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Synthesis report: SIMPATIC micro-econometric research on clean innovation and the impact of climate policy

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SEVENTH FRAMEWORK PROGRAMME

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SYNTHESIS REPORT OF SIMPATIC MICRO-ECONOMETRIC RESEARCH ON CLEAN INNOVATION AND THE IMPACT OF CLIMATE POLICY

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Synthesis report of SIMPATIC micro-econometric research on clean innovation and the impact of climate policy

Introduction

An essential margin for the reduction of greenhouse gas (GHG) emissions is the development of new emission reducing technologies and processes. It is well established that market forces alone are unlikely to provide optimal levels of R&D towards this kind of innovation, because of the combination of both positive knowledge externalities and negative environmental externalities.

Policies that primarily target the environmental externality such as carbon emissions pricing – through carbon taxing or a trading system – might not only reduce GHG emissions. By putting a price on carbon, they could also provide incentives for companies to direct R&D to clean areas. Direct empirical evidence on the underlying mechanisms is very limited. There are a few studies showing a link between energy prices and clean innovation. However these rely on aggregate data or are very specific in terms of geographic range or the sector of the economy considered. Consequently, providing empirically robust evidence on this issue is a major objective of our work. Importantly, the impact of climate policy on innovation is a first order issue to adequately model policy scenarios in integrated assessment model and similar macro models.

Because of the presence of knowledge externalities, even a global carbon price could lead to a sub-optimal innovation level in clean technologies. Policies that directly target the knowledge externality are needed. But how strong must these policies be? The answer to this question crucially depends on the degree of knowledge spillovers in clean technologies compared to other (in particular dirty) technology areas. There is a striking lack of evidence on this issue, and another objective of our current work is to provide accurate measures of knowledge spillovers in clean technologies that can be used to inform policies and be fed into macro-models.

We are currently making progress along all of these lines. In the following section we summarise current results. We try to as much as possible translate our results into simple elasticities that can easily be integrated into a macro-modelling framework. We also give a short preview on on-going work and the kind of results we expect to uncover in the coming months.

Results so far

The effect of energy prices on clean and dirty innovation

In Aghion et al (2012) we examine the link between energy prices and innovation using firm level data for the automotive industry, globally. Identification of price effects comes from variation of retail transport fuel prices between countries over time and variation in the importance of different countries for different firms. Importantly, we account separately for price effects on radical clean transport technologies areas – e.g. electric or hydrogen propulsion - as opposed to innovation into internal combustion engines. Our results suggest that there is

- A short run price elasticity of clean innovation of 0.97
- A short run price elasticity of dirty innovation of -0.57

In other words: clean innovation increases and dirty innovation reduces in response to a uniform global increase in fuel prices. If the price increase is not global our model implies that the elasticities have to be multiplied by the share of the global market that where the price increase occurs.

We also try to use the tax component of fuel prices as an explanatory variable instead of tax-inclusive fuel prices. In quantitative terms the resulting figures are more likely closer to the impact that might be expected in response to a carbon tax. We find slightly smaller values, consistent with the idea that only part of a cost increase will be imposed on consumers.

- A short run tax elasticity of clean innovation of 0.40

- A short run tax elasticity of dirty innovation of -0.23

We also find evidence for two different dynamic channels which determine the long run response at the firm level. Firstly there is a strong path dependency whereby firms are more likely to engage in the same type of innovation that they have been conducting in the past. Similarly we find evidence for stronger innovation spillovers within innovation types. Both these effects give clean innovation a disadvantage when starting from a state of the world where dirty innovation is historically more dominant. However, these feedback effects also create a multiplier effect leading to a stronger long run response of a given policy intervention such as an increase in fuel taxes. Because these effects operate in a highly non-linear fashion it is hard to summarise them with a simple elasticity.[1] In Table 1 we report instead the short run elasticities for both internal clean and dirty knowledge stocks as well as external (spillover) knowledge stocks. For instance we see that an increase of the clean knowledge stock of a firm by 1% increases clean innovation of this firm by 0.31% ceteris paribus. Also note, that if the clean knowledge stock in all firms worldwide would increase by 1% we can use the sum of the own effect and the spillover effect as an approximation of the first order effect; i.e. in terms of the impact on clean innovation it would be equal to 0.31%+0.27%=0.58%.

Table 1: Knowledge stock effects

		Clean Innovation	**Dirty Innovation**
Direct Effect	**Clean Knowledge**	0.31	-0.00
	Dirty Knowledge	0.14	0.56
Spillover Effect	**Clean Knowledge**	0.27	-0.09
	Dirty Knowledge	-0.17	0.15

Notes: The figures report the percentage effect on innovation of a 1% increase in various kinds of knowledge stock measures.

The effect of unilateral climate policy on innovation

The European Emissions Trading System (EUETS) is arguably the largest climate policy initiative to date which has now been operating for 8 years. In Calel and

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[1] Elasticities will be contingent on the levels of the distribution of knowledge stocks across all firms.

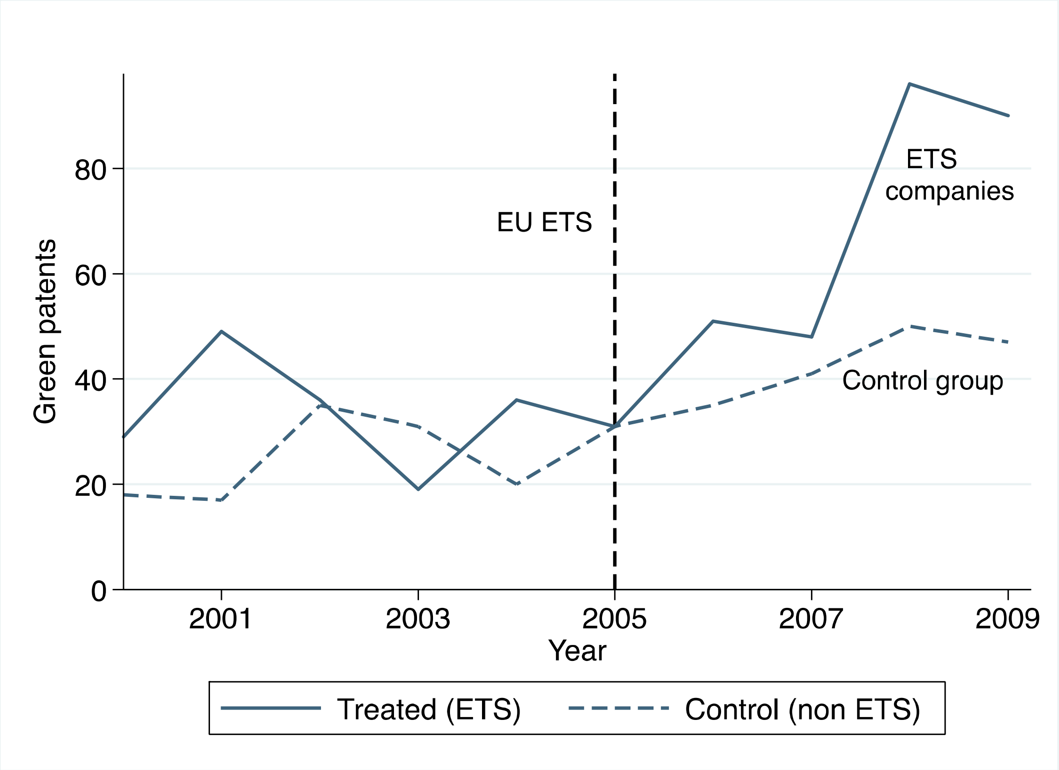
Dechezlepretre (2012) we examine its impact on innovation using a firm level perspective and a matching technique.

We compared nearly 3,500 companies that, by virtue of operating at least one sufficiently large installation, came under EU ETS regulations in 2005, with over 4,000 comparable companies that were exempted. Before 2005, these two groups were similar in size, in patenting activities, and operated in the same countries and economic sectors. Both groups would have faced similar macroeconomic conditions but from 2005 they faced different regulatory obligations for their emissions.

The firms look similar over the period 2000-2004, but since the EU ETS launched in 2005, EU ETS regulated firms have started filing more patents to protect low-carbon technologies (see Figure 1). The main finding of our paper is that EU ETS firms have increased their low-carbon patenting by about 10% compared to a counterfactual scenario without the EU ETS.

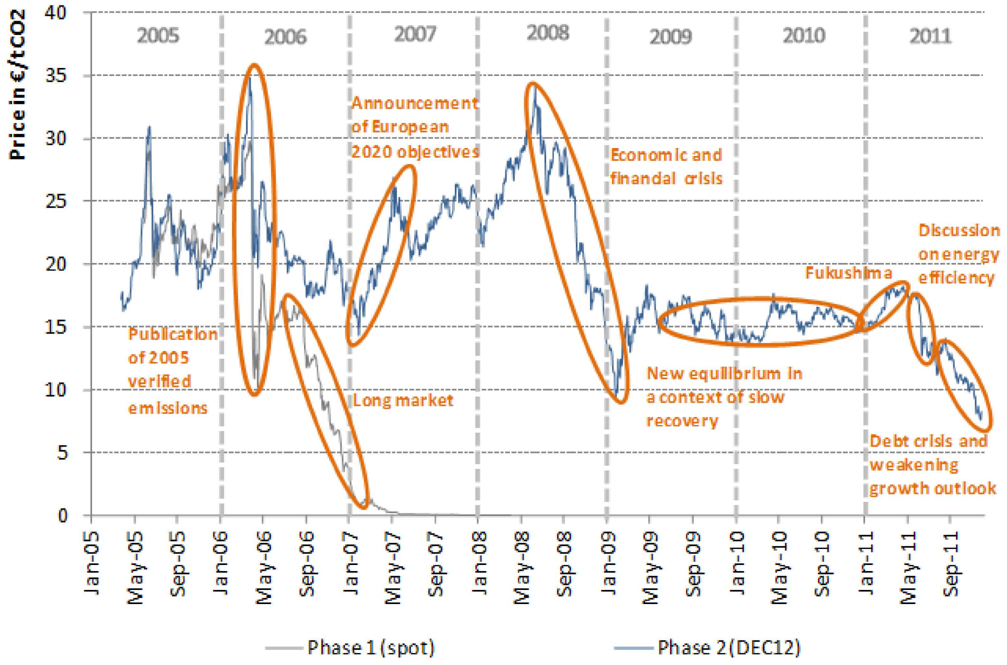
In order for our result to be more readily useful in a macro model we can try to translate it into an elasticity. Consider for that purpose the development of the EU ETS price path in Figure 2. The first take away from that is that the ETS price is notoriously volatile. In particular in the wake of the recent economic crisis the price plummeted. However, assuming that increase in innovation observed towards in 2008 and 2009 was based on higher expected price paths reflecting the rather high price of more than €30 in mid 2008 we can attempt to compute a carbon price elasticity by suggesting a price increase of $\frac{\Delta P}{P} = \frac{30-20}{20} = 50\%$ going form Phase I to early Phase II. Hence we would get a carbon price elasticity of $\frac{10}{50} = 0.2$.

Figure 1: Comparing low carbon patents for regulated and unregulated



Source: Calel and Dechezlepretre (2012)

Figure 2: The EU ETS price



Source: Climate Economics Chair from BlueNext and ICE ECX Futures

With respect to concerns that low-carbon innovation would crowd out development of other technologies, we find evidence that the EU ETS has in fact encouraged patenting for other technologies, but by a very small amount. This result thus differs form that of the first paper presented above, where we find that the increase in clean innovation is accompanied by a decrease in dirty innovation.

Spillovers and clean innovation

As suggested earlier, the existence of knowledge externalities or spillovers is an important reason why carbon pricing is not sufficient to trigger a socially efficient response from clean innovation activities.

However, such knowledge externalities are a feature of all types of innovation, not only of clean innovation, and there are a range of policy measures already in place to deal with this such as patent protection and general R&D subsidies. Hence specific policy measures for clean technologies would only be warranted if these spillovers would be higher for clean technologies. Spillovers are also relevant to understand the likely impact of climate policies on short and medium term economic growth. If spillovers in clean technologies are higher there might be positive growth effects.

Dechezleprêtre et al (2013) examine the evidence for differences in knowledge spillovers between clean and dirty technologies using patent citation data. Our estimates suggest that spillovers from clean technologies are about 20 to 30 percent higher than spillovers from dirty technologies.

We also examine if there are similar relative differences between clean technologies and other emerging technologies such as IT or biotechnology. In this case we don't find clear evidence for higher spillovers from clean technologies. Hence, from a normative point of view our results suggest that some extra support for clean technologies is warranted although not more than for other emerging technologies.

In terms of potential growth effects the evidence suggests that it depends very much on the type of displacement that is being induced by increasing support for clean technologies. If this leads to less investment in dirty technologies there seems to be scope for short and medium run growth effects. If it means that other emerging areas are displaced such effects are less likely.

Going Forward

There is still a wide range of open questions in this area, some of which we hope to address in our on-going research.

- Indirect regulation effects: regarding the innovation effects of the ETS a gap in the existing work concerns non-direct innovation effects; i.e. we might expect an innovation response not only for firms directly regulated by the ETS but also – maybe even primarily – for firms that are supplying technology to regulated firms. The challenge here is to be able to identify which firms are supplying technology to ETS firms. We are currently working on new empirical strategies to identify these linkages.
- Improving spillover measures: There is no unique way to measure knowledge spillovers. While patent citations might capture a direct effect of one innovation on another, the real value of many innovations could me more indirect; i.e. an innovation might itself not be cited very much, however it could have nevertheless have been an important stepping stone for an innovation that is highly cited. To explore this issue we are currently applying the Page Rank algorithm which is driving Google’s search engine to our patent citation data.
- The economic value of spillovers: measuring spillovers with citations implicitly assumes that every citation generates the same external economic value. This might not be the case. Moreover, there is rightly concern that patent citations are often a legal or strategic matter and do not necessarily reflect any causal effect on the innovation production process. These concerns can be addressed by identifying potential spillovers using proximity indicators; i.e. we examine if an innovation by one firm has any effects on another firm that is close to the first firm in terms of different proximity measures; e.g. closeness in geographic space or technology space. Such designs have been used in the literature before. However, we are currently applying such designs while distinguishing between clean and dirty

technologies. We are also developing new measures of proximity based on fine-grained firm level data.

References

Aghion, P., Dechezleprêtre, A., Hemous, D., Martin, R., & Reenen, J. V. (2012). Carbon taxes, path dependency and directed technical change: Evidence from the auto industry. Working Paper 18596, National Bureau of Economic Research.
URL http://www.nber.org/papers/w18596

Calel, R., & Dechezleprêtre, A. (2012). Environmental policy and directed technological change: Evidence from the european carbon market. Grantham Research Institute on Climate Change and the Environment Working Paper No. 75, London School of Economics, London, UK.

Dechezleprêtre, Antoine, Ralf Martin, Myra Mohnen; Knowledge spillovers from clean technologies: A patent citation analysis (2013), mimeo LSE