costs into product prices. Consequently, this represents a drawback of the framework too, since the latter relies on the Commission's indicator. While it is assumed that downstream cost pass-through, evaluated in step 3, is possible, the value at stake step does not take into account carbon cost embodied in suppliers' product prices. This aspect has been also pointed out in the expert consultation[2].

A second drawback of the Commission's approach lies in the conceptual and mathematical formulation of the indicator. Direct and indirect costs are summed up together with no distinction. While on one hand this is useful to picture a sector's overall exposure to carbon costs, the relative contribution of the two cost shares should be carefully analysed. As we have seen in the case studies, this shortcoming becomes particularly evident in the aluminium sector, for which the large majority of carbon costs are indirect. The sector would thus not benefit from the inclusion in the CLL, as the latter compensates only for direct emissions. Therefore the relative influence of direct and indirect costs on the total carbon cost should be carefully taken into account. A third drawback is the incorrect, according to the most recent price projections, carbon price assumption that has the effect of overestimating compliance costs.

The first drawback, i.e. assumption of no upstream cost pass-through, could not be overcome, as it would have required a reformulation and recalculation of the indicator with new parameters, data and assumptions, which was not the goal of this thesis. Accounting for cost pass-through from upstream suppliers would have likely raised compliance costs to some extent. The second drawback, on the other hand, has been addressed, first, in the value at stake section and, second, further articulated and analysed in the discussion part of every case study, offering very valuable insights. This is especially true considering the case of aluminium and iron and steel. The two sectors have roughly the same overall carbon costs but while the former has virtually only indirect costs from electricity consumption the latter has the majority of costs arising from direct emissions. As discussed in the case studies, this difference deeply affects even a

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[2] By Sean Healy and Paul Blinde (see Annex 3)

sector's convenience of being in the CLL. Therefore, reflecting on the consequences of the different influence of direct and indirect costs on the overall carbon costs turned out to be a pivotal point of discussion. The third drawback has been overcome with the application of a factor to correct the price assumption according to the most recent projections, which revealed that overall compliance costs are much smaller than those estimated by the Commission. It has not been possible to address assumptions about free allowances allocation and electricity emission factors, which have also been enlightened in Chapter 3.4. Nevertheless their impact is likely to be smaller than the impact of the carbon price.

Moving to the second step of the framework, the two determinants should be addressed separately. CO_2 emissions abatement and electricity consumption reduction potential proved to be a tricky indicator in all three case studies. For none of the studied sectors it has been possible to find detailed quantitative data on specific potential for emissions abatement or consumption reduction, e.g. MACCs or BATNEECs. In the best cases some rough indications of global potentials were available. Therefore it has been only possible to get a sense of whether some measures could internally reduce compliance cost. A quantitative evaluation of sectoral CO_2 emissions abatement and electricity consumption reduction potential is far from being realistic. Moreover, as suggested in the expert consultation[3], the analysis of CO_2 emissions abatement and electricity consumption reduction potential would only be truly valuable if carried out at a firm level rather than at a general EU level. This level of detail seems even harder to be achieved with the current data availability. Even though this determinant is not easily representable by a quantitative indicator due to the lack of data, it has been useful to gain qualitative insights for the analysis. This is especially true with regard to cement. The analysis revealed that clinker production is at risk of CL due to sea transportation, but at the same time the second step of the framework revealed that clinker substitution and blended cement are the two most promising way of reducing CO_2 emissions in the process. Therefore using the insights gained here, it seems that moving towards a less clinker-intensive cement is a realistic and practicable way to reduce CO_2 emissions and the risk of CL at the same time.

The surplus of allowances proved to be an interesting parameter to be considered. Taking this determinant into account is an adequate way of dealing with and account for the significant allowance surplus that has formed in Phase II and has been banked to Phase III. Overabundance of allowances could protect sectors from compliance costs and even grant them windfall profits, if we consider that most of the allowances have been freely allocated in Phase II. This determinant is also easily representable by a quantitative indicator since data on sectoral emissions and allowances allocation are publicly available and can be easily related to each other in order to assess whether a sector falls long or short of allowances and how big the surplus is compared to its annual emissions. Analysing the allowances surplus revealed that cement and iron and steel sectors, that are usually considered to be extremely endangered by carbon pricing, in fact

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[3] By Peter Coenen (see Annex 3)

hold an enormous quantity of permits that potentially shields them from compliance costs to a large extent. Nevertheless, the iron and steel case study unveiled that allowances surplus is not equally distributed among firms, at least in some sectors. Therefore, similarly to the previous indicator of the second step, the analysis would provide better insights if carried out at a firm level, but would be significantly more data-intensive as well.

The analysis carried out in the third step of the framework reflected the expectations, proving to be interesting and delivering meaningful results. First of all, there is evidence that several sectors have been able to pass on to consumers a certain share of carbon costs without triggering CL. This step of the framework was therefore aimed to assess whether and under which condition a sector could pass on costs "safely", i.e. with no CL.

Price elasticity turned out to be a versatile indicator for the market sensitivity and responsiveness to a change in product price. Data were available for all the sectors studied and therefore this indicator could easily be employed in a quantitative and reliable way. With regard to the case studies, price elasticity classified cement's demand as the most inelastic and aluminium's as the most elastic, reflecting product's characteristics and literature findings.

Market concentration also proved to be an interesting determinant. Although data about the Herfindahl-Hirschman Index were not available, it has been still possible to gain valuable insights thanks to information about market shares of a sector's biggest incumbents. This determinant could indeed give a sense of whether or not firms could be price makers in a certain sector, which is in turn an indication of their cost pass-through ability. As we have seen in the case studies, in the cement and iron and steel sectors high market concentration corresponded to good cost pass-through ability, while the aluminium sector, despite having a concentrated market, turned out not to be able to pass on costs, mainly as a consequence of fixed world prices and high exposure to international trade.

Product differentiation and substitutability has proven to be rather hard to be assessed quantitatively. Data about Armington Elasticities could not be withdrawn from the sources consulted and seem not to be available for industrial sectors at the EU level. Nevertheless qualitative insights could be gained thanks to literature review, which allowed understanding the degree of differentiation and specialization of a sector and of its products. Being familiar with a sector's product characteristics has been useful in all the case studies in order to understand the degree of exposure to foreign competition.

Transportation cost and transportability resulted important to understand the tradability of a sector's products and thus its exposure to foreign competition. The data availability changed from case study to case study but generally this determinant provided good results and useful insights. This indicator has been particularly useful in the cement and aluminium case studies. In the former it shed light on the fact that cement is not economically transportable over long distances and in the latter enlightened that aluminium has a low weight in relation with its value and is thus economically tradable at a global level. These two results have been confirmed by the following indicator.

In order to evaluate a sector's trade exposure the Commission's TII has been employed. Data availability was good due to the fact that the same indicator has been used for the first CLL. Matching the results of the previous indicator, Trade Exposure confirmed that cement is not intensely traded and therefore could be expected to have a good cost pass-through ability, while aluminium sector is largely traded at a global level and can thus be expected to have scarce possibilities to adjust prices. Additionally, critics to the Commission's approach with regard to the TII are mainly focused on its use, e.g. the TII >30% criterion, rather than to the formulation of the indicator itself, which could therefore be employed in the analysis leading to meaningful results. With regard to this indicator, it has been pointed out in the expert consultations[4] that one option could have been to split the indicator into an indicator of import intensity and one of export intensity, in order to better depict a sector's exposure to international trade. Nevertheless the development and calculation of "ad hoc" indicators was not the goal of this research that therefore relied on the Commission's TII, which sums up import and export in the same indicator giving an idea of the overall trade exposure.

It is worth underlining that the five indicators constituting the third step of the framework can be grouped in two sub-groups according to their focus, with the first three depicting an industry's characteristics and market type and the last two focusing more on the sector's exposure to international trade. Therefore there is a certain degree of overlap among indicators belonging to the same sub-group. For example, as pointed out in the expert consultations[5], price elasticity and product characteristics are two sides of the same coin and, as it could reasonably be expected, transportation costs and trade intensity are deeply interwoven. Nevertheless, such overlaps do not necessarily entail redundancy, but instead are very useful to complement information and to improve the soundness of the conclusions. It has also been pointed out in the expert consultation[6] that carbon intensity of likely substitutes would be an interesting indicator to be considered. This aspect was taken into account when possible, as in the case of hydro-powered aluminium production in non-EU countries, in the discussion part of the case studies.

Overall, assessing a sector's cost pass-through ability turned out to be quite straightforward in two cases, especially cement, and more controversial another one, iron and steel. For the first sector almost all indicators pointed in the same direction, given that price elasticity is extremely low, market concentration is high, transportation costs are generally high and trade exposure is low. The only exception is clinker, which is easily importable in Mediterranean countries, and therefore does not allow passing on costs safely. Iron and steel sector, on the other hand, has a rather inelastic price, a high market concentration,

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[4] By Katja Schumacher (See Annex 3)

[5] By Katja Schumacher and Matthew Smith (see Annex 3)

[6] By Sean Healy, Katja Schumacher and Matthew Smith (see Annex 3)

specialized and differentiated products and high transportation costs, which indicate good cost pass-through ability. Nevertheless, according to the Commission's TII the sector has a high trade exposure and is therefore at risk of foreign competition. In this case different determinants of cost pass-through ability were in contrast with each other and it has not been possible to come to a clear-cut conclusion. This problem has been overcome thanks to literature review. Analysing aluminium's cost pass-through ability proved to be quite straightforward, with almost all the indicators pointing towards a low ability.

The last step of the framework also provided interesting results. In particular it allowed understanding what the consequences on a sector would be in case of no possibility to pass on costs downstream. This step was thus mainly aimed at assessing whether or not there is a risk of investments leakage. In all cases it has been possible to find information about a sector's profit margins. In the cases of cement and aluminium it has been possible to find evidence of investment trends and in the case of iron and steel it has been possible to show how profit margins would change in relation to different carbon prices, which is very useful in this context.

Having analysed in details the step-by-step application of the framework we can now discuss its strengths and weaknesses in more general terms. First of all the framework allows addressing different channels of CL, with the third step being more focused on the short-term risk of market preference shift towards foreign competition and the fourth step considering the risk of long-term investment leakage due to profit margins reduction. This is indeed important to gain a full understanding of a sector's situation and likely reaction to carbon pricing.

Moreover, as the application of the correction factor has shown, current low allowance prices reduce compliance costs to acceptable levels even for the most exposed sectors. Especially cement is generally classified among the most endangered sector, but current price projection would determine a carbon cost in relation to the sector's GVA of 15.2%, which is well below the >30% Carbon Cost threshold. This has the effect of significantly lower compliance costs and consequently risk of CL for all the sectors. As already mentioned before, accounting for the surplus of allowances is another strength of the framework. As mentioned in Chapter 3.1, evidence suggests that the surplus could be well over 1.5 billion allowances at the beginning of Phase III (European Commission, 2012d), and a study carried out by Elsworth et al. (2011) estimated, based on analysis of CITL data, that in the current Phase of the ETS the ten most benefiting companies hold a surplus of 240 million allowances, equivalent to the annual emissions of Austria, Denmark, Portugal and Latvia combined. Therefore it is crucial to take this determinant into account when undertaking an assessment of the CL risk. Although a number of studies focuses on the surplus of allowance, none of the studies analysed in the literature review considered it as a factor to assess the risk of CL.

As pointed out in the expert consultations[7], it is important to differentiate between sector and product level as the choice entails differences in the analysis. It has been decided to carry out the current analysis at a sector level due to better data availability. Nevertheless, when possible, some product specific characteristics and implications have been discussed, as in the case of clinker in the cement sector, primary vs. secondary production in the aluminium sector and “long” vs. “flat” products in the iron and steel sector.

Nevertheless, as enlightened in Chapter 3.4, it has already been shown that there is no direct evidence that sectors meeting only the TII >30% criterion are exposed to CL, or at least their situation is not altered by the compliance to the ETS. What has been one of the most interesting findings of the framework is that also sectors facing high carbon costs are not necessarily exposed to CL, especially as in the case of cement. This is a consequence of the fact that CL risk is the combination of the interaction of several factors, which are difficult to take into account using two quantitative indicators only. The framework, by using a larger set of indicators organized in a flowchart structure, has been able to shed light on aspects that the Commission’s approach could not grasp.

There is therefore evidence that, when assessing a complicated phenomenon such as CL, there is the need to employ a more comprehensive approach. On the other hand, such an approach has proven to be very data-intensive and time-consuming. It is also likely that industry representatives will not allow decision-makers to draw the CLL, which has an enormous financial impact on sectors, basing their conclusions solely on qualitative data, which are more arguable and debatable, at least in term of homogeneity, than a quantitative approach. Therefore, the only realistic way to apply this proposed approach extensively to all the sectors covered by the ETS is by converting it into a quantitative approach. With the only exception of CO_2 emissions abatement and electricity consumption reduction potential and product differentiation and substitutability, all the indicators proved to have good data availability. A starting point for future research is the development of a quantitative approach based on the framework’s indicators and determinants by setting criteria and thresholds. Such an approach would be indeed more resource-intensive but also more proper and accurate than the current one. Nevertheless, by including only sector really at risk, the list would certainly be shorter, and thus the investment made in a first place to develop a more reliable approach would likely be paid back in a very short time, considering that Martin et al. (2010) estimated that improving the design of the CLL indicators could raise additional incomes from the scheme up to € 7 billion annually.

There are three main differences between the theoretical formulation of the framework and its application. First of all, not all the “ideal” indicators outlined in the theoretical formulation of the framework could be employed. As anticipated by some in the expert consultations[8], data for some indicators could not be

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[7] By Peter Coenen, Paul Blinde and Katja Schumacher (see Annex 3)

[8] By Sean Healy, Paul Blinde and Matthew Smith (see Annex 3)

gathered, especially with regard to CO_2 emissions abatement and electricity consumption reduction potential and product differentiation and substitutability. Nevertheless, whenever it has not been possible to find data on indicators, qualitative insights gained via literature review have been useful to cover for the lack of data and could be employed to draw conclusions.

As mentioned in Chapter 4, the framework has been structured as a flowchart to allow stopping after each step, if the sector proves not to be at risk in the specific step. In the expert consultation[9], it has been questioned whether it was true that it is indeed possible to come to a definite conclusion after every step, stopping at the first “no risk” signal, even without assessing all the steps. When applying the framework to the case studies of the present thesis, it has been decided to carry out the whole analysis in order to test each step of the framework. Nevertheless, the experience revealed that it would have been indeed possible to stop at the first step revealing “no risk”. Effectively, in none of the case studies later steps would have altered the conclusions. Therefore in future application there is the possibility to adhere to the original formulation of the flowchart and stop the analysis at the first “no risk” signal, saving time and resources.

Lastly, regulatory conditions deserve to be discussed. Although they have not been taken into account in the Commission’s quantitative assessment nor in the qualitative, they have been mentioned in the Cambridge Econometrics (2010) study. According to the latter, regulatory conditions are another important factor to understand the risk of CL. Taxes, subsidies and standards play a role when evaluating firm’s production location decision. Moreover certain kinds of regulations, such as international sectoral agreements, can significantly reduce the risk of CL (Cambridge Econometrics, 2010). Due to the broadness of the topic and the difficulty of researching, evaluating and including them in the context of the framework, which would not have fitted the timeframe and the scope of the thesis, it has been decided to leave regulatory conditions out of the scope of this work. Nevertheless, after mentioning regulatory conditions among the determinant of CL, also the study by Cambridge Econometrics (2010) decided to leave them out of their work due to a lack of standardisation in the variables chosen to represent them in literature and a lack of data allowing comparability between sectors.

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[9] By Paul Blinde (see Annex 3)

7 Conclusion

The present work showed that an alternative approach to the assessment of the carbon leakage risk is possible. Such approach has been developed in the form of a flowchart-like framework of indicators, depicted below.

Table 8. Flowchart steps, carbon leakage determinants and indicators constituting the framework

Flowchart Step	Determinant	Indicator
Value at Stake	Carbon costs	Commission's CCI (Corrected for the Carbon Price)
Internal Minimization of Carbon Costs	CO_2 Emission abatement and electricity consumption reduction potential	MACCs BATNEECs
	Surplus of Allowances	Number of Unused Allowances
Cost Pass-Through Ability	Price Elasticity	Price Elasticity
	Market Concentration	Herfindahl-Hirschman Index
	Product Differentiation and Substitutability	Armington Elasticities Product's Characteristics
	Transportation Costs and Transportability	Transportation Costs Product's Transportability
	Trade Exposure	Commission's TII
Profit Margins	Profit Margins	Profit Margins

The framework, through its set of determinants, proved to be able to deliver meaningful insights on the risk of carbon leakage. The flowchart-like approach appears to better depict and capture the real nature and dynamics of carbon leakage, thus being more appropriate than the Commission's two indicators method. Moreover, the proposed stepwise approach allowed applying the different indicators when more relevant in relation to a sector's situation.

As witnessed in the case studies, the framework indeed proved to be able to deliver extremely meaningful results, enlightening several aspects and complexities that would have remained unaddressed by the Commission's approach. Just to mention few of the insights gained in the case studies, cement, for instance, has significant compliance costs but is hardly exposed to international trade; therefore the risk of carbon leakage is low. The sector also holds a significant surplus of allowances. Clinker, a cement sub-product, has been spotted as a possible issue, due to its better transportability, but blended cement, i.e. a cement mix with low clinker content, could reduce both leakage concerns and CO_2 emissions at the same time. Aluminium is indeed highly exposed to international trade and historical trends show that European producers are progressively losing competitiveness. Nevertheless, the sector would not benefit from the inclusion in the carbon leakage list as virtually all its compliance costs are indirect carbon costs from electricity prices and the list only compensates for direct emissions, which are very marginal. Iron and steel, despite being an energy-intensive and highly traded sector, seems to be currently shielded from compliance costs by low carbon prices and by a significant surplus of allowances. Nevertheless the sector could be exposed in the future, if the situation changes.

Concluding, the formulation of the framework directly addresses the main research question, showing which indicators should be considered in developing an alternative approach to carbon leakage and what are their strengths and weaknesses. This research showed that a more accurate approach is possible and identified a new methodology, consisting in a flowchart-like four-step framework, its determinants and relative indicators. This constitutes a sound basis for the development of a new quantitative methodology for the assessment of the carbon leakage risk, leading to a more accurate carbon leakage list.

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9 Annexes

9.1 Annex 1: Commission’s Qualitative Approach Carbon Leakage Determinants

Annex 1 reports the CL determinants and indicators taken into account in the Commission’s qualitative approach Commission’s indicators. Everything in the current Annex is part of the document *Impact Assessment Accompanying document to the Commission Decision determining a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage pursuant to Article 10a (13) of Directive 2003/87/EC* (European Parliament & Council, 2009 p. 32 - 36).

“The criterion labeled as “Technological assessment” looks at “the extent to which it is possible for individual installations in the sector and/or sub- sector concerned to reduce emission levels or electricity consumption, including, as appropriate, the increase in cost of production that the related investment may entail, for instance on the basis of the most efficient techniques”.

In the technological assessment the following indicators were considered:

- Emission factor: “The objective was to assess the emission intensity and fuel mix of a sector/subsector and see whether it would be possible for a given technology to use lower carbon fuels or lower carbon industrial processes. The average CO_2-emission intensity of a given production process depends on the mix of energy sources used, e.g. electricity and fuels like gas, oil, coal, biomass in comparison with the output of that specific production process. Emission factors are used to derive estimates of CO_2 emissions based on the amount of fuel combusted and on the level of industrial production. By employing emission factors a linear relationship between production and emissions are assumed:
  $\text{Emission}CO_2 = \text{Production level} * \text{Emission Factor } CO_2$
  Carbon dioxide (CO_2) emissions from the combustion of fuel can be estimated almost exclusively on the carbon content of the fuel, which is generally known with a high degree of precision. Emission estimation methods and the associated emission factors for air pollutants are published in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.”;
- Investments (CAPEX) for CO_2 emission reduction: “The objective was to assess what would be the impact of investments into emission reduction technology on the financial position of companies in the sector concerned. This can be related to the gross operating surplus, Earning Before Interest and Tax (EBIT) and/or production value.
  This indicator targets investments required for CO_2 emissions reduction in terms of capital expenditure. Capital expenditure is incurred when a business spends money either to buy fixed assets or to add to the value of an existing fixed asset with a useful life that extends beyond the taxable year. CAPEX is used by a company to acquire or upgrade physical assets such as equipment,

property, or industrial buildings. In accounting, a capital expenditure is added to an asset account ("capitalized"), thus increasing the asset's basis (the cost or value of an asset as adjusted for tax purposes). CAPEX is commonly found on the Cash Flow Statement as "Investment in Plant Property and Equipment" or something similar in the Investing subsection";

- Marginal abatement cost (MAC): "The objective was to assess whether the financial effort to reduce CO_2 emissions of a certain sub-sector would be relatively high or low.
- Given that a specific level of activity in a production process leads to a specific level of CO_2 emissions, the marginal abatement costs represent either the marginal loss in profits from avoiding the last unit of emissions or the marginal cost of achieving a certain emission target with a certain (abatement) technology, given a certain level of output. Whereas the latter focuses on abatement technologies such as filters for air or water pollutants, the former concept is more interested in the overall adjustment of a firm to an emission constraint including adjustments in the level of output. The MAC concept is used to derive benchmarks based on BATNEEC for example".

The criterion labelled as "Market Characteristics" looks at "market characteristics (current and projected), including when trade exposure or direct and indirect cost increase rates are close to one of the thresholds mentioned in paragraph 9b, second subparagraph".

In the Market characteristics the following indicators were considered:

- Market Concentration (HHI index): "The objective was to assess the concentration level of the market, which can be related to the ability of a company to pass through to prices the increased production costs due to CO_2 emission reduction cost or due to CO_2 allowances purchase costs.

  The Herfindahl-Hirschman Index or HHI, is a statistical measure of concentration, often used to characterize the size of firms in relation to the industry and used as an indicator of the level of competition. It is widely applied in competition law and in anti-trust cases. It is defined as the sum of the squares of the market shares of all n firms within the industry, where the market shares are expressed as percentages. The result is proportional to the average market share, weighted by market share. The elasticity of substitution between products/product groups produced in different countries is called Armington elasticity. Alternatively, import and export price-elasticities can be derived, to understand likely trade changes due to asymmetric cost increases as a result of the CO_2 cost (in the EU only)";
- Level of integration along the value chain: "The objective was to assess the impact of the product price increase upstream on product applications downstream for cases of integrated production processes. This would help to identify the risk of carbon leakage of sectors where CO_2 intensity and trade intensity refer to different production steps and products in an integrated production chain.

  If the cost of carbon can be passed through the value chain, the downstream products will be affected through the increase of the cost of input. This is of particular relevance for integrated production processes. In case where an up-stream product is not traded, its carbon intensity, unless >30%, would not be identified to contribute to a sector's risk of carbon leakage. Conversely, the downstream products that are traded would most likely not have high carbon intensity. Hence, the true risk of carbon leakage of a sector might simply be left uncovered unless trade intensity and emission intensity of both upstream and downstream products are considered together";

- Transport cost: "The objective was to assess the extent to which transport costs, as far as they were not already captured in the trade intensity data of the quantitative assessment, can influence investment decisions and have an impact on competition between EU and non-EU producers with asymmetric carbon costs. Transport cost can e.g. be related to gross operating surplus or gross value added at factor cost.
- Transport cost in this context has two dimensions. For one it can influence investment decisions of energy intensive industries and it impacts the possible extent of competition from producers outside the EU depending on their distance to the EU market. The higher domestic production cost and the lower transport costs, the more likely it is that investments could go outside the EU. Moreover, producers from outside the EU are more likely to export to the EU market, if transport costs are low compared to EU-production costs".

The criterion labelled "Profit Margins" looks at "profit margins as potential indicator of long-run investment and/or relocation decisions".

In profit margins the following indicators were considered:

Profit margin can be calculated as Gross Operating Surplus divided by turnover as this data is available in EUROSTAT. These two indicators are described below.

- Gross operating surplus: "Gross operating surplus is the surplus generated by operating activities after the labour factor input has been recompensed. It can be calculated from the value added at factor cost less the personnel costs. It is the balance available to the unit which allows it to recompense the providers of own funds and debt, to pay taxes and eventually to finance all or a part of its investment.

  Income and expenditure classified as financial or extra-ordinary in company accounts is excluded from gross operating surplus";
- Turnover/production value: "Turnover comprises the totals invoiced by the observation unit during the reference period, and this corresponds to market sales of goods or services supplied to third parties.

  Turnover includes all duties and taxes on the goods or services invoiced by the unit with the exception of the VAT invoiced by the unit vis-à-vis its customer and other similar deductible taxes directly linked to turnover. It also includes all other charges (transport, packaging, etc.) passed on to the customer, even if these charges are listed separately in the invoice. Reduction in prices, rebates and discounts as well as the value of returned packing must be deducted.

Income classified as other operating income, financial income and extra-ordinary income in company accounts is excluded from turnover. Operating subsidies received from public authorities or the institutions of the European Union are also excluded”.

9.2 Annex 2: Cambridge Econometrics Carbon Leakage Determinants

Annex 2 reports the CL determinants and indicators taken into account in the Cambridge Econometrics study (Cambridge Econometrics, 2010).

Cost structures:

- Total emissions
- Employment
- Value at stake
- Increase in direct costs
- Increase in indirect costs
- Sunk costs
- International transport costs
- Percentage of potential cost increase
- Increase in direct and indirect costs
- Energy intensity of production

Cost Pass-through:

- Profit margins
- Return on investment (RoI)
- Substitutability of final products
- Overall demand elasticity
- Market segmentation and industry structure
- Product differentiation
- service differentiation
- Demand growth
- Import volumes
- Export volumes
- Elasticity of substitution between imported and domestically produced goods (Armington elasticities)
- Extra-EU trade intensity
- Changing patterns of world trade
- Cost pass through rate
- Export and import intensities
- Global trade imbalances

Abatement potential:

- Substitutability of inputs
- Substitutability of fuels
- Substitutability of capital investment for energy consumption
- Market penetration rate for new technologies
- Relative profitability of technical change

Regulatory and Legal Constraints:

- Subsidies
- Import restrictions
- Legal and political environment

- Infrastructure quality
- The effect of energy and climate policy in the rest of the world.

9.3 Annex 3: Expert Consultation

9.3.1 Peter Coenen

- Do you think that the framework, in its setting, adequately reflects the nature of carbon leakage? Yes

- Do you think that the set of determinants/indicators is complete? Yes but the issue of using The surplus of allowances leftover from the previous years should be determined in detail as I do not know if this is possible in all cases

- Do you think that the framework could lead to a valuable analysis, according to its purpose? Yes

- Is there any comments/suggestions/critics that you would like to make? A weak point in all analysis is the fact that the risk is determined on a sectoral basis. Especially in the abatement cost it is difficult to find good representative sectoral averaged values as the actual abatement costs will differ from plant to plant.

9.3.2 Matthew Smith

Dear Stefano,

Your work is interesting as it touches on many areas we at Ecofys have recently been working on in preparing updated guidelines for the European Commission on qualitative assessments for carbon leakage. This project I mention has recently been completed and therefore some kind of publication may be expected in the next few weeks/months – so please keep an eye on the DG Clima website. Obviously as it is not yet published I cannot say exactly what is within, but some remarks on your approach:

- A step-wise approach and the steps you apply seem logical – a sector is likely to only be at risk of leakage if all conditions are fulfilled, and the step-wise approach is useful for managing the resources needed for any such assessment.

- On the specific indicators:

It could be argued that price elasticity and market concentration are two sides of the same coin – market concentration being a proxy for price elasticity (i.e high concentration, high market power for suppliers to set prices, low elasticity as consumers have to accept price changes). Though this is not necessarily always the case, depending on the availability and suitability of substitutes. I think it is useful to have them both for this contrast.

Abatement potential – MACC curves and BATNEEC are good approaches – but are likely to quite resource intensive to undertake for each sector. To what extent can you look at and use the sector benchmarks and past figures to help in this?

Substitutes – should we take into account leakage to substitute products which may have higher life-cycle emissions? Indeed how do we account for different life-cycle impacts, i.e. ETS encouraging substitution to products with lower production emissions, therefore lower costs, but which are then less efficient than other products when in use and lead to greater emissions over the full product lifecycle?

Just a few thoughts, but I think overall your analysis and indicators are quite robust and logical.

9.3.3 Katja Schumacher

Thank you again for sharing your framework of indicators with us and providing us with the opportunity for feedback. My colleague Sean and myself looked into your documents and both agreed that your proposed framework is very high quality. It is highly interesting and covers all of the important and relevant aspects of carbon leakage. Your systematic approach is very nice and well structured which makes it easy to follow, and provides a sound and clear basis for assessing the potential risk of carbon leakage of a sector.

In the following you find a few comments from my side and further down in the second email from my colleague Sean Healy.

Comments:

1. Production versus investment leakage (plus energy channel leakage) – It may be important to differentiate in how far the proposed approach and indicators cover the different channels of leakage which may occur. My feeling is that most of the indicators are related to production leakage (i.e. leakage for existing production units) and less for leakage with respect to investment in new capacity. While this may be more an issue of time (short term versus medium or long term perspective), I believe it deserves discussion within this context. Which of the indicators are able to tackle which channel of leakage? I.e. price elasticities are usually short term (but may affect investment decisions), transportability can relate to both production and investment leakage etc. Also, the question of emissions abatement that is possible within existing production technologies versus the potential for investment in new capacity might differ substantially.

2. As to your document 2 Explanation of indicators, I have a few more specific points (and a few additional comments in the attached document):

Price Elasticity: While I agree that this is an important indicator, I would think that a few additional aspects may be important. One, currently the text does not make clear whether this relates to domestic demand elasticities or international ones (e.g. Armington style). Second, price elatisticies are very different depending on the aggregation level. While the elasticity for steel or cement may be high in the aggregate, it may be much more rigid on a product level. This touches the issue of product specialization and a cross-reference would be needed here. Third, in terms of interpretation: An elastic demand may mean that consumers respond in shifiting demand away from this product. As long as they substitute their demand with a lower emissions intensive product from within the EU (rather than importing the emissions intensive product), this effect may actually be desired. A risk of carbon leakage only occurs if domestic demand gets replaced by increased demand for imports. This should be considered here. On another note, price elasticities are very challenging to estimate and they very much depend on the data, time period, region etc. considered. Thus, all in all they may be a helpful indicative indicator but they will not be able to provide a clear insight. In a way, they are overarching for some of the other indicators.

Transportability: I agree with using the weight-to-value indicator, but I would add a little bit of a discussion related to the indicator, in a way that this is only a rough indicator (implying that heavier products are more expensive to transport and thus have a higher indicator) but does not cover the "real" costs of transportation which is unkown in most cases, but would be desirable to know. The first best indicator would be transportation costs related to value of product. Also, you may mention that weight is not always the right factor, as volume may matter as well.

Product differentiation and substiutability: As an idea: The section on price elasticties could also be moved here and the discussion split into two parts: a) domestic demand reaction (and why it may not matter) and b) international demand reaction (the way you currently have it in this section)

Trade Intensity: It may be useful to split the indicator into an indicator of import intensity and export intensity. This is because imports continued to increase while exports went down (which happened in the manufacture of primary plastics), which has led to a downward pressure on prices and reduced the ability to pass through costs. Also a high continous export intensity could indicate some specialization (if it shows a trend) and be an argument in favor of costs pass through.

Profit margins: Of interest would also be the indicator of "additional carbon costs in relation to profit margins".

I have also seen people look at the carbon intenstity of likely substitutes in order to assess the effect on emissions and potential carbon leakage.

On a general note: I would prefer to not use the term Carbon Footprint as it may include all emissions from cradle to grave and raises many more points. I would rather stick to the term "emissions intensity", but of course this is a matter of personal preference and does not compromise the high quality of your work.

I hope these points are of help. Please don't hesitate to contact us if you have any questions.

9.3.4 Paul Blinde

Thank you for sending me your papers on this interesting topic. In general I found your paper clearly written and structured. Please find my comments below which I hope are useful for your further work. Please don't hesitate to come back with any questions.

Do you think that the framework, in its setting, adequately reflects the nature of carbon leakage?

Yes. Although it direct dives in the detail. I like the linear order in which you look at different elements (value at stake, internal minimimization, etc). I do have some comments though:

What could be nice for your final thesis is to introduce set the concept of carbon leakage a bit more setting it in the context of the impacts of carbon pricing on competitiveness.

After each step you now have the option to conclude a sector is not exposed. Are you sure this is always correct? E.g: could there not be sectors in which the value at stake is low, but the competitive impact of carbon costs could be high anyway? I do not have the answer to these and similar questions, but it would be good for you to think this over carefully before you conclude a sector is not exposed.

From a practical perspective it may sometimes be more efficient to take short cuts: e.g. if it is extremely expensive to ship a product overseas then the internal minimization of costs is not so important to look into detail. Similar for the electricity sector for which the passing on costs is very easy and transportability physically limited.

It would be good to form the beginning be clear whether you intend to look at the sector level/of product level. Product level is most accurate, but it is difficult to find data on that level. E.g. Milk powder would probably be subject to a significant risk of carbon leakage, whereas the dairy industry as a whole (including large quantities of liquid milk) would not.

Do you think that the set of determinants/indicators is complete?

Yes I think so. What I did not find back (although I may have missed it) are the indirect costs from purchased raw material or purchased heat. Try to think of the value chain with multiple companies in an ETS. Carbon costs may be passed on multiple companies in the chain. Of course it is difficult to estimate indirect carbon costs from purchased raw material. You may want to leave it out of the scope of your analysis, or find a way to account for them. Anyway, I think it would be good to describe this effect.

I cannot really judge the quality and suitability of all indicators that you use. I guess different indicators would have advantages and disadvantages. A point you rightfully make is availability of information: e.g. developing a MACC curve is not something that is easily done for each product.

Do you think that the framework could lead to a valuable analysis, according to its purpose?

Two barriers that would need to be overcome:

Availability of information.

Criteria setting: suppose you would have all the data and could come to a perfect quantitative result: with what outcome would a sector be considered to be exposed to a significant carbon leakage? What would be a low value at stake, good option for internal minimalisation etc.

Is there any comments/suggestions/critics that you would like to make?

What I would like suggest to you is to clearly define the scope of your analysis. You can spend years looking into this problem. I assume you do not have an infinite amount of time. At some point you need to say: this good enough. Set a deadline and come to a result before that deadline.

9.3.5 Sander de Bruyn

I read your framework with interest. I think that it would be very valuable if you could quantify such a framework, however I fear that data-availability might be a hindrance in this. But I would be very interesting to see how far you could come using this framework.

The indicator-analysis would be very useful, but there are 3 issues:

1. The mere quantification of these indicators does not imply what would be meaningful thresholds. Under which threshold does carbon leakage not pose a problem? That is still a discussion point because in essence the chosen thresholds by the EC may implicitly take into account these other factors (e.g. price elasticities, Armington elasticities, MACC). So the mere notice that companies may pass through part of the costs, have cheaper options available through abatement (do not cancel out here the use of CDM, as a CER is only worth €0,20/tCO2 nowadays), does not necessarily mean that they would no longer qualify for being on the carbon leakage list.

2. The framework implicity assumes that a reduction of profits is the main cause of carbon leakage. I would not agree with this. I think that the main mechanism is through trade, in which cost-disadvantages for EU industries result in a loss in market shares. So in my view carbon leakage especially occurs if companies have high carbon costs which are passed through to the consumers who decide to prefer non-EU products because of relative prices. This is according to economic theory. So while your framework is useful, there is an implicit assumption in it that does not adhere to economic theory. Just something to be aware off.

3. The framework more or less assumes that companies only take into account real tangible costs. However, from an economic point of view it is more likely that they are involved in marginal cost pricing based on opportunity costs (marginal cost pricing would imply that opportunity costs are taking into account in most cases). In other words, even if they have free allowances, they would still facture in the full costs of allowances into the product prices. This is because the free allowances were given as lump-sum (irrespective of their current production).

Nevertheless, I do hope that you continue with this and are able to provide a nice draft of the quantification of these indicators. But just be aware that they do not automatically assume that carbon leakage does not take place in the real world (because of reasons 2 and 3).

9.3.6 Sean Healy

I think that your proposed framework is very interesting and reflects the nature of carbon leakage. I particularly like the systematic approach that you follow eliminating sectors depending upon the value at stake, ability to reduce, pass through or absorb carbon costs. The list of indicators should provide good insights into the carbon leakage problem, however you may also like to consider additional indicators:

§ You may want to consider indirect carbon costs from suppliers (i.e. indirect costs from raw materials from supplier sectors (upstream), which are likely to be passed through to the sector being assessed.) This would not be included within the value at stake calculation ratio.

§ You may also wish to include within your framework an indicator for the carbon intensity of likely substitutes (i.e. assess the carbon intensity of tradable substitutes, both from the EU and non-EU, have the same functionality). For example, even if the carbon costs faced by a sector are high, and the ability to pass these costs through is low, there would be no significant risk of carbon leakage if the sector can absorb these costs if the substitution of the product overall leads to a lower carbon footprint.

The only potential problem I can see is the availability of data and the acceptability of the data to operators participating in the EU ETS. I would expect that information on MACCs and cost pass through rates are limited to a selection of studies in the literature and this may be disputed by sector lobby groups. However as an approach for the qualitative assessment on carbon leakage I think that this is a very useful approach to use in combination with the quantitative assessment (which is based on data that is more accepted by EU ETS participants). There is a need to improve the quantitative assessment in the 2015-19 carbon leakage list (i.e. changing the carbon price for the value at stake indicator / setting more ambitious thresholds to reduce the number of sectors on the list).