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A series of background briefings on the policy issues in the May 2015 UK General Election

#ElectionEconomics

Energy and the Environment: a cold climate for climate change policies?

Ralf Martin, Jonathan Colmer and

Antoine Dechezleprêtre

CENTRE *for* ECONOMIC PERFORMANCE

CEP ELECTION ANALYSIS

Energy and the Environment: a cold climate for climate change policies?

- Global temperatures have increased by 0.8°C since pre-industrial times. Without additional efforts to reduce emissions, temperatures are likely to rise by between 2.6°C and 4.8°C before the end of the twenty-first century. Cautious calculations suggest that global income will be 5% lower as a result of these changes.

- World leaders agreed in 2010 to adopt the target of limiting temperature increases to 2°C. This requires reducing (net) emissions to zero by the end of the century. It also requires a reduction of about 40% (relative to 1990 levels) by 2050.

- Between 1990 and 2012, UK emissions fell by a quarter, meeting the Kyoto target and the objective of the first 'carbon budget' proposed by the UK government covering the period 2008-12. Most of this (18.4%) happened after 1997 when Labour came to power.

- Climate policies have been effective in reducing UK emissions, but an important factor in achieving these reductions over the last five years has also been the recession: because of lower economic activity, emissions fell faster than expected.

- While production-based emissions have fallen since 1990, there has been an increase in consumption-based emissions, which account for the emissions contained in net imports by the UK. Consumption-based emissions have only slowed in the wake of the Great Recession, implying that they are likely to increase as the economy recovers.

- The UK lags behind most OECD countries in innovation and the adoption of clean technologies.

- UK climate policy consists of a patchwork of different policy instruments and exemption rules, resulting in a diverse menu of carbon prices. This is inefficient as different emitters face very different incentives to reduce emissions even though the damage that a tonne of carbon is always the same irrespective of where it is emitted.

- A good strategy would be to work towards harmonising carbon prices by abolishing exemption rules and increasing carbon taxes for emitters that currently face low prices. This will reduce emissions, enhance efficiency and raise additional revenue that can be channelled towards research and development (R&D) in clean technologies.

Centre for Economic Performance
London School of Economics and Political Science
Houghton Street, London WC2A 2AE, UK
Tel: +44 (0)20 7955 7673
Email: cep.info@lse.ac.uk Web: http://cep.lse.ac.uk

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Introduction

While UK political leaders have pledged to combat climate change whatever the result of the general election, actions speak louder than words.[1] This Election Analysis explores the environmental and energy policies of recent governments in the light of the UK's commitments to address climate change.

The last Labour government was instrumental in introducing a number of important climate change policies, which have all been continued by the coalition government. In addition, new policy initiatives have been started. Hence, there is no question that all the main parties have been very active in this area.

In fact, one criticism that could be levelled is that of *too much* activity. There is an increasingly confusing array of policies that aim to regulate greenhouse gas (GHG) emissions. These policies vary considerably in the explicit or implicit cost that they impose on the release of a given unit of emissions.

This creates economic inefficiencies: the same reduction in emissions could be achieved at lower cost if all emitters were facing a uniform carbon price. But in many instances, the same emitters are subject to overlapping policies. This often triggers complex procedures to avoid multiple regulations over the same unit of emissions, increasing compliance costs. Furthermore, where exemption rules are only partially successful, much overlap remains, distorting the incentives to reduce emissions.

Nevertheless, at first glance, the UK's overall record on emissions looks impressive. Total emissions have fallen by a quarter in the last 25 years. Consequently, the UK met both its Kyoto protocol commitment and fell within the 'carbon budget' set by the Committee on Climate Change. This group of eight independent experts is charged with advising the government on a reduction path that will lead to an 80% reduction in annual emissions compared with 1990 levels by 2050.

While research conducted by the CEP[2] and others has shown that many climate policies have been instrumental in reducing emissions, an important driver of the observed emissions reductions was also the recession, which reduced economic output and any associated emissions contained within output. This raises concerns that emissions will not continue to meet targets once the economy bounces back, requiring a further tightening of policy.

Another concern is the UK's performance in the innovation and adoption of clean technologies. While efforts have improved in recent years, the UK still lags behind other countries. This is important because clean technology leadership and the development of a specialisation in this area could potentially have medium-term economic benefits irrespective of its long-term impact on climate change.

This points to an opportunity for UK climate policy to move forward. Harmonising carbon prices across emitters and abolishing exemptions from policies will provide further incentives to reduce emissions while also generating additional revenue for the government. This additional revenue could, in turn, be earmarked for further R&D support in areas such as clean innovation to improve the UK's performance and standing as a leader in the 'new' industrial revolution.

[1] Financial Times, 14 Feb 2015 (http://tiny.cc/hp8qvx).
[2] Martin et al (2014a).

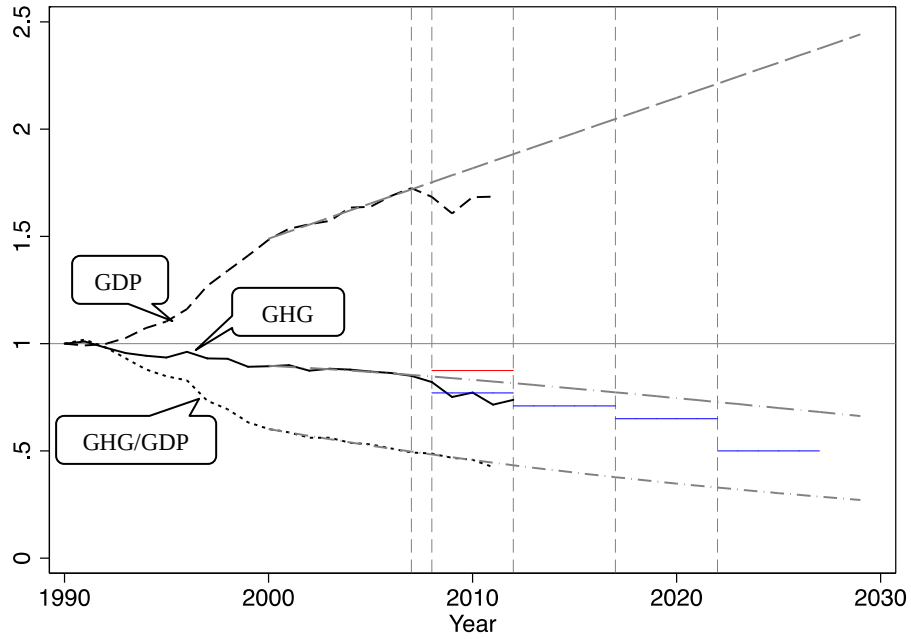
The UK's emissions performance

In 2012, emissions were down by 25% compared with levels observed in 1990, keeping the UK comfortably within both its Kyoto allocation (the red line in Figure 1) and the carbon budget set by the UK's own Committee on Climate Change (the blue lines in Figure 1). This was partly achieved by the continuous reduction in the emissions intensity (GHG/GDP) of the economy.

But as Figure 1 illustrates, emissions only nudged below the carbon budget target as a result of the contraction in output following the onset of the economic crisis in 2007-08. If the economy had continued on the same output trend that it had prior to the recession (2000-07), emissions would still have fallen, but they would have exceeded the domestic targets set by the Committee on Climate Change.

Nevertheless, when compared with most other countries, the UK's performance is notable. Compared with eight of the largest economies in terms of GHG emissions, only Germany and Russia[3] have reduced emissions by a similar amount relative to their 1990 levels. By contrast, the United States, Canada, Japan, India, China and South Korea all have emissions levels that are greater than their 1990 levels.[4]

Figure 1: UK emissions and GDP – actual and counterfactual projections

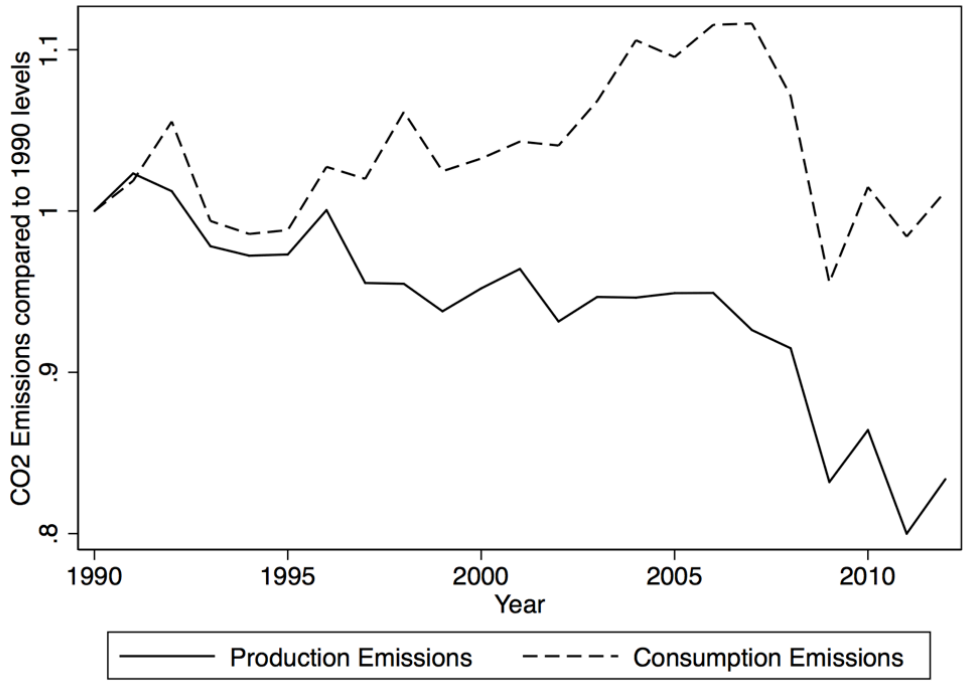


Notes: Red line = Kyoto Target, blue lines = various carbon budgets. Counterfactual projections for GDP and GHG/GDP are based on 2000 to 2007 values. The GHG projection is the GHG/GDP projection times the GDP projection.
Source: Authors' calculation based on data from the UNFCCC (emissions) and the Penn World Tables (GDP).

[3] The Russian emissions reduction appears to be a consequence of the collapse of the socialist economic system rather than any active climate policy-making.
[4] See Figure A1 in the Annex.

An important consideration is the difference between emissions that are produced domestically and the emissions that are consumed through trade. Drawing on data from the Global Carbon Budget 2014,[5] which provides estimates of domestically produced and consumed carbon emissions, we map the UK's progress since 1990 in Figure 2.

Figure 2: Consumption versus production emissions for the UK



Notes: The data are updated from Peters et al, 2011. For an explanation of the issues around consumption emissions, see Peters et al, 2012.
Source: Global Carbon Budget 2014.

While the domestic production of carbon emissions has fallen substantially during this period and is the main contributor to reductions in total GHG emissions, the consumption of carbon emissions in the UK is at the same level as it was in 1990. Comparing the UK's experience with the other eight largest emitters of GHG emissions, we observe a series of interesting patterns.[6] For developed economies like Germany, Japan, the UK and the United States, consumption emissions are greater than production emissions – that is, these countries are net consumers of carbon emissions. By contrast, developing countries such as China and India have production emissions greater than consumption emissions – that is, these countries are net producers of carbon emissions.[7]

Since countries like China face less stringent regulation on emissions than countries within the European Union (EU), this could raise concerns about carbon 'leakage' – that far from reducing worldwide emissions, climate policy in the UK or Europe simply shifts these emissions elsewhere. But attempts to identify direct evidence for leakage – some of which we discuss below – have not been very successful, which is good news. It is therefore more

[5] http://www.globalcarbonproject.org/carbonbudget/
[6] See Figure A2 in the Annex.
[7] For the remaining countries in our sample – Canada, Russia, and South Korea – the pattern is less clear with the relationship between consumption and production emissions changing over time; but for the most part production emissions exceed consumption emissions, that is, similar to India and China, these countries are net producers of carbon emissions.

likely that the pattern reflects other factors such as low labour costs and capabilities for manufacturing in China.

Nevertheless – as many critics of climate policy have pointed out – the UK only emits a small share of global emissions, accounting for 1.2% of global emissions in 2012 – a decrease from 2.5% in 1990. By contrast, the major polluting countries – China, India and the United States – accounted for 49% of global emissions in 2012, an increase from 35% in 1990. Unless these countries take more drastic action, a reduction in UK emissions to zero would have very little direct impact on global emissions, even if there were no carbon leakage whatsoever.

Clean innovation

The UK's impact is potentially larger if the policies implemented domestically lead to technological innovation in clean technologies that can be adopted elsewhere. Moreover, innovation in clean technologies can have direct positive effects on economic growth. This can happen via 'knowledge spillovers' – that is, if innovations not only benefit the original inventors and their customers but also other companies and future inventors.[8]

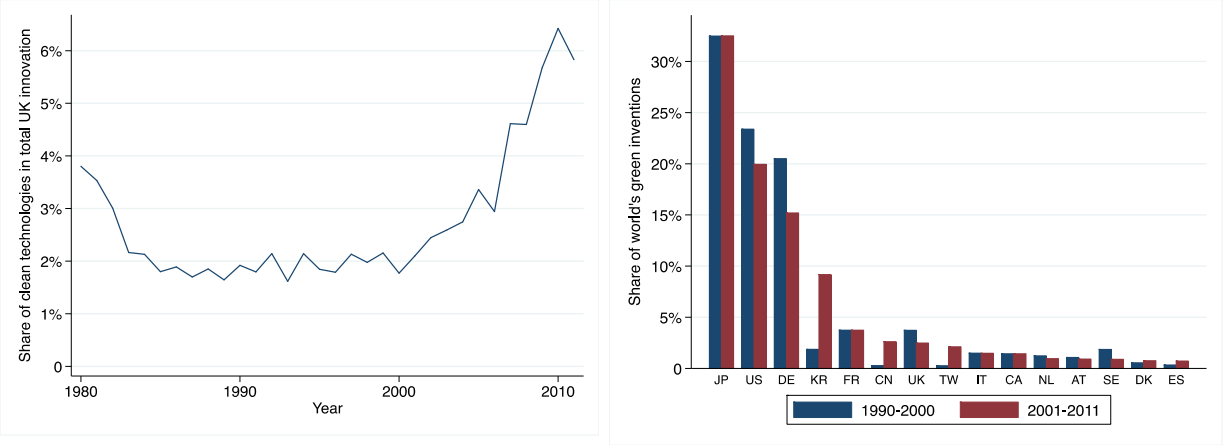
Climate policy typically encourages clean innovation while discouraging dirty innovation.[9] Hence, for climate policies to generate a positive growth effect, it is necessary for the social returns from innovation in clean technologies – the knowledge spillovers – to outweigh the social returns from the dirty technologies that they replace.

Recent CEP research estimates that across a wide range of clean technologies, this condition holds so that there is a net social benefit associated with innovation in clean technologies.[10] Furthermore, evidence suggests that the returns from these spillovers are localised – that is, the additional beneficiaries of clean innovation spillovers tend to be located in the same country as the original innovator. This is good news for unilateral climate policy that manages to promote innovation. It also suggests that there might be a direct benefit from being a global leader in innovation in clean technologies.

So what does the UK's performance look like when it comes to clean technologies? The left panel of Figure 3 presents the share of clean innovation (measured by patent counts) in total innovation by UK-based inventors. There is clear evidence of an increase in the importance of clean innovation in the UK. But when the UK is compared with other leading economies, as presented in the right panel of Figure 3, it is equally clear that the UK is lagging behind. The UK also appears to be losing ground as countries such as South Korea and China have overtaken it in recent years.

[8] For example, Apple's invention of the iPhone surely was a good move for Apple. But it also helped other companies such as Google and Android to come up with improved products highly valued by their customers. It also was the basis for thousands of innovative app developers and service providers who built a business model around iPhone-like smartphones.
[9] See Aghion et al (2012) for evidence of this for the automotive industry.
[10] For details, see Dechezleprêtre et al (2014b).

Figure 3: The UK's clean innovation performance



Notes: The left panel represents climate change mitigation inventions patented by UK-based inventors as a share of inventions in all technology areas. The right panel shows the contribution of the top 15 inventor countries in climate change mitigation innovation globally, for the periods 1990-2000 and 2001-11.
Source: Authors' calculations based on the PATSTAT database.

Further analysis (see Figure A3 in the Annex) shows that the UK is lagging in all areas except ocean and hydro technologies, a niche field that currently accounts for only 2% of global innovation.[11] Looking at a key measure of clean technology adoption (the share of electricity generated using renewable technologies), a similar pattern emerges. The share has increased sharply from below 5% in 2004 to over 10% in 2012, but compared with other countries, the share remains low in the UK.[12]

UK climate policy

UK climate policy consists of a patchwork of policies that address emissions from a variety of different sources. Some policies are further motivated by auxiliary issues, such as specific barriers to the adoption of technologies or the need for additional incentives for innovation. This section provides a brief overview of the key policies.

Long-term targets

With the 2008 Climate Change Act, the UK government committed itself to reducing domestic emissions by 80% in 2050 compared with 1990 levels. This is in line with the target of limiting emissions to 40% of 1990 levels globally (UNEP, 2014), which can only be achieved if industrialised countries such as the UK reduce emissions by more. Against this overall target, the Committee on Climate Change has specified five-yearly carbon budgets, as checkpoints to reaching this overall target.[13]

The European Emissions Trading System (EU ETS)

The European Union Emissions Trading scheme (EU ETS) is the first – and still by far the largest – international cap-and-trade system for carbon emissions. Since its inception in 2005, the EU ETS has changed the way that business is conducted in Europe by establishing a uniform carbon price for around 45% of the EU's emissions (5% of global emissions).

[11] For further details, see Figure A3.
[12] For further details, see Figure A4.
[13] These budgets are illustrated in Figure 1.

Since its inception, the EU ETS has been heavily criticised. Interestingly, the two main concerns conflict: on the one hand, the EU ETS is accused of being ineffective; on the other, it is accused of being too effective in increasing the costs of regulated firms, thereby endangering their competitiveness in global markets.

CEP research has explored both of these concerns in depth. Using data for Germany and France,[14] we find a significant causal effect of the EU ETS on carbon emissions, suggesting that the EU ETS reduced emissions by more than 10% in regulated firms. We also interviewed nearly 800 managers in firms across six European countries. In most sectors, we find no evidence that climate policy would lead to downsizing or business relocation abroad.[15] We also examined country-level emissions data for a sample of approximately 400 multinational enterprises, finding no evidence that such firms are shifting emissions away from Europe.[16]

The evidence suggests that the EU ETS has by and large been effective at reducing emissions without endangering the competitiveness of regulated firms, in direct contrast to the criticisms levied against it.

The Climate Change Levy and Climate Change Agreements

Introduced in 2011, the Climate Change Levy (CCL) is a tax on the energy consumption (including electricity) of businesses. Tax rates vary across fuel types, to some extent increasing in the carbon content of fuels; but coal is relatively under-taxed, as a result of lobbying by industry. Climate Change Agreements (CCA) allow for exemptions from the levy in exchange for firm-level targets on emissions for the most energy intensive sectors.

The official policy rationale is that the CCA achieves emissions reductions that are similar to if not stronger than the CCL, but without the financial burden on firms associated with paying the CCL. The aim is to mitigate any effects on competitiveness or employment in energy intensive sectors.

But CEP research[17] shows that firms not receiving exemptions reduced energy consumption and in turn emissions by *more* than CCA firms, which suggests that these targets were rather lax and probably not enforced. The same research also finds no evidence of job losses in several sectors that were not eligible for CCAs despite being relatively energy intensive, raising the question of whether the policy had any serious effects on competitiveness at all.

The CRC energy efficiency scheme – formerly known as 'carbon reduction commitment'

The CRC was introduced in 2010 to reduce emissions in energy intensive businesses not regulated by the EU ETS.[18] It requires regulated businesses to purchase carbon allowances at a fixed mandated price for the carbon contained in their gas and electricity consumption.

Initially, the scheme included a benchmarking exercise (where businesses were ranked according to their success in reducing emissions) along with a rebate scheme, where any revenue from the scheme was supposed to be returned to businesses according to their performance in the benchmarking exercise. But as a result of the government's efforts to

[14] We are still working on results for the UK.
[15] For details, see Martin et al (2014b, 2014c).
[16] For details, see Dechezleprêtre et al (2014a).
[17] Martin et al (2014b).
[18] In practice this means businesses consuming more than 6GWh of electricity per year.

reduce the deficit, this rebate was cancelled along with the benchmarking exercise so that the CRC is now effectively another carbon tax in all but name.

Given the characteristics of the CRC and in the absence of the benchmarking and rebate exercise, one questions whether it is justified as a separate policy. Arguably, it would make a lot of sense to simply combine it with the CCL, resulting in a more stringent policy. Initial results suggest that the policy has had a statistically significant effect in reducing carbon emissions in regulated firms compared with unregulated firms.

Support for renewable energy sources

The EU ETS provides some support for renewable energy by making fossil fuel power generation technologies more expensive. But generally the current price level in the EU ETS is too low to close the cost (and risk) gap fully. This is the rationale for a number of policies giving particular support for this sector. These include:

- A renewable obligation: energy suppliers are required to source a certain amount of their supply from renewable sources.
- A feed-in-tariff for small-scale renewable generators: this gives small-scale generators (for example, homeowners with solar panels) a fixed mark-up on the market electricity price.
- A carbon price floor: fossil fuel energy suppliers are required to pay an additional levy on carbon when the EU ETS price falls below a certain limit.

Measures for domestic emissions

Compared with non-domestic sectors, where in some cases overlapping policies distort the incentives of emitters, there is little intervention concerning emissions from domestic sources. Specifically, domestic emissions are not explicitly priced other than through the impact of the EU ETS on the electricity consumed by households. Nevertheless, there are a few policies that target domestic emissions. These include:

- *The Green Deal*: this is a scheme to make it easier for homeowners to invest in energy saving home improvements. Government-approved consultants and providers identify and implement energy saving improvements, and homeowners pay for the improvements through charges included in their subsequent energy bills. As energy efficiency improves, this should result in lower energy bills, resulting in an implicit subsidy. Most importantly, if homeowners sell their property, they are not liable to continue payments, as the financing arrangement remains attached to property.
- *Carbon emissions reduction targets* (CERT): this is a regulation imposed on electricity suppliers, but it targets energy consumption by household customers. It requires energy suppliers to finance energy saving measures for its customer base, such as the provision of insulation or energy saving light bulbs.

The Green Investment Bank

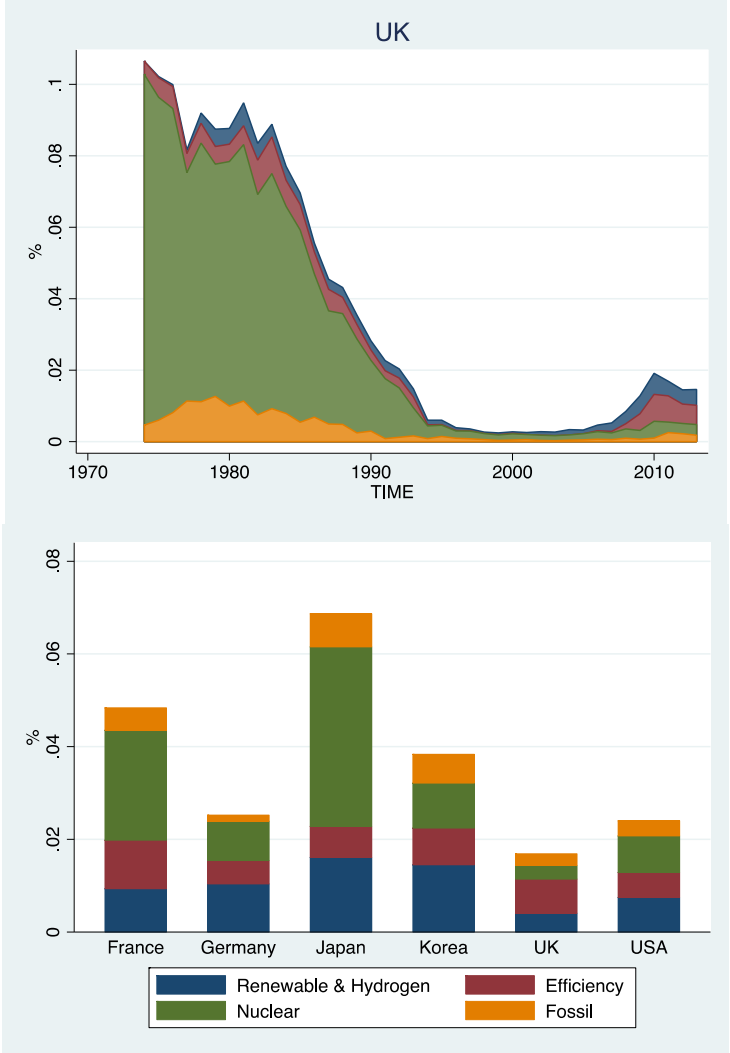
The Green Investment Bank was launched in 2012. Its sole shareholder is the UK government and it provides (low cost) funding for projects in a variety of areas related to GHG emissions. To date, it has invested around £2 billion, primarily in bio-energy and offshore wind projects.

Government funding for energy R&D

One important lever for governments to affect GHG emissions is through the provision of subsidies and support for energy R&D. Figure 4 shows the share of energy R&D support by government for various countries over time.

While the UK share has increased in recent years, levels are still far below the expenditure shares observed during the early 1980s when spending amounted to as much as 0.1% of GDP. Furthermore, with a spending share of less than 0.02%, the UK is lagging behind other countries (as can be seen in the second panel of Figure 4, which shows the figures for the last available year across countries). The UK deficiency is especially weak with regard to spending on renewable energy.

Figure 4: Share of government R&D spending on energy technologies



Source: Authors' calculations based on International Energy Agency data.

Discussion and recommendations

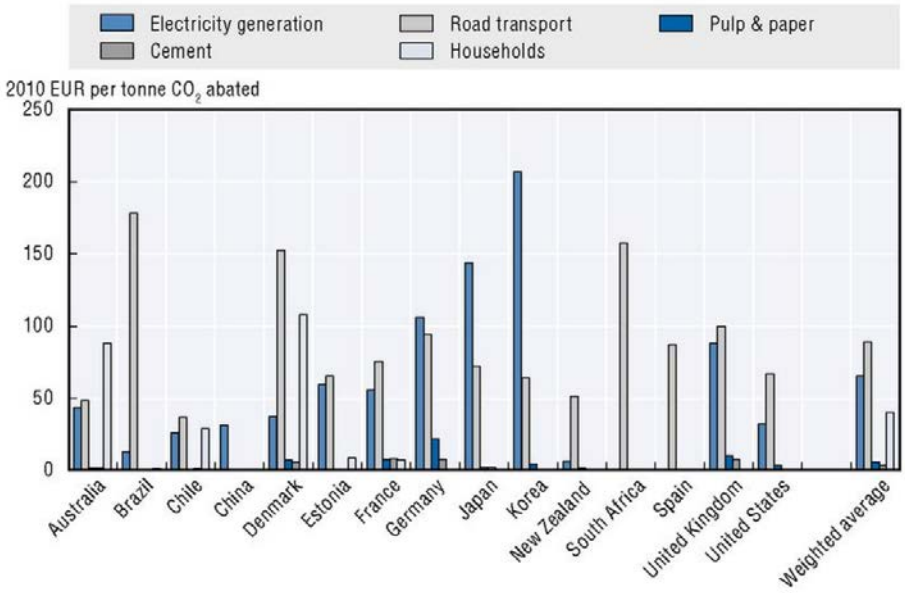
At face value, climate policy in the UK has been a resounding success. There is a long-term emissions reduction target combined with a wide range of active policies to achieve it. Moreover, the evidence suggests that these policies have, so far, been effective with all targets having been met to date. But closer inspection raises a number of issues:

- An important factor in meeting current targets was the recession. It is far from clear that future targets will be achieved with the current policy levels once the UK has fully recovered from the recession.
- Emissions targets and the focus of climate policy are in terms of production emissions. In light of this, there should also be concern for the consumption of emissions through trade. Defined in this way, there is no sign of any reduction in emissions.
- The complex interactions between different climate policies has resulted in considerable variability in the effective carbon price, and consequently in the incentives that different types of emitters face.
- The UK's performance in terms of clean innovation and the adoption of clean technologies is disappointing.

These issues lead to a number of considerations. First, given that the reduction in output during the recession was responsible for the UK meeting its recent emissions targets, there is no room for complacency. Rather, there is scope for further tightening of climate policies, especially where there is already slack.

A policy measure that could directly address consumption emissions is the introduction of consumption-based carbon taxes[19] whereby imported goods would face a tax that tries to account for the difference in carbon pricing between the UK and the origin countries of imports. But at present, there seems little appetite among policy-makers to pursue such policies. There are fears that going down this route could antagonise trading partners and undermine efforts to liberalise world trade (potentially violating World Trade Organization rules).

Figure 5: Estimated effective carbon prices in selected sectors by country



Source: OECD, 2013.

[19] Taking into account carbon content of goods in their origin country.

Second, Figure 5 illustrates the dramatic variability in the pricing of emissions between different emitters. For the UK,[20] the biggest gap arises between emissions from electricity generation and transport emissions where carbon is priced to the tune of around £100, whereas household emissions (from non-electricity sources) are not priced at all.

One of the factors making politicians reluctant to act on domestic users is 'fuel poverty'. But there are many ways in which incentives to act on emissions could be deployed in progressive ways, thus minimising the burden on the poor.[21]

Carbon price variability *within* the non-domestic sector is also substantial. Many firms now pay a carbon price three times for the same amount of carbon: all firms pay for the electricity they consume via the EU ETS, as well as implicitly via the renewable support schemes; most firms also pay for the CCL, which nets out at about £10 per tonne of carbon; some firms pay in addition for the CRC allowances, which, at present prices, adds another £12 (£15 from next year onwards).

But some of the most energy intensive firms are almost exempt from all carbon prices. They can claim a reduction on the CCL of 90%–100% in a few cases – through the CCA scheme.[22] Consequently, these firms pay £21 less per tonne of carbon than a firm that does not receive these exemptions.

This suggests the following strategy for improving UK climate policy: by moving towards a more harmonised carbon price across different emitters, through the abolition of exemptions, combined with an increase in carbon prices for emitters that face lower prices, the UK will strengthen climate policy, reduce inefficiency and raise additional funding that can be earmarked for clean R&D subsidies or other investments.

As an illustration, the tax revenue lost as a result of CCA exemptions is in the order of £360 million.[23] If the CCA was abolished and the resulting revenue channelled towards R&D on renewables and hydrogen, the UK would become the world leader on R&D spending in this category (as a share of GDP – compare Figure 4). These funds would increase further if firms were in addition liable to pay the CRC.

Where do the UK parties stand on climate change?

The three main parties have pledged to combat climate change whatever the result of the general election.[24] Yet much of the discussion is largely rhetoric, with limited focus on actionable policy commitments.

An exception is Labour whose leader Ed Miliband has committed to making the UK's electricity supply carbon-neutral by 2030 and reducing policy uncertainty to encourage green investment and innovation.[25] But there appears to be a conflict between Labour's climate change and energy policies: while they are committed to act on climate change, they also aim

[20] The graph also illustrates that the UK is not the only country with heterogeneous carbon pricing.
[21] For example, the government could implement a tax on domestic fuels combined with a tax-free allowance that decreases with fuel consumption.
[22] This was in response to concerns that these firms might face threats to their competitiveness as discussed earlier. But CEP research suggests that such concerns are not well founded (Martin et al, 2014a).
[23] Comparable to 0.02% of the UK's total GDP in 2011.
[24] Financial Times, Feb 14th 2015 (http://tiny.cc/6e9qvx).
[25] The Guardian, 21 Feb 2015 (http://tiny.cc/s6j5wx).

to freeze energy bills until 2017 and set up regulation to reduce energy prices. Unfortunately, a move to carbon-neutral generation is likely to increase costs and feed into price increases.

Most action on climate change is happening as the result of policies implemented by the last Labour government. Indeed, the Conservatives and Liberal Democrats have arguably been less committed to action on climate change since coming to power. In their manifesto, the Conservatives aim to continue support for the Climate Change Act while expanding nuclear and gas (including shale), and removing subsidies for onshore wind farms. The Liberal Democrats' manifesto seeks to introduce a number of 'green laws' and encourage innovation and R&D spending. While the renewed commitment to tackling climate change is honourable, the lack of commitment while in power raises the question of whether such policies will result in real action or a lot of hot air.[26]

The Greens, unsurprisingly, have a lot to say about climate change; indeed, their website and manifesto reads like a veritable Wikipedia page of information and positions relating to green issues. But their position in many areas reads as idealism rather than practical policies.

UKIP have proposed the most actionable policies on climate change: they would repeal the Climate Change Act (which is the legal basis for the carbon budgets); abolish 'unnecessary government departments', including the Department of Energy and Climate Change (DECC) and the Department for International Development (DfID); scrap green subsidies; and abolish green taxes. It should be apparent that these policies are the complete antithesis of the commitments made by the main parties.

In addition to a renewed commitment to combatting climate change by the major parties, it is our hope that whatever the outcome of the general election there will also be renewed action on climate change. By following a strategy that focuses on tightening existing climate policies, reducing inefficiencies, and earmarking revenues to support innovation and R&D in clean technologies, the UK will experience improvements, not only in its environmental performance, but also its economic performance, positioning itself as a leader in emerging global markets.

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For further information, contact:
Ralf Martin (r.martin@lse.ac.uk)
Or Romesh Vaitilingam on 07768-661095 (romesh@vaitilingam.com)

[26] Both metaphorically and literally.

Further reading

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Annex

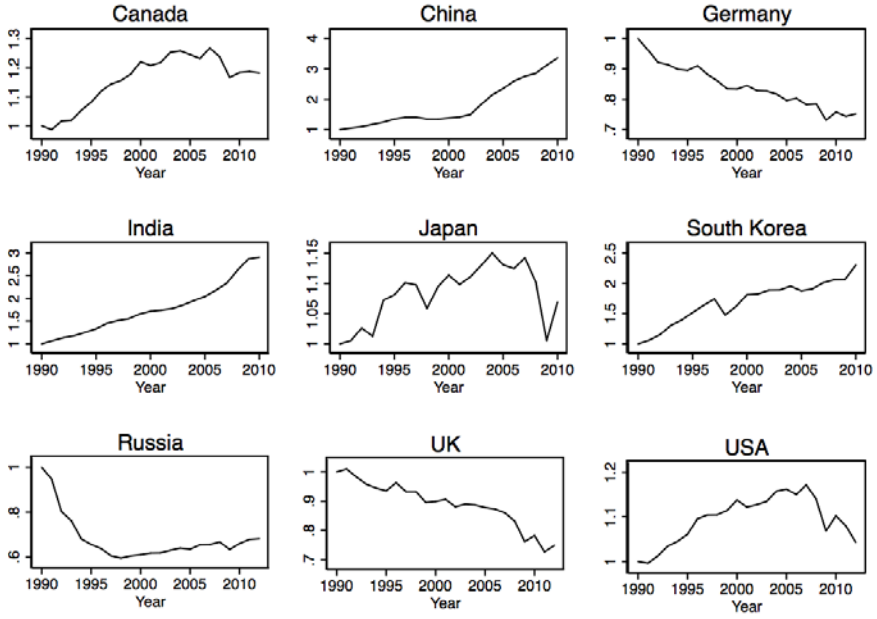
Emissions – comparing the UK with other countries

Compared with most other major economies, the UK has reduced emissions by more. While UK emissions have reduced compared with 1990, they have increased in most other countries with the exception of Russia and Germany (Figure A1).

But things look rather different when looking at consumption-based emissions – that is, accounting for the (net) emissions contained in imports minus exports. Before the recession, these were sharply increasing relative to 1990. With the onset of the recession, there was a sharp decline: in the last year for which data are available, emissions are still as high as they were in 1990 (Figure A2).

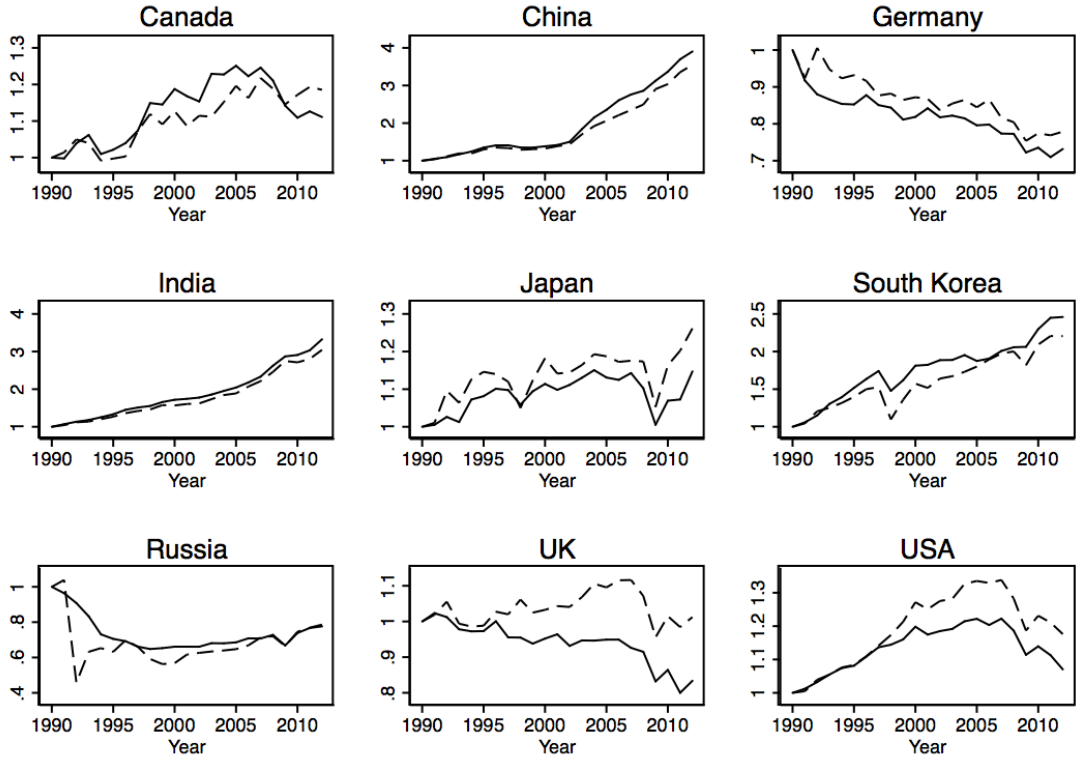
In the UK, the gap between consumption- and production-based emissions is particularly large. But the UK follows the same pattern as other industrialised countries of having higher consumption than production emissions. This is reversed for emerging economies such as China or India, where production emissions are higher than consumption emissions.

Figure A1: Emissions trends for selected countries



Notes: Data on GHG emissions are collected for Canada, Germany, Japan, South Korea, Russia, the UK and the United States. Data on carbon emissions are collected for China and India as data are not available on total GHG emissions from the UNFCCC.
Source: UNFCCC and Global Carbon Budget 2014.

Figure A2: Consumption versus production emissions for selected countries

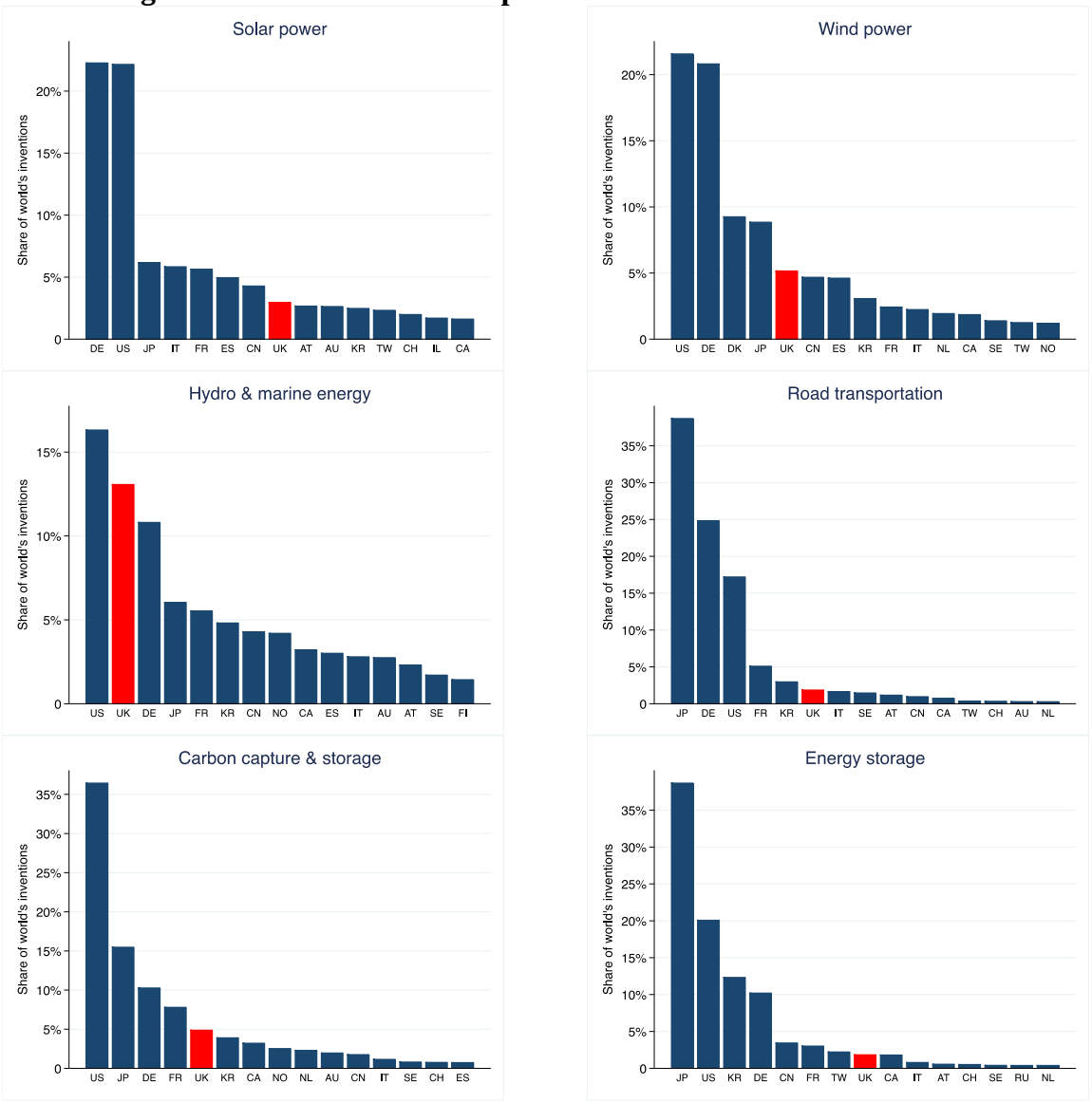


Notes: Solid lines are production emissions, dashed lines are consumption emissions. The data are updated from Peters et al, 2011. For an explanation of the issues around consumption emissions, see Peters et al, 2012.
Source: Global Carbon Budget 2014.

The UK's clean technology performance by technology field

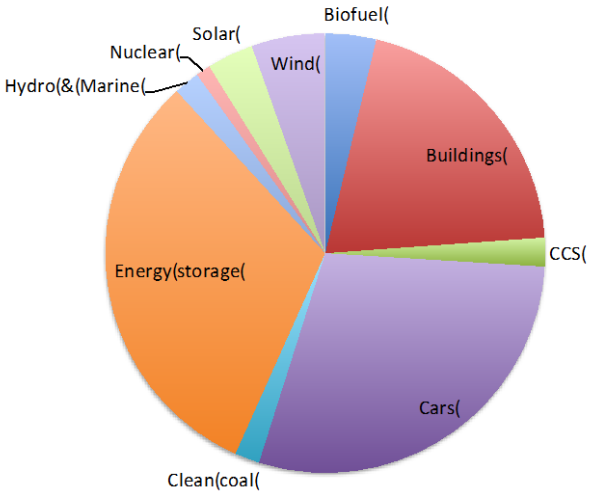
The UK is lagging behind other major economies in most technological fields with the exception of hydro and marine energy generation technologies (Figure A3). While this is encouraging, hydro and marine technologies are still a niche area accounting for less than 2% of all innovation activity globally (Figure A4). The UK is also lagging behind when it comes to adoption of renewable technology as Figure A5 illustrates, even though the share of electricity generated from renewables as been increasing steadily in recent years.

Figure A3: The UK's relative performance in selected innovation areas



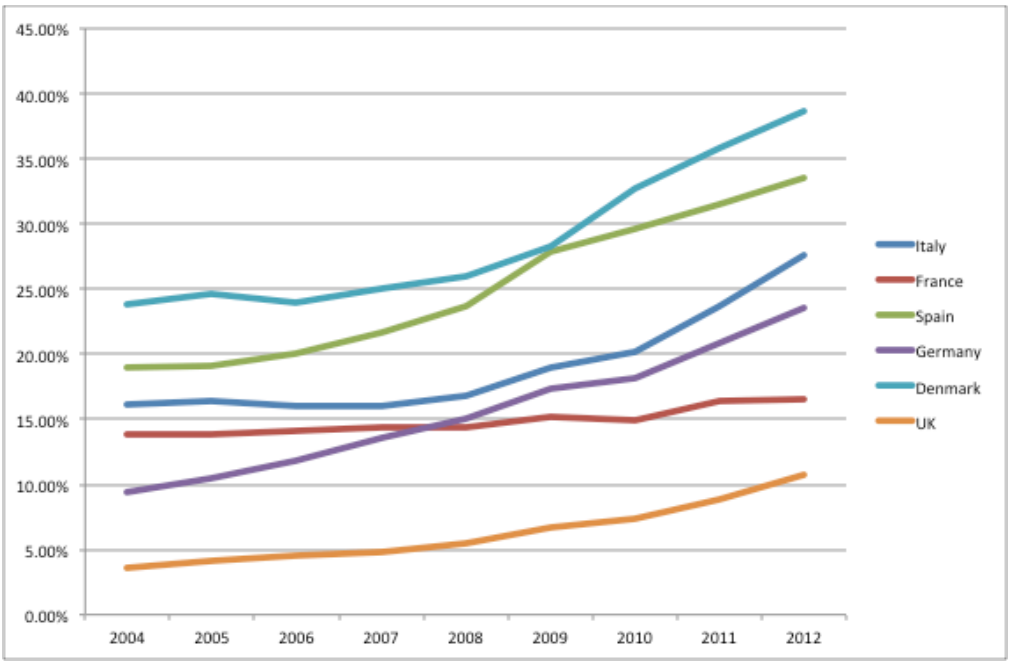
Notes: Each graph shows the contribution of the top 15 inventor countries in selected climate change mitigation technologies globally for the period 2001-11.
Source: Authors' calculations based on the PATSTAT database.

Figure A4: Clean inventions by technology 2001-11 (world)



Source: Authors' calculations based on the PATSTAT database.

Figure A5: Share of electricity generated from renewable sources in major EU countries



Source: Authors' calculations based on Eurostat data.

CENTRE for ECONOMIC PERFORMANCE

Centre for Economic Performance
London School of Economics and Political Science
Houghton Street London WC2A 2AE UK
Tel: +44(0)20 7955 7673 Email: cep.info@lse.ac.uk Twitter: @CEP_LSE
Facebook: https://www.facebook.com/centre4economicperformance