HOW

to ensure the level playing field for eco-innovation, taking into account possible adverse effects of existing policy measures?

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Outlook 9

How to level the playing-field for eco-innovation? The case of R&D tax credits

By Will McDowall, UCL ISR

8 DECENT WORK AND ECONOMIC GROWTH

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

10 REDUCED INEQUALITIES

Key messages

R&D tax credits have been overlooked in policy debates about funding energy innovation.

Data suggests that R&D tax credits can be a significant source of support for high-carbon R&D, and may undermine policy efforts to re-orient investment towards low-carbon R&D.

Depending on the policy design, R&D tax credits are often most beneficial to large incumbent firms in established industries, including those involved in fossil fuel extraction and development. Changes to R&D tax credit design can reduce this pro-incumbent bias

There may be a case for explicitly reducing R&D tax credits for high-carbon activities.

1 INTRODUCTION

In most industrialised countries, direct government support for energy R&D has increasingly been targeted at low-carbon energy. In contrast, the role of indirect public support via R&D tax incentives has been almost completely overlooked in the policy debate. Yet indirect support via tax credits is in many countries a significant share of overall public support for R&D. It is not clear whether R&D tax credits provide significant support to R&D in high-carbon technologies.

This paper begins to address this gap in the policy debate. First, the paper illustrates the extent to which the policy and research literatures have focused on direct public energy R&D, and have overlooked indirect financial support to R&D. The paper then presents new administrative data two countries, showing that the volume of indirect funding of R&D in firms related to fossil fuel extraction can be significant. Finally, the paper discusses the public policy arguments around the targeting of R&D tax credits, and sets out an agenda for future research in this area.

The idea of a "level playing field" for emerging eco-innovations is attractive, and is frequently invoked in policy discourse (see, e.g., OECD 2013; IRENA 2018). Yet it is not always straightforward to identify what a 'level' playing field really looks like. Established technologies benefit from decades of accumulated 'returns to adoption'. User practices, supply chains, regulatory and market structures, infrastructures and so on have all co-evolved around the incumbent technology. In such a context, policies that appear to treat all technologies equally will be of greatest benefit to the incumbents that are best place to take advantage of them. R&D tax credits are an interesting case in point. As a 'neutral' instrument, they are likely to disproportionately benefit incumbent firms and technologies, which typically have larger tax bills to offset, and lower barriers to market entry. Little is known about the volumes of R&D tax credits that support energy innovation, and this INNO4SD Policy Outlook provides evidence that the scale of R&D tax credits can be large, and has been overlooked in the policy debate.

In most large industrialised countries, direct government support for energy R&D has increasingly been targeted at low-carbon energy, as a result of a broad policy consensus about both the urgency of dealing with climate change and the importance of directed technical change in achieving that goal (Acemoglu et al. 2012). This consensus is in part rooted in the awareness that innovation and R&D contributes to (or facilitates break-out from) a state of 'carbon lock-in' (Unruh 2000), i.e. the path-dependent processes by which make a quick switch to low-carbon energy difficult and costly. With a long-term perspective, it is clear that public subsidies directed towards low-carbon technologies are an important part of a robust policy mix (Acemoglu et al. 2012; Stern 2007).

The policy debate, and associated research, has focused on questions related to direct public funding of R&D. Key policy questions have been as follows: how much should governments spend on energy R&D (Nemet and Kammen 2007)? Which technology areas should be the priorities for spending (LCICG 2014; Pugh et al. 2011)? What is the appropriate balance of spending between R&D versus deployment support (Laleman and Albrecht 2014)?

In contrast, the role of indirect public support via R&D tax incentives has been almost completely overlooked in the policy debate. Yet indirect support via tax credits is in many countries a significant share of overall public support for R&D (OECD 2017). There is very little data about where that support goes, in terms of broad categories of energy technology, since data is only reported at the highest levels of sectoral aggregation, such as 'mining and quarrying'. In light of the substantial debate about the appropriate volume and targeting of direct energy R&D expenditure, it is striking that there is so little knowledge of the volume and distribution of indirect energy R&D support.

This Policy Outlook begins to address this gap in the policy debate. First, the paper illustrates the extent to which the policy and research literatures have focused on direct public energy R&D, and have overlooked indirect financial support to R&D. The paper then presents new administrative data from two national tax offices, showing that the volume of indirect funding of R&D in firms related to fossil fuel extraction can be comparable to clean energy direct funding. Finally, the paper discusses the public policy arguments around the targeting of R&D tax credits, and sets out an agenda for future research in this area.

2 POLICY AND RESEARCH LITERATURE: FOCUS ON DIRECT PUBLIC R&D

A review of the literature on R&D policies in the energy sector reveals that studies have largely focused direct, rather than indirect, R&D expenditures. For example, these studies have used such data to:

- Explore the relative impacts of R&D expenditure vs. learning-by-doing induced by deployment (Nemet 2009; Johnstone et al. 2010; Söderholm and Klaassen 2007; Klaassen et al. 2005), and the interactions between these (Lindman and Söderholm 2016)
- Measure overall policy support for low-carbon innovation (Nemet and Kammen 2007; Jamasb et al. 2008)
- Characterise policy support for specific technologies (McDowall et al. 2013; Scordato 2010; Bointner et al. 2016)
- Explore divergences or commonalities in public vs. private R&D priorities (Rhodes et al. 2014)

None of these studies makes clear that public direct funding of R&D is only one form of R&D subsidy, suggesting that the research literature has largely overlooked indirect support.

Beyond academia, the public policy debate has also overwhelmingly focused on direct public expenditure. For example, energy innovation strategy documents from Australia (Campey et al. 2017), the UK (CCC 2010; LCICG 2014) and the EU (Wiesenthal et al. 2009) examine spending patterns based on direct expenditure. The baselines and pledges outlined by the countries involved in the Mission Innovation initiative are all based on direct R&D expenditure. None of these documents or initiatives provide any serious discussion or analysis of R&D tax incentives. Indeed, though no systematic search has been conducted, the author has been unable to find any public policy analysis focusing on the role that R&D tax credits play in funding energy innovation. Available data on direct energy R&D budgets over the past 20 years suggests that R&D priorities have gradually shifted away from fossil fuels, despite the very high oil and gas prices during this period (Figure 1).

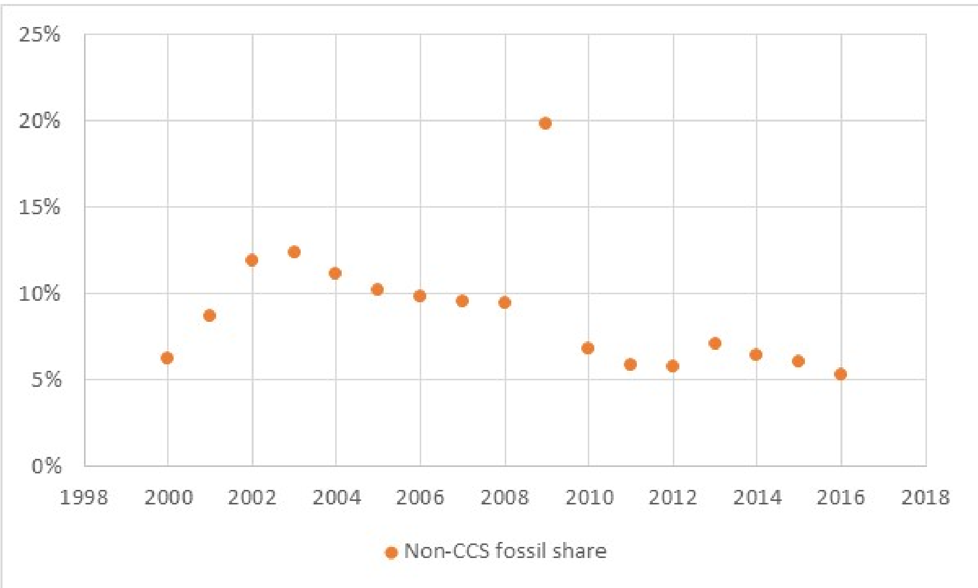
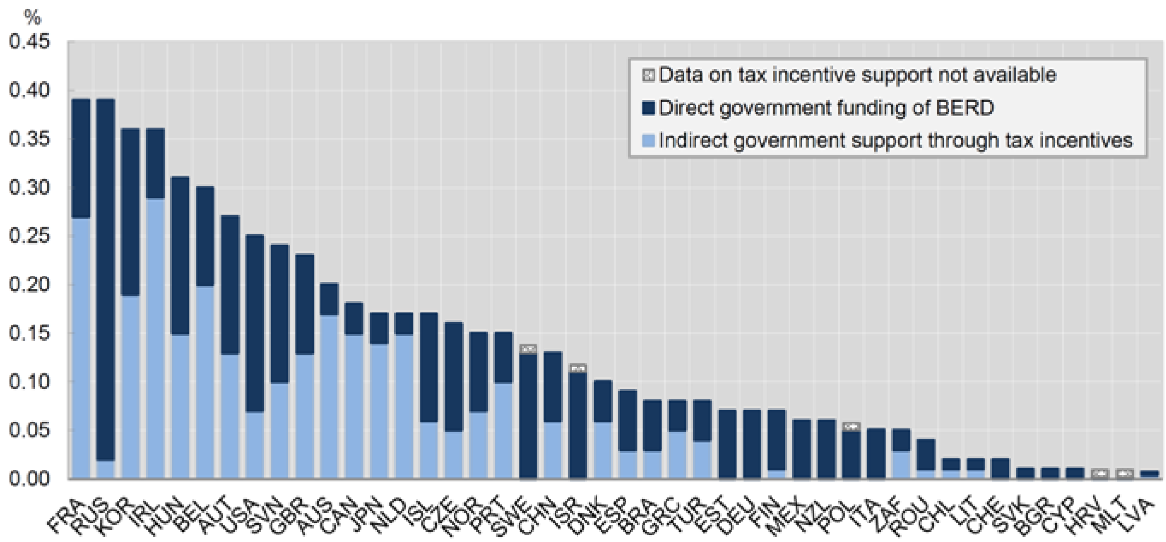


Figure 1. Share of public energy R&D budgets dedicated to fossil fuels (excluding CCS). Includes all OECD countries, except Chile, Israel, Mexico and Slovenia, which do not report data to the IEA. Note the outlier in 2009 relates to stimulus measures taken in the US in that year. Source: IEA

Yet it might be anticipated that R&D tax credits are not irrelevant to such debates, since indirect R&D tax support constitutes significant expenditures. Indirect supports are often a sizeable share of government support to business R&D (Figure 2).

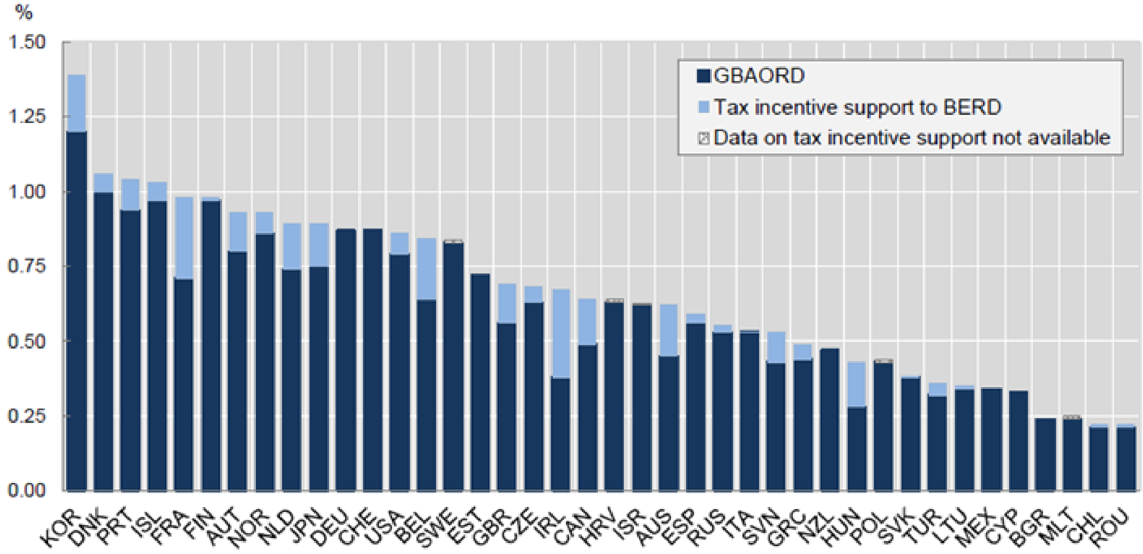


Source: OECD, R&D Tax Incentive Indicators, http://oe.cd/rdtax, Main Science and Technology Indicators 2016/2, www.oecd.org/sti/msti.htm and Eurostat R&D statistics http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database. See Annex for detailed notes.

Figure 2. Direct and indirect support for business enterprise R&D, as a % of GDP, for the year 2014.

Source: OECD 2017

The total share of indirect support is smaller as a share of total government support for R&D across the economy (i.e. including non-business R&D that takes place in universities, for example), but still substantial in many countries (see Figure 3). In Australia, for instance, R&D tax credits make up 27% of total public support to R&D. It is thus striking that this policy instrument has been almost wholly excluded from the debate about appropriate policy mixes for low-carbon innovation and transitions.



Source: OECD, R&D Tax Incentive Indicators, http://oe.cd/rdtax and Main Science and Technology Indicators 2016/2, www.oecd.org/sti/msti.htm, and Eurostat R&D statistics http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.

Figure 3. Total budget appropriations and outlays for R&D, and indirect support via tax incentives, as a share of GDP, in 2014. Source: OECD 2017

3 R&D TAX CREDITS, ECO-INNOVATION AND TRANSITIONS

R&D tax credits as innovation policy

There is an active policy debate about the importance of tax credits in stimulating an effective innovation system. The argument in favour of tax credits as a means of supporting R&D is intuitive: private firms are the best able to determine which R&D projects are most likely to generate valuable results, bringing together technological opportunities with market demands. Under this perspective, government lacks the knowledge to select the best R&D projects to support, and the choice should therefore be left as much as possible to the private sector. Moreover, the administrative burden is much less great than for direct support of R&D: with tax credits, governments do not need to select projects, or run competitive processes for the allocation of funds, nor do they need to make decisions about the priority areas of R&D to pursue.

Yet there are also concerns about the additionality of R&D tax credits. Would the firms receiving R&D tax credits have conducted the R&D anyway? If so, the subsidy is poorly targeted, and simply represents a transfer from the public to private sector. Most studies do find evidence that R&D tax incentives induce additional R&D expenditure, particularly when support is maintained over the long run (Appelt et al. 2016).

R&D tax credits: structurally anti-transition?

How might we judge R&D tax credits from an eco-innovation and sustainability transitions perspective? Technology neutral R&D tax incentives might be expected to disproportionately benefit incumbent technologies, which face fewer systemic failures in their innovation systems, and which are the beneficiaries of dynamic increasing returns to past deployment. In the context of energy innovation, this is often characterised as 'carbon lock-in' (Unruh 2000). In contrast, as is well established in the transitions literature, firms developing emerging technologies must confront a wide range of challenges, including lack of fit with established physical infrastructure, regulatory structures, social norms and other institutional rules, and so on. Unlike firms in incumbent sectors, firms developing radical technologies face challenges recruiting staff with relevant skills, attracting investment, navigating a regulatory environment that may not accommodate their technology, working to establish wider social legitimacy, and establishing a market.

Technology support that is available to offset R&D-related expenditures for any firm across the economy can thus be expected to disproportionately benefit incumbent firms. Far from being neutral, such policies are also selective, benefiting some sectors and technology fields more than others (Borras et al. 2009). Indeed, there is evidence that R&D tax credits in practice do indeed disproportionately benefit incumbent firms (Bravo-Biosca et al. 2013). Moreover, there is wide agreement that R&D tax credits are more suitable for fostering close-to-market innovation, while direct grants are more appropriate for longer-term and higher-risk projects, and those that generate public goods (Appelt et al. 2016).

In general, firms best able to take advantage of support in the form of tax credits are those with large tax liabilities, i.e. incumbent firms with large incomes. However, the detailed design of such instruments reduces this incumbent-bias:

- Most R&D tax credit systems do differentiate between large and small firms, offering smaller incentives for the former. Alternatively, but with a similar aim, some countries provide additional support to young firms.

- Some R&D tax credit systems offer carry-forward credits (so that firms can carry the credits forward to future years when they will have a tax liability to offset), or even refundable credits that are directly payable to loss-making firms, i.e. they are made available regardless of whether the firm is profit or loss-making. One of the rationales for this policy design is to ensure that R&D tax credit support is available to new technology-based firms that have raised capital to develop and commercialise a product, but have not yet generated a positive cash flow (i.e. it supports firms to conduct R&D even when they are in the classic 'valley of death'). However, it is also open to exploitation by multi-national firms able to shift profits to low-tax jurisdictions.

- Many R&D tax credit systems provide tax relief on payroll taxes, rather than income tax. This ensures that loss-making firms can still benefit from the relief, though the additionality of such measures depends on the elasticity of supply of researchers: if researchers are fixed in supply, such subsidies might simply drive up researcher wages, with no corresponding increase in R&D activities (Appelt et al. 2016).

- Some R&D tax credit systems put caps on the overall volumes of support available to individual firms. Again, this limits the extent to which large incumbents disproportionately benefit from the instrument, since it can be expected that larger firms with bigger R&D expenditures are most affected by such a cap.

Clearly, such measures reduce the extent to which R&D tax incentives disproportionately benefit large and profitable incumbent firms. This mitigates some of the concerns around incumbent-bias, but by no means eliminates them. A new technology-based firm developing a radical technology can be expected to be confronting numerous system failures that an equivalent start-up firm working within the established regime does not face, as is well documented in the sustainability transitions literature.

4 INDIRECT SUPPORT FOR R&D IN FOSSIL FUEL EXTRACTION AND PROCESSING

A likely reason for the relative neglect of indirect R&D support in debates about low-carbon innovation is the difficulty of obtaining the data. Tax agencies are typically bound by stringent data-protection rules, in order to protect taxpayers from disclosure of commercially sensitive information. While tax statistics are provided in the aggregate, no publicly available national data has been identified that provides a breakdown of tax credit data that can be allocated to specific areas of energy technology. To access such data, researchers must navigate the data protection systems of tax agencies in a wide range of countries.

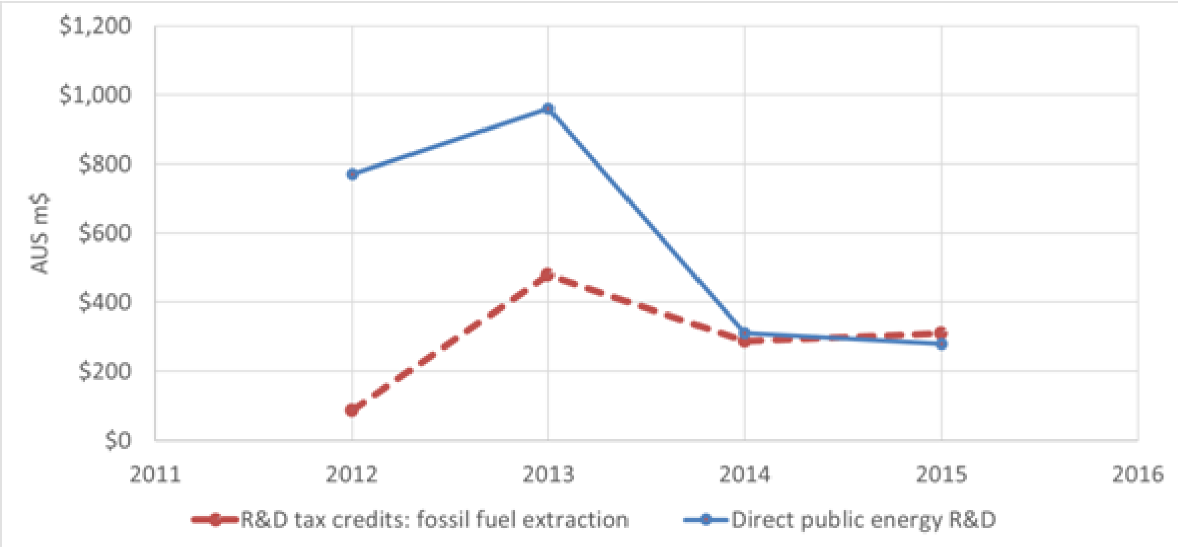
Data is presented here for Norway and Australia. Both are fossil fuel exporters, and both make substantial use of R&D tax credits as policy instruments to support innovation. These two countries are presented because the data reveals strikingly different levels of support to fossil fuel R&D. Data has been collected on the R&D tax allowances granted by tax authorities, for firms in the sectoral categories shown in Table 1.

Table 1. Industry classifications for sectors engaged in fossil fuel extraction and processing

Australia	**Norway**
ANZIC codes	NACE codes
06000 Coal Mining 07000 Oil and Gas Extraction	05 Mining of coal and lignite 06 Extraction of crude petroleum and natural gas 19 Manufacture of coke and refined petroleum products 08.92 Extraction of peat 09.10 Support activities for petroleum and natural gas extraction 35.20 Manufacture of gas; distribution of gaseous fuels through mains

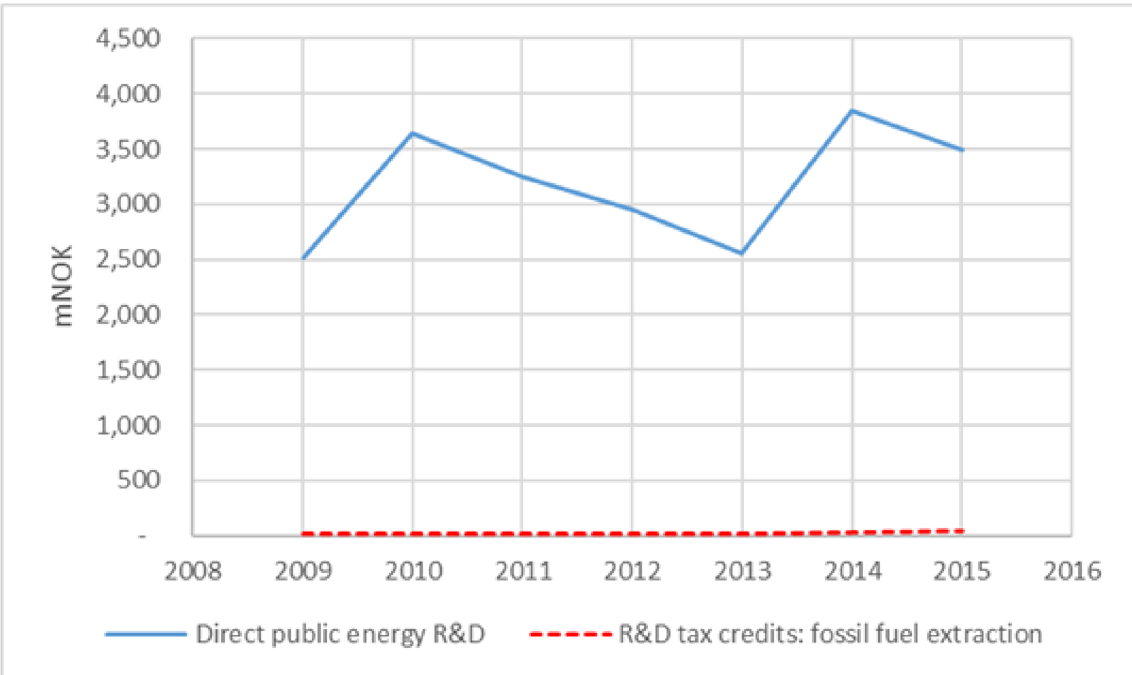
Figure 4 shows the value of Australian tax credits received by firms involved in fossil fuel extraction sectors. The data is compared in the figure to public direct energy R&D expenditure, with data taken from the International Energy Agency. The figure shows that the scale of support for fossil fuel extraction R&D via tax credits is comparable to the entire public energy R&D budget. In 2015, indirect support for fossil fuel extraction R&D exceeded the total public direct energy R&D budget. Ideally, such a comparison would also include the indirect R&D expenditure on non-fossil energy, but this is not possible to extract from sectoral classifications. It is worth highlighting that 2015 R&D tax credits to fossil fuel extraction sectors exceeded even the pledged target direct spending on low-carbon R&D under Australia's Mission Innovation commitments.

(Next page) Figure 4. Australian R&D tax credits and direct energy R&D. Source: Australian Tax Office; IEA.



The data for Norway presents a stark contrast with the Australian picture. Despite both countries having substantial fossil fuel extraction and export sectors, and both making extensive use of R&D tax credits as a form of innovation support, the total value of R&D tax credits received by firms in fossil fuel extraction and processing sectors is negligible in comparison to the total public energy R&D budget (Figure 5).

Figure 5. NorwegianR&D tax credits and direct energy R&D. Source: SSB; IEA.

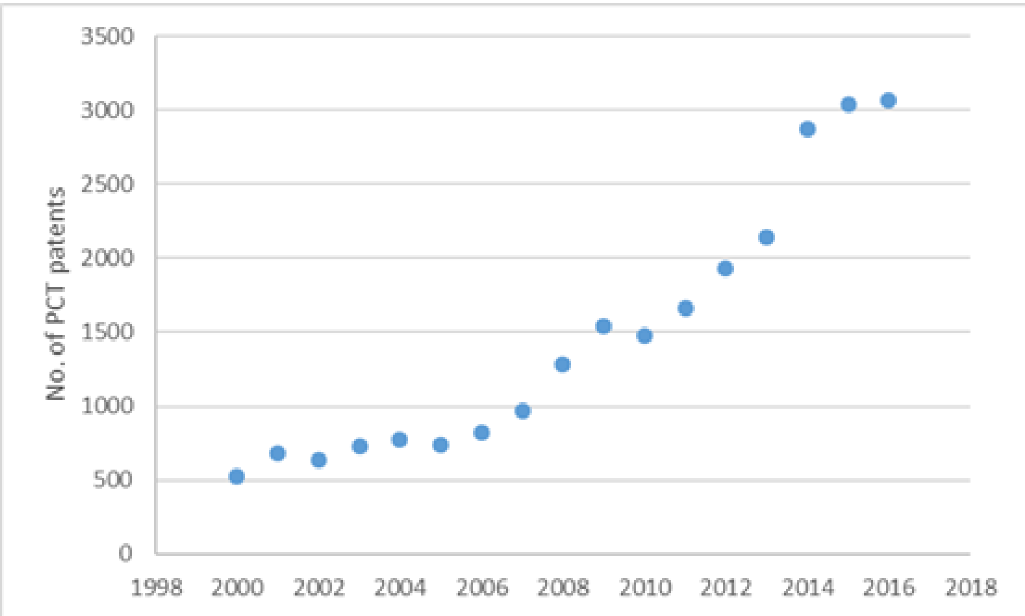


The principal reason for this divergence between Australia and Norway relates to different designs of R&D tax credit schemes. Norway operates a cap on the R&D tax credits that can be received by any given firm. Given the very substantial concentration of R&D activities in many fossil fuel extraction sectors, this design difference may explain much of the difference. This policy design, introduced to avoid non-additional expenditure and to constrain total costs of R&D support, appears to be driving large differences in the levels of R&D tax support going to fossil fuel extraction firms in Norway compared to Australia.

5 IMPLICATIONS OF R&D SUPPORT FOR FOSSIL FUEL EXTRACTION

While the research and policy literature have extensively studied the processes of developing and deploying new, cleaner technologies, there has been relatively less attention on patterns of innovation within fossil fuel regimes. This is despite a widespread belief in the relevance of "sailing ship effects", in which regimes undergo improved performance in response to threats from emerging alternatives. Indeed, it is clear that there has been considerable innovation success in fossil fuel regimes over the past twenty years, with the expansion into what were once considered 'unconventional' resources. Figure 6 shows international patenting trends in oil and gas extraction technologies. The trend is striking, and indicates the considerable efforts being made to reduce the costs of extraction, and to open up new resources of fossil fuels for commercial exploitation. Despite the wide agreement that innovation support should be re-directed towards low-carbon technologies, these innovation activities have been subsidised by governments throughout the OECD.

Figure 6. Estimate of annual PCT patent applications related to oil and gas extraction. Data from WIPO.



Clearly, many fossil-fuel companies are also involved in clean energy, and in R&D that reduces the per-output environmental burdens associated with their activities. The attempts of oil supermajors to play a significant role in the solar PV industry have been well documented (Miller 2013; Pinkse and Van den Buuse 2012), and corporate reports from fossil fuel firms highlight R&D on cleaner processes. It is certainly not the case that all R&D expenditure in such sectors is counterproductive from the perspective of sustainability transitions.

However, there are major gaps in evidence base here. First, there is little evidence on the relative share of R&D investments that might be characterised as sustaining vs. reorienting fossil fuel regimes. Second, we have little understanding of the impacts of subsidy support for R&D in fossil fuel extraction and processing. While estimates have been made of the potential global impacts of removing fossil fuel subsidies (Jewell et al. 2018), such studies have not included R&D support.

6 TOWARDS DIFFERENTIATION IN R&D TAX CREDITS?

The data and arguments above suggest that R&D tax credits have been over-looked in low-carbon innovation policy debates. They also suggest that there are options to make R&D tax credits less hostile to sustainability transitions, through ensuring that R&D tax credit systems do not over-reward profitable incumbents while neglecting emergent new entrants. But such policy options do not overcome the core issue about differences in the long-term social returns to different areas of R&D: i.e. they neglect the fact that investments in R&D to facilitate fossil fuel extraction risks substantially increasing the costs and difficulties of avoiding dangerous climate change. Might we envisage differentiated tax credits, based on sectoral and technological differences?

Quite unrelated to the question of innovation policy for decarbonisation, there is an ongoing policy debate about the value of sector-neutral R&D tax credits as innovation policy instruments. This is because the additionality of R&D induced by R&D tax credits differs across sectors (Freitas et al. 2017; Castellacci and Lie 2015), because sectors have structurally different patterns of innovation and research behaviour (Pavitt 1984; Peneder 2010).
There are thus clear arguments in favour of differentiating R&D tax credits along sectoral lines, as well as between small vs. large, or young vs. old. Such arguments rest emerge from an economic efficiency perspective, even before one takes into account the imperatives of sustainability, though it is clear that such arguments must be weighed against the administrative and legal challenges associated with introducing sector or technology differences.

Yet there are examples of R&D tax credit regimes that do make such differentiations, by targeting specific sectors or technologies. Many US States provide some form of R&D tax relief, and several of these include sector- or technology specific provisions:

- Wisconsin provides additional tax credits (at twice the normal R&D tax credit rate) for R&D on internal combustion engines and for certain energy-efficient products.

- Other states restrict R&D tax credits to specific targeted industries (Florida, Arkansas, New York's "Excelsior Jobs Program"), generically "high technology businesses" (Hawaii) or extend the duration of 'carry-forward' for specific industries (New Jersey). North Carolina provides higher rates for 'eco-industrial parks'.

It seems clear, then, that such targeting can be administratively feasible. However, (Appelt et al. 2016) suggests not underestimating the administrative burdens of more targeted mechanisms, for both governments and firms (noting that such burdens will reduce the number of firms able to access the support). There appears to be a good case for further research, and perhaps experimentation, with R&D tax credits that are targeted away from activities that further entrenching the dominant position of fossil fuel energy sources.

7 CONCLUSIONS

A large literature emphasises the importance of "lock-in" and path dependence in technological change related to the environment. This literature spans widely diverging disciplinary traditions, some of which are well known to transitions scholars (science technologies studies, evolutionary economics), others less so (Schumpeterian growth theory (Acemoglu et al. 2012)). The idea of lock-in has long been seen as a strong justification for technology-specific policies to combat climate change, alongside market-based and regulatory instruments (Stern 2007).

The policy debate has largely accepted the argument that R&D budgets should be increasingly dedicated towards low-carbon energy sources, precisely because of a recognition that regulatory and carbon pricing instruments alone are insufficient in the face of lock-in. Recent years have seen a gradual erosion of the share of fossil fuels in energy R&D budgets, and many countries have pledged to increase expenditure on low-carbon energy R&D.

Until, the debate has overlooked the role of R&D tax credits. This initial research suggests that they can be a significant source of policy support for fossil fuel innovation, and the research raises several important questions:

- What are the implications of current R&D tax credit expenditures: how significant is this expenditure in inducing R&D that contributes to carbon lock-in?

- What are the legal and administrative challenges in reforming R&D tax credits to avoid subsidising R&D that contributes to carbon lock-in?

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ABOUT

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9. How to ensure the level playing field for eco-innovation, taking into account adverse effects of existing policy measures?

10. How to design and implement science, technology and innovation (STI) roadmaps to foster eco-innovation for sustainable development?

11. How to account for macro-economic framework conditions in designing eco-innovation policy?

12. Can environmental product standards enable eco-innovation?

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The Innovation for Sustainable Development Network (inno4sd.net®) brings together networks dedicated to innovation for sustainable development with the aim of reducing fragmentation and supporting collaboration, whilst engaging policy-makers, research & development, and businesses to achieve the sustainable development goals.

The H2020 Green.eu project and inno4sd® network was coordinated by the Netherlands Organisation for applied Scientific research TNO in the period March 2015-January 2019. As of February 2019 the inno4sd Steering Board oversees the activities and management of the network.

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