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EU ETS and Competitiveness of Irish Industry

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Rialtas na hÉireann
Government of Ireland

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EU ETS and Competitiveness of Irish Industry

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by

University College Cork

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DISCLAIMER

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

- Reforms to the European Union Emissions Trading Scheme (EU ETS) in Phase IV create a potential risk to industrial competitiveness in the power generation and heavy industry sectors through increased costs. The costs may be directly linked to greenhouse gas (GHG) emissions via European Union Allowances (EUAs) or may be indirect via increased energy costs. The focus of this research is to examine the impact of the EU ETS regulation on Irish companies.
- In Ireland, GHG emissions from ETS enterprises (excluding aviation) fell by 20.6% between the introduction of the EU ETS in 2005 and 2016. The GHG intensity of economic activity in Ireland has been declining steadily for the past 25 years but this may be a function of Ireland's economy becoming more services driven rather than the widespread deployment of clean technology.
- In 2014, only 20% of Irish manufacturing firms reported expenditure on environment (current or capital) and only 9.3% reported capital investments in environment. We find that there has been a lack of capital investment in environmental projects even though environmental regulation has increased during the period studied. We also find that the size of the capital investments is generally small, i.e. <1% of total spend. Not surprisingly, the proportion of firms investing in clean technology is higher amongst carbon-intensive firms. The size of capital investment in clean technology by these firms is approximately comparable with the lower range for Organisation for Economic Co-operation and Development (OECD) countries of 1–5% of total capital expenditure.
- There is some debate in the academic literature regarding the impact of environmental regulations on competitive effects. We find that investment in innovative clean technology increases resource efficiency and business performance. The exception for this is carbon-intensive firms in sectors with high emissions, i.e. the firms most likely to be regulated by the EU ETS. Our analysis shows that sequential EU ETS phases did not increase the probability of capital green investment. We also find that the EU ETS has had no impact on firm survival in Ireland.
- The consensus in the literature is that over-allocation of free allowances combined with a recession failed to provide a price signal for capital investment in carbon reduction technologies. In Ireland it is reported that 26% of free allocations have been traded as assets rather than surrendered for emissions. It appears that lack of stringency resulted in a pay-as-you-go approach and a lack of strategic trading experience for Irish firms. Since the agreement, in 2018, of the forthcoming reforms of the EU ETS, emissions costs are rising and now start to represent a significant cost of production for high GHG emission industries. There is acceptance that both regulation stringency and the cost of EUAs will increase. The attendance at our workshop and the interest in this work from stakeholders signals that there is now a move away from a "wait and see" attitude towards action in response to these costs.
- Results of our survey, based mainly on ETS-regulated firms, finds that access to finance and uncertainty in calculating the payback period are significant barriers to obtaining internal approval for decarbonisation projects. More risk-averse executives hedge their bets by making smaller investments, hence the low relative size of investments (<1% of total spend). Energy costs and corporate strategy were cited as important drivers underpinning investment. The survey revealed that 50% of respondents are concerned about the impact of increased energy costs on their business and 25% are very concerned.
- It is envisioned that a carbon price floor would accelerate emission reductions. Our models show emissions reductions at the EU level of –0.2% to –2.0% depending on whether Germany

participates. We find that implementing a carbon price floor results in a very modest reduction in Irish emissions compared with emissions in other countries, ranging from –0.1 to –0.2 Mt for 2020 and from –3.5 to –3.6 Mt in 2030, depending on the scenario used. These results for Ireland are influenced by the large coal/gas price differential. The impact on wholesale electricity prices is higher in Ireland than in many of the other EU countries, ranging from increases of 40–44% in 2020 and 30–34% in 2030. This could translate to an increase of approximately €350 to an annual electricity bill (consuming 4200 KWh/yr).

1 Project Background and Introduction

1.1 Introduction

This project addresses the impact of the European Union (EU) Emissions Trading Scheme (ETS) on Irish industry competitiveness. The EU directives governing the EU ETS, 2003/87/EC and 2008/29/EC, suggest that the scheme is designed "in order to promote reductions in greenhouse gas (GHG) emissions in cost-effective and economically efficient manner". However, the system has raised concerns for firms and industries over competitiveness in European and international markets (Meleo, 2014). The structural reforms of the EU ETS Phase IV and the creation of a Market Stability Reserve create a significantly different set of conditions for regulated companies. Many Member States have stated an intention to introduce a carbon price floor (CPF) for allowance trading. Both ETS-regulated firms and non-ETS-regulated firms are impacted by passed-through costs for energy and products from ETS-regulated firms. The competitiveness impacts of direct emission costs and subsequent power prices on carbon-intensive companies and industry in general are not well understood. It is not clear how resilient Irish companies are to future carbon prices or what impact higher power prices will have on profitability and competitiveness.

1.2 The EU ETS

Tackling global warming is one of the central public policy issues of our time. In December 2015 the Paris Agreement (also known as COP21)[1] committed the majority of the world's nations to limit warming to less than 2°C above pre-industrial levels, with a commitment to engage in further efforts to limit warming to 1.5°C above pre-industrial levels. Ultimately, to limit warming to no more than 2°C, global emissions will need to fall to net zero (or even net negative) by later this century, and time is running out to meet the policy targets agreed in Paris and avoid "dangerous" warming (Myhre *et al.*, 2013; UNFCCC, 2015; Rogelj *et al.*, 2016).

The development of a resilient Energy Union with a forward-looking climate policy is one of the strategic objectives of the EU. The EU has adopted climate and energy targets. The target is to reduce emissions by 20% and 40% by 2020 and 2030, respectively, relative to 1990 levels. There is a long-term goal to reduce EU-wide GHG emissions by 80–95% by 2050 relative to 1990 levels. The EU ETS was established in January 2005 against the institutional backdrop of the Kyoto Protocol (Convery, 2009), which required European countries to reduce GHG emissions on average by 8% by 2012 compared with 1990 levels (UNFCCC, 1997). The EU ETS is the world's largest market for emissions permits covering 45% of EU GHG emissions from 11,000 installations in power generation and heavy industry.[2] This accounts for about 5% of global GHG emissions (Muûls *et al.*, 2016). In Ireland, the ETS covers 29% of the total GHG emissions compared with an EU average of 45% (Muûls *et al.*, 2016).

To meet their obligations, European Member States – including Ireland – divide their emissions into two categories: those included in the EU ETS, which predominantly covers energy producers and various other heavy industrial emitters, and those not included in the scheme (non-ETS), which covers all other sources of GHG emissions. The ETS works by setting a cap each year on total emissions by participants in the scheme and allowing regulated firms to trade allowances [European Union Allowances (EUAs)] to cover the emissions that they produce. One allowance unit is the equivalent of 1 tonne of carbon dioxide equivalent (CO_2eq). The cap on emissions within the ETS has an annual reduction factor. The fundamental objective of the scheme is to initiate a structural change in power generation assets away from carbon-intense generation. The EUA market should provide a price signal for investment in decarbonisation.

1 See https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (accessed 6 February 2019).

2 See https://ec.europa.eu/clima/policies/ets_en (accessed 25 January 2019).

The scheme consists of consecutive phases each with increasing GHG emission constraints. In addition to the cap annual reduction factor, there is also a reduced percentage of the cap consisting of "grandfathering" allowances (free allocation based on historical emissions) and a higher percentage of the cap consisting of auctioned allowances. However, it is widely acknowledged that the EU ETS has failed to provide a price signal for investment in low-carbon assets because of overgenerous allocation of free allowances and falling electricity demand because of a recession (Donovan, 2015). The scheme is now in its third phase, which runs from 1 January 2013 to 31 December 2020. However, allowances are valid for the entire phase and surpluses can be carried forward or "banked" beyond 2020. Tol (2018) notes that this intertemporal fungibility to accommodate unpredictable emissions makes hedging much easier and reduces risk of compliance.

Reform of the EU ETS has been agreed for Phase IV, commencing in 2021.The rate of the cap annual reduction factor will be increased from 1.74% to 2.2% per year until 2030. The Market Stability Reserve, which began in January 2019, has the objective of keeping EUA prices above €30.[3] Excess allowances will be placed in the reserve if the price of traded EUAs is low. Backloading was introduced from 2014 to 2016 – this process, in response to an oversupply of EUAs, reduced the number of annual EUAs issued at the time. These EUAs were to be released before the end of Phase III in 2019 and 2020. Now, the 900 million backloaded EUAs will be transferred to the Market Stability Reserve. In addition to the reserve, many Member States have stated an intention to introduce a CPF to maintain an effective EUAs price. These reforms create a strong expectation of an increase in the cost of EUAs in the future. This may lead to stronger effects on regulated firms than have been observed to date and might also have knock-on effects for firms not included in the scheme, via the effect of compliance costs on electricity prices. These aspects are explored more fully in Chapter 5.

The Effort Sharing Decision (ESD) sets national emissions targets for EU Member States for each year between 2013 and 2020 in the sectors of the economy not covered by the EU ETS. Here, the onus is on national administrations to deliver the reductions. The target for Ireland is a 20% reduction in 2005 emissions by 2020. However, in this project we are more focused on the EU ETS regulation and its impact on firms.

1.3 Regulation and Competitiveness

The EU ETS means that carbon emissions are a cost of production. Capital markets theory (Fama, 1991) suggests that a rising price for any factor of production could increase costs and reduce competitiveness. Loss of competitiveness can lead to reduced production, profit margins and international trade. Reduced competitiveness can mean that investment is diverted to other locations, survival rates of firms decrease and jobs are lost. However, these effects depend on the extent to which these costs can be passed on to consumers (the price elasticity of demand), the availability of close substitutes, market structure, reactions of rivals, etc.; see Oberndorfer and Rennings (2007) for a full discussion of these effects.

Increasing internationalisation of production has raised concerns that industrial activity may move to countries with laxer environmental policies, in line with the so-called pollution haven hypothesis (Levinson and Scott Taylor, 2008). A recent report by the Organisation for Economic Co-operation and Development (Koźluk and Timiliotis, 2016) finds that more stringent domestic policies have no significant effect on overall trade in manufactured goods but are linked to a comparative disadvantage in "dirty" industries. Although the analysis showed that some carbon-intensive sectors were put at a slight disadvantage, this was balanced out by growth in cleaner industries.

Previous research suggests that EUA prices are significantly influenced by regulatory actions (Daskalakis and Markellos, 2009; Kossoy and Guigon, 2012; Koch *et al*., 2014). Deeney *et al*. (2016) demonstrate that decisions of the EU influence both EUA prices and volatility. For example, the share prices of E.ON and RWE dropped by 5% and 2%, respectively, on 16 April 2013 following the EU Parliament rejection of a carbon dioxide (CO_2) "backloading" plan (*Financial Times*, 2013).

Implementation of Phase IV of the EU ETS (the increased cap reduction rate, the Market Stability Reserve, removal of backloaded EUAs from the

3 See the European Commission website: https://ec.europa.eu/clima/policies/ets_en (accessed 3 July 2018).

market) and the ongoing debate on a CPF at EU level is likely to have significant implications for Irish industry in terms of international cost competitiveness. This could impact the competitiveness of sectors both with greater exposure to emissions costs directly and indirectly through electricity prices. Depending on the system-wide electricity generation mix, significant carbon costs can be passed through to energy users. There are conflicting views on the impact of carbon emissions prices on competitiveness in the academic literature (Klepper and Peterson, 2004; Oberndorfer and Rennings, 2007). In fact, the impact of emissions costs on companies is not generally well understood. There is substantial research which suggests that the cost and competitiveness impacts of carbon liabilities are not fully evaluated (Goldman Sachs, 2009; Lovell *et al*., 2010; Lovell and Mackenzie, 2011; Stern, 2011; FTSE4good, 2012). This has made it difficult to assess carbon liabilities and the potential impact of these liabilities on competition. The International Accounting Standards Board (IASB) attempted to introduce guidance on accounting for carbon emissions in 2005. It was withdrawn 6 months after its introduction, following lobbying by major EU ETS participants (Lovell and MacKenzie, 2011).

A recent report from by Stern and Zenghelis (2016) suggests that carbon-intensive companies are not ready for the impact of the Paris Agreement's commitments. They suggest that climate risks are expected to increase with time and that the vulnerability of companies will depend on their forward strategies. They propose that "In such circumstances, all companies will benefit from building resilience and planning for decarbonisation, through access to new technologies and markets and compliance with new policies, but the degree to which they expect to benefit will depend on the costs of taking action and the distribution of risks. Some will be more exposed than others, but even in heavily carbon entangled sectors, competitive losses can be limited or avoided through proactive attempts to transform production processes and business models" (Stern and Zenghelis, 2016, p. 9).

1.4 Irish Policy Context

The energy policy White Paper (DCCAE, 2015) sets out a vision for transforming Ireland's fossil fuel-based energy sector into a clean, low-carbon system by 2050. The report specifically addresses the need to address cost control in industry to maintain a competitive and job-friendly business environment. As discussed above, a change in the competitiveness of Irish industry could happen (1) directly through variable and potentially much higher carbon prices or (2) indirectly through energy prices. Reduced competitiveness could significantly impact Ireland's balance of trade, as exports and imports can become more or less competitive depending on sector exposure to these effects.

The Climate Action and Low Carbon Development Act 2015 (Government of Ireland, 2015) provides a statutory basis for the national objective of transition to a low-carbon, climate-resilient and environmentally sustainable economy by the year 2050 and gives a solid statutory foundation to the institutional arrangements necessary to enable the State to pursue GHG emission mitigation and climate change adaptation measures. The recently launched National Development Plan 2018–2027 (DPER, 2018) includes a commitment of €21.8 billion investment (€7.6 billion Exchequer/€14.2 billion non-Exchequer) towards achieving the 2050 goal (National Sustainable Outcome 8). There is an indicative allocation of €8.6 billion for environmentally sustainable public transport (National Sustainable Outcome 4). Our project will provide information for Irish policymakers in devising evidence-based sector-specific approaches and guide on the level of incentivisation required when considering supports and interventions.

1.5 Project Objectives and Methodology

Ireland has ambitious targets for renewables uptake across the electricity, heat and transport sectors. Although the electricity sector is covered by the ETS, heat and transport fall largely into the non-ETS sector. These interlinked targets will not be met without significant behaviour change and capital investment from Irish companies. In this project we strive to identify the challenges of balancing industry competitiveness, a healthy economy and the decarbonisation transition. The outcomes will be useful for policy development in terms of how to prepare Irish companies to adapt to the reformed EU ETS Phase IV and beyond. We look at the past, present and future for insights into how to help Irish industry prepare for this transition and future-proof the competitiveness and sustainability of Irish business. An understanding of previous responses by Irish industries to regulation and forecasting future energy costs can provide valuable information for policy and investment decisions.

To this end our objectives are to:

- conduct a review of international and national literature on the impact of environmental regulation on firm competitiveness;
- examine green investment by Irish industries during Phases I–III;
- provide evidence of the impact of green expenditure on business competitiveness through its effects on resource efficiency;
- examine recent trading activity by Irish firms;
- assess industry preparedness for ETS trading;
- forecast future electricity costs for EU Member States.

We use a number of different methods to achieve these objectives. We examine the published literature to explore Irish and international experiences of the impact of regulation, including the EU ETS, on competitiveness. Most published literature regarding competitiveness and the EU ETS covers only Phase I of the scheme. We focus on the response of Irish firms to Phases I–III of the EU ETS by empirical analysis of Central Statistics Office (CSO) data. We assess the impact of green investment and the EU ETS on the competitiveness of Irish industry thus far. A survey is used to capture current thoughts and expectations of business managers on the cusp of Phase IV. To study the likely impacts of the reforms in Phase IV, including the prospect of Ireland’s participation in a CPF, we simulate the full EU interconnected electricity market for the years 2020 and 2030 under varying CPF assumptions to estimate the effect on future electricity prices.

1.6 Report Layout

This report presents the output from each of the project objectives. Chapter 2 describes a comprehensive literature review to identify the impact that environmental regulation, in particular the EU ETS, has on industry competitiveness, identifying sectoral impacts internationally and in Ireland. In Chapter 3 we examine green investment by Irish industries during Phases I–III of the EU ETS and quantify the impact of EU ETS reforms on green expenditure and the competitiveness of Irish industry. In Chapter 4 we use Environmental Protection Agency (EPA) and EU emissions trading data to identify the main sectors and companies affected by the agreed Phase IV changes to the EU ETS. Chapter 5 presents the results of a survey conducted to understand the experience of Irish firms operating within the EU ETS and to assess the state of preparedness of Irish industry for deep decarbonisation scenarios. Lastly, in Chapter 6, we model future EU-wide electricity pricing to identify potential opportunities/threats in Ireland and examine the effect of electricity prices on Irish competitiveness.

2 Literature Review

2.1 Introduction

The Irish economy has below average exposure to the EU ETS; however, it depends highly on international trade and foreign direct investment (FDI). Plants regulated by the ETS in Ireland include a number of key sectors for FDI such as pharmaceuticals and information technology. Ireland could be particularly vulnerable to any competitiveness impacts of environmental regulation. The Irish economy is also unusual in terms of the relatively large contribution of agriculture to total GHG emissions. In section 2.2 we briefly review Ireland's GHG emissions profile over recent years. In section 2.3 we review the international evidence of the impact of efforts to cut pollution on business competitiveness. The discussion focuses on the effects of environmental regulation on business and consider how these apply to Ireland. In section 2.4 we examine how prepared Irish firms are for the significant emissions reduction that is required under the EU ETS and other EU and national targets. This draws on available evidence from published empirical analysis of firm-level data and surveys of Irish firms, as well as from the international academic literature. In section 2.5 we present some conclusions.

2.2 Ireland's GHG Emissions Profile 1990–2015

2.2.1 Total emissions and sources

As noted previously, in comparison with other EU Member States Ireland has an unusual economic structure in that the ETS covers 29% of total GHG emissions in Ireland compared with an EU average of 45% (Muûls *et al.*, 2016). An overview of 2016 GHG emissions under different sectors is given in Figure 2.1. Total emissions in Ireland are dominated by three main sources: energy industries (powergen) (20% of total emissions in 2016), transport (20%) and agriculture (32%). Non-ETS emissions are dominated by agriculture and transport (see Figure 2.1). Residential emissions accounted for a further 9.8% of non-ETS GHG emissions. Industry (here we have combined the contribution of manufacturing combustion and industrial processes) contributed 13% of total GHG emissions in 2016, about 9% of which is covered by the EU ETS. This picture of relative contributions has not changed dramatically since 1990. One exception is the growth of transport emissions, which have more than doubled, from 9% in 1990 to 20% in 2016 (EPA, 2018a).

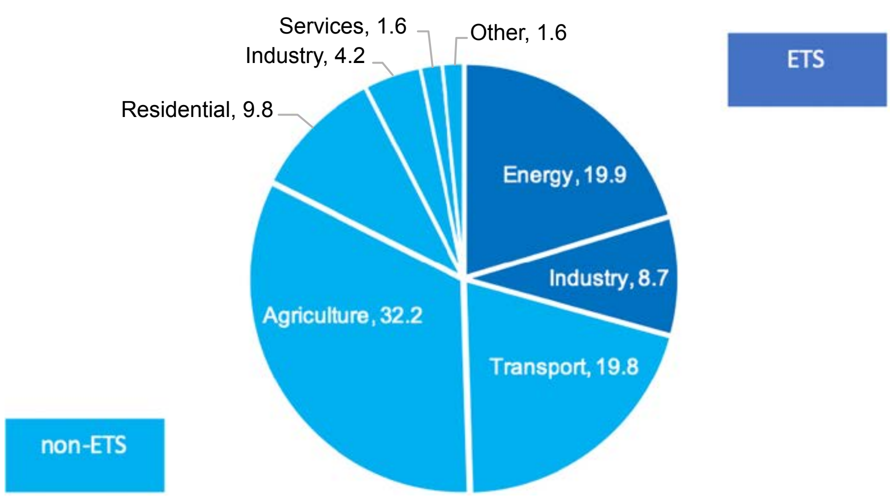

Figure 2.1. The distribution of Ireland's GHG emissions in 2016 (%).

2.2.2 Trends since the introduction of the EU ETS

Total GHG emissions in Ireland rose from 1990 to a peak in 2001 and have been falling in most years since 2002. Since 2005, when the ETS was first introduced, emissions by Irish firms regulated under the scheme have declined by 21%. Combined, total GHG emissions in Ireland declined by 11.5% from 2005 to 2016. Total GHG emissions in Ireland in 2016 were 61.54 million tonnes of CO_2 equivalent ($MtCO_2eq$) (Table 2.1). Total GHG emissions in 2016 were 3.6% higher than in 2015 and 10.9% above 1990 levels (EPA, 2018a).

We calculated that the emissions intensity of economic activity, i.e. the quantity of GHGs emitted per unit of economic output), has been declining steadily over the past 25 years, at a rate of about 4% per year, resulting in a total decline in emission intensity of Irish economic activity of around 65% since 1990 (data not shown). The latest predictions for 2020 by Ireland's EPA (EPA, 2018b) indicate that emissions from those sectors of the economy covered by the EU ESD could be between 0% and 1% below 2005 levels.

2.3 Competitiveness of Firms Subject to Environmental Regulation

2.3.1 Introduction

In this section we assess the international evidence on the competitiveness effects of environmental regulation, with a particular focus on the key issues of costs, innovation and relocation risk and the net

Table 2.1. GHG emissions in Ireland since the introduction of the EU ETS: 2005 and 2016 and percentage change

	2005			2016			2005–2016
	$MtCO_2eq$	% of total	% of ETS	$MtCO_2eq$	% of total	% of ETS	% change
Total emissions	69.54			61.55			–11.5
ETS	$MtCO_2eq$	% of total	% of ETS	$MtCO_2eq$	% of total	% of ETS	% change
Total ETS	22.33	32.1		17.73	28.8		–20.6
Powergen	15.66	22.5	70.1	12.25	19.9	69.1	–21.7
Industry	6.59	9.5	29.5	5.37	8.7	30.3	–18.5
Services	0.06	0.1	0.3	0.03	0.0	0.2	–56.6
Other	0.01			0.08			
Non-ETS	$MtCO_2eq$	% of total	% of non- ETS	$MtCO_2eq$	% of total	% of non- ETS	% change
Total non-ETS	47.21	67.9		43.81	71.2		–7.2
Subject to carbon tax	26.07	37.5	55.2	23.00	37.4	52.5	–11.8
Not subject to carbon tax (agriculture and waste)	21.14	30.4	44.8	20.81	33.8	47.5	–1.6
Non-ETS sectors							
Energy	0.26	0.4	0.6	0.30	0.5		16.2
Transport	13.06	18.8	27.7	12.21	19.8	27.9	–6.5
Agriculture	19.85	28.5	42.0	19.85	32.3	45.3	0.0
Residential	7.26	10.4	15.4	6.05	9.8	13.8	–16.7
Industry	3.06	4.4	6.5	2.60	4.2	5.9	–15.0
Services	1.41	2.0	3.0	0.97	1.6	2.2	–31.5
Other	2.57			1.83			

Source: total emissions from EPA (2018a). Industrial production refers to sectors included in the CSO's Census of Industrial Production, i.e. International Standard Classification Code (Nomenclature statistique des activités économiques dans la Communauté européenne; NACE) B0510 to E3900, and includes industrial processes, manufacturing combustion and F-gases. Values may not sum due to rounding. Emissions "subject to carbon tax" includes all sectors not covered by the ETS, except for agriculture and waste. The carbon tax, introduced in 2010, was not applied in 2005.

effects of environmental regulation on the bottom line for regulated firms. Many indicators have been used to measure the effects of environmental regulation on competitiveness at the firm level including productivity, gross value added (GVA), profitability, employment, product prices, output, market share, investments, net imports and innovation activity, as measured by patent counts or research and development (R&D) expenditure (Dechezleprêtre and Sato, 2017).

Environmental regulations have long been seen as a threat to business competitiveness. Going back to the first major environmental regulations of the 1970s, concerns have been expressed over the potential impacts on business (Delmas *et al*., 2015; Dechezleprêtre and Sato, 2017). There is now a substantial and growing literature that looks at the effects of environmental regulation on economic performance of regulated firms (for recent reviews see Ambec *et al*., 2013; Koźluk and Zipperer, 2013; Dechezleprêtre and Sato, 2017; Muuls *et al*., 2016). This literature has received renewed impetus in recent years as a result of efforts to reduce GHG emissions and the perception that such efforts will harm the economies of countries that take the lead in tackling climate change. Such concerns are perhaps not surprising given the historical dependence of economic development on fossil fuel exploitation (e.g. Fouquet, 2016; Fankhauser and Jotzo, 2017).

Broadly speaking, efforts to reduce GHG emissions are justified on the basis of the avoided future damages from climate change. Government intervention is required to "internalise" the pollution externality by bringing the private cost of polluting activity into line with the social cost, for example by putting a price on carbon emissions. Environmental regulation should lead to improved outcomes for society. It is also important to note that an assessment of the competitiveness or business effects of environmental regulation needs to consider the appropriate reference scenario (Oberndorfer and Rennings, 2007). If inaction is not an option for policymakers, for example because of international commitments, then business as usual is not an appropriate reference scenario for the evaluation of a particular policy. For example, in the absence of the EU ETS, achieving emissions reduction targets using some other mechanism would likely impose much larger costs (Oberndorfer and Rennings, 2007).

Furthermore, in the case of GHG emissions, the costs of regulation aimed at reducing emissions are borne locally whereas the benefits (the avoided future damages) are dispersed globally, leading to the risk of free-riding behaviour internationally, notwithstanding the potential for local co-benefits from reduced GHG emissions (Graff Zivin and Neidell, 2013; Green, 2015).

Potential impacts such as added costs, reduced profits and damaged competitiveness in international trade mean that attempts to regulate GHG emissions have become a highly political issue in many countries and fears are regularly expressed over potential competitiveness effects. If the strength and enforcement of environmental regulation varies across jurisdictions, local firms facing higher direct and indirect costs might struggle to compete internationally, whereas multinational firms might seek out locations with the lowest "burden" of environmental regulation, moving jobs and production overseas – known as the "pollution haven" hypothesis. Others argue for a "green growth" paradigm, whereby environmental regulation (and more generally the transition towards a low-carbon economy) stimulates innovation and economic growth (e.g. Porter, 1991; Bowen and Fankhauser, 2011).

2.3.2 *The Porter hypothesis*

According to the "induced innovation" hypothesis of Sir John Hicks, price signals are expected to drive innovation: "a change in the relative prices of the factors of production is itself a spur to invention, and to invention of a particular kind – directed to economising the use of a factor which has become relatively expensive" (Hicks, 1932, pp. 124–125, as quoted in Newell *et al*., 1999). The induced innovation hypothesis has often been applied in the analysis of labour markets, formulated as the expectation that increases in real wages will induce labour-saving innovation.

Michael Porter was one of the first economists to apply this theory to environmental regulation. He put forward the idea that environmental regulation could actually enhance competitiveness of regulated firms (Porter, 1991; Porter and van der Linde, 1995). This can appear counterintuitive for business. For the individual firm, environmental regulation represents an additional constraint on the firm's maximisation of profit and therefore must involve some cost (Ambec *et al*., 2013). Considering that firms are rational and profit-maximising then profitable opportunities that are also pro environment (eco-innovations) would already be exploited. The analogy often used is that we do not expect to see dollar bills lying on the ground – if there were, someone would already have picked them up. However, there are a number of reasons to believe that firms may be leaving bills on the sidewalk when it comes to environmental behaviour.

Porter's theory, based on evidence from case studies, was that firms might benefit from their attention being drawn to (costly) waste in the production process – the idea being that pollution itself represented a waste of resources: "Pollution is a manifestation of economic waste and involves unnecessary or incomplete utilisation of resources … Reducing pollution is often coincident with improving productivity with which resources are used" (Porter and van der Linde, 1995, p. 98). By reducing waste, firms might reduce costs and therefore gain an advantage over competitors. In addition, Porter argues that "properly designed environmental regulation can trigger innovation that may partially or more than fully offset the costs of complying with them" (1995, p. 98). Note the emphasis here on well-designed regulation, which refers in particular to market-based instruments such as cap-and-trade schemes or pollution taxes. The Porter hypothesis, as it has become known, has garnered substantial attention in the academic literature. However, the results have been mixed and many open questions remain (Ambec *et al*., 2013).

2.3.3 Why Porter might be right

Porter and van der Linde (1995) put forward some mechanisms to explain why environmental regulation might benefit firms: by signalling potential resource inefficiencies or raising corporate awareness; by reducing uncertainty about the value of environmental investments; by motivating innovation; or by levelling the transitional playing field. However, the Porter hypothesis still relies on the idea that firms are neglecting potentially profitable opportunities. There are a number of reasons that this could happen. Firms may be focused on survival strategies rather than profit maximisation (Alchian, 1950). Firm strategy is partly determined by individual managers, who may prioritise other incentives or motivations, or who may be risk averse or resistant to change. This could lead to missed opportunities that are potentially profitable for the firm. Similarly, organisational failures, to do with information asymmetries or governance structures within the firm, may lead to missed opportunities (Ambec *et al*., 2013, Meleo, 2014). There is also the more general problem of an under-supply of innovation activity, in the absence of any intervention (Jaffe *et al*., 2005).

2.3.4 How do firms respond to regulation?

Firms have various options to comply with environmental regulation, ranging from "soft" or behavioural changes to new investments and innovation activity. In the case of GHG emissions, behavioural or "soft" changes might include buying allowances and passing through costs, changes to production practices, efforts at improving energy efficiency or fuel switching (reducing the GHG content of energy used). These are low-cost and low-commitment-type responses. Soft responses are typical in response to modest regulation.

Alternatively, firms may decide to invest in new pollution-reducing capital or to invest in R&D with the aim of producing emissions-reducing innovations. Such investments involve a greater degree of commitment (or sunk costs) and are therefore sensitive to uncertainty in cost–benefit analysis. Uncertainty means that waiting for new information on how the regulatory environment will evolve is a viable option (Anderson *et al*., 2011). A survey of OECD countries found that manufacturing firms spent between 1% and 5% of total capital expenditure on pollution control investments (Pasurka, 2008). Of course, diverting investment towards pollution control is likely to involve an opportunity cost in the form of foregone opportunities to invest in (possibly more productive) alternative uses (Lanoie *et al*., 2011). For example, Gray and Shadbegian (1998, 2003) found that more stringent air and water regulations encouraged investment in "cleaner" production technologies among US paper mills, but that such investment tended to divert from productive investment, reducing productivity.

Finally, firms may simply decide to reduce activity (in regulated plants) or even relocate their activities to jurisdictions with less stringent regulation (the pollution haven hypothesis).

2.3.5 Innovation

The effect of environmental regulation on innovation is a large determinant of the success of the regulation as innovation activity will ultimately reduce the future costs of compliance/abatement and help to shift the economy on to a "green" growth path (Acemoglu *et al*., 2012; Calel and Dechezleprêtre, 2014). Innovation is also a key determinant of a firm's competitiveness, and the potential effect of regulation on innovation is one of the primary mechanisms by which regulation might benefit a firm, according to the Porter hypothesis. The impact of environmental regulation on innovation depends on the type of environmental regulation regime implemented and the stringency of the regulation.

Porter (1991) emphasised that only "*properly designed*" regulation should be expected to stimulate innovation. In general, regulations that set minimum technological standards direct innovation efforts towards minimising the costs of meeting the required technology standard. A regulatory system that puts a price directly on the pollutant is more likely to direct innovative efforts towards improvements in environmental performance up to the point where the cost of abatement is balanced by the cost of polluting. The market-based EU ETS cap-and-trade system is an example of the latter.

Popp (2003) found that reform of the US Clean Air Act in 1990 shifted innovation effort from cost-minimisation to innovation aimed at improvement in environmental performance. Prior to 1990, regulation required power companies to install scrubbers that removed sulphur dioxide from their emissions with a 90% removal rate. Therefore, the innovation effort was focused on scrubber technology: improving scrubber performance and reducing the costs of installing and maintaining scrubbers. With reform of the regulation, and the introduction of emissions trading, the innovation effort was expanded to address reducing emissions. Similarly, a study of the impact of charges on nitrogen oxides in Sweden over the period from 1990 to 1996 found that substantial emission reduction had taken place at zero or very low cost (Hoglund Isaksson, 2005).

When the "induced innovation" idea is applied to environmental issues, we expect higher energy prices to stimulate investments that lead to advances in less energy-intensive technologies (Newell *et al*., 1999). There is strong evidence of the effect of energy prices on energy-saving innovations; for example, using detailed product-level data for the USA over the period from 1953 to 1993, Newell *et al*. (1999) found that high energy prices associated with the oil price hikes of the 1970s induced innovations in air-conditioning that both reduced costs for consumers and improved energy efficiency. Similarly, using US patent data for 1970–1994, Popp (2002) found that high energy prices resulted in an increase in patenting of energy-saving innovations. Acemoglu and Finkelstein (2008) show something similar for health care; they found evidence suggesting that capital investments and technology adoption are highly responsive to changes in relative prices caused by regulation.

Environmental policy stringency has been shown to be associated with increases in environmental patent counts (e.g. Jaffe and Palmer, 1997; Brunnermeier and Cohen, 2003). Calel and Dechezleprêtre (2014) found convincing evidence that the ETS has had a causal effect in stimulating environmental innovation and, moreover, that the induced innovation has not displaced other forms of innovation. However, perhaps not surprisingly, given the relatively modest price signal from the EU ETS to date, the observed effects are modest in scale, with regulated companies found to have increased clean-tech patenting activity by 8.1%, which corresponds to a 0.85% increase in total clean-tech patents filed at the European Patent Office. It is also worth noting that patent count data are likely to understate the true scale of innovative activity, given strategic patenting decisions by firms and the often long time lag between innovation effort and patent application. This last point may be particularly relevant given the relatively short time span of the EU ETS (Muûls *et al*., 2016). Data on R&D spending by Italian firms suggest that those regulated by the EU ETS were more likely to be involved in environmental innovation (Borghesi *et al*., 2012). An earlier EU-wide survey (conducted by the European Commission Directorate-General for Environment; McKinsey & Company and Ecofys, 2005) also found evidence suggesting that the EU ETS has had a more powerful impact on innovation activity than might have been anticipated, given the relatively weak price signal (Oberndorfer and Rennings, 2007).

The modest effects of the ETS on innovative activity to date reflects the low stringency of the scheme. The relatively weak price signal as well as the institutional set-up of the market (how it has functioned so far), i.e. limited coverage of the scheme (not all sectors or firms are included), widespread and generous grandfathering of permits in the initial phases and uncertainty about how the system will evolve over time, combined with an inability to bank permits at the end of Phase I, have reduced the incentive for innovation to address GHG emissions. As the EU ETS reforms for Phase IV come into effect, we can expect stronger effects on environmental innovation activity.

Lanoie *et al*. (2011) list factors likely to affect the propensity of firms to conduct environmental R&D, including a firm's location and sector, firm size, market concentration, multinational or multi-facility status and whether or not a firm sells to final consumers or to other firms, as well as the geographical scope of a firm's target market.

2.3.6 Carbon leakage and relocation risk

A common concern for any regulatory regime with limited coverage (across geography or across business units) is that reductions in pollution will be achieved through displacement, i.e. pollution will show up elsewhere in non-regulated firms or locations with weaker regulatory regimes. With reference to the ETS, the idea of "carbon leakage" refers specifically to the possibility that emissions "escape" from regulated to non-regulated entities via international trade (Dechezleprêtre and Sato, 2017). Another related concern for policymakers is the perceived risk that jobs will be lost overseas if stringent environmental regulations are imposed, known as the "pollution haven" hypothesis or simply relocation risk. There are two aspects to deterring carbon leakage and relocation risk occurring in the EU: the development of carbon markets internationally and the EU carbon leakage list.[4]

The development of international carbon markets, especially in China (Sun *et al*., 2016), means that, in 2018, 20% of global GHG emissions were covered by a carbon pricing initiative (World Bank and Ecofys, 2018). There are 51 carbon pricing initiatives implemented or planned to cover 45 national jurisdictions and 25 subnational jurisdictions (World Bank and Ecofys, 2018). The integration of these carbon markets is envisioned. In effect, the opportunity to move to a jurisdiction with more relaxed GHG emission regulation has reduced.

Notwithstanding the development of ETSs in other regions, the EU still regards carbon leakage as a major issue. In an effort to combat the perceived risk that firms will simply relocate to other jurisdictions if the competitiveness burden is too severe, free allowances are allocated to firms in sectors deemed to be at high risk of relocating. These sectors are listed on the carbon leakage list. How the EU determines sectors at risk of carbon leakage is specified in Article 10a of the EU ETS directive.[5] Broadly speaking, for Phase IV of the EU ETS, serious risk of carbon leakage is based on a sector's trade intensity with third countries multiplied by the sector's emission intensity scoring above the threshold of 0.2.

In addition, a limited number of some sectors are eligible for assessment at a qualitative level or at a subsector level. The placement of a sector or subsector on the carbon leakage list grants to each installation in those (sub)sectors 100% of their calculated free allocation based on the relevant benchmark(s), whereas those not on the list will receive 30% (up to 2026), which will be gradually phased out by 2030.

There is evidence from the USA that environmental regulation has had modest negative effects on employment in pollution-intensive sectors (Greenstone, 2002, Kahn and Mansur, 2013), whereas other studies find no effect (Berman and Bui, 2001) or even a positive effect in some industries (Morgenstern *et al*., 2002). In relation to the EU ETS, some evidence suggests that the first phase of the

4 "Sectors and subsectors in relation to which the product resulting from multiplying their 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 European Economic Area (annual turnover plus total imports from third countries), by their emission intensity, measured in kgCO_2, divided by their gross value added (in euros), exceeds 0,2, shall be deemed to be at risk of carbon leakage. Such sectors and subsectors shall be allocated allowances free of charge for the period until 2030 at 100% of the quantity determined pursuant to Article 10a". Directive (EU) 2018/410. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0410&from=BG (accessed 6 February 2019).

5 See https://ec.europa.eu/clima/policies/ets/allowances/leakage_en (accessed 6 February 2019).

EU ETS had no effect on employment in regulated companies relative to unregulated companies (Anger and Oberndorfer, 2008; Commins *et al*., 2011; Petrick and Wagner, 2014), with other studies finding ambiguous effects (Abrell *et al*., 2011; Chan *et al*., 2013). Survey evidence from six European countries indicated that managers in regulated firms did not expect carbon pricing to affect their location decisions but they were more concerned about downsizing of production and employment than managers of unregulated firms (Martin *et al*., 2014a,b).

Overall, the available evidence on the pollution haven remains mixed, in part because of empirical challenges in estimating the effects of regulation on firm location choice, for example related to problems finding good measures of the relative stringency of environmental regulations across jurisdictions (Dechezleprêtre and Sato, 2017). Evidence from the USA shows that states with more stringent environmental regulation tend to receive lower flows of FDI (List and Co, 2000). In contrast, a study of 21 European countries found that greater stringency was associated with higher investment (Leiter *et al*., 2011). In sum, although there is evidence that environmental regulation can affect firm location choices, these effects appear more likely to occur within countries – where relocation barriers are lower – rather than across borders (Dechezleprêtre and Sato, 2017).

According to the evidence cited in Muûls *et al*. (2016), the reduction in emissions achieved by the EU ETS has been real and not merely the result of carbon leakage (or the displacement of emissions). Firm-level studies using French and German data have shown that participating firms have reduced emissions, mainly through reductions in the energy intensity of production (Wagner *et al*., 2015). In addition, evidence indicates that carbon leakage within multinationals has been limited (Dechezleprêtre *et al*., 2014). Muûls *et al*. (2016) point out that the trade intensity criterion appears to be ill-suited to identifying companies with the highest absolute risk of relocation (Martin *et al*., 2014a). There is also the risk of transferring large subsidies to heavy emitters, if overcompensation occurs (see Pahle *et al*., 2011).

Further research in this area appears warranted, especially given the political attention devoted to fears over job losses and the effect of this on the design of environmental regulation, as witnessed in the allocation of permits under the EU ETS.

2.3.7 Environmental regulation and the success of regulated firms

Regulated firms and their lobbyists have long been expressing concern about the competitiveness effects of environmental regulation (Delmas *et al*., 2015; Dechezleprêtre and Sato, 2017). In response to implementation of the EU ETS in 2005, firms in energy-intensive industries complained about the potential loss in competitiveness because of higher energy prices (Oberndorfer and Rennings, 2007).

As previously stated, the impacts of environmental regulation on the competitiveness of a particular firm or sector will depend on a combination of the impact of the regulation on direct and indirect costs. More specifically, Meleo (2014) identifies a number of firm- or sector-specific characteristics that determine competitiveness effects:

- The relative burden of the regulation – costs of compliance relative to a firm's total costs. In the case of the ETS, this is largely determined by a firm's carbon or energy intensity of production.
- The shape of the (firm-specific) marginal abatement cost (MAC) curve, which depends on past investments.
- The ability to pass through regulatory costs to customers, which in turn depends on a combination of the degree of exposure to international trade, the price elasticity of demand and market concentration.

For most industries, even energy-intensive industries, energy prices make up a relatively small fraction of total costs compared with labour costs. Oberndorfer and Rennings (2007) cite German data showing that a 6% rise in energy costs would have the same effect on total costs for energy-intensive sectors as a 1% rise in labour costs (Eikmeier *et al*., 2005). Moreover, ex-ante modelling analysis suggested that the effects of the EU ETS on costs would be modest for most sectors, even compared with business as usual (Oberndorfer and Rennings, 2007). The evidence since the scheme's introduction shows that most sectors did not see high cost increases – in part because of the relatively generous allocation of free EUAs in the initial phases of the scheme and the consequently low price of EUAs. For example, regulated firms in the power sector saw material cost increases of between 5% and 8% in the first two phases of the ETS (Dechezleprêtre and Sato, 2017). Recent evidence suggests that energy-intensive industries (including powergen companies) have been successful in passing through costs of the EUAs to their customers. Although the relative cost burden of the regulation may be higher for these firms, the nature of the markets they operate in (less easily traded internationally, lower price elasticity of demand) combined with generous free EUA allocations appear to have insulated them from competitiveness effects in the early EU ETS phases.

As noted by Meleo (2014), when firms can pass through regulatory costs to customers, their competitiveness is not in danger and only distributional effects arise from regulation. However, it is important to note that, by power companies passing on the costs of the permit system to their customers, these higher energy costs could have a knock-on effect on the competitiveness of other firms. Although detailed studies of cost pass-through have been carried out at the firm level for power companies, the evidence for manufacturing is more limited and has tended to rely on aggregate prices at the sector level (Muûls *et al.*, 2016). Further research at the firm level is required to understand the competitiveness effects on manufacturing firms.

Reflecting on trading data from Phase I of the ETS, Ellerman *et al.* (2013) point out that what they term the “much more passive attitude to market participation” of industrial firms was a result of the relatively modest effect of the CO_2 price on the variable cost of their final output as compared with powergen companies.

Evidence from the stock market has also shown a somewhat perverse positive correlation between carbon prices and returns on stocks of major European power generation companies. In other words, as allowance prices rose (fell), stock market valuations of heavy emitters also rose (fell), indicating that markets considered these firms to be net beneficiaries from the permit system, reflecting their ability to pass through costs to customers, as well as power companies profiting from freely allocated permits (Veith *et al.*, 2009). This appears to be evidence of overcompensation of some industries; in an effort to compensate for potential competitiveness effects of the ETS, the initial free allocation of emissions permits has effectively provided a large transfer (or subsidy) to heavy emitters (Pahle *et al.*, 2011).

Investments by regulated firms in pollution control divert resources away from other productive uses. This may involve opportunity costs, particularly in the form of lost productivity. There is some evidence to support the idea that environmental regulation is associated with reduced firm productivity (Greenstone *et al.*, 2012), although there is no apparent consensus on this issue (Koźluk and Zipperer, 2013).

There is a “strong” version of the Porter hypothesis which suggests that environmental regulation spurs innovation, resulting in net benefits for regulated firms (Jaffe and Palmer, 1997; Ambec *et al.*, 2013). The available empirical evidence on this point again appears somewhat mixed. Some studies have found that more stringent environmental regulation is associated with lower productivity (Greenstone *et al.*, 2012), although these studies do not assess the intermediate step of the effect of regulation on innovation activity. Lanoie *et al.* (2011) attempt to quantify the full causal chain in the Porter hypothesis, from environmental regulation to innovation activity to firm performance. They found that regulation does induce innovation and that the induced innovation is beneficial for a firm’s bottom line. However, the effect is not enough to fully offset the costs of compliance with environmental regulation. Another study found evidence that green innovation induced by environmental regulation did not increase labour productivity (van Leeuwen and Mohnen, 2013). In contrast, Rexhäuser and Rammer (2014) found evidence of a positive effect on firm-level profitability from regulation-induced innovations that reduce material or energy consumption. This finding is in line with Porter’s original contention that environmental regulation might “shine a light” on costly waste or inefficiency in the production process. We find similar results for Irish firms, in which capital green investment is associated with improved resource efficiency, which in turn is good for business (see Chapter 3).

2.4 Looking to the Future

2.4.1 How prepared are Irish firms?

There is little evidence to indicate that Irish firms are prepared for increasing stringency of the EU ETS. A previous study of firm-level determinants of current and capital expenditure on pollution control for Irish firms, using Census of Industrial Production (CIP) data from 2006 and 2007, found that larger, exporting and energy-intensive firms were more likely to spend and, more generally, that it was the largest and most polluting firms that appeared to be doing most to reduce pollution (Haller and Murphy, 2012). A related study found that Irish manufacturing firms respond to energy price increases by substituting capital for energy; specifically, a 1% increase in the price of energy was found to result in a 0.04% rise in demand for capital, with greater responsiveness observed in capital-intensive firms and lower responsiveness observed for foreign-owned firms (Haller and Hyland, 2014).

In a survey of Irish firms, Anderson *et al*. (2011) found that the introduction of the EU ETS had not had a large effect on investment behaviour – most firms were able to meet their obligations using “soft” process or behavioural changes, or what Anderson *et al*. (2011) refer to as the “low hanging fruit” of emissions reduction. When firms had adopted less polluting technologies, they tended to refer to the ETS as a consideration, but with energy prices and expectations as the major incentive driving investment decisions. Uncertainty over permit prices was cited as a reason for not taking action by 19% of firms (a theme we return to later), with lack of funding also a commonly cited barrier to investment. Their survey also found that little or no resources were being devoted to low-carbon R&D during Phase I of the ETS.

Separate survey evidence on Irish firms suggests that regulation and customer pressure are important determinants of the decision to pursue various forms of eco-innovation, as reported by firms (Doran and Ryan, 2012). There is also some evidence that eco-innovation by Irish firms can be associated with improved firm performance (in terms of turnover per worker), but only for certain types of eco-innovation (e.g. efforts to reduce the CO_2 footprint) and when multiple or complementary forms of eco-innovation are pursued simultaneously (Doran and Ryan, 2014).

Although capital investment in emissions reduction is low, there is already a strong energy management culture in Ireland, particularly for larger commercial enterprises. A number of support schemes have been introduced in Ireland to support Irish companies with the transition to complete decarbonisation. This includes the Large Industry Energy Network (LIEN), the Energy Agreements Programme, the Excellence in Energy Efficiency Design (EXEED) and the National Energy Services Framework, which have led to significant energy savings for participating enterprises.

The National Energy Efficiency Fund provides specialist financial expertise and appropriately structured funding for large-scale energy efficiency projects in the private and public sectors. The Accelerated Capital Allowance Scheme encourages capital investment in highly efficient plant and machinery by allowing accelerated tax relief on the expenditure.

The Energy Efficiency Obligation Scheme (EEOS) implemented pursuant to the Energy Efficiency Directive 2012/27/EU, Article 7, which imposes a legal obligation on Member States to achieve reductions of 1.5% of the annual energy sales to final customers, has been the single biggest catalyst for investment in energy-efficient equipment. This is because the supply companies are paying part of the upfront capital cost and recouping these over the lifetime of the assets from customer bills.

The Better Energy Communities Scheme has also been a catalyst for energy-efficient retrofits for similar reasons. See Johannsdottir and McInerney (2016) for an overview of innovative financing structures being employed to encourage investment in the low-carbon transition.

2.4.2 Lessons for design of environmental policy

The business impacts of environmental regulation depend on the design of the specific policies implemented. Indeed, Porter argued that only properly designed regulation should be expected to deliver the innovation and competitiveness benefits associated with the Porter hypothesis (Porter, 1991; Ambec *et al*., 2013). This generally refers to market-based mechanisms, such as carbon taxes or cap-and-trade regimes, which, by putting a price on pollution, create a signal and an incentive for firms to reduce pollution at least cost, including via the stimulation of green innovation. The commercial and industrial sectors account for a significant proportion of energy use in Ireland and are central to economic growth and employment. The commercial and industrial sectors combined account for close to 30% of the total final energy consumption. Evidence specific to Irish firms has also found that a price instrument alone may be insufficient to incentivise firms to switch from oil to electricity (considered a necessary precondition for decarbonisation of manufacturing) (Haller and Hyland, 2014). Acemoglu *et al*. (2012) argue that putting a price on carbon may on its own be insufficient to trigger an efficient transition to clean technology as it may not address the under-supply of innovation activity. Private markets generally under-supply innovation activity because of spillovers from the innovator to other firms. Simply, investment in R&D benefits competitors as well as the firm making the investment. There is not always a first-mover advantage in process innovation. The efficient transition path may therefore require both a price on carbon and subsidies for low-carbon innovation to push the economy onto the least-cost transition path (Acemoglu *et al*., 2012).

The Porter hypothesis also emphasises the potential for environmental regulation to direct firms' attention towards wasteful and costly practices that may otherwise have gone unnoticed. These effects might be particularly relevant for small and medium-sized enterprises (SMEs) where managerial time and technical expertise may be lacking (Ambec *et al*., 2013). Two recent studies that evaluated training programmes in Canada (Lanoie and Rochon-Fabien, 2012) and Mexico (Lyon and van Hoof, 2009) that aim to help small businesses to identify profitable opportunities that are also good for the environment have found evidence of their success in reducing costs and pollution at the same time for the participating firms.

There is also a growing trend towards industry-led initiatives, including, for example, the Carbon Disclosure Project, quasi-mandatory reporting requirements from stock exchanges and other voluntary corporate reporting initiatives (Ambec *et al*., 2013). Voluntary schemes, involving industry networks, have already shown some promise in delivering emissions reductions. For example, an assessment of the LIEN – a voluntary network of large energy users in Ireland – suggests that 38% of the energy savings achieved by LIEN companies is attributable to their participation in the scheme (Cahill and Ó Gallachóir, 2012).

2.4.3 Carbon price uncertainty

An additional and often-cited constraint on low-carbon innovation is the perceived uncertainty around carbon prices. However, price volatility is not a new phenomenon for firms – all markets exhibit this phenomenon to a greater or lesser extent and financial instruments are available to hedge against unfavourable future price movements. As Ellerman *et al*. (2013) have shown, the volatility of allowance prices in the initial phase of the EU ETS was "comparable to that for other energy commodities and generally greater than the volatility of coal and crude oil but less than that for natural gas and electricity" (p. 150). Planned reductions in the emissions cap in the ETS over coming years and the Market Stability Reserve should help to create a stronger price signal over time. Some Member States are proposing to implement a CPF in the scheme to create a guaranteed minimum price on carbon. This is explored further in Chapter 5.

A stronger price signal should help to induce greater innovation and a speedier transition to a low-carbon economy. However, a higher carbon price could also result in stronger competitive effects than the relatively modest impacts observed in the literature to date. These effects will vary substantially by firm and by sector, and policymakers will likely want to offer supports to vulnerable industries, where job losses might be anticipated during the transition to a low-carbon economy, particularly those that might be politically sensitive because of geographical, historical or other considerations. However, such supports need to be carefully considered to avoid subsidising "dirty" technologies, adding further to the cost, or unnecessarily delaying the period, of transition. Particularly important will be the ability to objectively and accurately identify which industries are most in need of such supports, so that these are targeted in an efficient and non-political manner. Our review has highlighted specific indicators that can be used to objectively identify the sectors and firms most likely to be vulnerable to increasingly stringent restrictions on GHG emissions.

2.5 Conclusions

It has been estimated that the EU ETS resulted in an aggregate reduction in emissions of between 100 and 200 MtCO_2eq across all regulated sectors and countries during the first 2 years of Phase I (Ellerman and Buchner, 2007, 2008), which is equivalent to a reduction of between 2.4% and 4.7% in total emissions (Muüls *et al*., 2016).

The GHG intensity of economic activity in Ireland has been declining steadily for the past 25 years and in recent years emissions have been falling modestly in absolute terms both during years of economic expansion and during recession, albeit emissions have started to rise again with the economic recovery. Total emissions (from the ETS and the non-ETS sectors) remain slightly above 1990 levels, however, and the latest forecasts from the EPA suggest that non-ETS emissions will remain well above target in 2020. The complete decarbonisation of the economy that is required by the second half of this century – to meet international commitments and avoid dangerous levels of global warming – represents a step change in the pace and scale of emissions reduction seen to date. What does that mean for the Irish economy, and for Irish business in particular?

We have highlighted a number of key metrics from the literature that can be used to identify which sectors and firms are most likely to be exposed to any competitiveness effects arising from a stronger price signal, including the GHG intensity of production [a combination of energy intensity, fuel mix and process emissions (in Ireland process emissions mainly arise in the cement and lime industries)], the firm-specific MAC curve (which depends on past investments by the firm) and the extent to which the firm is exposed to (international) competition.

Evidence to date on the preparedness of Irish firms for a future with more stringent restrictions on GHG emissions is somewhat mixed. Firms participating in the EU ETS reported that they were able to meet their obligations in the first phase of the scheme through soft or behavioural changes (e.g. fuel switching), with little or no resources being devoted to low-carbon R&D. A lack of funding (related to the scale of Irish operations) and uncertainty over future regulation were cited as important barriers to innovation. Separate survey evidence (without distinguishing regulated from non-regulated firms) suggests that Irish firms are pursuing various forms of eco-innovation, motivated by regulation as well as by consumer demands, with efforts to reduce carbon footprints associated with improved firm performance. Our own analysis of Irish firm-level data found that, in 2014, one in five manufacturing firms in Ireland reported some non-capital expenditure on pollution control, whereas 12% reported capital investments in pollution control or cleaner technologies. However, the size of these investments is relatively small, averaging less than 1% of firms' total capital spend.

As the intensity of efforts to decarbonise the economy increases, policymakers both internationally and locally will need to focus on how best to design GHG regulations such that emissions reduction occurs efficiently and at least cost, while also supporting the continued competitiveness of regulated firms and sectors. Available evidence to date, as reviewed here, suggests that price-based mechanisms (e.g. the EU's ETS) can be effective in reducing emissions and stimulating clean-tech innovation, without imposing large competitiveness costs on regulated firms, whereas, at the local level, policy could target specific constraints faced by firms (particularly SMEs), including informational and financial barriers to reducing the pollution intensity of their operations, although these need to be within state aid rules.

3 Evidence of Green Investment during EU ETS Phases I–III and Its Impact on Business

3.1 Introduction

The purpose of environmental regulations aimed at business sectors is twofold: (1) to reduce current pollution and (2) to effect long-term change to a less damaging way of doing business. Here, we investigate the second aspect. An ambitious innovation strategy is needed to decarbonise the EU industrial sectors by 2050. The EU ETS is expected to deliver innovation and investment in green technology. The progressively reducing free allocation of emissions allowances, the Market Stability Reserve and the CPF proposed by some Member States are mechanisms to alter the MAC in favour of investment.

In this chapter, we consider green expenditure by Irish manufacturing firms. We employ the CIP survey returns over the period from 2006 to 2014. This provides us with an unbalanced panel of 8147 firms and just over 35,000 observations in our estimations. It provides a unique and comprehensive view of the activity of every manufacturing firm in Ireland. A drawback of the data source is that the anonymised survey data preclude identifying which specific firms are regulated by the EU ETS. However, we can get a measure of firm fuel intensity and we can identify if a firm belongs to a sector that has high emissions.

In the first instance we examine the data to discover what type of green expenditure Irish firms are investing in. We then analyse the data to see if the different types of green expenditure impact on the resource efficiency and competitiveness of Irish firms. Finally, we analyse the data to see if the different types of green expenditure have affected business failure rates.

3.2 Types of Business Green Expenditure

Innovative green expenditure involves implementing new or modified processes, techniques and systems to reduce environmental harm. We assessed three types of business green expenditure with different levels of inherent innovation (Figure 3.1): current expenditure on the environment, capital expenditure on pollution control and capital expenditure on clean technology. Current expenditure on the environment leaves processes unchanged and is not an innovative response to regulation. It includes spending on monitoring, reporting and verification costs associated with pollution. The costs are incurred with respect to operation processes and allowance trading for ETS-regulated firms (Jaraitė *et al.*, 2010). The second and more innovative approach is capital expenditure on pollution control. Here, the focus is on integrated or end-of-pipeline pollution abatement with minor change to the process. It involves using filters, scrubbers, water purification techniques, etc. to deal with pollution and to keep within compliance limits. The third and most innovative approach is investment in clean technology. Pernick and Wilder (2007, p. 2) defined clean technology or "cleantech" as "a product, service, or process that delivers value using limited or zero non-renewable resources and/or creates significantly less waste than conventional offerings". The largest clean technology sector is renewable energy but other or overlapping strategies such as advanced materials, new chemical processes and recycling can be included under clean technology. Examples of capital expenditure on clean technology and pollution control are given in Figure 3.2.

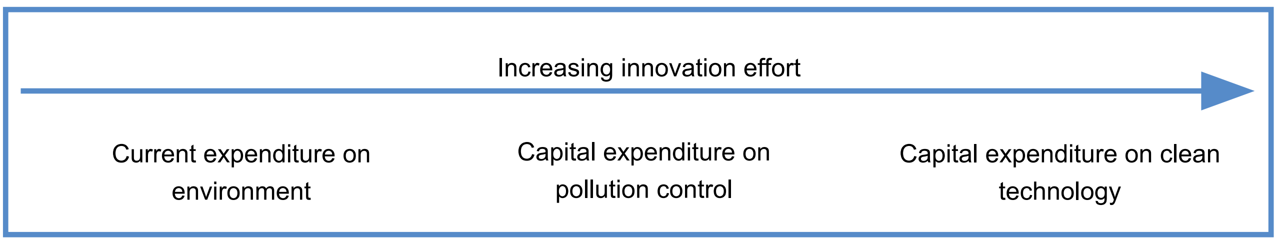

Figure 3.1. Three forms of green expenditure and their relative position in innovation efforts.

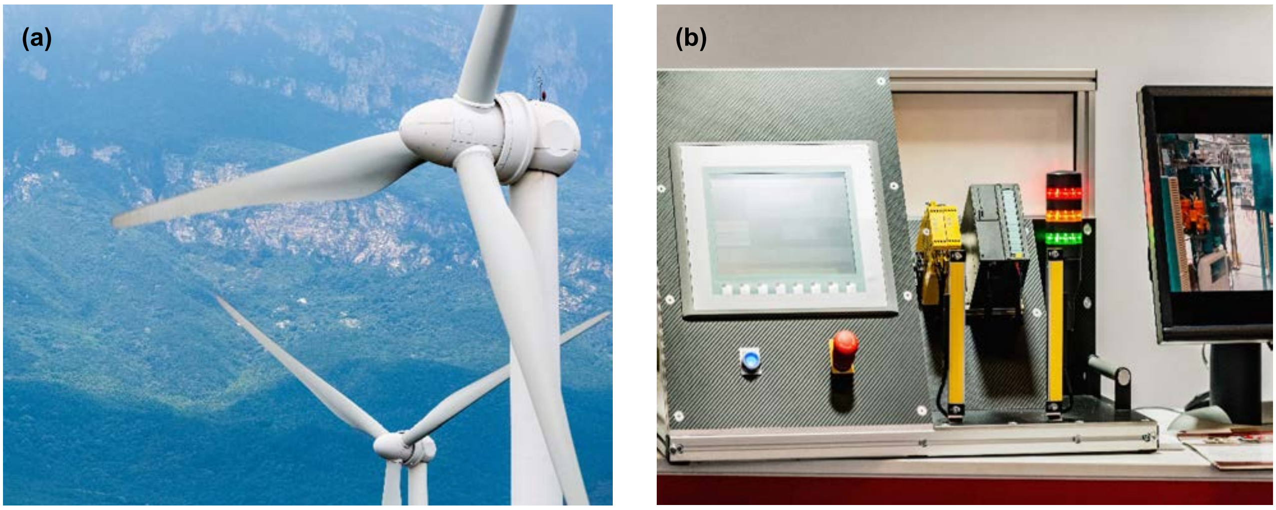

Figure 3.2. Clean technology and pollution control. (a) Clean technology optimises natural resources and reduces waste. In the context of GHG emissions it means sustainable energy sources. Example: GlaxoSmithKline (GSK) is a member of the Cork Lower Harbour Energy Group. GSK has installed a wind turbine. The 3 MW wind turbine started generating electricity in April 2014. It is expected to reduce emissions by 4000 $MtCO_2eq$/annum and provide 30% of the site electricity requirements. (b) Pollution control focuses on integrated or end-of-pipeline technology with minor changes to the process. Pollution results from the industrial or manufacturing process, but measures are taken at the end of the process to reduce polluting emissions. Pollution control involves using filters, scrubbers, water purification techniques, etc. to deal with pollution. Example: heat recovery or waste water treatment at the end of the industrial process.

3.3 Evidence of Green Investment by Irish Firms

Table 3.1 shows that the proportion of Irish enterprises with green expenditure (capital, non-capital or both) is low: 20% or less in each year over the period from 2006 to 2014. A reduction in the proportion of firms spending on the environment during the economic crisis suggests that green expenditure is sensitive to the business cycle. The increase in the number of firms expending (capital and/or non-capital) on the environment since 2013 is due to increases in the number of firms' current spending rather than significant increases in capital spending on clean technologies and/or pollution control (Table 3.1). The proportion of firms investing in clean technologies has increased only slightly to 6.6% in 2014 from 4.9% in 2006 (Table 3.1). The number of firms spending on the environment, either capital and/or non-capital, was slightly higher for those firms classified as high carbon intensity enterprises[6] (Table 3.2). This group is likely to include ETS-regulated firms. The numbers are still low but there are small peaks in the number of high fuel intensity firms investing around the time of the introduction of the EU ETS (2006) and at the start of Phase III (2013). It may be that awareness of the ETS is having an effect even without a strong price signal.

For those that did invest in environmental protection, the size of the investments in green expenditures (capital, non-capital, total capital and non-capital) were modest relative to total spend (Tables 3.3 and 3.4). Mean percentage expenditures on plant and equipment for clean technologies or pollution control are considerably less than 1% (Table 3.3). Taken together, the mean percentage capital expenditure is close to or just above 1% per annum (Table 3.3). Comparable mean percentage expenditures for carbon-intensive firms (Table 3.4) are slightly higher but they are in the lower range compared with international trends, i.e. 1–5% by firms in OECD countries (Pasurka, 2008). In addition, there is no

6 High carbon intensity: fuel intensity is measured as the ratio of the value of fuel used relative to gross value added per annum at constant prices in 2014. Firms with a fuel intensity level of 10% or higher were classed as high fuel intensity firms and include the upper 75th percentile of firms.

Table 3.1. Percentage of enterprises undertaking green expenditure

Expenditure	Phase I		Phase II					Phase III	
	2006	2007	2008	2009	2010	2011	2012	2013	2014
Capital spend on environment (%)	9.3	6.0	7.1	6.9	5.2	8.7	7.9	9.1	9.3
Capital spend on clean technologies (%)	4.9	3.8	4.1	4.4	3.8	6.5	5.6	5.6	6.6
Capital spend on pollution control (%)	5.8	3.4	4.5	3.8	3.4	3.3	3.5	4.4	4.0
Current spend on environment (%)	8.1	5.8	5.1	5.3	5.8	5.8	6.3	13.3	12.2
Capital and current spend on environment (%)	15.9	10.8	11.3	11.2	10.8	13.7	13.2	20.6	20.0

Table 3.2. Percentage of high carbon intensity enterprises undertaking green expenditure

Expenditure	Phase I		Phase II					Phase III	
	2006	2007	2008	2009	2010	2011	2012	2013	2014
Capital spend on environment (%)	10.4	8.1	6.6	8.8	6.9	8.5	8.3	12.2	7.9
Capital spend on clean technologies (%)	6.1	5.9	4.4	6.3	5.8	3.4	4.5	7.8	5.5
Capital spend on pollution control (%)	6.4	4.5	4.1	4.2	2.8	6.3	4.8	6.1	5.5
Current spend on environment (%)	11.8	9.9	7.5	8.1	7.3	9.4	9.5	23.8	20.8
Capital and current spend on environment (%)	19.2	15.9	12.7	15.4	13.3	16.8	16.0	32.7	24.5

Table 3.3. Percentage of total expenditure spent on green expenditure

Expenditure	Phase I		Phase II					Phase III	
	2006	2007	2008	2009	2010	2011	2012	2013	2014
Capital spend on environment (%)	1.18	0.62	1.10	0.94	0.89	1.52	1.21	1.49	0.85
Capital spend on clean technologies (%)	0.56	0.34	0.71	0.46	0.53	0.82	0.69	0.89	0.51
Capital spend on pollution control (%)	0.52	0.30	0.38	0.47	0.32	0.70	0.52	0.60	0.34
Current spend on environment (%)	0.05	0.04	0.03	0.04	0.04	0.05	0.04	0.09	0.07
Capital and current spend on environment (%)	0.20	0.09	0.14	0.13	0.12	0.19	0.15	0.20	0.18

Table 3.4. Percentage of total expenditure spent on green expenditure by high carbon intensity enterprises

Expenditure	Phase I		Phase II					Phase III	
	2006	2007	2008	2009	2010	2011	2012	2013	2014
Capital spend on environment (%)	1.62	0.84	0.95	1.15	1.05	2.46	1.57	3.17	0.87
Capital spend on clean technologies (%)	1.09	0.43	0.45	0.60	0.82	0.47	0.47	2.24	0.32
Capital spend on pollution control (%)	0.54	0.45	0.50	0.55	0.23	1.99	1.10	0.93	0.55
Current spend on environment (%)	0.07	0.06	0.07	0.08	0.09	0.09	0.09	0.18	0.11
Capital and current spend on environment (%)	0.28	0.10	0.14	0.16	0.20	0.24	0.17	0.30	0.19

sustained increase in the mean percentage green capital expenditure undertaken by firms, whether intense fuel users or not, as the ETS progresses from Phase I to Phase III. The reasoning behind the low investment figures in Phase I was investigated in a survey of Irish firms (Anderson *et al*., 2011). Anderson *et al*. (2011) found that, where firms had adopted less polluting technologies, they tended to refer to the ETS as a consideration, but current and forecasted energy prices were the major incentives driving investment decisions. Uncertainty over permit prices was cited as a reason for not taking action by 19% of firms.

Lack of funding was also a commonly cited barrier to investment. The survey also found that little or no resources were being devoted to low-carbon R&D during Phase I of the ETS.

3.4 The Impact of Green Expenditure on the Competitiveness of Irish Firms

The induced innovation hypothesis, and evidence on the link between energy prices and energy-saving innovation, help us understand why a regulatory system that puts a price on carbon emissions should be expected to result in innovation in carbon-saving technologies of various kinds (and not just by firms that are directly regulated – there may also be indirect inducement of innovation via the effects of permit prices on energy prices). Market mechanisms harness the power of the market and create a price signal that induces innovation. But this observation also complicates the identification of the causal effects of any environmental regulation on innovation activity. For example, if we find that environmental innovation has increased since the introduction of the EU ETS, this may be the result of the incentives created by the scheme, or it could be due to a coincident rise in energy prices.[7]

Separating out these effects is not straightforward. One option is to compare the innovative response of regulated and non-regulated firms (which by design omits any indirect effects of the scheme on the innovation activity of non-regulated firms). However, the results of this comparison are also likely to be biased as they include the effects of the ETS *plus* any underlying differences between regulated and non-regulated firms. This would not be an issue if regulated and non-regulated firms were identical, or if regulation was randomly assigned across firms. In reality, there are systematic differences, by design, between regulated and non-regulated firms in the ETS (Calel and Dechezleprêtre, 2014).

For this analysis we used regression techniques in a three-step chain approach to examine if we can establish a chain response from regulation to business performance (Figure 3.3). In this way we test the Porter hypothesis (see section 2.3.2) and ask two questions: (1) Has Phase II and Phase III of the ETS motivated firms to invest in capital green expenditure relative to Phase I? and (2) Does it pay to be green?

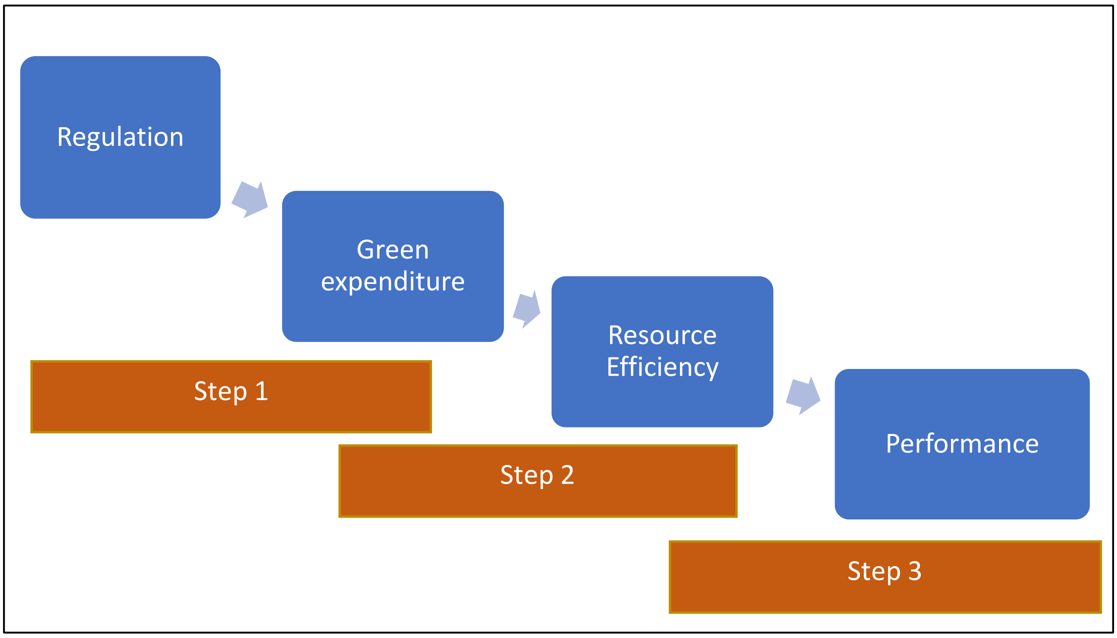

Figure 3.3. The three-stage approach to assess the impact of regulation on business.

7 While the ETS may have an effect on energy prices, it is not the predominant cause of movements in energy prices.

3.4.1 Step 1: do progressive phases of the EU ETS increase the likelihood of green investment?

In the first step we examined whether the phases of the EU ETS, representing increasing levels of perceived regulation stringency, increased the likelihood of green investment. Anderson *et al*. (2011) found that the introduction of the EU ETS had not had a large effect on investment behaviour – most firms were able to meet their obligations using "soft" process or behavioural changes, or what Anderson *et al*. (2011) refer to as the "low hanging fruit" of emissions reduction. We used data from Phase I as the baseline comparison to see if the subsequent ETS phases had a stronger impact on green investment. We controlled for sector, region and a range of firm characteristics such as firm size, foreign ownership and exporting and importing activity. A summary of the variables used in our analysis is given in Appendix 1 (Tables A1.1 and A1.2). A summary of the results is presented in Table 3.5, including results for firm fuel intensity, GHG intensity of production and international trade exposure, which were identified in Chapter 2 as having the potential to impact on firm competitiveness via increased carbon costs. We find the probability of investing in clean technology is reduced from Phase I to Phase II. We also find that the probability of current expenditure on the environment is reduced from Phase I to Phase II. Phase III does not significantly change the probability of any of the three types of green expenditure compared with Phase I. Our key finding is that ETS Phases II and III are not driving green technology investment and were not perceived to be more stringent than Phase I.

3.4.2 Step 2: is there a relationship between green expenditure and resource efficiency?

In the Porter hypothesis, pollution is seen as a waste of resources. Maintaining output while reducing consumption is the key step through which the positive effects of innovation can operate (Porter and van der Linde, 1995). Resource efficiency quantifies how efficiently industry uses both energy and material resources – both of which contribute to GHG emissions (Allwood *et al*., 2011). Step 2 examines the relationship between green expenditure and resource efficiency. The results are presented in Table 3.6. We also investigate the impact that green emissions expenditure has on resource efficiency in firms segregated on the basis of their sector emission levels and their carbon intensity (Table 3.6). Capital investment in pollution control is associated with improved resource efficiency in firms with high carbon intensity. Unsurprisingly, current expenditure on the environment reduces resource efficiency except for sectors in which emissions are high or very high (Table 3.6). Phases II and III of the ETS have had a general positive effect on resource efficiency of businesses but the effect is lost as

Table 3.5. Average marginal effects[a] (change in probability) for forms of green expenditure due to Phase II and Phase III and other firm characteristics (*n* = 35,700)

Variable	Capital expenditure		Current expenditure
	Clean technology	Pollution control	Environment
ETS Phase III vs Phase I	–	NS	–
ETS Phase III vs Phase I	NS	NS	NS
Sectorial emissions per output[b]	NS	NS	NS
Trade exposure[c]	+	NS	NS
Firm carbon intensity[d]	NS	–	NS

[a]Effects: +, significant positive effect; –, significant negative effect; NS, no significant effect.

[b]Sectorial emissions per output: emissions of each two-digit NACE (Nomenclature statistique des activités économiques dans la Communauté européenne) Rev. 2 code divided by the total GVA of that sector in 2005. The sectoral emissions data for 2005–2014 were obtained via the CSO Environmental Accounts Air Emissions survey (CSO, 2017).

[c]Trade exposure measures participation in international trade at the sector level by calculating the total value of imports and exports for each NACE Rev. 2 four-digit sector code and dividing this value by the market value of the aggregated output for that sector.

[d]Firm carbon intensity: the value of fuel used by each firm in time *t* divided by the GVA of the enterprise at time *t*.

Table 3.6. The impact of green expenditure on resource efficiency in Irish industrial enterprises[a]

Expenditure	Full sample	Sector emission levels				High carbon intensity	High carbon intensity in high emission sectors
		Low	Medium	High	Very high		
Current spend on environment	–	–	–	NS	NS	–	–
Capital spend on pollution control	NS	NS	NS	NS	NS	+	+
Capital spend on cleantech	+	+	+	+	+	+	–
ETS Phase II vs Phase I	+	+	+	NS	NS	NS	+
ETS Phase III vs Phase I	+	+	+	+	NS	NS	NS

[a]Effects: +, significant positive effect; –, significant negative effect; NS, no significant effect.

Table 3.7. The impact of resource efficiency on competitiveness (GVA per worker)[a]

Variable	Full sample	Sector emission levels				High carbon intensity	High carbon intensity in high emission sectors
		Low	Medium	High	Very high		
Resource efficiency	+	+	+	+	NS	+	+
ETS Phase II vs Phase I	–	–	–	–	NS	–	NS
ETS Phase III vs Phase I	+	NS	+	NS	NS	+	NS

[a]Effects: +, significant positive effect; –, significant negative effect; NS, no significant effect.

emissions increase and for firms with high carbon intensity. Phase II of the EU ETS had a positive effect on resource efficiency for carbon-intensive firms with high emissions. The emission levels and the sectors included in the different levels are described in Appendix 1 (see Table A1.3). A key finding is that capital investment in clean technology has a positive impact on resource efficiency in all cohorts except for firms with high carbon intensity in sectors with high GHG emissions.

3.4.3 Step 3: is there a relationship between resource efficiency and business performance?

To finish our chain of events model we look at the impact of resource efficiency on competitiveness measured as GVA per worker[8] (Table 3.7). The results show a positive link between resource efficiency and competitiveness across all cohorts except for firms in sectors with very high emissions. We find that, compared with Phase I, ETS Phase III has a positive impact on competitiveness although it was reduced in the intermediary Phase II. Our results agree with a previous study which found that eco-innovation by Irish firms can be associated with improved firm productivity (in terms of turnover per worker) (Doran and Ryan, 2014). This study also found that any business benefit depended on the type of eco-innovation (e.g. efforts to reduce the CO_2 footprint) or whether multiple or complementary forms of eco-innovation are pursued simultaneously.

3.5 Green Expenditure and Firm Closures

In this section we explore whether there is a link between green expenditure and the survival of

8 Gross value added per employee is the value of the output less the value of goods and services consumed as inputs by the production process for the relevant year divided by the number of employees for that year. The logarithmic value of GVA per employee is used in the analysis.

manufacturing firms in Ireland. We have seen in the previous analysis that green expenditure can have positive or negative impacts on the business performance of surviving firms depending on the different type of green expenditure incurred, sectoral emission levels and the carbon intensity of an enterprise. We now wish to examine whether current expenditure on the environment and green investment raises or lowers business failure rates. For this analysis we link our panel data set constructed using the CIP data to the business demography data to identify firms that ceased trading over the period from 2006 to 2014.

The results are presented in Tables 3.8 and 3.9. The analysis investigates the probability of firm exits so a factor with a significant positive coefficient is understood to raise the probability of exit and a factor with a significant negative coefficient is interpreted as decreasing the probability for exit, i.e. contributing to firm survival. Capital expenditure on clean technology had no impact on business failure. Capital expenditure on pollution control also had no impact on business failure except for enterprises in high-emitting sectors and carbon-intensive enterprises, where investment in pollution control reduced the probability of firm exits. Current expenditure is modestly associated with reduced business closures and this seems to be mainly in high emission sectors (see Table 3.8). Both Phase II and Phase III of the ETS reduced business failure rates compared with ETS Phase I.

We then looked at the impact of green expenditure on firm closures in key sectors that have been considered vulnerable to exit by closure: metals, food and water. We find that green expenditure did not impact on firm failure rates in these sectors (see Table 3.9). Similar to Irish industry generally, ETS Phases II and III were associated with reduced business failure rates compared with ETS Phase I.

3.6 Conclusions

Flexible market-based regulation is accepted as the modern approach to reduce current pollution and induce investment into innovative long-term solutions. An earlier EU-wide survey conducted by

Table 3.8. The impact of different types of green expenditure on firm exit[a] (closure or relocation)

Expenditure	Full sample	Sector emissions			High carbon intensity	High carbon intensity in high emission sectors
		Low	Medium	High		
Current spend on environment	–	NS	NS	–	NS	–
Capital spend on pollution control	NS	NS	NS	–	–	–
Capital spend on cleantech	NS	NS	NS	NS	NS	NS
ETS Phase II vs Phase I	–	–	–	–	–	–
ETS Phase III vs Phase I	–	–	–	–	–	–

[a]Effects: –, significant negative effect on exit, i.e. good for firm survival; NS, no significant effect.

Table 3.9. The impact of different types of green expenditure on firm exit[a] (closure or relocation) in key sectors[b]

Expenditure	Full sample	Manufacturing with basic metals	Food and beverage	Utilities
Current spent on environment	–	NS	NS	NS
Capital spend on pollution control	NS	NS	NS	NS
Capital spend on cleantech	NS	NS	NS	NS
ETS Phase II vs Phase I	–	–	–	NS
ETS Phase III vs Phase I	–	–	–	–

[a]Effects:–, significant negative effect on exit, i.e. good for firm survival; NS, no significant effect.

[b]Sectors (NACE, Nomenclature statistique des activités économiques dans la Communauté européenne, Rev. 2 code range in brackets): manufacturing with basic metals (2410–2932); food and beverage (1011–1107); utilities: electricity, gas, water and waste (3511–3900).

the European Commission Directorate-General for Environment (McKinsey & Company and Ecofys, 2005) found evidence suggesting that the EU ETS has had a more powerful impact on innovation activity than might have been anticipated, given the relatively weak price signal (Oberndorfer and Rennings, 2007). Our analysis covers a broad base of industrial sectors. Our study shows that the proportion of Irish manufacturing firms investing in clean technology is relatively small. Most certainly the economic downturn from 2008 to 2014 hindered the ability of firms to invest in capital projects. There has been an increase in the proportion of Irish manufacturing firms investing in clean technology from 16% in 2006 to 20% in the last 2 years examined here, i.e. 2013 and 2014. Not surprisingly, the proportion of firms investing in clean technology is higher amongst energy-intensive firms. This group of carbon-intense firms reach the lower range of 1–5% of total capital expenditure spent on capital green investments reported for international firms (Pasurka, 2008).

The results show that the stringency of Phases II and III have not been strict enough to drive major long-term investment in cleaner technological solutions. Yet Ireland has reduced its GHG emissions for the period under study (see Chapter 2). Firms have various options to comply with environmental regulation, ranging from “soft” or behavioural changes to new investments and innovation activity. In the case of GHG emissions, behavioural or “soft” changes might include changes to production practices, efforts at improving energy efficiency (reducing energy use) or fuel switching (reducing the GHG content of energy used). These are low-cost and low-commitment-type responses and might be typical in response to modest regulation and/or uncertainty regarding future regulation. Anderson *et al*. (2011) found that in Phase I most emissions reduction efforts by Irish firms regulated under the EU ETS were of the “soft” or behavioural type. Our results indicate that this continued for Phase II and Phase III.

One drawback of this analysis is that the anonymised survey data used preclude identifying what specific regulations individual firms are exposed to, i.e. whether firms are participants in the EU ETS or not. We address this by extending the analysis based on sector emission levels and carbon-intensive firms, which are likely to be the ETS-regulated firms.

Current expenditure on the environment is generally associated with reduced resource efficiency, except for high and very high emission sectors, suggesting that firms are absorbing the additional costs rather than passing through costs to their customers. This pay-as-you-go approach of current expenditure does not represent innovation but indicates that substitution material or technology is not available or that the regulation is too lax or that companies have doubts regarding the future stringency of the regulation. We see that investment in clean technology is associated with improved resource efficiency except in firms with high carbon intensity. Although increased resource efficiency results in increased competitiveness for all but those in the very high emission sectors, we find that the route to realising improved resource efficiency differs according to a firm’s carbon intensity.

We find that green expenditure has very little effect on firm failure rate and, when there is an effect, it is to reduce the likelihood of failure. This is the case even for current expenditure on the environment, which we see has a negative effect on resource efficiency.

The implications for industry and for policy development are apparent. It is important to identify the barriers that are preventing firms from investing in clean technology and improving competitiveness. These barriers are explored further in Chapter 5. Managers must decide on the appropriate response to regulation that balances compliance and competitiveness (Dechezleprêtre and Sato, 2017). Policymakers, in considering future policy changes, need to review the effect of past regulation on clean technology uptake, environmental performance and firm competitiveness to develop effective policy instruments to meet short-term and long-term international obligations (Vogt-Schilb and Hallegatte, 2014). It appears that a “one size fits all” model for green investment strategy is not appropriate. There are a number of approaches open to firms and differentiating the impact of different types of green investment provides a clearer picture to policymakers and business managers. Capital investment in pollution control may be more attractive in carbon-intensive enterprises when the decision considers the financial return only. Getting the message out regarding the benefits of green investment will be important to encourage industry to invest in clean technology.

4 Allowance Trading and Stakeholder Survey

4.1 Introduction

An allowance trading strategy or emissions reduction investments will become bigger issues for ETS-regulated firms as the structural changes of the EU ETS are applied to create scarcity. In this chapter we examine EU ETS allowance trading data to investigate the pattern of emissions and allowances in different sectors. We also present the results of a survey conducted to understand the experience of Irish firms operating within the EU ETS and to assess the state of preparedness of Irish industry for deep decarbonisation scenarios.

4.2 Trading Activity in Ireland

Irish companies regulated by the EU ETS may have little experience of strategic trading of allowances because of over-allocation of free allowances, the low price of auctioned allowances and operating through a global economic downturn. The overall picture of free and auctioned allowances for Ireland is presented in Figure 4.1. It can be seen that in the years from 2009 to 2012 there was an excess of allowances at the national level. De Bruyn *et al*. (2016) have estimated that for the EU from 2008 to 2014 over €8 billion of freely allocated emissions were used for creating additional profits for companies. The change in freely allocated allowances from Phase II to Phase III as a result of benchmarking and cross-sector correction in Phase III can be seen between 2012 and 2013 in Figure 4.1

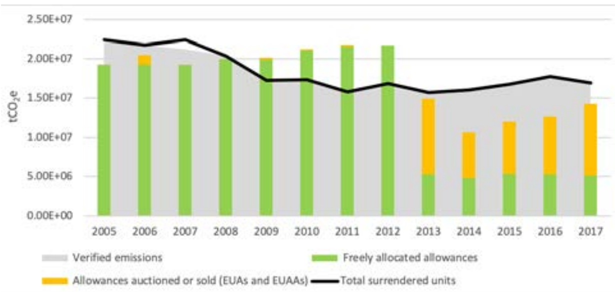

Figure 4.1. Free and auctioned allowances surrendered in Ireland from 2005 to 2015. Source: EEA (2018).

In 2013, installations received 80% of their benchmarked allocation, which is scheduled to decline to 30% in 2020. There are two exceptions to this: (1) dedicated electricity producers have not been eligible for free allocations since 2013 and (2) sectors that are deemed to be at a significant risk of carbon leakage continued to receive 100% of the benchmark allocations for Phase III. Phase III is when we see an increased level of trading between operators and between operators and carbon traders on the European Union Transaction Log (EUTL),[9] which records and authorises all transactions between accounts in the Union Registry. ETS-regulated firms are registered with operator accounts. There are other types of holding accounts registered as it is possible for other entities such as banks and carbon brokers and private individuals to trade allowances.

There are several different types of trading:

- ETS enterprise selling freely allocated allowances;
- ETS enterprise requiring allowances to surrender;
- ETS enterprise buying allowances for future use;
- non-ETS enterprise trading in carbon commodities.

4.3 Emissions and Allowances for Sectors

We aggregated data from the EUTL to look at EUA trading for Irish sectors. The Phase III change in allocation for electricity producers falling within the EU ETS is seen in Figure 4.2, which shows the removal of allowances for dedicated energy producers. ETS-regulated firms within the non-powergen sectors have faced a drop in the free allocation of emissions allowances in Phase III. Certain industries are identified as being at a high risk of carbon leakage (see section 2.3.6) and continue to receive free allowances in Phase III. Those sectors not deemed to be subject to carbon leakage faced the biggest drop (Figures 4.3 and 4.4). In Ireland, 11 energy-intensive

9 See http://ec.europa.eu/environment/ets/ (accessed 26 June 2018).

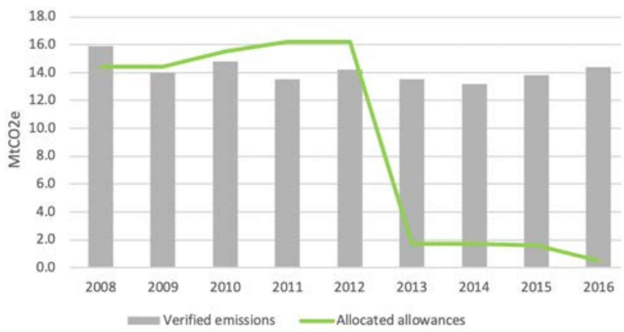

Figure 4.2. Allocated and verified carbon allowance units for Irish electricity producers (*n* = 22). Source: EEA (2018).

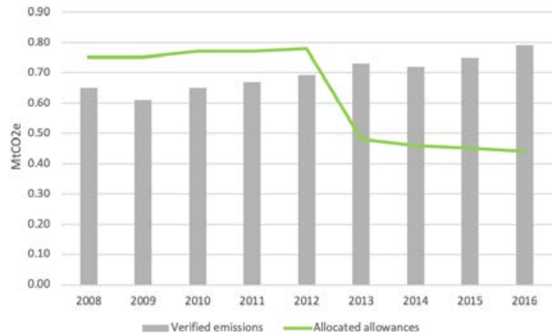

Figure 4.3. Allocated and verified carbon allowance units for Irish food and beverage companies (*n* = 32). Source: EEA (2018).

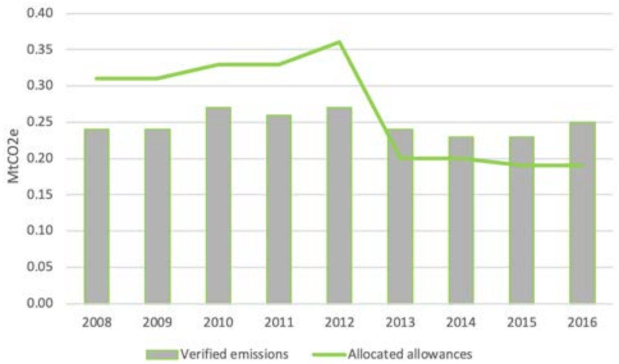

Figure 4.4. Allocated and verified carbon allowance units for Irish pharmaceutical and chemical companies (*n* = 23). Source: EEA (2018).

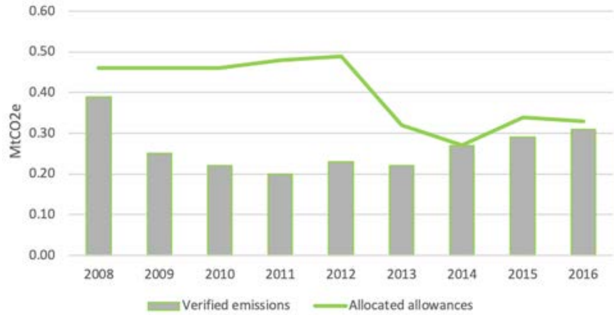

Figure 4.5. Allocated and verified carbon allowance units for Irish energy-intensive manufacturing (*n* = 11). Source: EEA (2018).

manufacturing firms included in the EU ETS come under the NACE (Nomenclature statistique des activités économiques dans la Communauté européenne) 2311–2399 classifications, including cement and lime manufacturers and peat briquette manufacturers (Figure 4.5). These firms remain on the carbon leakage list. Free allowances in Phases I and II combined with a global recession resulted in excess EUAs issued. In Ireland it is estimated that 26% of free allocations were traded as assets rather than surrendered for emissions (de Bruyn *et al*., 2016). This phenomenon occurred in all EU countries to some extent.

4.4 Workshop

Cork University Business School, the Environmental Research Institute and the EPA co-hosted a workshop as part of this project on the topic of "EU ETS Reform, Emissions Trading and Brexit". The workshop was held in Wynn's Hotel, Dublin, on 1 May 2018. The workshop provided up-to-date information about amendments to the ETS for Phase IV, what sectors will be most impacted by the EU ETS reforms and potential impacts on businesses. The event was attended by over 100 stakeholders from across industry, consulting services and government.

Dr Celine McInerney of University College Cork (UCC) chaired the sessions. Dr Maria Martin of the EPA and Dr Jonathan Healy of the Department of Communications, Climate Action & Environment presented key changes in the EU ETS that will be introduced in Phase IV. Fergus Sharkey of the Sustainable Energy Authority of Ireland (SEAI) reviewed national supports for energy efficiency and compliance with the Energy Efficiency Directive. This was followed by presentation of some key results from this project. Dr Bernadette Power and Dr Ellen O' Connor presented an overview of their findings on Irish company expenditure on carbon abatement technologies and Dr Paul Deane presented his work regarding the potential impact of increased carbon prices on electricity prices in Ireland.

Trends and pricing in the international carbon market were addressed by Louis Redshaw of Redshaw Advisors and Anders Nordeng of Thomson Reuters Commodities Research.

The workshop finished with a panel discussion of the impact of EU ETS reform and Brexit for Irish emitters. The expert panel consisted of Professor John Fitzgerald, Head of the Climate Change Advisory Council; Dave Fitzgerald, Group Head of Sustainability and Business Continuity at Dairygold; Marian Troy, Head of Corporate Affairs, Ireland and Northern Ireland, SSE energy company; and Fergal Mee, Environmental Director with the consultants Chris Mee Group. The presentations from the workshop are available on the project website: https://www.ucc.ie/en/eri/projects/euets/ (accessed 26 June 2018).

4.5 Survey

We undertook a stakeholder survey to elicit experiences, opinions and concerns regarding the impact of the EU ETS on businesses, both ETS regulated and non-ETS regulated. Our survey was distributed as part of the “EU ETS Reform, Emissions Trading and Brexit” workshop. We received 66 complete responses to the survey. The questions asked for the experiences and opinions of the individual respondents rather than the company policy. Some companies could have been represented by more than one respondent. A demographic profile of the respondents is given in Table 4.1. In total, there were 51 respondents from the ETS-regulated sector. There was an even split between respondents from companies with foreign ownership and respondents from companies with Irish ownership. Respondents had spent, on average, 6.5 years in their current role in their respective organisation and, on average, the organisation that they represented had been trading in Ireland for just under 36 years. The key results are presented in the following sections.

4.5.1 *Impact of carbon pricing*

We asked respondents if the current ETS regulation/carbon tax on fuel has had an impact on different aspects of their business (e.g. risk of business closure). Respondents provided ratings on a Likert scale from 1 (positive impact) to 5 (negative impact), with the middle rating of 3 representing a neutral outlook for the effect of ETS regulation/carbon tax on fuel on different aspects on their business (Figure 4.6).

In total, 35% of respondents reported that administrative costs had been negatively affected by ETS regulation/carbon tax on fuel. Administrative costs are unavoidable for ETS-regulated firms

Table 4.1. A summary of the demographic profile of respondents to the survey

Variable	Total (*n* = 66)	ETS (*n* = 51; 77%)	Non-ETS (*n* = 15; 23%)
Ownership, *n* (%)			
Foreign	34 (52)	31 (47)	3 (5)
Irish	31 (47)	20 (30)	11 (17)
Sectorial coverage, *n*			
Airport	2	2	–
Pharmaceuticals	16	14	2
Power generator	11	9	2
Cement/lime	5	5	–
Construction/engineering	2	–	2
Manufacturing	8	8	–
Hospital	2	2	–
Refinery	2	2	–
Information technology	1	–	1
Agri/food	8	7	1
Other	8	2	6
More than one sector	1	–	1

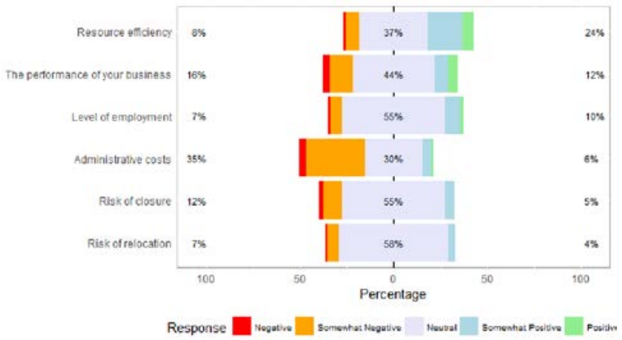

Figure 4.6. What has been the impact of ETS regulation/carbon tax on fuel on the following aspects of your business?

for monitoring, verification and reporting of GHG emissions. Business performance was reported to be negatively impacted by 16% of respondents and positively impacted by 12% of respondents. In our empirical analysis (see section 3.5) we observed no increased risk of closure as a result of green expenditure although 12% of the respondents here reported that the ETS regulation/carbon tax on fuel had increased the risk of business failure. The areas around resource efficiency (24%) and level of employment (10%) were reported to be positively affected by ETS regulation/carbon tax on fuel.

4.5.2 Perceived risk

We wanted to know how respondents rated the level of risk to their business, in terms of profitability, from increased carbon taxes or increased GHG emissions regulations. We also wanted to know if respondents felt that the related issues of climate change and increased electricity costs were risks to their business. We also asked the same question about a further six potential business risks to see how risks related to GHG regulation and climate change were ranked in relation to other potential business risks. The respondents were asked to select the level of risk from 1 (low risk) to 5 (high risk) for these potential risks to the profitability of their business (Figure 4.7).

As can be seen in Figure 4.7, over 50% of the respondents felt that increased energy costs were a high or very high risk to their business. This

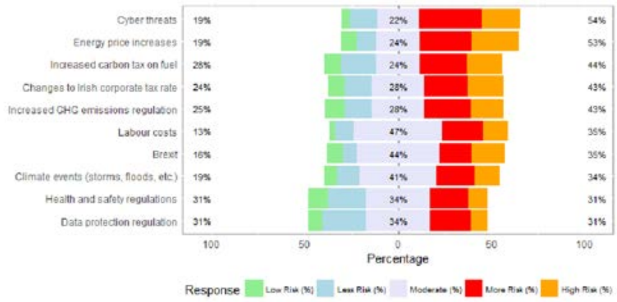

Figure 4.7. Perceived risks to business.

was on a par with the perceived risk from cyber attacks. In total, 25% of respondents believed their business to be at high risk from energy price increases. Previous research has shown that rising labour costs can have a larger impact on total costs than rising energy costs, even in energy-intensive sectors (Eikmeier *et al.*, 2005), but here rising labour costs were perceived to be a risk to business by 35% of respondents, ranking below energy cost increases. Increased carbon prices and an increase in regulation of GHG emissions were perceived to be a risk by 44% and 43% of respondents, respectively. One-third of the respondents believed that climate events could negatively impact their business. A similar percentage of respondents considered that Brexit posed a risk to their business.

4.5.3 Sources of information

Information regarding emissions reduction and energy-efficient investment are important for organisations. The source of this information can act as a guide to help organisations reach a decision regarding their own energy investment projects. Survey respondents were asked to rank, in order, their top three sources of information regarding emissions reduction and energy-efficient investment. Figure 4.8 highlights the most important sources of information for the organisations surveyed. As Figure 4.8 highlights, engineering consultants are viewed as the most important source of information regarding emissions reduction and energy-efficient investment. The SEAI and the EPA are viewed as the second most important source of information. The accountant category was listed as the third most

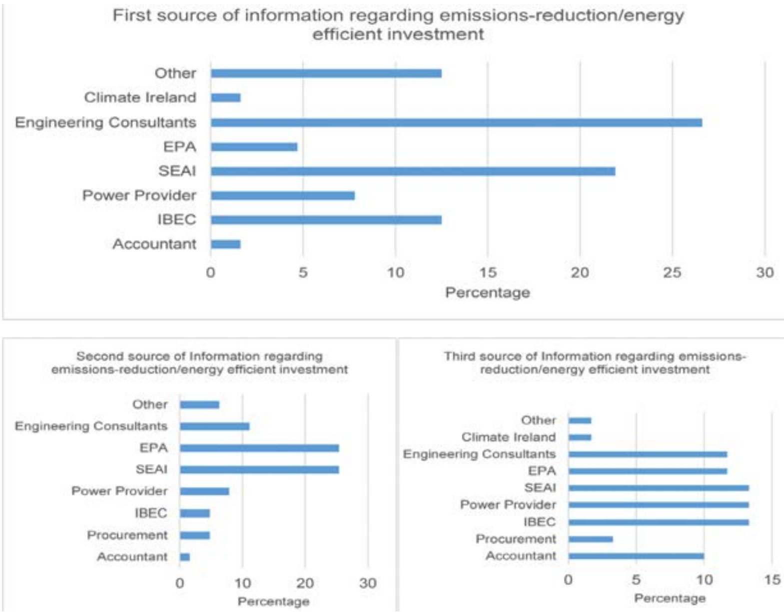

Figure 4.8. First source of information regarding emissions reduction/energy-efficient investment.

Figure 4.9. A word cloud of keywords in response to the question, "What drivers contribute to the initiation and implementation of emissions reduction/energy-efficient projects?" Keywords: the 50 most frequent words used after stop words were removed.

important source of information. The "other" category included, among others, corporate R&D, internal assessments and industry experts.

4.5.4 Drivers and barriers

Respondents were asked to explain what drivers contribute to the initiation and implementation of emissions reduction and/or energy-efficient projects in their organisations. The first driver of energy investment projects was potential cost savings/reductions (Figure 4.9). Organisations would be willing to initiate and implement an energy investment project if they could successfully reduce their costs, with the money saved allocated to other areas of their business. Other important drivers of emissions reduction and/or energy-efficient projects were corporate strategy and targets (see Figure 4.9). If a corporate strategy was implemented, organisations would work towards reducing emissions to satisfy corporate policy initiatives.

Of course, regulation compliance is mentioned too, as is the importance of having an in-house enthusiastic champion. A frequency plot of the most used words for drivers of emissions reduction/energy-efficient projects is presented in Appendix 1 (see Figure A1.1).

Respondents were also asked to explain what obstacles exist to the initiation and implementation of emissions reduction and/or energy-efficient projects in their organisation. Feedback from the survey points to an overall theme of uncertainty regarding payback periods (Figure 4.10). This is a major obstacle and barriers such as the availability of finance and the cost of capital to finance these projects are closely related to it (Figure 4.10). The respondents noted that these types of projects were not core business activities in their organisations. The words "lack" and "availability" were used in

Figure 4.10. A word cloud of keywords in response to the question, "What obstacles exist to the initiation and implementation of emissions reduction/energy-efficient projects?" Keywords: the 50 most frequent words used after stop words were removed.

relation to lack of knowledge about the problem and lack of expertise in providing the solutions rather than in relation to a lack of alternative technology or material inputs. A recent Sandbag (2018) survey reported that the narrative of unavailable alternative technology and unavailable suitable material substitutions is incorrect. It may reflect the industrial profile of Irish industry that the respondents did not put forward the lack of alternative technology or material inputs as a barrier. Disruption of the production process was described as a barrier several times but was not caught in the word frequency analysis.

4.5.5 Corporate strategy and environmental reporting

We had anticipated that corporate strategy is an important driver of investment in emissions reduction and/or energy-efficient projects. Corporate social responsibility, customer demand and projects such as the Carbon Disclosure Project mean that companies can be put under pressure to report on environmental issues. Others may see it as an opportunity to promote their values to customers and differentiate themselves from rivals. We wanted to see how many of the respondents belonged to companies that included environmental reporting in their annual accounts. The results are presented in Figure 4.11. It can be seen that 47 of the 51 ETS-regulated firms and 10 of the 14 non-ETS-regulated firms have an environmental statement. In total, 92% ($n=47$) of respondents from ETS-regulated firms reported that their firm included environmental reporting in its annual accounts compared with 60% ($n=6$) of non-ETS-regulated firms (see Figure 4.11). In addition, 71% ($n=36$) of respondents from ETS-regulated firms reported that their firm reports emissions and emissions targets compared with 50% ($n=3$) of non-ETS-regulated firms (see Figure 4.11). It is expected that the act of measuring and reporting will drive through projects by raising awareness within companies. It is often said in business that "You can't manage it if you don't measure it."

4.6 Conclusions

The low level of green investment in the introductory phases of the ETS can be explained by over-allocation of allowances. Most Irish manufacturing firms began buying significant quantities of EUAs only in Phase III. Irish firms seem to have adopted a pay-as-you-go approach rather than invest in energy-efficient/emissions reduction projects. There is a risk that a lack of strategic EUA trading experience may leave some firms open to financial pressures. The UK ran a pilot emissions trading scheme (UK ETS) in anticipation of its mandatory contribution toward the EU Kyoto Protocol targets. A review of the system showed that participating firms gained experience in pricing strategies and were prepared in advance of the start of the mandatory scheme. The international speakers at our workshop indicated that Irish companies should actively plan their EUA requirements for the future and trade accordingly. They believe that the UK will remain in the EU ETS after Brexit.

Our results highlight that both the main drivers and the main barriers to implementing emissions reduction and/or energy-efficient projects are financial. Making decisions under conditions of uncertainty is not a comfortable position for managers. The aim of structural changes in the EU ETS is to maintain the price of EUAs at an effective level. Price stability in addition to an effective price will assist in project evaluation for emissions reduction projects.

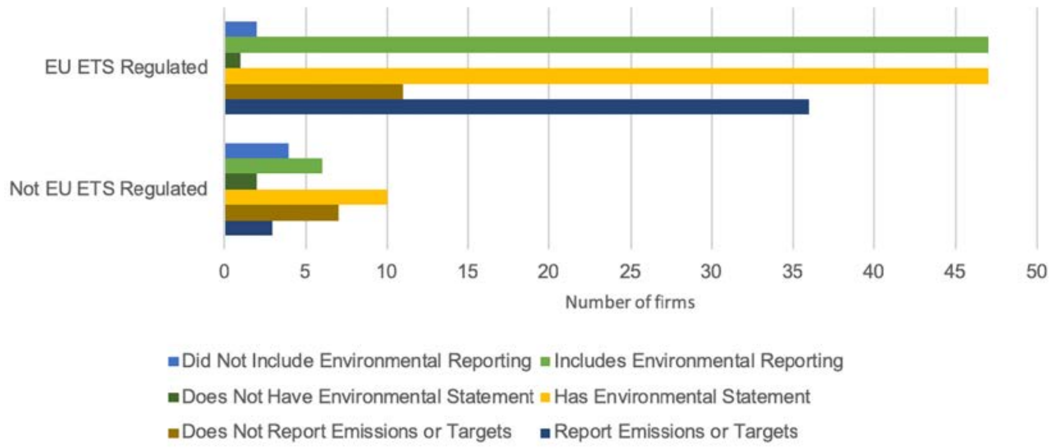

Figure 4.11. The number of respondents that belong to organisations that produce environmental statements and/or that participate in environmental reporting.

Our results also highlight the importance of corporate strategy and corporate social responsibility in initiating emission reduction projects. Although the accounting bodies and companies have failed to develop standards and measurement tools for environmental and sustainability reporting, a number of investor-led initiatives have emerged to account for environmental liabilities, including the Carbon Disclosure Project, described by Ascui and Lovell (2012, p. 55) as “the great success story of the social/environmental carbon accounting”. Johannsdottir and McInerney (2016) provide an overview of some of the voluntary carbon market initiatives that have emerged to fill this gap, including initiatives from the International Emissions Trading Association and the World Business Council for Sustainable Development. Although there is broad consensus that the EU ETS has failed to provide the price signal necessary for investment in low-carbon assets, processes and businesses, there is significant evidence that companies that “do the right thing” in terms of corporate social responsibility can reap significant brand and financial benefits (Ambec and Lanoie, 2008; Serafeim, 2014).

The literature suggests that consumers may be willing to pay more for products with green credentials (Cronin *et al*., 2011). Business practitioners are beginning to realise the importance of sustainability and a high percentage of ETS-regulated firms include environmental reporting in their annual accounts, produce an environmental statement and report on emission levels and targets. Under the EU Account Directive (2014/95/EU), from 2017 large companies are required to report on a whole series of corporate and social responsibility issues. When this legislation is transposed into Irish law, companies with more than 500 employees will be required to provide details of “the current and foreseeable impacts of the undertaking’s operations on the environment, and, as appropriate, on health and safety, the use of renewable and/or non-renewable energy, greenhouse gas emissions, water use and air pollution” (EU, 2014).

5 International Comparison: Impacts of a Carbon Price Floor on Electricity Prices

5.1 Introduction

In this chapter, we evaluate the financial and environmental effects of implementing a CPF in selected EU Member States for the years 2020 and 2030. The analysis is developed using the European Commission's reference scenario projections of the future EU power system combined with a detailed hourly electricity market model.

Although reforms to the EU ETS agreed in 2018 will improve its functioning, some have already noted that the reforms will not bring the ETS price to the level needed to meet the Paris Agreement commitments and that further remedial action will be required, (Clò *et al*., 2013; Knopf *et al*., 2014; Koch *et al*., 2016; Kollenberg and Taschini, 2016; ENDS Europe, 2018). Commentators have suggested that a carbon prices well in excess of current prices is required to meet the Paris goals. In light of the low expectations for the EUA price, some EU Member States have taken or are planning to take national measures to support the carbon price signal in their respective ETS sectors. The UK has applied a CPF on fossil fuel-generated electricity since 2013 (Hirst, 2018). In 2013, the UK CPF was set at £9/tCO_2eq and rose to £18/tCO_2eq in 2015, where it has since been held fixed with no plans for further increases. The UK CPF has been credited as the main driver for the rapid reduction of coal-fired power generation in the UK (Hirst, 2018). In 2017, a Dutch government coalition agreement included plans for the introduction of a CPF for the power generation sector of €18/tCO_2eq from 2020, rising to €43/tCO_2eq by 2030.[10] The French government has also announced its plans to continue to pursue a CPF in the electricity sector and to implement a carbon tariff at Europe's external border for countries that do not sign up to the Paris Agreement (Simon, 2018). The French government has committed to stop subsidising fossil fuels and, under the *Energy Transition for Green Growth*,[11] the French Act of Parliament carbon tax on fossil fuels will quadruple by 2020. Some Scandinavian countries have expressed their determination to pursue national measures if the EU ETS does not sufficiently drive low-carbon transformation. There are also reports that Germany is interested in such an initiative (Montel, 2018).

There has been much discussion in the literature on the regulation of emissions (Wood and Jotzo, 2011; Brauneis *et al*., 2013; Brink *et al*., 2016; Tol, 2018). Yet, it is an open question in the literature what the competitiveness effects of implementing a CPF for a coalition of EU Member States would be with regard to electricity prices and hence industrial competitiveness in individual countries. Electricity prices range from having only a minor role in production costs to making up to 20% of total production costs in most energy-intense industries (Ecofys, 2016).

Prior research examines the impact of unilateral adoption of a CPF for electricity prices in individual countries and interconnected countries. For example, Woo *et al*. (2017) found that California's carbon price affects electricity prices in four interconnected market hubs in Western USA. Egli and Lecuyer (2017) found that models with a German CPF of €40/tonne result in a median German electricity price increase of €37/MWh. In Ireland, the impact of the UK CPF on the All-Ireland single electricity market (SEM), which is connected to the GB electricity market, was examined in Curtis *et al*. (2013). The authors found that, regardless of the Northern Ireland exemption, the higher price for carbon in the GB market would result in increased generation in Ireland. This increased generation in Ireland and Northern Ireland will engage less efficient plants, i.e. carbon leakage. The authors also found that electricity prices in the SEM would increase because of this extra demand from GB.

10 See https://www.government.nl/documents/publications/2017/10/10/coalition-agreement-confidence-in-the-future (accessed 3 September 2018).

11 See http://www2.developpement-durable.gouv.fr/IMG/pdf/16172-GB_loi-TE-les-actions_DEF_light.pdf (accessed 3 September 2018).

5.2 Scenario Modelling of the Carbon Price Floor

To examine the impacts of a CPF we simulate the full EU interconnected electricity market at hourly resolution considering both variable renewable and thermal generation plants for the years 2020 and 2030 under varying CPF assumptions for select Member States. Power plant portfolios, fuel prices, electricity demand and interconnection capacities are based on the European Commission's reference scenario, which is a projection of where current EU policies coupled with market trends are likely to lead.

Three scenarios are considered:

1. A reference scenario, which assumes a unified ETS price across all Member States and follows projections of the ETS price for 2020 and 2030 based on the EU reference scenario.
2. Scenario 1 (S1), which assumes that a CPF is applied to the following countries: Ireland, Belgium, Denmark, Finland, France, Luxembourg, the Netherlands, Norway, Sweden and the UK (Figure 5.1).
3. Scenario 2 (S2), which assumes that a CPF is applied to all S1 countries and Germany (see Figure 5.1). S1 countries capture 45% of the total EU electricity demand, 19% of the total EU CO_2 emissions and 46% of EU gross domestic product (GDP). S2 countries capture 62% of the total EU electricity demand, 43% of the total EU CO_2 emissions and 66% of EU GDP.

A series of reference carbon prices and carbon prices are examined for 2020 and 2030 and are presented in Table 5.1. Fuel prices used in this analysis are from the European Commission's reference scenario and have a significant impact on the results. These are presented in Table 5.2.

The software used to model the EU electricity market is the PLEXOS Integrated Energy Model,[12] available from Energy Exemplar. PLEXOS is a tool used for electricity and gas market modelling and planning. In this analysis, we focus on the electricity system, i.e. gas infrastructure and delivery are not considered. The methodology used to develop this European model is as presented in Collins *et al*. (2017). Model equations are shown in Deane *et al*. (2014).

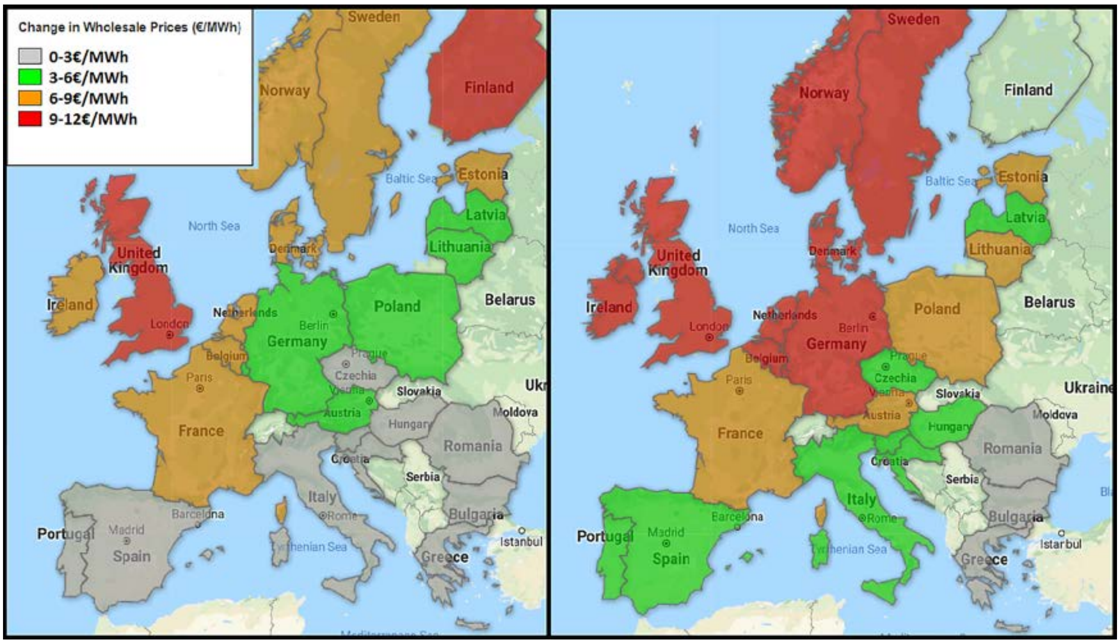

Figure 5.1. Increases in wholesale electricity prices (€/MWh) for S1 (left) and S2 (right) in 2020 relative to the reference scenario.

12 See http://energyexemplar.com/ (accessed 5 September 2018). The full model and data used are available via https://www.dropbox.com/sh/1xhjk3e19xc7xdq/AACS8ln_sjt3Aa_zSj7nzRYoa?dl=0 (accessed 5 September 2018).

Table 5.1. Carbon prices and CPFs examined (€/tonne)

Year	Reference carbon price	S1 and S2 CPF
2020	18	35
2030	35	50

Table 5.2. Fuel prices from the EU reference scenario (€/GJ)

Fuel	2020	2030
Coal price	2.0	3.1
Natural gas	8.1	9.7
Nuclear	1.9	1.9
Oil	11.5	15.8

5.3 Results

The results are examined in terms of wholesale electricity prices, CO_2 emissions, total generation costs[13] and net profits for generators for 2020 and 2030 for all scenarios. All results are presented relative to the reference scenario and are first presented for the year 2020.

5.3.1 2020 carbon price floor results

Summary results in terms of emissions reduction, revenue raised from the CPF, impact on consumer costs, changes in total generation costs (fuels costs, carbon costs and start-up costs to generators) and changes in net profits[14] are presented as absolute values and values relative to the reference scenario (Table 5.3). For the given assumptions, a CPF in S1 countries reduces emission in those countries by 75 Mt and raises emission in other countries by 50 Mt. This results in a net reduction of 25 Mt or 2% of total emissions across the EU. Governments in S1 countries earn revenue from the CPF,[15] amounting to 0.03% of GDP. For generators, total generation costs decrease as generators produce less power and net profits marginally increase as generators benefit more from the increase in wholesale electricity prices than they lose in extra emissions costs. In non-S1 countries, emissions increase by 50 Mt as countries produce more power for export, which also results in marginally higher prices in these countries. Electricity companies in non-S1 countries see increased profits from extra generation, lower carbon prices in their countries and increased exports to higher priced markets.

A CPF applied in S2 countries reduces emissions in those countries by 105 Mt and raises emissions in other countries by 68 Mt. This results in a net reduction of 37 Mt or 3% of total emissions across the EU. Governments in S2 countries earn revenue from the CPF amounting to 0.07% of GDP (expressed as % of GDP of S2 countries). For generators, total generation costs increase marginally and net profits reduce, primarily because of the inclusion of Germany with its significant emissions and associated emission costs. In non-S2 countries, emissions increase by 68 Mt as countries produce more power for export. Electricity companies in non-S2 countries see increased profits from extra generation, lower carbon prices in their countries and increased exports to higher priced markets.

5.3.2 2020 wholesale electricity prices

The biggest increase in wholesale electricity prices is seen in the UK, Finland and Ireland. It is not possible to convert this to an increase in retail price as the wholesale electricity price contribution to retail electricity costs across Europe is not fully reported in

13 Total generation cost = generation fuel cost + start and shutdown cost + emissions cost.

14 Net profit = (market price received × volume of electricity sold) – (total generation cost).

15 Defined as the price difference between the CPF and the ETS price multiplied by the emissions quantity in each country.

Table 5.3. Summary results for S1 and S2 for 2020 presented in absolute values and values relative to the reference scenario

	S1			S2		
	CPF group	Non-CPF group	EU wide	CPF group	Non-CPF group	EU wide
2020 (absolute values)						
Environment: change in emissions scenario (Mt)	–75	50	–25	–105	68	–37
Government: revenue from CPF (m€)	2461	–	2461	8049	–	8049
Consumers: change in consumer costs (m€)	11,269	4765	16,034	21,317	5064	26,381
Producers: change in energy net profits for electricity generators (m€)	1198	12,455	13,653	–8630	10,837	2207
2020 (relative values)						
Environment: change in emissions scenario (%)	–34	5	–2.1	–18	12	–3
Government: revenue from CPF (% of GDP)	0.03	–	–	0.07	–	–
Consumers: change in consumer costs (% of GDP)	0.15	0.05	0.10	0.20	0.09	0.16
Producers: change in energy net profits for electricity generators (% of GDP)	0.02	0.17	0.08	–0.08	0.20	0.01

m€, million euro.

Eurostat data.[16] However, for context, an increase of 8.5€/MWh in wholesale electricity prices in Ireland translates to an increase of approximately €350 to an annual electricity bill (consuming 4200 KWh/yr). The impact on the public service obligation (PSO) is not considered although higher wholesale prices will reduce the PSO amount. For S2, the addition of Germany to the S1 CPF countries has a significant impact on the results as Germany has 50 GW of installed coal capacity in 2020 and 11 interconnections to neighbouring countries. The inclusion of a 35€/tonne ETS price in Germany reduces coal-fired generation (including lignite) by 15% relative to the reference scenario. This leads to a strong reduction in exports to Italy (via Switzerland) and Austria and increased imports from the Czech Republic and Poland. Wholesale electricity prices increase by 10€/MWh in Germany, with Finland seeing the largest increases relative to the reference scenario.

5.3.3 2020 CO_2 emissions

Emissions reduce in all CPF countries, with the largest absolute reductions seen in the UK, France and Finland (see Figure 5.2). In S1, total emissions in CPF countries reduce by 75 Mt and these countries receive extra revenue of €2.4 billion from the difference between the ETS price and the CPF. Total emissions increase in the remaining countries by 50 Mt and the cost of ETS emissions permits increases by €900 million. Overall, there is a net reduction in emissions at the EU level of 2% relative to the 2020 reference scenario. In S2, total emissions in CPF countries reduce by 106 Mt and these countries receive extra revenue of €8.0 billion from the difference between the ETS price and the CPF. Total emissions increase in the remaining countries by 68 Mt and the cost of ETS emissions permits increases by €1.2 billion. Overall, there is a net reduction in emissions at the EU level of 3% relative to the 2020 reference emissions. Emissions reductions in Ireland are low as the coal/gas price differential is large and a carbon price increase

16 Energy and supply costs include wholesale prices and market operator costs, capacity costs, imperfection costs and taking into account distribution loss adjustment factors for distribution-connected customers.

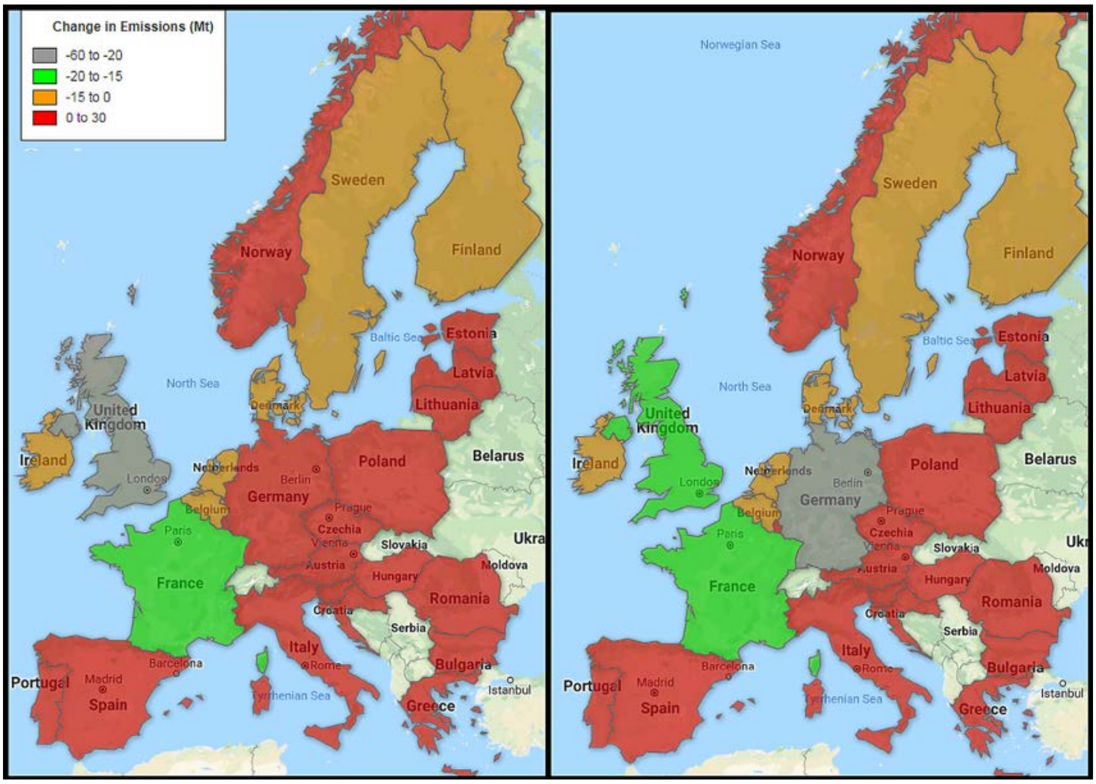

Figure 5.2. CO_2 emissions impacts for 2020 S1 (left) and S2 (right) relative to the reference scenario.

to 35 €/tonne is not sufficient to make the cost of electricity generation from gas cheaper than the cost of electricity generation from coal. A lower gas price or a higher carbon price (approx. 40 €/tonne) would be required to achieve this.

5.3.4 2030 carbon price floor results

Summary results for 2030 (see Table 5.4) in terms of emissions reduction, revenue raised from the CPF, impact on consumer costs, changes in total generation costs (fuels costs, carbon costs and start-up costs to generators) and changes in net profits are presented in absolute values and values relative to the reference scenario.

For the given assumptions, a CPF in S1 countries reduces emissions in those countries by 37 Mt and raises emissions in other countries by 36 Mt. This results in a net reduction of 1 Mt across the EU. Governments in S1 countries earn revenue from the CPF,[17] amounting to 0.03% of GDP (expressed as % of GDP of S1 countries). For generators, total generation costs decrease as generators produce less power (this offsets the increase in cost from emissions permits) and net profits marginally increase as generators benefit more from the increase in wholesale electricity prices. In non-S1 countries, emissions increase by 36 Mt as countries produce more power for export and electricity companies in non-S1 countries see increased net profits from extra generation, lower carbon prices in their countries and increased exports to higher priced markets. A CPF applied in S2 countries reduces emissions in those countries by 67 Mt and raises emissions in other countries by 47 Mt. This results in a net reduction of 20 Mt or 2% of total emissions across the EU. Governments in S2 countries earn revenue from the CPF, amounting to 0.06% of GDP (expressed as % of GDP of S2 countries). For generators, total generation costs increase marginally and net profits increase primarily because of the extra revenue earned from higher wholesale prices. In non-S2 countries, emissions increase by 47 Mt as these countries produce more power for export. Electricity companies in non-S2 countries see increased profits from extra generation, lower carbon prices in their countries and increased exports to higher priced markets.

17 Defined as the price difference between the CPF and the ETS price multiplied by the emissions quantity in each country.

Table 5.4. Summary results for S1 and S2 for 2030 relative to the reference scenario

	S1			S2		
	CPF group	Non-CPF group	EU wide	CPF group	Non-CPF group	EU wide
2030 (absolute values)						
Environment: change in emissions/relative to reference scenario (Mt)	–37	36	–1	–67	47	–20
Government: revenue from CPF (m€)	2089	–	2089	6073	–	6073
Consumers: change in consumer costs (m€)	6849	7143	13,992	14,096	7758	21,855
Producers: change in energy net profits for electricity generators (m€)	9758	3839	13,598	9558	2025	11,583
2030 (relative values)						
Environment: change in emissions/relative to reference scenario (%)	–21	5	–0.2	–14	11	–2
Government: revenue from CPF (% of GDP)	0.03	–	–	0.06	–	–
Consumers: change in consumer costs (% of GDP)	0.09	0.08	0.09	0.13	0.14	0.13
Producers: change in energy net profits for electricity generators (% of GDP)	0.13	0.05	0.08	0.09	0.04	0.07

5.3.5 2030 wholesale electricity prices

The biggest increase in wholesale electricity prices is seen in Ireland, the UK and Belgium (see Figure 5.3). The impact on the PSO is not considered although higher wholesale prices will reduce the PSO amount. For S2, the addition of Germany to the S1 CPF countries has a significant impact on the results as Germany has 36 GW of installed coal capacity in 2030. The inclusion of a 50 €/tonne CPF in Germany reduces coal-fired generation (including lignite) by 17% relative to the reference scenario. This leads to a strong reduction in exports to Italy (via Switzerland) and Austria and increased imports from the Czech Republic and Poland. Wholesale electricity prices increase by 7 €/MWh in Germany, with Ireland seeing the largest increases relative to the reference scenario. Ireland's limited interconnection options (extra interconnection to France is modelled but newly proposed interconnectors to the UK are not), high reliance on gas, which leads to increased output to compensate from reduced electricity generation from coal, and geographic location, with neighbours who also have a CPF, contribute to higher wholesale price increases.

5.3.6 2030 CO_2 emissions

Emissions reduce in all CPF countries (see Figure 5.4), with the largest absolute reductions seen in the UK, France and the Netherlands. Emissions in Ireland reduce by 3.5 Mt as the gas to coal price differential and combined CPF make coal generation expensive compared with gas. The running hours of Moneypoint power station decrease significantly and Ireland leverages increased imports from France to meet demand. Note that the government's National Development Plan 2018–2027 contains a commitment to the conversion of Moneypoint power station to end the burning of coal by 2025. This commitment is not included in this analysis as the EU reference scenario was finalised before this decision was made.

5.4 Conclusion

The implementation of a CPF will increase wholesale electricity prices in countries where it is applied but will also impact neighbouring countries through interconnection. Impacts are generally more pronounced in 2020 than in 2030 as higher levels of interconnection in 2030 smooth out imbalanced

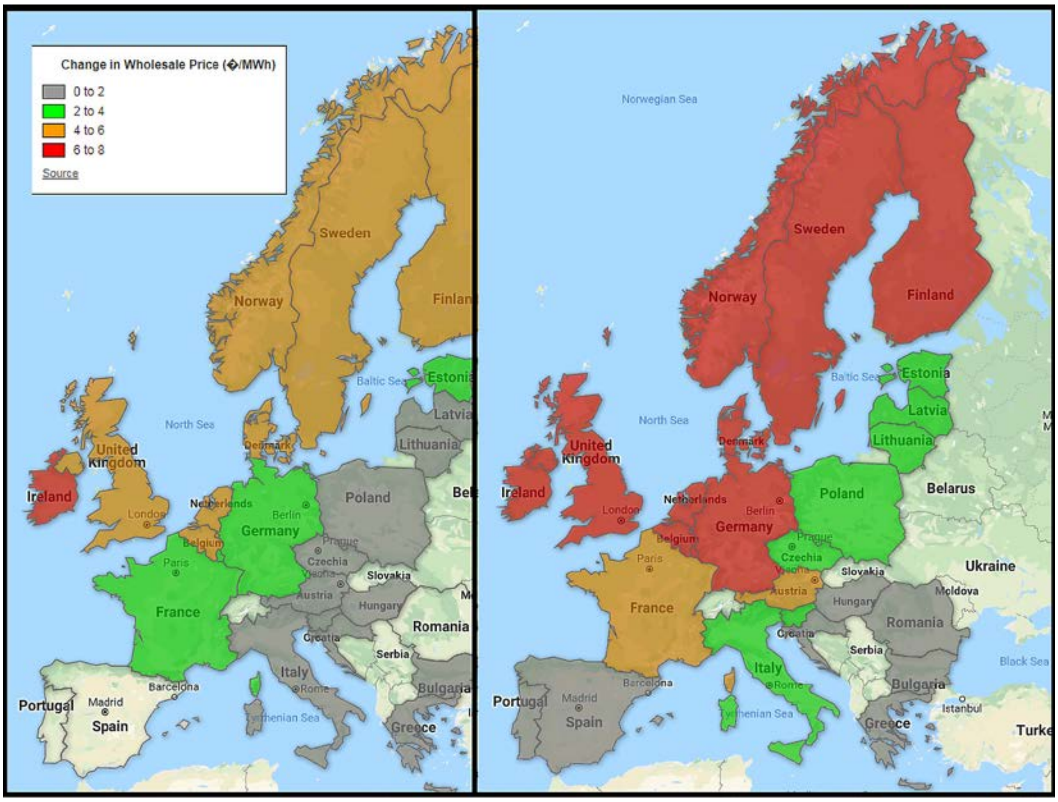

Figure 5.3. Increases in wholesale electricity prices (€/MWh) for 2030 S1 and S2 relative to the reference scenario.

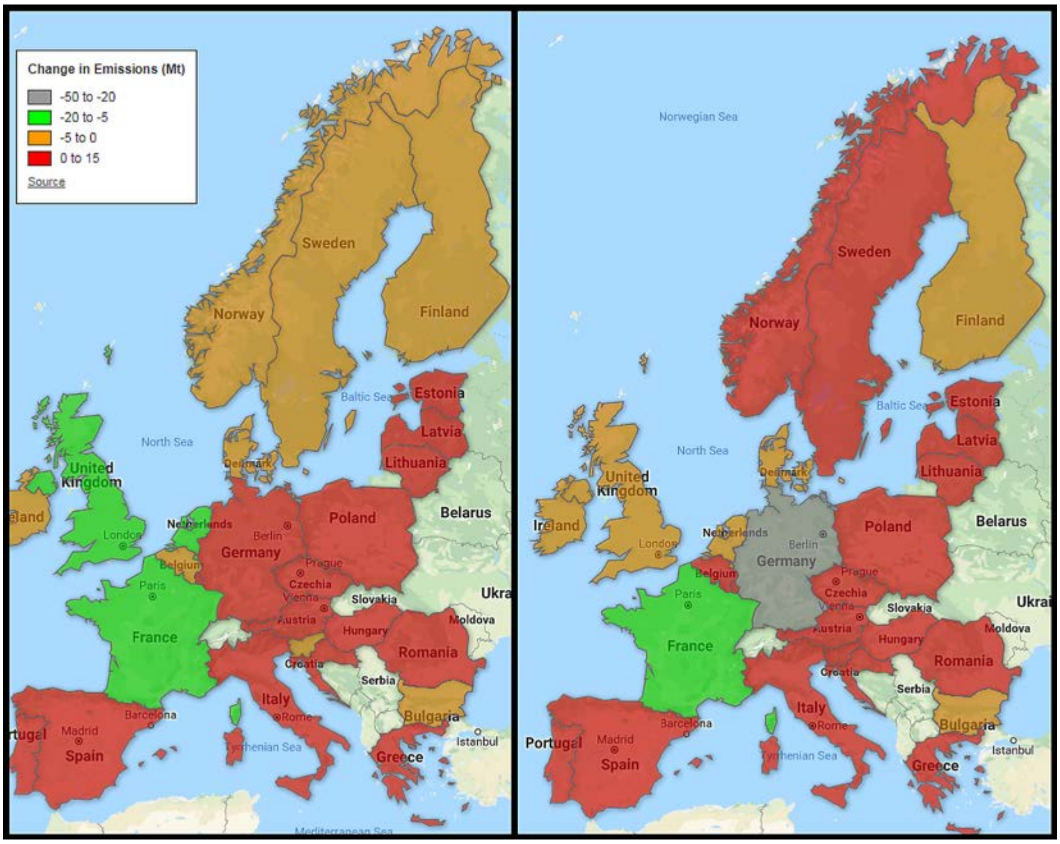

Figure 5.4. CO_2 emissions impacts for 2030 S1 (left) and S2 (right) relative to the reference scenario.

power flows. The impact of a CPF will vary depending on a number of factors, including the make-up of the electricity portfolio in a country and the level of electricity interconnection. The portfolio for Ireland is taken from the European Commission's reference scenario,[18] which assumed a level of renewable electricity of 42% and 43% for 2020 and 2030, respectively. Peat stations are assumed to be closed. Countries with higher levels of thermal generation, especially coal, and lower levels of renewable electricity generation are more exposed to increases in the carbon tax. Likewise, countries with limited interconnection options are also more likely to be impacted by a wholesale electricity price increase. A 10 €/tonne increase in the ETS price generally adds 4 €/MWh to the cost of gas-fired electricity generation and 10 €/MWh to the cost of coal-fired electricity generation. Countries that export more electricity will generally experience higher prices than countries that import. Taken as a whole, countries where the CPF is applied change from a net exporter position to a net importer of power from across the EU.

18 See https://ec.europa.eu/energy/en/data-analysis/energy-modelling (accessed 5 September 2018).

6 Conclusions and Policy Recommendations

In previous chapters we presented the findings from the work packages of the project. These covered an overview of the project and project background, a literature review, data analysis using CSO data on Irish company expenditure on pollution control and clean technology investment, a survey of heavy emitters on factors motivating investment and model-based analysis of the impact of a CPF for Irish electricity prices. These chapters provide evidence of the impact of the EU ETS and the competitiveness of Irish industry.

Reform of the EU ETS will pose challenges for businesses that try to forecast prices against a backdrop of price volatility and uncertainty. The price for emissions allowances of €14/tonne in mid-2018 will motivate companies to re-examine their emissions reduction plans. Previous research has shown that low-cost, low-commitment-type responses were employed in Phase I rather than capital investment in clean technology projects. Our results indicate that this continued for Phase II and Phase III. To date, the EU ETS has not been strong enough to drive major long-term investment in cleaner technological solutions. However, EUA prices are already increasing in response to Phase IV amendments.

We provide evidence that, for most firms, clean technology investment represents good business practice. Our analysis, based on a broad range of industrial sectors, shows that, in general, capital investment in cleaner technologies improves resource efficiency, which in turn improves business competitiveness (as measured by GVA per worker). However, businesses with a high carbon intensity in high-emitting sectors (which are likely to be the ETS-regulated businesses) gain improvements in resource efficiency only through capital investments in pollution control. Incentivising capital investment in clean technology may be necessary in high fuel intensity enterprises but for other firms it can be seen as good business practice. We find that green expenditure does not contribute to business failure rates but acts to reduce the probability of business failure. Grants, tax breaks and other kinds of assistance should be used to leverage adoption of ambitious and innovative projects that move states towards a decarbonised economy.

Our survey shows that cost savings and corporate strategy are important drivers of investment in decarbonisation projects. Feedback from our survey shows that access to finance is still a significant barrier. The level of uncertainty in calculating the payback period means that companies are unwilling to allocate capital to energy investment projects. Traditional methods of project evaluation and decision making using discounted methods may not be appropriate for long-lived strategic clean technology investments. Lack of expertise and disruption of core business activity have been put forward as barriers to investment. However, there now appears to be acceptance that regulation stringency will increase and that the cost of carbon emissions will increase. The attendance at our workshop and the interest in this work from stakeholders indicates that, with regard to capital investment in pollution reduction projects, the risk of taking action under uncertainty over payback periods is diminishing and the risks of inaction are increasing. This is a result of amendments to the EU ETS for Phase IV.

Policymakers need to review the effect of past regulation on clean technology uptake, environmental performance and firm competitiveness to develop effective policy instruments to meet short-term and long-term international obligations. There is also a significant need to continue to educate companies about the cost benefit of investment in emissions reduction. Energy costs are currently less than 2% of total costs for most firms so a high carbon price alone may not be sufficient to motivate pollution control and clean technology investment. In addition to financial incentives, a more holistic approach needs to be taken to educate companies about emissions reduction. Our survey shows that energy consultants are an important information channel for firms regarding support for emissions reduction projects. Customer demand is another driver of green investment.

Public procurement also offers an opportunity to promote sustainable business.

The CPF is being presented as a method to provide a high and stable price for carbon emissions. We have modelled different scenarios in the implementation of a CPF in the EU. Uneven introduction of the CPF, in selected countries only, results in changes in the pattern of thermal generation and the import and export of electricity. The CPF does result in a net reduction in emissions but the burden is largely borne by consumers in the participating countries. The magnitude of the effect of the CPF at a European level is determined by whether Germany is included in the cohort of countries. Ireland faces a cost increase in response to participation, mainly because of the carbon price pass-through rather than changes in imports/exports in the scenarios examined. We find that the effects of implementing a CPF for electricity prices results in a modest reduction in Irish emissions, ranging from –0.1 to –3.6 Mt, and higher wholesale electricity prices, ranging from a 30% to a 44% increase.

Bringing all aspects together, we note that Irish firms have not invested in green technology to a great extent nor have Irish firms been impacted negatively by the EU ETS. We provide evidence that, for most firms, clean technology investment represents good business practice in terms of increasing productivity. However, we find that capital spending on pollution control rather than clean technology might be more financially attractive for firms with high fuel intensity and emission levels.

Policymakers, in considering future policy changes, need to review the effect of past regulation on clean technology uptake, environmental performance and firm competitiveness to develop effective policy instruments to meet short-term and long-term international obligations. It is important to identify the barriers that are preventing firms from investing in clean technology and improving competitiveness. Targeted policy responses to address the issues of internal “know-how” and a review of financial incentives may be required if these key barriers are to be overcome.

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Abbreviations

CIP	Census of Industrial Production
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalent
CPF	Carbon price floor
CSO	Central Statistics Office
EPA	Environmental Protection Agency
ESD	Effort Sharing Decision
ETS	Emissions Trading Scheme
EU	European Union
EUA	European Union Allowance
EUTL	European Union Transaction Log
FDI	Foreign direct investment
GDP	Gross domestic product
GHG	Greenhouse gas
GVA	Gross value added
LIEN	Large Industry Energy Network
MAC	Marginal abatement cost
Mt	Million tonne (10^6)
MtCO_2eq	Million tonnes (1 Mt = 10^6 kg = 1 Gg) of CO_2 equivalent
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne
OECD	Organisation for Economic Co-operation and Development
PSO	Public service obligation
R&D	Research and development
S1	Scenario 1
S2	Scenario 2
SEAI	Sustainable Energy Authority of Ireland
SEM	Single electricity market
SMEs	Small and medium-sized enterprises
tCO_2eq	Tonnes of CO_2 equivalent

Appendix 1

Table A1.1. Key dependent and independent variable definitions and summary statistics

Variable	Definition	Mean	SD	Min.	Max.
ETS Phase I	= 1 if 2006–2007; = 0 otherwise (reference ETS Phase)	0.26	0.44	0	1
ETS Phase II	= 1 if 2008–2012; = 0 otherwise	0.64	0.48	0	1
ETS Phase III	= 1 if 2012–2014; = 0 otherwise	0.10	0.30	0	1
Current spend on environment	= 1 for current expenditure on the environment; = 0 otherwise	0.066	0.249	0	1.00
Capital spend on cleantech	= 1 for capital expenditure on the cleaners; = 0 otherwise	0.048	0.215	0	1.00
Capital spend on pollution control	= 1 for capital expenditure on the pollution control; = 0 otherwise	0.039	0.193	0	1.00
Log resource efficiency	Logarithmic value of material and fuel resources used in production of output in year *t* divided by the value of production in year *t*	–1.003	0.732	–12.900	5.720
Log GVA	Logarithmic value of GVA in year *t* divided by the total number of employees in year *t*	3.837	0.969	-2.745	12.590
Exits	Enterprise deaths in the year *t*. An enterprise is included in the count of deaths if it remains inactive for 2 years. If activity resumes within the 2-year period, the status of the enterprise is revised. The count is equal to ‘1’ if the firm died in year *t* and ‘0’ otherwise.				

SD, standard deviation.

Table A1.2. Control variable definitions and summary statistics

Variable	Definition	Mean	SD	Min.	Max.
Age	Years trading in year *t*	17.4	14.7	0	114.0
Firm size	Logarithmic value of the total number of employees in year *t*	2.6	1.32	0	8.99
Multi-plant	= 1 for multi-plant enterprise; = 0 otherwise	0.03	0.16	0	1.00
Foreign	= 1 for foreign owned; = 0 otherwise	0.11	0.31	0	1
Importer	= 1 for importer; = 0 otherwise	0.08	0.27	0	1
Exporter	= 1 for exporter; = 0 otherwise	0.55	0.49	0	1
Firm fuel intensity	The value of fuel used in time *t* divided by the GVA of the enterprise at time *t*	0.09	2.93	0	294
% freight	Current expenditure on freight charges in year *t* divided by total purchases in year *t*	3.26	3.71	0	60.4
% water	Current expenditure on water charges in year *t* divided by total purchases in year *t*	0.09	0.72	0	57.1
R&D intensity	Capital expenditure on R&D divided by revenue in time *t*	0.004	0.14	0	19.3
Imports	Percentage of turnover exported in year *t*	34.6	41.72	0	208
Exports	Percentage of materials imported in year *t*	23.98	34.50	0	100
Herfindahl Index (market concentration)	The number of employees in each firm divided by total employment in its NACE Rev. 2 four-digit sector code for each year *t*, where *N* is the number of establishments within the industry	0.15	0.21	0	1
Trade exposure	Total value of imports and exports in each NACE Rev. 2 four-digit sector code divided by the market value of these of aggregate output in each NACE Rev. 2 four-digit sector	0.33	0.31	0	1.54
Sectorial carbon intensity	Total value of fuel used in each NACE Rev. 2 four-digit sector code divided by the total GVA in each NACE Rev. 2 four-digit sector at constant 2014 prices	1.24	55.24	0	2734.0
Sectorial emissions	Emissions of each two-digit NACE Rev. 2 sector code divided by the total GVA of that sector in 2005	0.17	6.53	0	284.0
Log labour cost	Logarithmic value of labour costs in year *t*	5.999	1.684	–0.006	13.600

Note: all monetary values are in constant 2014 prices.

SD, standard deviation.

Table A1.3. Definition of sector-level emissions and the associated sectors[a]

Category of emitter (000s CO_2 eq GHG)	Sector
Very high emitters (>5000)	Electricity gas, steam and air supply
High emitters (2000–4999)	Rubber, plastics and non-metallic mineral products
Medium emitters (1000–1999)	Food and beverages; tobacco; metals and fabricated metals; water, sewage and waste management
Low emitters (101–999)	Mining and quarrying; pharmaceutical products; wood and paper products; reproduction of recorded media; manufacture of coke, refined petroleum, chemicals and chemical products; computers and electronic products; furniture, other manufacturing, repair and installation of machinery
Very low emitters (1–100)	Textile, apparel and leather; electrical equipment, machinery and equipment and transportation equipment

[a]Based on sector emissions data from the CSO Environmental Accounts Air Emissions survey (CSO, 2017).

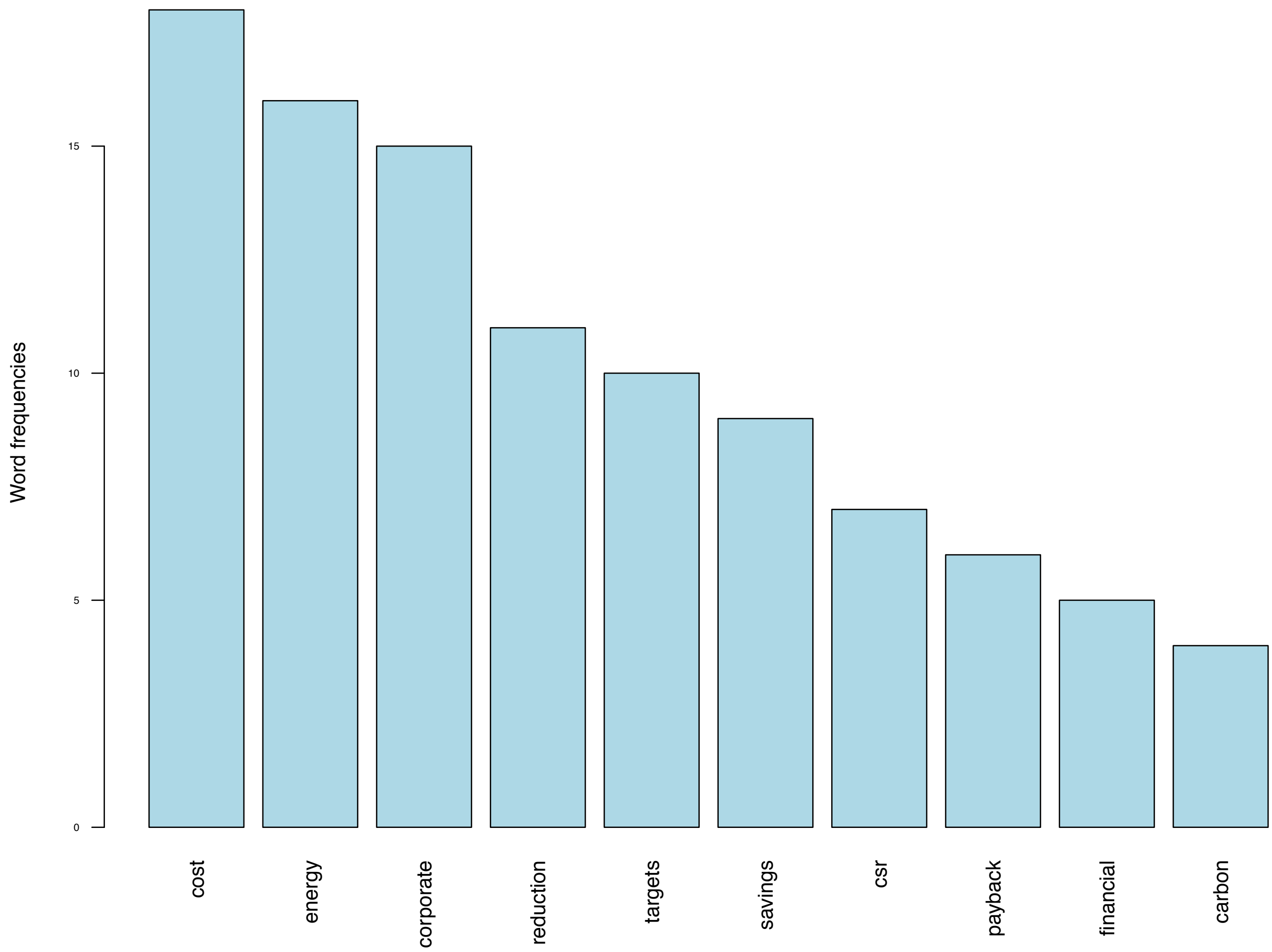

Figure A1.1. Word frequency plot of the most used words in response to the question, "What drivers contribute to the initiation and implementation of emissions reduction/energy-efficient projects in your organisation?"

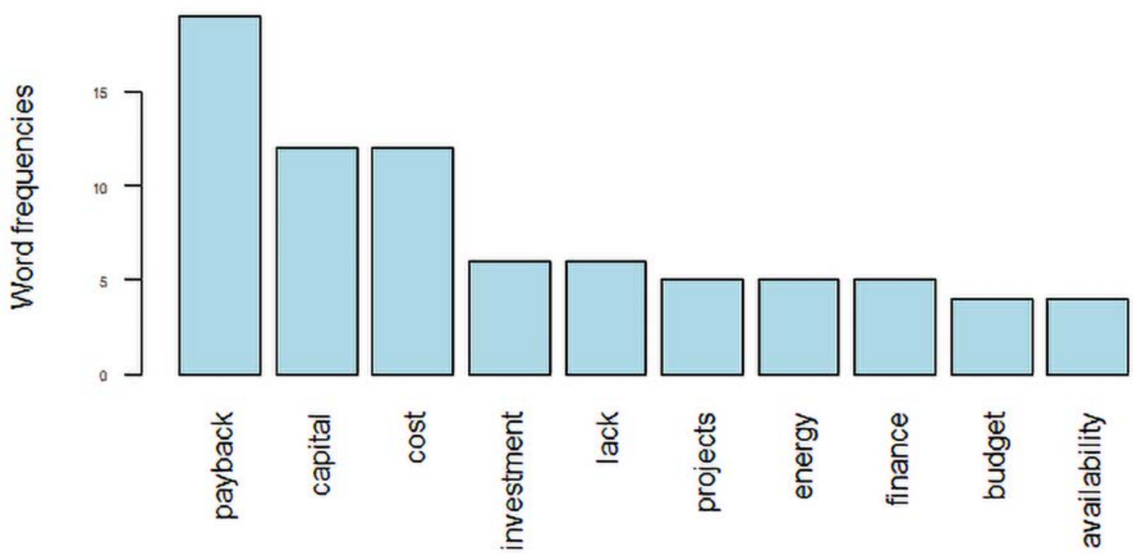

Figure A1.2. Word frequency plot of the most used words in response to the question, "What obstacles exist to the initiation and implementation of emissions reduction/energy-efficient projects in your organisation?"

Table A1.4. Scenario 1 results for 2020 by Member State relative to the reference scenario

Country	Change in wholesale price (€/MWh)	Change in emissions (Mt)	Government revenue from CPF ($000)	Delta consumer costs (€000)	Change in wholesale price as % of 2017 price	Government revenue for floor (% of GDP)
Austria	3	0.2	0	206,279	15	0.00
Belgium	6	–1.0	24,850	573,442	30	0.01
Bulgaria	0	0.5	0	13,383	4	0.00
Croatia	1	0.1	0	28,117	12	0.00
Czech Republic	1	10.4	0	82,296	10	0.00
Denmark	7	–7.5	141,179	242,030	29	0.05
Estonia	6	1.0	0	64,239	52	0.00
Finland	11	–13.4	166,070	969,460	83	0.07
France	6	–17.9	89,344	3,028,999	37	0.00
Germany	4	16.3	0	2,189,005	13	0.00
Greece	1	0.2	0	40,328	3	0.00
Hungary	2	0.3	0	66,550	14	0.00
Ireland	8	–0.2	127,185	248,076	40	0.04
Italy	2	7.6	0	693,342	7	0.00
Lithuania	4	0.8	0	43,794	29	0.00
Latvia	4	0.5	0	33,641	25	0.00
Luxembourg	4	0.2	8263	27,945	22	0.01
The Netherlands	6	–7.8	563,918	758,731	31	0.08
Poland	3	5.3	0	448,390	19	0.00
Portugal	2	0.3	0	100,249	9	0.00
Romania	0	1.4	0	28,660	3	0.00
Slovakia	2	0.0	0	54,441	13	0.00
Slovenia	2	0.1	0	30,318	14	0.00
Spain	2	5.4	0	642,019	11	0.00
Sweden	7	–0.3	3072	1,068,825	45	0.00
UK	9	–27.1	1,330,458	3,465,588	45	0.06
Norway	6	0.0	0	806,023	62	0.00

Table A1.5. Scenario 2 results for 2020 by Member State relative to the reference scenario

Country	Change in wholesale price (€/MWh)	Change in emissions (Mt)	Government revenue from CPF ($000)	Delta consumer costs (€000)	Change in wholesale price as % of 2017 price	Government revenue for floor (% of GDP)
Austria	6	1.0	0	497,850	37	0.00
Belgium	9	–0.1	40,202	854,166	44	0.01
Bulgaria	1	1.2	0	22,818	6	0.00
Croatia	3	0.4	0	56,784	24	0.00
Czech Republic	3	26.3	0	234,009	29	0.00
Denmark	11	–2.5	225,670	393,145	48	0.08
Estonia	8	1.1	0	76,219	62	0.00
Finland	12	–10.8	210,473	1,083,241	93	0.09
France	8	–15.4	132,175	4,335,790	53	0.01

Table A1.5. Continued

Country	Change in wholesale price (€/MWh)	Change in emissions (Mt)	Government revenue from CPF ($000)	Delta consumer costs (€000)	Change in wholesale price as % of 2017 price	Government revenue for floor (% of GDP)
Germany	10	–57.1	5,130,442	6,128,406	36	0.16
Greece	1	0.2	0	93,676	8	0.00
Hungary	3	1.1	0	143,547	30	0.00
Ireland	9	–0.1	129,450	270,683	44	0.04
Italy	4	13.1	0	1,290,847	12	0.00
Lithuania	6	1.3	0	71,288	47	0.00
Latvia	5	0.8	0	43,827	33	0.00
Luxembourg	10	0.5	13,653	74,575	60	0.02
The Netherlands	10	–0.2	693,747	1,227,399	50	0.09
Poland	6	9.8	0	1,090,080	45	0.00
Portugal	3	0.4	0	163,223	14	0.00
Romania	1	3.1	0	53,325	6	0.00
Slovakia	4	0.2	0	120,311	29	0.00
Slovenia	4	0.3	0	65,566	30	0.00
Spain	4	7.7	0	1,040,566	17	0.00
Sweden	11	–0.2	4298	1,611,065	68	0.00
UK	10	–19.3	1,462,351	3,934,400	51	0.06
Norway	10	0.0	40	1,317,278	101	0.00

Table A1.6. Scenario 2 results for 2030 by Member State relative to the reference scenario

Country	Change in wholesale price (€/MWh)	Change in emissions (Mt)	Government revenue from CPF ($000)	Delta consumer costs (€000)	Change in wholesale price as % of 2017 price	Government revenue for floor (% of GDP)
Austria	1	0.6	0	102,890	7	0.00
Belgium	4	–1.2	321,786	370,016	18	0.07
Bulgaria	0	–0.4	0	–12,744	–3	0.00
Croatia	0	0.1	0	4364	2	0.00
Czech Republic	1	4.3	0	73,239	8	0.00
Denmark	4	–2.9	108,789	148,818	17	0.04
Estonia	2	2.9	0	15,755	12	0.00
Finland	5	–4.2	220,665	442,992	36	0.10
France	3	–7.8	68,353	1,641,742	19	0.00
Germany	2	9.9	0	1,248,235	7	0.00
Greece	0	0.1	0	–15,981	–1	0.00
Hungary	0	0.9	0	11,111	2	0.00
Ireland	6	–3.6	59,551	198,235	30	0.02
Italy	1	7.5	0	201,753	2	0.00
Lithuania	1	0.3	0	18,773	12	0.00
Latvia	1	0.4	0	7672	5	0.00
Luxembourg	2	0.1	23,001	22,847	15	0.04
The Netherlands	4	–7.8	549,678	578,153	22	0.07

Table A1.6. Continued

Country	Change in wholesale price (€/MWh)	Change in emissions (Mt)	Government revenue from CPF ($000)	Delta consumer costs (€000)	Change in wholesale price as % of 2017 price	Government revenue for floor (% of GDP)
Poland	1	1.6	0	261,617	9	0.00
Portugal	–1	0.1	0	–41,892	–3	0.00
Romania	–1	2.3	0	–38,258	–4	0.00
Slovakia	1	0.2	0	21,105	4	0.00
Slovenia	1	–0.4	0	13,434	5	0.00
Spain	–1	5.4	0	–158,014	–3	0.00
Sweden	4	–1.3	73,446	621,797	25	0.02
UK	5	–8.3	629,788	1,959,929	25	0.03
Norway	4	–0.1	2117	565,953	39	0.00

Table A1.7. Scenario 2 results for 2030 by Member State relative to the reference scenario

Country	Change in wholesale price (€/MWh)	Change in emissions (Mt)	Government revenue from CPF ($000)	Delta consumer costs (€000)	Change in wholesale price as % of 2017 price	Government revenue for floor (% of GDP)
Austria	4	1.9	0	325,785	22	0.00
Belgium	6	0.4	345,889	573,779	28	0.08
Bulgaria	0	–0.5	0	14,276	4	0.00
Croatia	1	0.1	0	26,435	11	0.00
Czech Republic	2	13.9	0	131,172	15	0.00
Denmark	6	–1.1	135,479	251,966	29	0.05
Estonia	2	3.2	0	22,817	18	0.00
Finland	6	–2.4	247,712	546,390	45	0.11
France	5	–8.0	66,390	2,833,004	33	0.00
Germany	7	–46.5	3,733,939	4,102,483	23	0.11
Greece	0	0.2	0	8253	1	0.00
Hungary	1	0.9	0	66,793	13	0.00
Ireland	7	–3.5	61,488	226,560	34	0.02
Italy	2	12.2	0	661,619	6	0.00
Lithuania	3	0.5	0	35,972	23	0.00
Latvia	2	0.6	0	16,313	11	0.00
Luxembourg	6	0.3	25,794	55,120	36	0.05
The Netherlands	7	–1.4	645,474	900,501	34	0.09
Poland	3	5.1	0	723,358	24	0.00
Portugal	0	0.2	0	–20,383	–2	0.00
Romania	0	2.5	0	20,926	2	0.00
Slovakia	2	0.5	0	69,451	14	0.00
Slovenia	2	0.7	0	34,911	14	0.00
Spain	0	5.3	0	1162	0	0.00
Sweden	6	0.2	95,659	942,495	38	0.02
UK	6	–5.0	678,839	2,438,626	31	0.03
Norway	6	0.0	2903	919,086	64	0.00

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú
Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:
- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil
- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce
- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol
- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn
- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil
- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta
- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch
- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas
- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta
- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil
Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:
- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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EU ETS and Competitiveness of Irish Industry

Climate - Water - Sustainability
Identifying pressures • Informing policy • Developing solutions

Authors: Celine McInerney, Ellen O'Connor, Bernadette Power, Paul Deane and Tom McDermott

Identifying Pressures

Irish electricity generators and energy-intensive industry are obliged to participate in the EU emissions trading system and this may lead to an increase in production costs for these companies. Reform of the European Union Emissions Trading System (EU ETS) has seen significant price increases and may lead to further volatility in prices for emissions allowances. There are concerns that increased costs of compliance will have a negative impact on business competitiveness in Ireland. This project aims to investigate the effects of the EU ETS on competitiveness by (i) reviewing the literature on regulation and firm competitiveness, (ii) analysing firm-level data to determine the impact of the EU ETS and green investment on the competitiveness of Irish industry thus far, (iii) using a survey to find the opinions of stakeholders regarding the EU ETS and emission reduction projects and (iv) estimating the effect on future electricity prices if Ireland were to participate in a carbon price floor.

Informing Policy

The research finds that Irish companies have adopted a pay-as-you go approach to emissions reduction, with only a small proportion making long-term capital investments. Our analysis of a broad range of industrial sectors shows that capital investment in cleaner technologies improves the resource efficiency of businesses, which in turn improves their business competitiveness. However, carbon-intensive firms, which are most likely to be ETS-regulated, face competitiveness issues when investing in green capital projects. The stakeholder survey shows that firms face financial and information barriers to reducing the pollution intensity of their operations. A carbon price floor is examined as a method to provide a high and stable price for carbon emissions and accelerate decarbonisation of the economy. The carbon price floor does result in a net reduction in EU emissions, but the burden is largely borne by consumers in the participating countries. The forecast emissions reduction for Ireland is small, although Ireland would face a cost increase of up to 44% in wholesale electricity prices in response to participation.

Developing Solutions

Consistent with previous research, we find that lack of finance and uncertainty of payback times are important barriers to pollution control and cleantech investment. Energy costs represent less than 2% of total costs for most firms so a high carbon price alone may not be sufficient to motivate pollution control and cleantech investment. In addition to financial incentives, a more holistic approach needs to be taken to educate companies about emissions reduction. Consumer demand and sustainability as a core part of corporate strategy are factors that motivate companies to invest in emissions reduction. Access to finance is still a significant barrier and lack of internal expertise also inhibits greater uptake of and investment in emissions reduction technologies. Policy interventions around these key areas are required if emissions reduction ambitions are to be realised.

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