Climate policy and the 'carbon haven' effect

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Climate Policy and the Carbon Haven Effect

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Abstract

In a world with uneven climate policies, the carbon price differentials across regions could shift the production of energy-intensive goods from carbon-constrained countries to “carbon havens”, or countries with laxer climate policy. This would reduce the environmental benefits of the policy (carbon leakage) while potentially damaging the economy (competitiveness concerns). A review on these questions is provided in this article. First we discuss the main terms involved such as carbon leakage, competitiveness, sectors at risk or climate spillovers. Then we analyse the studies evaluating the carbon leakage risk. Most *ex ante* modelling studies conclude to leakage rates in the range of 5-20% (if no option to mitigate leakage is implemented) whereas *ex post* econometric studies haven't revealed statistically significant evidence of leakage. Different policy options to face these issues are then examined with an emphasis on Border Carbon Adjustments (BCA). BCA consist in reducing the carbon price differentials of goods traded between countries. Properly implemented, they can reduce leakage (by around 10 percentage points in *ex ante* modelling studies) in a cost-effective way but are controversial because they shift a part of the abatement costs from abating countries to non-abating countries. Their impact on international negotiations is unclear: they could encourage third countries to join the abating coalition or trigger a trade war. Besides, their consistency with WTO rules is highly contentious among legal experts.

The Kyoto Protocol has been an attempt to set a global climate architecture aimed at abating carbon emissions on a global scale. The commitment period of the protocol ended in 2012 with mixed results. While abating technologies have improved, in particular renewable energies, the world's CO_2 emissions reached a record in 2011 with 31.6 Gt[1], an increase of 50% compared to 1990 emissions, and are likely to keep increasing in the next decade. Despite the growing emergency of serious climate change impacts, international negotiations are blocked because of strong free-riding incentives (Carraro and Siniscalco 1993), lobbying from energy intensive sectors and equity concerns about the North-South burden sharing. Climate policies will remain sub-global in the years to come, and unilateral or regional policies, including regulations, subsidies, carbon taxes and carbon markets, have emerged as some industrialized countries decided unilaterally to reduce their emissions. The top-down global Kyoto approach is shifting towards a bottom-up architecture with different CO_2 prices (Rayner 2010, Weischer 2012).

In a world with uneven climate policies, the carbon price differentials across regions modify production costs and may shift the production of energy-intensive goods from carbon-constrained countries to “carbon havens”, or countries with laxer climate policy. Since a decrease in emissions in one part of the world leads to an increase in emissions in the rest of the world, this phenomenon is referred to as carbon leakage.

The Pollution Haven effect, that is, the migration of dirty industries to countries with less stringent regulations, is one of the most contentious debates in international economics (Taylor 2005). A major difference exists between local pollutants, which constitute the overwhelming part of studies in the pollution haven literature, and CO_2. CO_2 is a global stock pollutant: the geographic location of emissions does not matter (Siikamäki 2012). A production shift would then reduce the environmental benefits of the policy while potentially damaging the economy.

In the context of growing globalisation, environmental policies can also have a strategic role. The fierce competition to attract foreign direct investment or the threat of industrial relocation could lead to a “regulatory chill” or even a “race-to-the bottom”, depending on the willingness of countries to downgrade environmental standards.

Indeed, the fear of carbon leakage and loss of competitiveness in energy-intensive industries are the main arguments against ambitious climate policies in industrialized countries. Modest mitigation targets have gone hand in hand with policy packages intended to protect sectors at risk of carbon leakage (mainly cement, iron and steel, aluminium and oil refineries). In the European Union Emission Trading System (EU ETS), the biggest carbon pricing experiment so far, tradable allowances are distributed free of charge for these sectors . In the US, the Waxman-Markey proposal, which was adopted by the House of Representatives in 2009 but not by the Senate, would have introduced a nationwide carbon market with measures to face these issues: allowances distributed freely on the basis of current output (output-based allocation) and border carbon adjustment (BCA). The latter, aimed at “levelling the carbon playing field”, is widely discussed among politicians, business leaders and academics. However, it is often considered as protectionism disguised as green policy (Evenett and Whalley 2009) among developing countries, and its World Trade Organisation compatibility

[1] http://www.iea.org/newsroomandevents/news/2012/may/name,27216,en.html,

remains contentious. The political outcome of its implementation is highly uncertain. BCA may increase the incentives of third countries to join the abating coalition but may also create international friction and lead to tit-for-tat trade retaliations (Bordoff 2009, IIFT 2010). The recent setbacks of the inclusion of aviation in the EU ETS are a reminder that any attempt to regulate emissions outside a country's jurisdiction is extremely problematic: foreign airlines and governments complained aboutthis inclusion, which pushed the EU to delay the inclusion of international flights by one year. Whether this inclusion will take place at the end of the delay period is still unclear.

This paper provides a literature review on competitiveness and carbon leakage issues from an economic, political and legal perspective. First, section 1 gives the definition of the main terms involved. Section 2 provides an evaluation of the carbon leakage risk, distinguishing *ex ante* Computable General Equilibrium (CGE) modelling from *ex post* econometric studies. Section 3 examines the policies aimed at reducing carbon leakage and competitiveness losses with an emphasis on Border Carbon Adjustment. Since the consistency of BCA with WTO is a decisive matter, it is discussed in further detail in section 4. Section 5 concludes.

1 Definitions

1.1 Carbon leakage

While competitiveness concerns and carbon leakage are often associated, they are two distinct phenomena. Carbon leakage is the increase of emissions in the rest of the world when a region implements a climate policy, compared to a situation where no policy is implemented (Quirion 2010). It can be measured by the leakage rate or leakage-to-reduction ratio, which is the rise in emissions in the rest of the world divided by the abated emissions in the region that has adopted a climate policy. A 50% leakage-to-reduction ratio means that half of the mitigation effort is undermined by the increase of emissions in the rest of the world, and not the misguided interpretation that 50% of emissions have "leaked" in the rest of the world. If this ratio is under 100%, emissions have decreased on a global scale, so the policy is environmentally beneficial. A ratio above 100% is theoretically possible, because the carbon intensity of CO_2-intensive products can be higher in the rest of the world, but has only been found in one outlier model (Babiker 2005). Estimates of leakage rates are typically in a range of 5%-20% depending on many factors (see below).

Carbon leakage occurs through two main channels: the competitiveness channel and the international fossil fuel price channel (Dröge et al. 2009). The root of the competitiveness channel is that the cost of compliance gives a comparative disadvantage for regulated firms vis-à-vis their competitors. This change of relative prices can lead to a change of the trade balance (less exports and more imports). In the short term, this would correspond to a change of the utilisation rate of existing capacities (operational leakage), while in the long term, it would correspond to a change in production capacities (investment leakage). These changes induce a shift of production, and then of emissions, from the regulated part of the world to the unregulated part of the world.

Besides, abating countries almost necessarily have to cut their fossil fuel consumption, which drives down the international prices of carbon-intensive fossil fuels: coal, oil and, perhaps even more, non-conventional fossil fuels (Persson et al. 2007). This decrease in prices reduces the net cost of climate policies in fuel-importing abating countries since a part of abatement is borne by fossil fuel exporters who lose a part of their rents. However it leads to a rise of their consumption in countries with less stringent policies. Because of international energy markets, the shrink in consumption in one region involves an increase in consumption in the rest of the world, causing carbon leakage through the international fossil fuel price channel. Yet two caveats are in order. First, CO_2 capture and storage (CCS) does not reduce fuel consumption. Quirion et al. (2011) show that for this reason, CCS brings down carbon leakage compared to a climate policy providing the same abatement without CCS. Second, the world oil market is dominated by OPEC, and alternative assumptions about OPEC's behaviour lead to opposite results regarding leakage through the oil market, which can even become negative (Böhringer et al., 2013).

The same reasoning applied to the whole world but with two temporal periods is known as the Green Paradox (Sinn 2008, Eisenack et al. 2012) which could be considered inter-temporal leakage: a rising CO_2 price would be seen as a future resource expropriation by fossil fuel owners who would then increase resource extraction. Yet, although the mechanism of the Green Paradox is well understood, its quantitative importance decreases when realistic features are included in the models (Gerlagh, 2010)

Despite the overwhelming importance of the competitiveness channel in the climate policy debate, in virtually all models including the two channels, the international fossil fuel price channel predominates (Gerlagh and Kuik 2007, Fischer and Fox 2009, Boeters and Boelen 2012, Weitzel et al. 2012).

1.2 Competitiveness

The term "competitiveness" has been used in numerous studies, reports and articles and underlies economic policies. However, this concept is difficult to define and susceptible to ambiguities.

At a firm or sectoral level, competitiveness can refer to "ability to sell" or "ability to earn". Competiveness as "ability to sell" is the capacity to increase market share, and can be measured through indicators involving exports, imports and domestic sales (Alexeeva-Talebi 2012a). Competitiveness as "ability to earn" is the capacity to increase margins of profitability, and can be measured with indicators involving some measures of profit or stock values. Distinguishing these two notions is useful since the same climate policy can have different impacts on both. For instance, distributing free emission allowances based on historic data only, as is the case in the US SO_2 ETS (Schmalensee and Stavins, 2013), increases the ability to earn but not the ability to sell, since an operator can close a plant and continue to receive the same amount of allowances. Hence, only competitiveness as ability to sell may generate leakage.

The notion of competitiveness at the national level is controversial, and is considered meaningless by some economists, such as Paul Krugman (1994). The main indicator is the balance of trade, that is, the difference between the monetary value of exports and imports, but an increase in the balance of trade may result from many factors, some of which are completely unrelated to the competitiveness of domestic firms, like a contraction in domestic demand.

Whether climate policies have to protect competitiveness at a national level or at a sectoral level is a legitimate question. EU ETS sectors contribute 40% of EU emissions, but less than 5% of its Gross Domestic Product (GDP) and an even smaller share of its jobs (Ellerman 2010). The sectors at risk of carbon leakage (see below) account for slightly more than 1% of GDP in the UK (Hourcade, 2008) and 2% in Germany (Graichen et al. 2008). However, they account for a much higher share of Greenhouse Gas (GHG) emissions so protecting their competitiveness in order to limit leakage cannot be discarded *prima facie*.

1.3 Sectors at risk

All sectors do not face the same risk of carbon leakage. The risk is higher if the carbon cost is high and the international competition is fierce. Hence, in the attempt to classify sectors exposed to carbon leakage, two indicators are generally used, one measuring the carbon cost and the other the trade intensity. For the EU ETS, the carbon cost is measured by the value at stake, defined as the carbon costs relative to the gross value added of a given industrial sector. The trade intensity is measured by the ratio in values between imports plus exports and the EU total market size. A sector is considered at risk if one or both of these indicators is above a certain threshold (see Figure 1). Table 1 shows the different indicators and thresholds to identify sectors at risk in the EU, the US and Australia. The most vulnerable sectors, usually gathered around the common denomination of Energy Intensive Trade Exposed (EITE) sectors, include iron and steel, cement, refineries and aluminium.

(Insert figure 1)

The EITE sectors are well-organized and constitute a strong lobby that has managed so far to influence climate policies. Indeed, all climate policies have provided more favourable rules for these sectors compared to others. In addition, these "specific rules" are generally more favourable in the final amendments than in first drafts (CEO 2010). The classification of sectors in itself (which sectors are at risk and which are not), because of its economic impacts, is subject to political and academic controversy and face strong industrial lobbying (Clò 2009, Martin et al. 2012).

(Insert table 2)

1.4 Positive impacts of climate policies on competitiveness and abatement in foreign countries

Though the political debate has focused on the negative impacts of climate policies, some authors argue that at least in some sectors or firms, stringent environmental regulations can force firms to be more efficient in their processes, and then more competitive. This is referred to as the Porter hypothesis (Porter and Van der Linde 1995), which is highly controversial but has been corroborated in Europe by a recent econometric study (Costantini and Mazzanti 2011). Further, it is possible to highlight two mechanisms symmetrical of carbon leakage and competitiveness losses: climate spillovers and first mover advantage.

Environmental regulations foster innovation and generate technological progress in GHG savings technologies (Newell et al. 1999, Jaffe et al. 2002, Dechezleprêtre et al. 2008). Diffusion of these technologies reduces emissions in non-abating countries and then creates negative leakage, or positive climate spillover (Gerlagh and Kuik 2007, Di Maria and Van der Werf 2008, Golombek and Hoel 2004, Bosetti et al. 2008). There is empirical evidence of climate spillovers, especially in energy-saving technologies (Popp 2002), but also in renewables. Feed-in tariffs in Denmark, Germany and Spain generated a massive induced technical change in wind and solar technologies (Peters et al., 2012) and are thus in part responsible for the spectacular development of windpower capacities in China, which became the world leader in terms of windpower installed capacities, shifting from 2.6 GW in 2006 to 75 GW in 2012 (Roney, 2013).

Another, yet even more difficult to quantify source of negative leakage is the international diffusion of climate policies: implementing any new policy involves some risks, and observing climate policies in other countries allows reducing these risks and possibly avoiding some mistakes. Just as the EU has closely observed the US SO_2 cap-and-trade to set up the EU ETS, subsequent ETS developments have benefited from the EU ETS experience. The same stands for other climate policies such as renewable subsidies (especially feed-in-tariffs pioneered by Denmark and then Germany) and energy efficiency regulations.

Finally, Fullerton et al. (2011) have recently identified a new mechanism generating negative leakage, which they label the Abatement Resource Effect (ARE). The intuition is that when a climate policy reduces emissions in one part of the economy, it may draw factors of production away from other, carbon-intensive activities. The authors show that if this effect is strong enough, an economy may exhibit negative net leakage in response to the policy change. While the possibility of negative leakage through this mechanism is not disputed, Carbone (2013) as well as Winchester and Rausch (2013) have recently assessed the ARE in more complex models and conclude that the negative leakage due to the ARE is more than offset by positive leakage mechanisms.

Technological knowhow in climate-related technologies gained by domestic firms could be used to capture market share in emerging markets (first-mover advantage). If other countries join the abating coalition, these firms have a comparative advantage vis-à-vis their competitors. This ability to gain market share by being the first to develop a technology is the first mover advantage. Emerging in models (Summerton et al. 2012), it could be considered a long-term competitiveness factor. The clearest case concerns the EU wind industry, which is the dominant supplier in all word markets except China, due to the already mentioned feed-in-tariffs implemented in the 1990s. However, while Germany benefited from a first-mover advantage the Photovoltaic (PV) industry until 2011, the German PV industry has since been largely surpassed by China, showing how fragile a dominant position can be in industries featuring fast technical progress (Kazmerski 2011).

2 Evaluation of carbon leakage

2.1 *Ex ante* studies

Climate change mitigation policies are diverse and include various forms of regulations, subsidies, carbon taxes and emission trading systems (ETS). Yet carbon leakage has mostly been assessed for ETS and carbon taxes. There is extensive literature assessing *ex ante* carbon leakage from hypothetical carbon taxes or ETS that can be traced back to Felder and Rutherford (1993). The majority of these studies rely on Computable General Equilibrium (CGE) models (Böhringer et al. 2012, Mattoo et al 2009, Fischer and Fox 2012, Dissou and Eyland 2011, Lanzi et al. 2012, Balistreri and Rutherford 2012, Peterson and Schleich 2007), but some use partial equilibrium models (Gielen and Moriguchi 2002, Mathiesen and Maestad 2004, Monjon and Quirion 2011, Demailly and Quirion 2006, Demailly and Quirion 2008). CGE models, which simulate the behaviour of entire economies, are pertinent to study the effect of policies on trade in different sectors (Kehoe et al. 2005) but they generally rely on more aggregated data (almost exclusively the Global Trade Analysis Project database) that may hide impacts on more specific sectors (Siikamaki 2012, Alexeeva-Talebi et al. 2012b). Moreover, most CGE models feature a zero-profit condition so cannot assess competitiveness as ability to earn. An exception is Goulder et al. 2010 whose model features capital adjustment costs, which implies that capital is imperfectly mobile across sectors and allows the model to capture the different impacts of policy interventions on the profits of various industries. Assessing a hypothetical federal ETS in the US, the authors conclude that freely allocating fewer than 15% of the emissions allowances generally suffices to prevent profit losses in the most vulnerable industries. Freely allocating all of the allowances substantially over-compensates these industries.

These models provide a wide range of estimations for leakage and competitiveness losses (as ability to sell). First, results depend on scenario hypotheses: the bigger the abating coalition, the smaller the leakage rate while the more ambitious the target, the higher the leakage. Linking carbon markets within the abating coalition (Lanzi et al. 2012), authorizing offset credits (Böhringer et al. 2012) or extending carbon pricing to all GHG (Ghosh et al. 2012) increases economic efficiency and then reduces leakage. Second, the models are very sensitive to two sets of parameters: fossil fuel supply elasticities (for the international fossil fuel price channel) and Armington elasticities (for the competitiveness channel) (Monjon and Quirion 2011, Alexeeva-Talebi et al. 2012b, Balistreri and Rutherford 2012). The former indicate to what extent a decrease in fossil fuel demand reduces the fuel price, while the latter represent the substitutability between domestic and foreign products.

A recent comparative study of 12 different models gave the most robust results so far (Böhringer et al. 2012). The estimate of leakage is 5-19% (mean 12%) when Annex I countries (except Russia) abate 20% of their emissions through carbon pricing without taking any measure to protect EITE sectors. The loss of output in these sectors is 0.5%-5% (mean 3%) in the coalition and an output gain of 1%-6.5% (mean 3%) is observed in the rest of the world. Some results of leakage estimates can be seen in Table 1.

(Insert Table 1 here)

These aggregate results hide differences among sectors, but even at sectoral levels, leakage estimates contrast sharply with alarmist predictions made by industry-financed studies. For example, according to a Boston Consulting Group (2008) study funded by the European cement industry, under carbon pricing at 25€/tCO2 without climate policy outside the EU ETS or measures against leakage, importers would supply 80% of the European cement market. A peer-reviewed study that analyses a very similar scenario (except that the CO_2 price is at €20/t) concludes that importers would only supply 8%, versus 3% absent climate policy (Demailly and Quirion, 2006). These contrasted results can be explained by different assumptions about available production capacities abroad and the nature of competition assumed in the cement market.

2.2 *Ex post* studies

The first studies assessing empirically the impacts of environmental regulations on trade dealt with local pollution issues (Kalt 1988, Tobey 1990, Grossman and Krueger 1993, Jaffe 1995). They showed little evidence to support the "pollution haven" effect: their estimates of the impact of environmental regulations on trade flows were either small or insignificant. However, recent studies have shown some evidence of the pollution haven effect in small proportions (Dean et al. 2005, Levinson and Taylor 2008). Paradoxically, dirty industries seem less vulnerable, because of capital intensity and transport costs (Ederington et al. 2005). The empirical validity of the pollution haven effect continues to be one of the most contentious issues in the debate regarding international trade and environment (Kellenberg 2009). Nevertheless a massive environmental relocation has never been observed.

Environmental tax reforms (ETR, i.e. carbon taxes whose revenues are used to cut other taxes, mostly on labour income) established in some European countries offer another natural experiment to empirically treat these questions. Kee et al. 2010 analyse the evolution of imports and exports in energy-intensive industries, comparing countries which did and did not implement a carbon tax. The authors find a statistically significant negative impact on exports of a carbon tax only in the cement sector while, strangely enough, they find a positive impact on exports in the paper as well as iron and steel sectors. No statistically significant impact was found on imports for any sector. Miltner and Salmons (2009) found that, out of 56 cases (seven countries and eight sectors studied), the impact of ETR on competitiveness was insignificant in 80% of the cases, positive in 4% and negative for only 16%. However, EITE sectors benefited from exemptions and lower taxation rates, which may explain why more negative impacts were not observed. If ETR didn't prove harmful for these industries, they had a positive impact on economic wealth, giving empirical arguments for the double dividend theory (Barker et al. 2009), e.g. a taxation shift from labour to pollution may stimulate economic growth as well as reducing pollution (Goulder 2002, Bento and Jacobsen 2007).

Aichele and Felbermayr (2012) econometrically assessed the impact of having an emission target under the Kyoto Protocol (i.e. being a developed country and having ratified the Protocol) on CO2 emissions, the CO2 footprint[2] and CO2 net imports, using a differences-in-differences approach on a panel of 40 countries. To account for a potential endogeneity bias (the fact that countries with an expected low or negative growth in emissions may be more likely to have ratified the Protocol) they use the International Criminal Court participation as an instrumental variable for Kyoto ratification. They concluded that countries with a Kyoto target reduced domestic emissions by about 7%

[2] The CO2 footprint equals domestic emissions plus CO_2 net imports, i.e. domestic emissions plus emissions caused by the production of imported products, minus emissions caused by the production of exported products.

between 1997-2000 and 2004-2007 compared to the countries without a target, but that their CO2 footprint did not changed (CO2 net imports increased by about 14 %). These results imply that domestic reductions have been fully offset by carbon leakage. However two caveats are in order. First, China became a member of the WTO in 2002, just when most developed countries ratified the Protocol. Since most CO_2 net imports are due to trade with China (Sato, 2013), the rise in net imports may well be due to China WTO membership rather than to Kyoto. Second, apart from those covered by the EU ETS, countries with a Kyoto target haven't adopted significant policies to reduce emissions in manufacturing industry. Hence, if Kyoto had caused leakage (through the competitiveness channel), it should show up on the CO_2 net imports of countries covered by the EU ETS rather than of countries covered by a Kyoto target; yet the authors report that EU membership does not increase CO_2 imports, when they include both EU membership and the existence of a Kyoto target in the regression. This conclusion invites to look more directly at the impact of the EU ETS.

The studies focusing on the EU ETS, the largest carbon pricing experiment so far, have not revealed any evidence of carbon leakage and loss of competitiveness in sectors considered at risk of carbon leakage, such as cement, aluminium, and iron and steel (Reinaud 2008, Ellerman et al. 2010, Sartor 2012, Quirion 2011). More studies will undoubtedly be conducted in the following years, for the EU ETS and the other carbon markets that have emerged, as more hindsight will be provided. So far, the empirical resultsare in sharp contrast to the "exodus of EU industry" claimed by the European Alliance of Energy Intensive Industries (Oxfam International 2010).

2.3 Synthesis

Ex ante modelling studies vary in their results because of policy scenarios (size of the coalition, abatement targets) and some crucial model parameters (Armington elasticities for the competitiveness channel, and oil supply elasticities for the international fossil fuel channel). A meta-analysis of recent studies which details the role of these factors is provided in Branger and Quirion (2013). In the absence of BCA, most of these studies suggest leakage rates in the range of 5-20%. Conversely, *ex post* econometric studies have not revealed empirical evidence of these issues. Why such a difference?

First, effects of carbon taxation are always in practice compensated by "policy packages". Because of carbon leakage and competitiveness concerns, sectors at risk in the EU ETS received allocations free of charge while in every case of CO_2 tax, they benefited from lower tax rates or exemptions. In addition, aluminium producers and other electricity-intensive industries, protected by long term electricity contracts, have not always suffered the pass-through of carbon costs to consumer by electricity companies (Sijm et al. 2006). Moreover, in the case of the EU ETS, the CO_2 price has been below €14 for the majority of the time since the launch of the system, arguably too low a value to entail noticeable impacts.

Further, empirical studies have focused so far on *operational leakage* and not *investment leakage* (change in production capacities), which could be studied through the analysis of foreign direct investments. Over time, new carbon markets are launched and time series get longer, giving more room for empirical research. However, assessing the "true" impact of asymmetric carbon pricing will always be hampered by the compensation measures aimed at reducing competitiveness losses.

Another reason for the gap between *ex ante* predictions and *ex post* analysis could be that models generally do not (or only vaguely) take into account positive aspects of climate policies, such as climate spillover and first mover advantage.

More research understandings of the positive aspects of climate policies would be useful when exploring the climate and competitiveness linkages. Other possible areas of improvement is further contribution to the empirical literature, which remains thin, and progress in international trade theories.

3 Policies to address leakage and competitiveness concerns

The elaboration of policy tools designed to "level the carbon playing field" has led to an extensive body of literature. One can classify these measures in three broad categories: a global approach, levelling down the cost of carbon and border adjustments (Carbon Trust 2010, Dröge et al. 2009). Each of these categories has many variants and a combination of different tools could also be considered. The next sections discuss their specific features, pros and cons. None of these instruments seems to be a "magic bullet" to address both economic efficiency, equity and practical feasibility concerns (Böhringer et al. 2012). Some argue that policies to address this problem should be sector-specific (Carbon Trust 2010, Dröge et al. 2009), but so far tools that have actually been implemented or considered to address competitiveness and leakage concerns only distinguished sectors "at risk" from the others: see Table 2 for Europe (EU ETS phase II and III), the US (Waxman-Markey amendment), Australia (Clean Energy Legislative Package), the California ETS and the New Zealand ETS.

3.1 Global approach

The first-best solution would be the existence of a uniform carbon price allowed by international climate agreements and flexibility mechanisms. However, because of the negative perspective of international climate negotiations, this option seems highly unlikely until at least 2020[3]. A pragmatic alternative would then be to embrace cooperative sectoral approaches (Houser et al. 2008, Zhang 2012, Hamdi-Cherif et al. 2011) but much confusion remains regarding what they should be. Developed countries favour the form of industry targets and timetables, and diffusion of performance standards, thus addressing leakage and competitiveness concerns. Conversely, developing countries such as India are suspicious of the imposition of binding targets through sectoral approaches and interpret sectoral agreements as a catalyst for technology transfer (Meckling and Chung 2009).

3.2 Levelling down the cost of carbon

Levelling down can be achieved through investment subsidies, sectoral exemptions or free allocation of permits, so as to decrease or even suppress the carbon cost for targeted sectors. All are equivalent to subsidies, and are then subject to the agreement on Subsidies and Countervailing Measures (SCM) of the World Trade Organization.

[3] The goal of international negotiations is to sign international agreements before 2015 that would be implemented after 2020.

Exempting the most vulnerable sectors was implemented in Norway (Bruvoll and Larsen 2004) and Sweden (Johansson 2006) when their carbon tax were introduced. It solves the competitiveness and leakage concerns but at a substantial economic cost (Rivers 2010, Böhringer et al. 2012): since emissions in these sectors will not be reduced, to reach a given aggregate target, more abatement must take place in the others, including less cost-effective options.

Instead of auctioning, three main options for allocating free allowances have been considered: historic, output-based and capacity-based allocation (used in the EU ETS). These free allocation methods induce side effects: in order to prevent competitiveness issues, other distributional and cost-effectiveness issues are created. In case of historic and capacity-based allocation the ability to pass-through carbon costs creates windfall profits for the operators of covered installations (Sijm et al. 2006, Morris 2012). Nevertheless, simulations indicate that output-based allocations seem more efficient to counteract leakage and protect industrial competitiveness while assuring political acceptability (Quirion, 2009, Rivers 2010).

3.3 Border adjustments

Border Carbon Adjustments (BCA) consist of reducing the carbon price differentials of goods traded between countries, inspired by measures in place for Value Added Tax. Based on theoretical grounds to improve the cost-efficiency of subglobal climate policies (Markusen 1975, Hoel 1996), BCA were also considered a way to "punish" the US for free-riding the Kyoto Protocol (Hontelez 2007). Later, the US incorporated BCA in the Waxman-Markey amendment, aiming mainly at Chinese products (van Asselt and Brewer 2010). However the fierce criticism of China and India led President Obama to dissociate the US administration from this proposal (declaring "We have to be very careful about sending any protectionist signals", Broder 2009). Among the advocates of BCA, one can cite Paul Krugman (2009), who argues that BCA are "a matter of levelling the playing field, not protectionism".

Many technical points are to be considered for the implementation of BCA (Cosbey et al. 2012, Monjon and Quirion, 2010), which are not inconsequential technical details, but would determine the viability of this option under international laws:

• *Covered sectors*. There is a general consensus that only sectors at risk should be covered by the scheme; however, the classification of sectors at risk may be controversial (for example for the third phase of EU ETS, see Clò 2009, Martin 2012).

• *Covered countries*. Country exceptions may occur, for example, for Least Developed Countries for equity purposes or, as in the Waxman-Markey bill, for countries that have taken "comparable action" on climate policies. However climate policies are so various, being a mix of carbon pricing, regulation and subsidies, that comparing different climate policies is not easy. One can distinguish two principles: "comparability in effectiveness" as in the WTO Shrimp-Turtle dispute or "comparability of efforts" as in the Common but Differentiated Responsibilities principle.

• *Inclusion of indirect emissions*. Taking into account the indirect emissions from electricity consumption is relevant for industries with high electricity costs, such as aluminium, but highly complicates the calculation of adjustment factors. The energy mix differs among countries, and calculation of emissions from electricity consumption is contentious, because of differences between marginal and average specific emissions.

• *Inclusion of export rebates*. They are useful to level the playing field also in third countries markets, but their WTO compatibility is not guaranteed.

• *Carbon content*. One can consider four options: exporter's average emissions, home country's average emissions, self-declaration or best available technology (BAT) based on benchmarks. A reliable knowledge of the carbon content of every foreign product seems out of range because of information asymmetry and administrative costs. To avoid a WTO challenge because of discrimination, these estimations should be rather conservative, which favours BAT benchmarking, or a choice between home country's average emissions and self-declaration (Ismer and Neuhoff, 2007).

• *Legal form of the adjustment*. The adjustment could take the form of a tax or of an obligation to surrender allowances. The origin of these allowance is to be determined (home region or under UNFCCC, with the possibility or not to come from offset credits).

• *Use of revenues*. The share of revenues between the importing country, the exporting country and an international body to be designated is crucial and may be the biggest levy of political acceptability. Many have argued that these revenues could be used to finance clean technology transfer or adaptation through a Green Climate Fund (Godard 2009, Grubb 2011, Springmann 2013).

• *Timing*. A period of good faith could be offered to third countries before the implementation of such measures. Clear conditions for phasing out must also be decided.

Among all these features, some are incorporated as scenario alternatives in models, such as the covered sectors (Ghosh et al. 2012, Peterson and Schleich 2007, Mattoo et al. 2009, Winchester et al. 2011) , the inclusion of indirect emissions (Bohringer 2012c, Monjon and Quirion 2011), the inclusion of export rebates (Lanzi 2012, Fischer and Fox 2012, Bednar-Friedl et al 2012), the carbon content (McKibbin and Wilcoxen 2009, Kuik and Hofkes 2010) and the use of revenues (Boeters and Bollen 2012, Böhringer 2012b, Rivers 2010). However, both technical difficulties and administrative costs (as input-output matrices for carbon content are “available” in models) and legal challenges (as they go beyond energy-economy modelling) are under-evaluated in these models.

Border adjustments are effective to reduce leakage through the competitiveness channel (but obviously not leakage through the international fossil fuel price channel): in model simulations, the leakage rate decreases by about 10 percentage points on average (Böhringer et al. 2012). They are also very effective to protect competitiveness but they shift a part of the mitigation burden to developing countries (Bao et al. 2012). With a CGE model, Mattoo et al. (2009) find that strong BCA imposed by US would depress India and China manufacturing exports between 16% and 21%. However, it must be remembered that China will in all likelihood consume domestically more than

98% of its steel production[4] and 99% of its cement production[5]: the effects of BCA on Chinese production would then be very small.

BCA might conflict with the Principle of Common but Differentiated Responsibilities of the UNFCCC (Dröge 2011). Its effect on international negotiations is unclear: they could be used as a "strategic stick" to force other countries to join the abating coalition (Lessmann et al. 2009), but they could also trigger a trade war because of "green protectionism" suspicions (IIFT 2010). For example, China strongly opposes BCA and claims that energy-intensive exports are already taxed (Voituriez and Wang 2011). Climate coalition countries have an incentive to deviate from the optimal carbon tariff rate to change their terms of trade (Weitzel et al. 2012), and even with good-quality data, there is room for judgement discretion in carbon content estimation and hence disguised protectionism (Holmes et al. 2011).

Some argue that the "carrot" of technology transfer would be more effective than the "stick" of BCA (Weber et al. 2009). Further, the benefits of internal improvements of emission trading systems within the abating coalition like linking markets and extending sectoral coverage could outweigh those of BCA (Springmann 2012, Lanzi 2012). Finally, the most controversial aspect of this measure is its compatibility with the WTO, discussed in the next section.

4 Border Carbon Adjustments and the World Trade Organization

The General Agreement on Tariffs and Trade (GATT) was established in a world without climate change on the international agenda, so its rules were not drafted to address climate policies, making the interpretation of legal texts particularly difficult. Past WTO cases, such as the Superfund, Tuna-Dolphin and Shrimp-Turtle reveal some information, but many features of BCA are unprecedented and WTO panels are not bound by previous decisions (no rule of *stare decisis*) (Zhang and Assunçao 2004). Hence, assessing the WTO consistency of BCA according to its specific features divides legal experts and has led to extensive literature on the subject (Biermann and Brohm 2004, Goh 2004, Frankel 2005, De Cendra 2006, Bhagwati and Mavroidis 2007, van Asselt and Biermann 2007, Ismer and Neuhoff 2007, Pauwelyn 2007, Green and Epps 2008, Sindico 2008, Quick 2008, Bordoff 2009, Low et al. 2011, Zhang 2012). If there is a consensus among legal experts, it is that all the technical points discussed above are key for BCA's WTO consistency.

[4] In 2007 (and, respectively, 2011), China produced 489 Mt (resp. 684 Mt) of steel and exported 50 Mt (resp. 13 Mt). Therefore China consumed 90% of its production in 2007 and 98% in 2011 (source http://www.issb.co.uk/asia.html). Steel production is expected to boom whereas exportations are expected to stay in the same level.

[5] China produced 2 Gt of cement in 2011 and exported 15,6 Mt in 2009 (we suppose the exports in 2011 have the same magnitude), meaning that China consumed 99% of its production. source http://www.globalcement.com/news/itemlist/tag/China and http://www.articlesbase.com/business-articles/chinese-cement-industry-realized-the-sales-of-cny-50072-billion-in-2009-1937146.html

4.1 World Trade Organization principles

The WTO was created in order to promote free trade by prohibiting unjustified protection and discrimination. The legal principle underlying all WTO regulation is the non-discrimination principle, divided into two key principles: the National Treatment principle (NT, article I) and the Most Favoured Nation principle (MFN, article III). NT prohibits country A to discriminate against country B or country C products over its own goods, whereas MFN forbids country A to discriminate against country B goods over country C goods (Avner 2007).

BCA could then respect the general regime of WTO providing they respect these core principles. However, a second-best option could be to fall under the GATT exception regime (article XX). Indeed, providing they are not used as a means of arbitrary discrimination (article XX chapeau, which is a lighter version of art. III), measures that do not find justification under the general regime can still be implemented if they follow one of the eight subparagraphs of art. XX. In the case of BCA, it could be Art. XX (b) or (g), if BCA are considered "necessary to protect human, animal, or plant health of life" or "relating to the conservation of natural resources".

In practice, assessing whether a version of BCA may follow the general or the exception regime of WTO involves answering many technical questions that are beyond the scope of this article. To convey a glimpse of the type of legal reasoning, this section briefly discusses perhaps one of the most important questions: can two products that differ onlyin their carbon content be considered "unlike" products? If the answer is positive, the discrimination between these two products under BCA does not violate the MFN principle. A difference in carbon content for "same" products is called, in WTO technical language, a difference in PPM (Product and Production Method, basically the way products are made). WTO distinguishes PPM into two categories: product-related PPM and non-product-related PPM, whether the PPM is considered "incorporated in the product" or not. First, legal experts disagree on whether carbon emissions are a product-related or a non-product-related PPM, depending on the interpretation of "incorporated in the product", whether as "physically present in the product" or "part of the product". Second, WTO rules allow discriminating product-related PPM, but are unclear for non-product-related PPM. A conservative interpretation would say that products differing only in non-product-related PPM are "like" products, but recent case law seems to take a different direction (Low et al. 2011).

4.2 Lessons from the past

[Insert Box 1 and Box 2]

Boxes 1 and 2 briefly explain two cases that provide some insights into the hypothetical consequences of BCA implementation, the first (the shrimp-turtle dispute) on the legal side and the second (the aviation inclusion in the EU ETS) on the political side.

The shrimp-turtle case teaches us that the exception regime of the WTO can rule, that this institution takes seriously into account the attempt to conclude international agreements before implementing trade measures (Tamiotti 2011), and that flexibility was the cornerstone of WTO dispute panel decisions (Zhang 2012). However the degree of legal complexity of BCA is far beyond a simple ban on shrimps.

The setbacks of the inclusion of aviation in the EU ETS show us that countries are deeply reluctant to relinquish some of their sovereignty, especially when financial consequences are at stake. One can reasonably assume that BCA for EITE industries are more controversial in terms of political acceptance than the inclusion of aviation in the EU ETS. Then, BCA implementation would certainly involve a strong diplomatic and economic response, especially from the developing countries.

4.3 Political and legal challenges of Border Carbon Adjustments

International institutions state that free trade has a role to play in climate policies by promoting clean technology transfer and suppressing murky subventions to dirty sectors, but remain ambiguous concerning the legality of BCA (WB 2007, UNEP and WTO 2009). The joint UNEP-WTO report (2009, p. 89) reads: "the general approach under WTO rules has been to acknowledge that some degree of trade restriction may be necessary to achieve certain policy objectives, as long as a number of carefully crafted conditions are respected". Legal experts are also divided on the subject, the bottom line of most analyses is that legal acceptability and political feasibility of BCA would depend on the specific designs of such measures (Tamiotti 2011). There is no guarantee of the legal success and political acceptability of BCA, but two features would help. First, in-depth discussions with third countries to identify the potential points of conflict, rather than unilateral imposition of trade measures, are desirable (Low et al. 2011). Second, flexibility must be a central piece of the policy package, which could mean allowing third countries national "comparable action" instead of systematic border carbon pricing.

Even with all these legal precautions, one can reasonably assume that, if BCA were to be implemented, third countries would publically condemn it as "green protectionism" or "eco-imperialism" (Dröge 2011). WTO and UNFCCC share the unpleasant fact of being bogged down in international negotiations blockage (the next step of the Kyoto Protocol for UNFCCC, and the Doha round for WTO), and a clash between climate and trade regimes would be detrimental to both global trade and climate agreements.

If BCA are not likely to be implemented in the following years, they will undoubtedly be considered more and more, as abatement targets gaps are growing among countries. A "weak" version of BCA, based on best available technologies benchmark with the handing back of revenues, would seem the most preferable option, offering less vulnerability to a potential WTO dispute and giving certain compensations to other countries (Godard 2009, Ismer and Neuhoff 2007).

Conclusion

The reality for the foreseeable future is that climate policies will remain sub-global. Different mitigation targets among countries are legitimate under the Principle of Common but Differentiated Responsibilities (Zhang 2012), but too uneven climate policies are less efficient if they cause carbon leakage and are unlikely to survive the national policy-making process if they entail significant competitiveness losses. These concerns are among the main arguments against the implementation of stringent climate policies in industrialized countries. How worrying are they?

Ex post studies have not shown significant evidence of leakage to date, but arguably the climate policies implemented so far may have been too moderate to allow measurement ofsuch effects. *Ex ante* studies indicate a leakage in the range of 5 to 20% in case of unilateral climate policies without measures to mitigate leakage. However, the induced diffusion of climate-friendly innovations generates abatement even in regions without climate policies, which may well compensate for leakage. Thus, leakage is clearly not a convincing argument against climate policies, although it invites actions to complement carbon pricing with specific measures in order to maximise their efficiency.

Is competitiveness a more convincing argument against climate policies? Carbon costs matter, but they are one factor out of many (capital abundance, labour force qualification, proximity to customers, infrastructure quality, etc.) contributing to the competitiveness of an industry (Monjon and Hanoteau 2007). Massive environmental relocations in case of stringent policies announced by Energy Intensive Trade Exposed (EITE) trade associations are not realistic: because these industries are very capital-intensive, they are less prone to relocation in general compared to "footloose" industries (Ederington et al. 2003). In the case of the EU ETS, competitiveness concerns have led to an over-allocation of permits, a generous use of offsets from the CDM and JI and finally a crash in carbon price. At this time the European Commission (2012) is struggling to tackle the growing structural supply-demand imbalance. The modest proposition of back-loading 900 million of allowances was rejected on 16 April 2013 by the European parliament, mainly for competitiveness reasons[6]. Hence, competitiveness, which was called a "dangerous obsession" for macroeconomic policy by Paul Krugman (1994), may be so for climate policy as well.

That said, because of the influence of EITE industries in the policy process, specific measures to protect these sectors are part of every realistic policy package. Moreover, they may allow countries in the abating coalition to raise the ambition of their climate policy, and also extend the size of the climate coalition, as they would lessen the incentives of free-riding. Simply exempting these sectors is too costly to be justifiable: since emissions in these sectors would not be reduced, more abatement should take place in the others, including less cost-effective options. On purely economic grounds and from the point of view of the abating coalition, economic analysis favours the implementation of BCA, but from a legal and diplomatic point of view, the situation is much less clear-cut. If properly discussed with emerging economies, a BCA based on best available technology benchmarks, with revenues earmarked for climate-related projects in developing countries, may be the best solution. A fall-back option is to distribute free allowances in proportion to current output of EITE industries (output-based allocation): although less cost-effective, it could be an acceptable compromise between efficiency and feasibility. However, just as free allowances based on historic or capacities, the option implemented in the EU ETS, it could generate massive lobbying and

[6] The spokesman for Conservative MEPs declared: " We fear [backloading] will (…) encourage further carbon leakage, and undermine much-needed market predictability as the EU economy strives to find a way out of the economic crisis" (source: http://www.guardian.co.uk/environment/2013/apr/16/meps-reject-reform-emissions-trading), arguments mainly taken from the position of the Alliance of Energy Intensive Industries (source:
http://www.cembureau.be/sites/default/files/documents/AEII%20Position%20on%20the%20Commission%20proposal%20to%20back-load%20EU%20ETS%20allowances.pdf)

competitive distortions since every industry tries to receive as much allowances as possible. Besides, the WTO compatibility of output-based allocation is not more granted than that of BCA (James, 2009).

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Box 1: The Shrimp-Turtle dispute

In order to protect five endangered species of sea turtles, the US banned in 1989 shrimps coming from countries where shrimpers were not equipped with turtle-excluders devices, a compulsory measure for US shrimp trawlers. In 1997, a coalition composed of India, Malaysia, Pakistan and Thailand challenged the US under the WTO, arguing that the import prohibition (Section 609 of Public Law 101-162) was inconsistent with the WTO rules. The Dispute Settlement Panel gave reason to the coalition, both in the first judgement and in appeal in 1998. The main reason was that the embargo undermined members' autonomy to determine their own policies, because it focused on turtle-excluder devices and did not provide enough flexibility in turtle protection policies to third countries.

After this dispute the US revised the conditions of Section 609. However these were still not satisfactory for Malaysia, which challenged the US again in 2000. The Panel this time gave reason to the US both in the first judgement and in appeal in 2001. It founded that the US provided "good faith" in negotiating an international agreement on the protection and conservation of sea turtles, as was recommended by the Appellate Body. It also concluded that conditioning market access on the adoption of a programme comparable in effectiveness allowed for sufficient flexibility.

Box 2: The political ordeal of aviation inclusion in the EU ETS

On November 2008, Directive 2008/101/EC launched the inclusion of aviation in the EU ETS starting in January 2012. Most of the allowances were supposed to be freely distributed, but because of the decrease in the global cap, the expected growth in air traffic and the limited ways of mitigation, it became clear that airline companies were going to buy a growing number of credits over time for their compliance.

Despite some precautions (free allowances, sophisticated rules protecting fast-growing companies, use of revenues for climate-related initiatives, exemptions in case of “equivalent measures” in other countries), the European Commission was attacked numerous times by airline companies, their trade bodies and governments. The points at issue were sovereignty, the Common but Differentiated Responsibilities principle of the UNFCCC (as airlines from developing and developed countries received the same treatment), the Chicago Convention of 1944 limiting taxation on aviation commercial fuel, and the use of revenues (Sandbag 2012).

In 2012, a growing “coalition of the unwilling” led by China, India, Russia and the US agreed on a series of retaliatory measures if EU states imposed sanctions for non-compliance. These pressures led the European Commission to “stop the clock” in November 2012, proposing a one-year deferral of the application of the scheme for intercontinental flights, leaving time for ICAO, the International Civil Aviation Organisation, to adopt a global policy. The implementation of the scheme as proposed in the directive remains highly uncertain at this time.

Figure captions

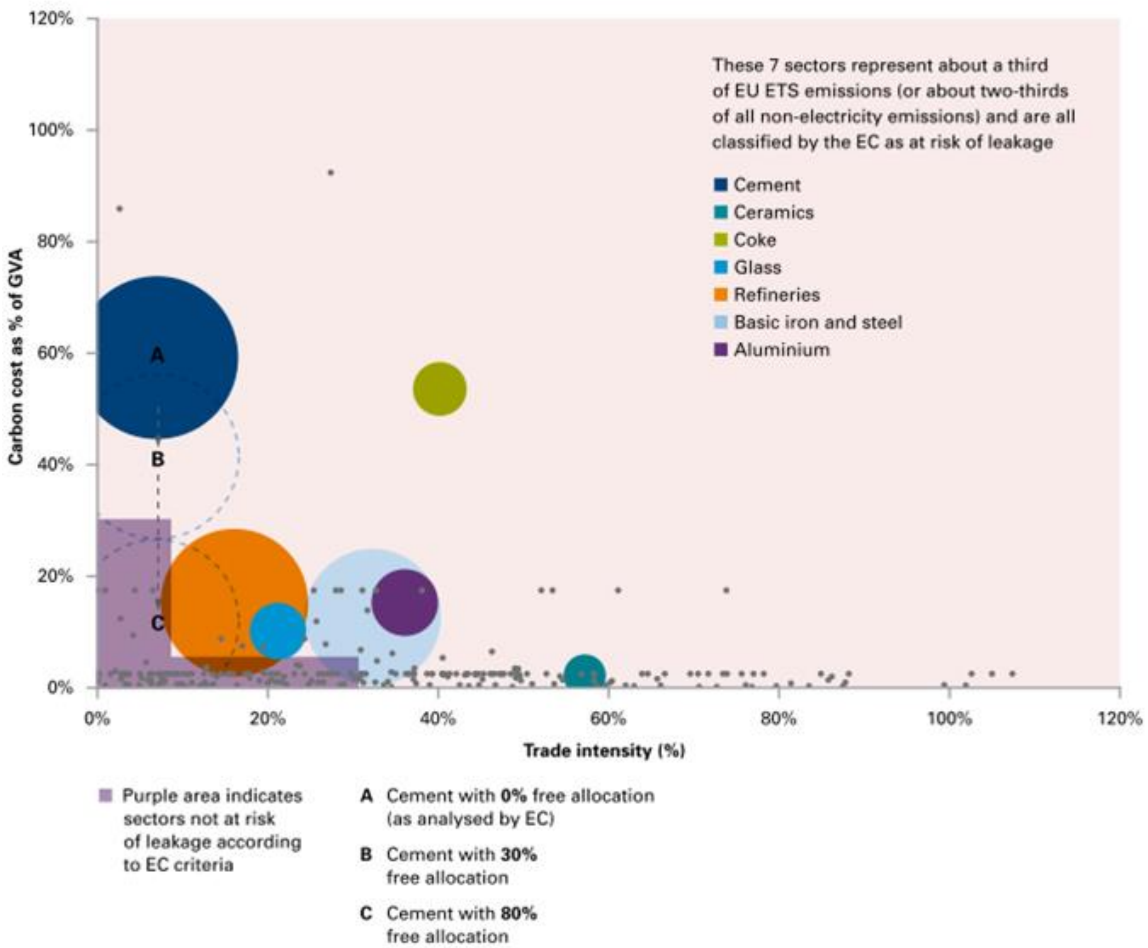

Figure 1: Sectors classified "at risk of carbon leakage" in Europe (source: Carbon Trust 2010). The size of the circles is proportional to the sector emissions.

Tables

Table 1: Leakage rates estimates in the literature

Article	Abating Coalition	Target	Sectors and Gases Covered	Leakage Ref	Leakage BCA	BCA Features
Böhringer et al. 2012	Annex I except Russia	20%*	All sectors CO2	5-19% (mean 12%)	2-12% (mean 8%)	Foreign CC Export Rebates EITE sectors
Ghosh et al. 2012	Europe	20%*	All sectors (+ Agri) All GHG	12%	-8%	Foreign CC Export Rebates All sectors (+ Agri)
Lanzi et al. 2012	Annex I	Kyoto*	All sectors CO2	4%	-17%	Foreign CC Export Rebates All sectors
Böhringer et al. 2012	Annex I except Russia	20%*	All sectors CO2	9%	5%	Foreign CC Export Rebates EITE sectors
McKibbin and Wilcoxen 2009	US	Price instrument ($20 in 2010 to $50 in 2050)	All sectors	3%	-30%	China CC Only imports All sectors
Peterson and Schleich 2007	Annex I	Kyoto	All sectors	25%	23%	Domestic CC Only Imports EU ETS sectors

Kuik and Hofkes 2010	Europe	Price instrument (20€)	EU ETS sectors	11%	10%	Domestic CC Only imports EU ETS sectors
Winchester et al. 2011	Annex I except Former USSR	31% (US) From 18% to 35% for others	All sectors	10%	7%	Domestic (US) CC Only imports All sectors
Mathiesen and Maestad 2005	Annex I	Kyoto	Steel only (partial equilibrium)	26%	-18%	Foreign CC Export rebates Steel sector
Monjon and Quirion 2011	Europe	15%	EU ETS sectors (partial equilibrium)	11%	-4%	Foreign CC Export rebates EU ETS sectors (except electricity)

Table 2: Policy packages for sectors at risk of carbon leakage (source: Hood 2010, IDDRI 2012)

See excel file