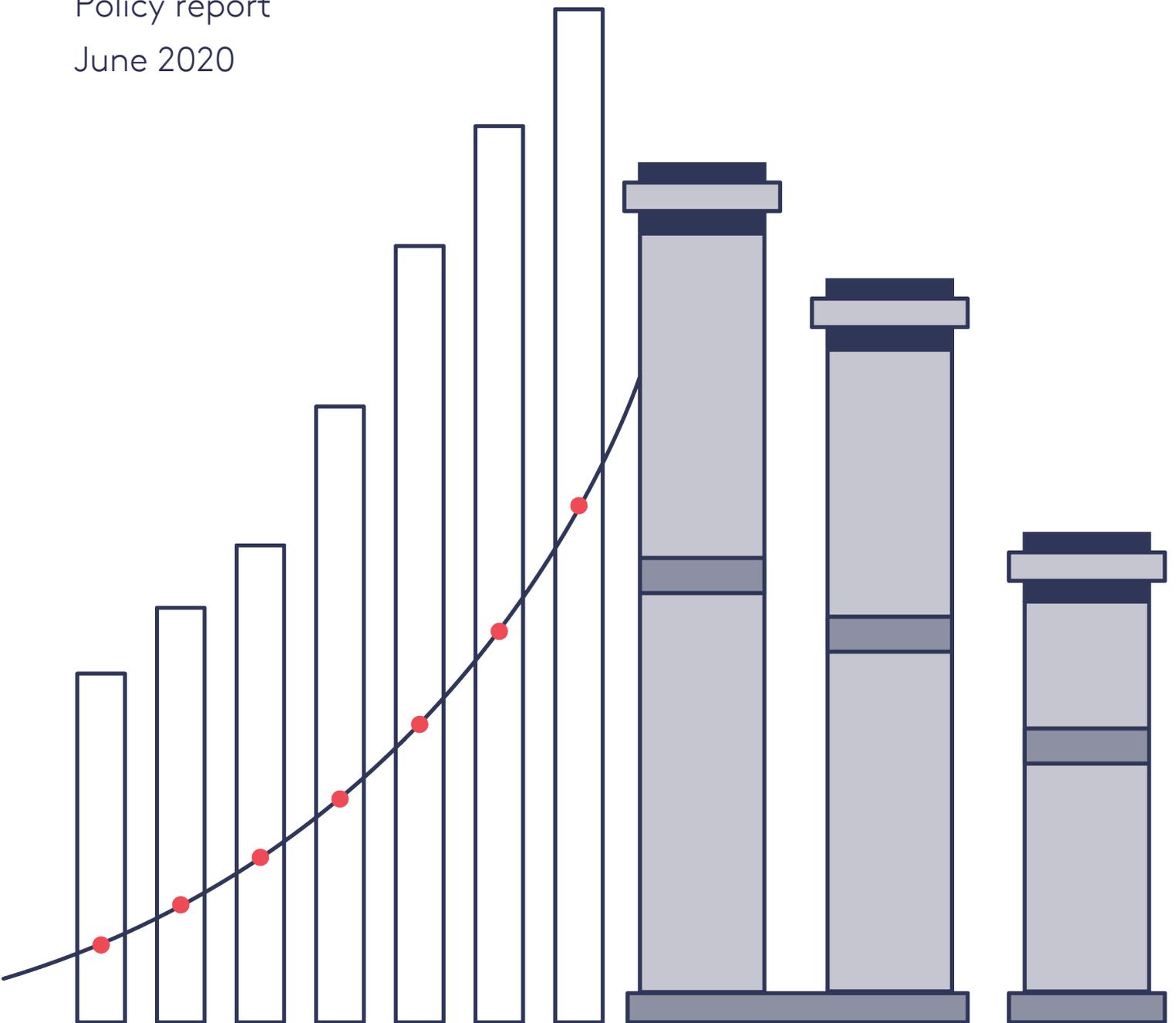


Does it pay for firms to go green?

Misato Sato, Tobias Kruse, Josh Burke, Myra Mohnen and Peter Pope

Policy report

June 2020



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About the authors

Misato Sato is an Assistant Professorial Research Fellow at the Grantham Research Institute on Climate Change and the Environment and Deputy Director of the Centre for Climate Change Economics and Policy.

Tobias Kruse is a former PhD student at the Grantham Research Institute.

Josh Burke is a Policy Fellow at the Grantham Research Institute.

Myra Mohnen is an Assistant Professor at the University of Essex and University of Ottawa.

Peter Pope is a Professor of Accounting at Università Bocconi and Emeritus Professor of Accounting at the London School of Economics and Political Science.

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Authors' declaration

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This policy paper is intended to inform decision-makers in the public, private and third sectors. It has been reviewed by internal and external referees before publication. The views expressed in this paper represent those of the authors and do not necessarily represent those of the host institutions or funders.

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Summary

Headline issues

- Firms that diversify into the green market space have higher profit margins than other firms, but not higher profitability as measured using accounting rate of return.
- Firms producing green goods and services tend to have lower asset turnover than other firms, perhaps reflecting both more recent capital investments and higher investment costs. The lower operating efficiency of assets explains why higher profit margins do not translate into higher profitability (return on investments).
- A notable exception is the energy sector, which has been the focus of climate policy over the past few decades. For this sector we find evidence that firms with higher green revenues on average have higher profitability, and that this is also associated with better stock market performance.
- The experience in the energy sector highlights the importance of comprehensive policy frameworks that target the decarbonisation of key emissions-intensive sectors, in addition to a strong carbon price signal in the economy, for triggering shifts in technology and investment towards carbon neutrality.
- Financial markets responded positively to the signing of the Paris Agreement, suggesting that strengthening climate policy signals and reducing regulatory uncertainty can help to open up and drive investments into new markets for green goods and services.
- However, the Paris Agreement has not triggered investors to divest substantially from fossil fuel firms and therefore additional policies are likely needed to establish clear incentives for decarbonisation.

Transitioning to low-carbon, climate-resilient and sustainable development will require a major shift in patterns of public and private sector financing and investment

Private sector action is vital for driving the global economy towards cleaner products and production processes. But how does 'going green' affect firms' performance in consumer and in financial markets?

Increasing the share of green activities increases profit margins but not profitability

We found evidence that increasing the share of green activities is not associated with higher profitability of firms, as measured by return on investment (accounting rate of return). However, there is mixed news underlying this finding. Firms with higher sales of green goods and services have higher profit margins (profits per unit of sales), but they also have lower asset turnover (higher assets to sales), perhaps because of the need to install new plant and equipment.

Policies to tackle barriers to investment

To achieve a broader low-carbon transition and encourage more firms to shift their commercial focus towards green goods and services, policies that tackle this investment barrier will likely play a key role in the future. These policies include, for example, investment tax incentives, preferential loans, or risk sharing through public-private partnerships to facilitate cheaper access to green capital. Policies that help create clearly distinguished markets for green goods (e.g. through labelling, mandatory disclosure of green and carbon-intensive activities, or green public procurement) may also help to achieve and sustain higher profit margins.

Defining 'green' economic activities

There is no clear boundary between 'green' and 'brown' firms and sectors and the concept is best thought of as a spectrum, where firms and sectors can engage in a mix of green and non-green activities.

The FTSE Russell dataset on which our analysis is based contains 10 broad green sectors and 60 green sub-sectors. These include sectors traditionally regarded as green, such as low-carbon energy generation, energy efficiency equipment, and waste- and natural resource management but also sectors that are not traditionally classified as green, such as finance and investment.

Evidence from the energy sector shows environmental policies play an important supporting role

The energy sector has, over the past few decades, been the focus of policies of the type described above and evidence from this sector suggests that it is possible to create an economically viable case for making climate-friendly production choices. In sectors where this has happened, firms with higher revenues derived from green goods and services are associated with better economic performance and with higher market valuations.

The evidence from the energy sector is consistent with environmental policies playing an important role in supporting companies through the green transition and encouraging shifts in investment. In addition to a strong carbon price signal in the economy, comprehensive, sector-specific policy packages are likely to play a significant role in bringing long-awaited shifts towards low-carbon technologies in other emissions-intensive sectors such as materials (e.g. steel and cement) and transport, by correcting prevailing market perceptions and creating robust investment frameworks.

Confidence in green markets increases as regulatory risk is reduced

To evaluate how financial markets respond to changes in regulatory risk, we examined the 2015 Paris Agreement, which marked a global commitment in the fight against climate change. In signalling countries' commitment to reducing greenhouse gas emissions, the Agreement reduced the uncertainty surrounding climate change regulations.

We found robust evidence that financial markets do indeed respond to reduced regulatory risk. Specifically, confidence in green markets rises:

- Firms in the United States that are engaged in the commercialisation of green goods and services on average experienced a significant stock price increase of 10 per cent in the week following the unexpected success of the Paris Agreement.
- This increase is equivalent to an increase in market capitalisation of approximately US\$200m per firm, and an aggregate increase in the market capitalisation of the 63 'greenest' US firms of US\$12.6bn.

We did not find significant effects of the Paris Agreement on emission-intensive firms. An exception is higher carbon-intensive firms in the oil and gas extraction sector, where negative and marginally significant abnormal returns are observed. This suggests additional policies are needed to trigger investors to divest substantially from fossil fuel firms.

Relevance for the recovery from COVID-19

Our work provides important insights into the potential role of climate policy within COVID-19 stimulus packages, linking COVID crisis economic support for firms to policies ensuring a green recovery. After the pandemic has subsided, many companies will be cash-strapped, face highly uncertain economic prospects and may have excess capacity in their conventional (non-green) production lines. In the absence of additional policy support, this could make it less attractive for firms to engage in green investment and production.

Climate change mitigation remains an urgent policy priority, requiring drastic emissions reductions – year by year – over the coming decades. There is thus a strong case for more public support in green technologies as part of a green recovery from the COVID-19 crisis as it can achieve both economic and environmental objectives.

Summary of support by governments to help firms transition towards carbon neutrality

- Policies that help create clearly distinguished green goods and production processes may further encourage the shift into green markets.
- Supporting financing costs for green investments and encouraging investment in new technologies along the supply chain will likely play an important role in ensuring 'going green' is economically viable.
- Learning from the energy sector experience, comprehensive policy packages should be implemented that target the decarbonisation of key sectors in order to trigger shifts in technologies and investments towards carbon neutrality in hard-to-decarbonise industries.

1. Introduction

To tackle the challenges of climate change, more investment needs to be mobilised in low-carbon technologies and capital assets. But what implications are there for firms as they diversify into the green marketplace?

This report draws on the following two complementary studies to present analysis on the revenues and profitability of firms following a green trajectory, and on firms' reactions to the Paris Agreement:

- *Green revenues, profitability and market valuation: Evidence from a global firm level dataset* (Kruse et al., 2020a)
- *Are financial markets aligned with climate action? New evidence from the Paris Agreement* (Kruse et al., 2020b)

Our research aims to contribute to the literature on whether environmental policy and economic performance are complementary or contradictory, how environmental innovation affects the bottom line and how financial markets respond to more stringent environmental regulations. It concludes with some recommendations for how government policy can help overcome market barriers to support firms to transition towards carbon neutrality.

2. Context: Scaling up investment in the green economy

The Intergovernmental Panel on Climate Change (IPCC) has shown that US\$1.6 to 3.8 trillion of investment in energy systems is needed annually to cap global warming at 1.5°C above pre-industrial levels, thus avoiding the most harmful effects of climate change (IPCC, 2018). Climate investments were estimated at around US\$500 billion in 2017, 54 per cent of which came from the private sector (Climate Policy Initiative, 2018). Therefore, a significant increase in investments is required to meet these overall goals.

Growth of the green economy and share across sectors

In responding to environmental problems and policies, a growing number of firms are altering their commercial focus towards the production of environmental goods and services. According to FTSE Russell (2018), the 'green economy', at 6 per cent of the globally listed equity market, was worth as much as the fossil fuel sector in 2018 – with the green economy growing more dynamically than fossil fuels (see Box 2.1 for definitions).

Figure 2.1, depicting the global green revenue share by industry, shows that the green economy spreads across many sectors but is largely concentrated in energy and manufacturing. Across most sectors, the revenue share ranges at roughly between 2 and 15 per cent. The industry with the highest green revenues in absolute terms is 'electricity, gas and sanitary services', generating approximately 25 per cent of total revenues from green goods and services on average. This sector includes renewable electricity generation, as well as water- and waste-management.

Box 2.1. Defining 'green' economic activities

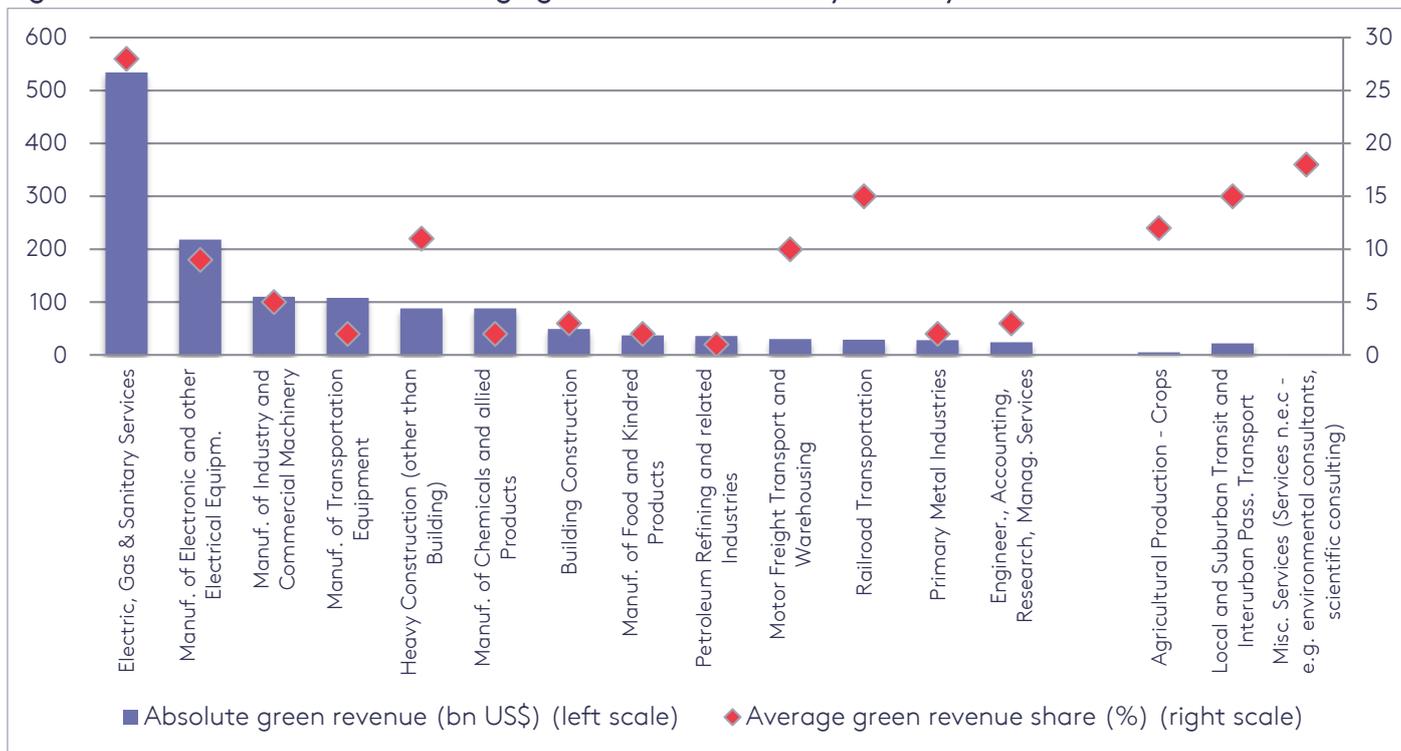
There is no clear boundary between 'green' and 'brown' firms and sectors and the concept is best thought of as a spectrum, where firms and sectors can engage in a mix of green and non-green activities.

The FTSE Russell dataset on which our analysis is based (see Box 3.2) contains 10 broad green sectors and 60 green sub-sectors. This includes sectors traditionally regarded as green, such as low-carbon energy generation, energy efficiency equipment, and waste- and natural resource management but also sectors that are not traditionally classified as green, such as finance and investment.

The FTSE Russell dataset highlights a number of features of the green economy, which include the size of the market (as a proportion of the global market capitalisation), its diversification (in terms of capitalisation size), the diversity of sectors that firms operate in, the global nature of green economies and market performance.

For a fuller discussion, see Kruse et al. (2020a).

Figure 2.1. Green revenues and average green revenue share by industry in 2016

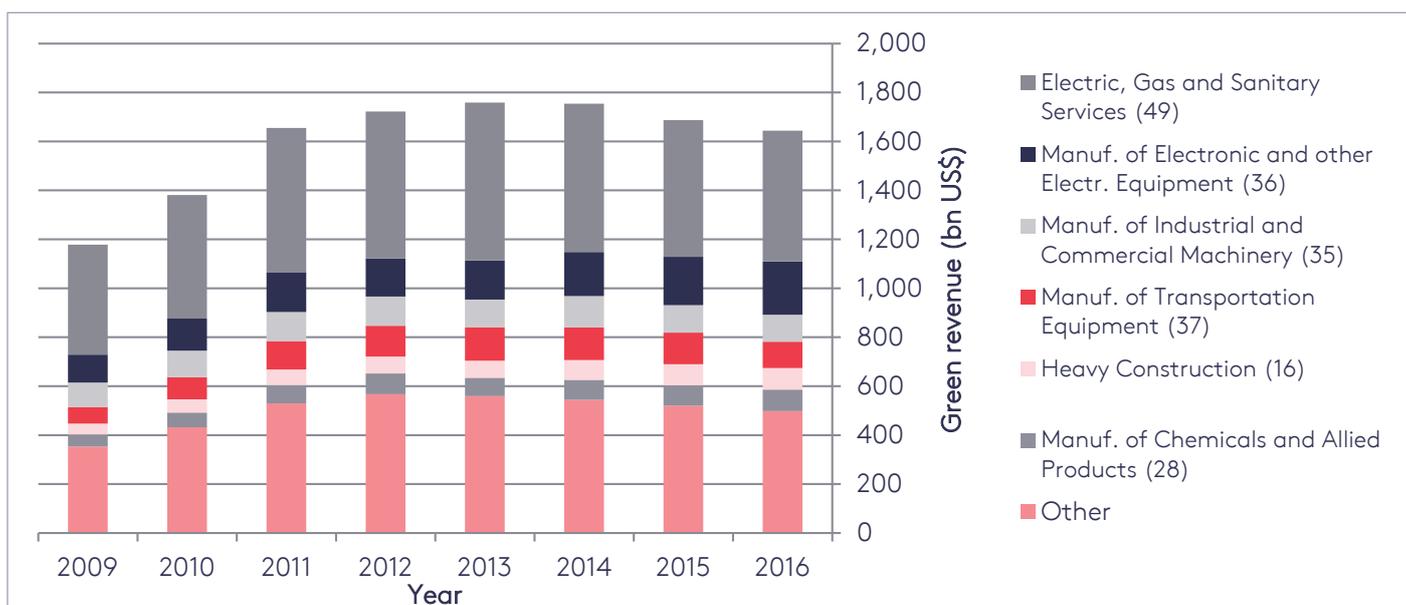


Source: Kruse et al. (2020a), based on FTSE Russell Green Revenues data (see Box 3.2)

Substantial levels of green revenues are also generated by manufacturing sectors. The four largest manufacturing sectors in terms of green revenues are, in descending order, manufacturing of electronics, industrial and commercial machinery, transport equipment and chemicals. Together they generate green revenues of approximately US\$550 billion globally.

Figure 2.2. shows an increase in green revenue from 2009 to 2013 and a slight decrease thereafter. Globally, green revenues accounted for approximately US\$1.6 trillion in 2016 (up from about US\$1 trillion in 2009). The global revenue of the largest 2,000 firms accounted for about US\$39 trillion (Forbes, 2018), therefore green revenues account for approximately 4 per cent of total turnover among globally listed firms.

Figure 2.2. Green revenue trends by sector, 2009–16 (billion US\$)



Source: Kruse et al. (2020a), based on FTSE Russell Green Revenues data (see Box 3.2)

3. Are environmental and economic performance conflicting or complementary?

The question of whether environmental performance and economic performance are complementary has been discussed ever since major environmental policies were enacted in the 1970s. The conventional view is that rational firms will invest in profitable opportunities, but any additional effort required to provide public goods by reducing pollution necessarily has to come at a cost that the market does not compensate for (Palmer et al., 1995). These arguments are used to oppose stringent unilateral environmental policies on the grounds that there is a trade-off between environmental performance (social benefits) and the economic performance of firms (private costs).

This rather static view is challenged by Porter and van der Linde (1995). In what has become the 'Porter hypothesis', they argue that polluting firms can benefit from environmental policies. Well-designed and stringent environmental regulation can stimulate innovations, to reduce the cost of compliance, and may in turn even increase the productivity of firms or the product value for end-users. Early mover 'clean' companies that innovate ahead of their competitors could therefore gain a lasting competitive advantage, but the empirical evidence on this remains inconclusive (see Ambec et al., 2013).

The publication of the UK's *Clean Growth Strategy* in 2017 made clear that the Government saw ambitious climate action as a vehicle for growth rather than as a competing priority (HM Government, 2017). The fact that since 1990 the UK's carbon emissions have fallen by 40 per cent while GDP has increased by 67 per cent – in a decoupling of economic growth from emissions – has further strengthened this argument. Many other countries, including France, Korea, the United States, Australia and Canada, have developed similar strategies, albeit with varying levels of ambition and policy support accompanying their pledges (OECD, 2020).

COVID-19 and green economic performance

The COVID-19 pandemic clearly brings additional challenges in the context of firms' environmental performance. As the world moves from economic rescue to recovery, investments need to be scaled up while simultaneously building a low-carbon and inclusive economy that is more resilient to future risks. At the same time there is a risk that old arguments that imply a trade-off between environmental and economic objectives are emphasised and deployed.

Orienting production towards green goods and services can help align economic growth with such low-carbon objectives. Stimulus packages should seek to avoid locking in high-carbon infrastructure that is incompatible with achieving net-zero emissions. Such infrastructure is already at risk; to counteract this, stimulus policies oriented at diversifying and specialising production towards green goods and services should be favoured. Policies of this nature can enhance and drive restoration of economic growth and firm performance while building a more environmentally-resilient economy (see Hepburn et al., 2020 for a broader discussion on such packages).

In particular, with the collapse of oil prices, governments should consider encouraging the switching of investment away from fossil fuels to greener sources of power, which would offer substantial economic benefits while tackling the climate emergency.

How does environmental innovation affect the bottom line?

Having established that firms can innovate in response to environmental policies, the second question is, how does this affect firms' bottom line performance?

Environmental innovation can impact firms' economic performance through one of two channels:

- **Through the 'cost channel'** firms reduce input costs – for example for energy and raw materials – through efficiency improvements. Additionally, environmental innovations can lower exposure to environmental risks, liabilities and lawsuits, reducing current and future costs.

- **Alternatively, the ‘revenues channel’** enables firms to increase revenue by developing new, cleaner products in response to changing customer preferences and capturing market share (Dechezleprêtre et al., 2019).

Most studies have tested the cost channel; fewer have examined the revenues channel. Yet examining the question of whether diversifying into the environmentally friendly market space is privately rewarded or not is important for informing policy debates. Private rewards imply that market forces can stimulate innovation and foster a profit-driven response to environmental problems. Incentivising low-carbon innovation by private firms can help generate knowledge spillovers and reduce costs of green technologies over the longer term (Dechezleprêtre et al., 2016). Lowering the cost of the transition will help to build enduring political coalitions and public support, which are vitally needed to sustain ambitious climate action.

Testing the ‘revenue channel’

We built on the handful of papers that empirically test the ‘revenue channel’ – looking at whether orienting production towards low-carbon goods and services contributes to economic performance and market value creation. We then linked firm profitability to public policy.¹ (Box 3.2 summarises our methodology.)

The possibility prevails that well-designed, stringent environmental policies could simultaneously reduce environmental impact and enhance economic performance of firms, such that the provision of public goods from the private sector results in a ‘win-win’. However, the question remains, how can private sector investments in low-carbon technologies be accelerated? Understanding the barriers to investment are even more important as the UK and countries around the world look to provide clean and green stimulus packages. It is important, therefore, to understand how policy design can be improved, in order to enhance the economic viability of ‘going green’ such that large-scale, private sector, low-carbon investments can be mobilised.

Box 3.2. Overview of methodology

We examined if strategic moves into new markets for low-carbon goods and services by frontier firms pay off in terms of profitability, and if they are rewarded or punished by investors. We used newly constructed global firm-level data that estimate green revenue as a proportion of total revenue, matching key firm characteristics and firm financial performance variables to the green revenue data. The green revenues data is from FTSE Russell and is, to our knowledge, the first database that provides comprehensive and detailed information about the environment-focused commercial activities of publicly listed firms. It uses corporate disclosures on business segment revenues to track the estimated share of revenues generated through green goods and services over time.

Our dataset includes information on more than 16,500 global publicly listed firms across 48 countries operating from 2009 to 2016. FTSE Russell uses its Green Revenues classification model to define the green economy covering a wide range of industries (60 sub-sectors) including energy, water, waste, environmental resource management, manufacturing, and services, as shown in Figures 2.1 and 2.2 above (FTSE Russell, 2017). The universe of companies in the dataset covers approximately 98 per cent of global market capitalisation. We identify over 3,500 firms with revenues derived from the production and sales of green goods and services.

In one of our studies (Kruse et. al. 2020a), using this data we tested the association between changes in the share of green revenues and the economic and market performance of firms (reported on above), overcoming a number of key limitations in the previous literature. The outcomes we examined include operating profit margin (how successful the management is in creating earnings from its sales), more comprehensive measures of investment profitability that capture return on the firm’s investments, i.e. Return on Assets and Return on Equity, and a market based measure (Tobin’s Q).

In our second study (Kruse et. al. 2020b) we used an event study approach to test if the stock market responds to changes in regulatory risk surrounding climate change (see Section 5 below). We looked at the Paris Agreement as an exogenous shock that signalled an increase in global commitment towards climate action. We examined the daily stock prices of major publicly listed US companies, distinguishing between green and emissions-intensive, using their green revenue share and carbon intensity respectively.

¹ This research and analysis is the subject of our working paper, *Green revenues, profitability and market valuation: Evidence from a global firm level dataset* (Kruse et. al., 2020a).

4. Green revenues and economic and market performance

Across industries, we found that increasing the share of revenue from green goods and services is associated with higher operating profit margins. This suggests that higher price premiums (or lower costs of sales) are available from proactive moves into the environmentally-friendly market space – possibly because consumers are willing to pay a premium or because markets are less mature. Our results suggest that public policy can play an important role in accelerating and harnessing private sector low-carbon investments by ensuring the level of firms’ ‘green effort’ is known to consumers and investors, for example through the provision of information.

However, higher profit margins do not necessarily imply higher profitability, measured as the accounting rate of return² (return on investment). This is in part due to the higher capital investment requirements of engaging in the production of green goods and services. In order to operate and produce revenue, firms require financing – through debt or equity – and they need to maintain and invest in physical assets such as manufacturing plants. The profitability of a firm therefore needs to adjust for the cost of financing (e.g. the rate of interest) and the cost of investing in and maintaining operating assets.

Higher capital needs could potentially pose a barrier for firms wanting to shift into green markets. Therefore, policy could tackle this barrier to make green investments economically viable across a broader range of sectors by facilitating cheaper access to green capital³ and by reducing the after-tax cost of operating assets. Initially, support for green investment may be in the form of tax incentives or risk sharing through public-private partnerships.

Example of the automotive sector

A prominent sector where higher investment needs are affecting market values and the return on assets is the manufacturing of motor vehicles and equipment. We observe a negative association between green revenue share and return on assets in this sector. Green revenues in the automotive sector are largely produced from manufacturing and selling hybrid and electric vehicles. Our findings suggest that profit margins for such vehicles are lower compared with conventional, gasoline/petrol or diesel vehicles. This is consistent with industry reports that profit margins are reduced by higher component costs, particularly of battery technologies, and relatively low production volumes currently limiting economies of scale.

Our findings for this sector suggest that car manufacturers that shift more aggressively towards producing hybrid and electric vehicles can expect lower profit margins in the short term but are well positioned to take advantage of long-term opportunities (see Unsworth et al., 2020 for more on this issue).

Does higher profitability attract investors?

One would expect that higher profitability makes green firms more attractive to investors, and should push up market valuations if product market growth is anticipated. However, on average in our sample a positive relation between market valuation and green revenue share is found only for green utility firms (energy generation, water-, waste management firms, etc.). Green revenues in the utility sector have grown steeply over the past decade, yet firms in this sector also face unique regulatory settings – often being sheltered from competitive forces in some jurisdictions.

For other sectors that are less protected by governments, producing green goods and services is overall not rewarded by investors, even if such firms generate higher profit margins. This is consistent with any growth in profits attributable to green products and services being riskier, this risk being priced. In such sectors investments in the green economy may be less attractive without longer term policy support to help mitigate investment risk.

² Measured as Return on Assets (ROA) and Return on Equity (ROE) in our paper (Kruse et al., 2020a), which enables use of the Du Pont Decomposition, an accounting identity, for analysis. Other outcome variables we examine are Return on Sales (ROS) and Tobin’s Q.

³ See for example Bloom et al. (2019) and Polzin (2017) for discussions on policy tools to mobilise private finance for low-carbon innovation.

Targeting non-utility sectors

Meeting the world's climate goals requires a transition to low-carbon alternatives across a broad set of sectors. While change in the utilities sector, and electricity generation in particular, is key for the low-carbon transition and indeed has been a large driver of decarbonisation in the UK, policies need to increasingly target non-utility sectors to achieve a broad diffusion of green technologies. This is especially important as countries move beyond sectors that are relatively easier to decarbonise, such as electricity generation, to tackle sectors where decarbonisation is more challenging and has been slow to date, such as surface transport, domestic heating and aviation. Innovating the next generation of technologies in hard-to-decarbonise sectors could also contribute to knowledge economies in the longer term (Rydge et al., 2018).

5. Do financial markets respond to changes in climate regulations?

To test how changes to regulatory risk around climate change affect the valuation of both green and brown (fossil-based) firms in the US stock market, we examined the Paris Agreement using an event study approach.⁴ The Agreement signalled countries' commitment to reducing emissions, lessening the uncertainty surrounding climate change regulations. The signatory countries collectively pledged to make "financial flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development" (United Nations, 2015).

Higher returns for US-listed green firms

We found that green firms listed in the United States significantly outperformed the market in the week following the Paris Agreement. The greenest firms observed on average 10 per cent higher returns compared with the overall market, equivalent to approximately US\$200 million in market capitalisation per firm. This is equivalent to an increase in market capitalisation of US\$12.6 billion for the greenest 63 firms. For a larger sample of nearly 250 US firms with some green revenue, we observed returns of about 3 per cent, which implies an increase in market capitalisation of about US\$45 billion.

Thus firms with high green revenue shares outperformed partly green firms, which in turn outperformed other brown firms in the market. On the flip side, we do not observe evidence that investors divested substantially from fossil fuel firms following the Agreement.

The positive returns for green firms suggest that strengthening climate policy signals and reducing regulatory uncertainty can help to open up and drive the valuations of firms involved in new markets for green goods and services. If stock markets are efficient and valuations linked to economic fundamentals of the underlying businesses, our results can be interpreted as evidence that policy commitments to sustain and develop the green economy enhance investor expectations about future profitability and growth, while reducing expectations that growth will be risky. Additional national and international efforts to establish clear incentives for businesses and consumers will facilitate financial markets' adaptation to decarbonisation and low-carbon objectives.

⁴ This research and analysis is the subject of our working paper, *Are financial markets aligned with climate action? New evidence from the Paris Agreement* (Kruse et al., 2020b).

6. Conclusions and policy recommendations

Currently, firms' decisions to move into environmentally-friendly products and processes may not always be evaluated as economically viable. If companies do not expect to increase profitability because increases in capital costs more than offset increases in profit margins, then investment in production and sales of green goods and services may be seen as relatively unattractive. Only in the energy sector, where there is strong public policy support, do we find evidence that firms can convert higher profit margins into higher return on investments through shifting to greener production – and doing so is reflected in stock market performance. Our results suggest that over the time period of our research, 2009–2016, the global stock market anticipated profitable growth opportunities related to green goods.

Overall, our findings imply potential shortcomings in the current policy and investment landscape for low-carbon technologies. Urgent action is needed to mobilise the large-scale investments in green products, production technologies and services necessary to meet mid-century net-zero-carbon goals.

The challenges are magnified as we move from economic rescue to recovery in responding to the fallout from the COVID-19 pandemic. Investments need to be scaled up while simultaneously building a low-carbon and inclusive economy that is more resilient to future risks. Coordination of economic recovery efforts to link them to low-carbon policy is both a challenge and an opening to 'build back better' as some brown sectors, e.g. airlines and aircraft manufacturing, have been particularly severely disrupted by COVID-19. A green policy perspective would link any support for such sectors to credible commitments to much more sustainable products and services.

There is a growing awareness that the financial sector plays a key role in filling the investment gap to help ensure that capital is available to low-carbon/green firms, facilitating achievement of a broader and more rapid shift into low-carbon markets across all sectors in the economy. Yet the investment gap remains large. The Intergovernmental Panel on Climate Change has stated that US\$1.6 to 3.8 trillion in low-carbon investments are needed annually to cap global warming at 1.5°C and thus avoid the most harmful effects of climate change (IPCC, 2018). Climate investments were estimated at around US\$500 billion in 2017, 54 per cent of which came from the private sector (Climate Policy Initiative, 2018).

It appears that public policies are making some headway in the energy sector in providing an investment case for making climate-friendly production choices and developing new low-carbon products and services. On the one hand this is encouraging news, as it suggests that policy support can correct market failure and harness the ability of markets to allow the private sector to pursue a low-carbon transition and deliver public goods. On the other, it highlights that greater policy intervention across a broader spectrum of the global economy may be required to align incentives to develop new, cleaner products and services that not only improve firms' environmental performance but also their economic and financial market performance.

Our analysis has relevant implications for policymakers. To correct prevailing market perceptions and create a robust investment framework, in addition to ensuring a strong carbon price signal in the economy, governments can support firms to transition towards carbon neutrality in the following ways:

- **Put in place policies that help create clearly distinguished green goods and production processes:** e.g. through labelling, mandatory disclosure of green and carbon-intensive activities, or green public procurement. This may further encourage the shift into green markets.
- **Support financing costs for green investments and encourage investment in new technologies along the supply chain:** Orienting production towards green goods and services may require investments in new assets, with potentially higher investment cost until scalability is achieved. Therefore, support is likely to play an important role in ensuring 'going green' is an economically viable strategy. For example, governments could provide subsidies through financing and corporate taxation channels, or risk sharing through public–private partnerships to facilitate such greater green investment.
- **Implement comprehensive policy packages that target the decarbonisation of key sectors, learning from the energy sector experience:** This is needed to trigger shifts in technologies and investments towards carbon neutrality in hard-to-decarbonise industries.

References

- Ambec S, Cohen M A, Elgie S, Lanoie P (2013) The Porter Hypothesis at 20: Can environmental regulation enhance innovation and competitiveness? *Review of Environmental Economics and Policy* 7(1):2–22
- Bloom N, Van Reenen J, Williams H (2019) A Toolkit of Policies to Promote Innovation. *Journal of Economic Perspectives* 33(3):163–184
- Climate Policy Initiative (2018) *Global climate finance: An updated view 2018*. Technical report, Climate Policy Initiative
- Dechezleprêtre A, Kozluk T, Kruse T, Nachtigall D, de Serres A (2019) Do environmental and economic performance go together? A review of micro-level empirical evidence from the past decade or so. *International Review of Environmental and Resource Economics* 13:1–118
- Dechezleprêtre A, Martin R, Bassi S (2016) Climate change policy, innovation and growth. In Fouquet R (Ed.) *Handbook on Green Growth*. Edward Elgar Publishing
- Forbes (2018) *Global 2000: The world's largest public companies*. <https://www.forbes.com/sites/kristinstoller/2018/06/06/the-worlds-largest-public-companies-2018/#6fefc02b769f>
- FTSE Russell (2018) *Investing in the global green economy: busting common myths - defining and measuring the investment opportunity*. Technical report, FTSE Russell
- FTSE Russell (2017) *FTSE Green Revenues Classification System – a taxonomy for benchmarking the industrial transition to a Green Economy*. Version 5.8.1. https://research.ftserussell.com/products/downloads/FTSE_Green_Revenues_Classification_System.pdf
- Hepburn C, O'Callaghan B, Stern N, Stiglitz J, Zenghelis D (2020) *Will COVID-19 Fiscal Recovery Packages Accelerate or Retard Progress on Climate Change?* Oxford Smith School of Enterprise and the Environment Working Paper No. 20–02. (Forthcoming in *Oxford Review of Economic Policy* 36)
- HM Government (2017) *The Clean Growth Strategy: Leading the way to a low carbon future*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf
- Intergovernmental Panel on Climate Change [IPCC] (2018) *Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte V, Zhai P, Pörtner H O, Roberts D, Skea J et al. (eds.)].
- Kruse T, Mohnen M, Pope P, Sato M (2020a) *Green revenues, profitability, and market valuation: Evidence from a global firm level dataset*. Centre for Climate Change Economics and Policy Working Paper 363/Grantham Research Institute on Climate Change and the Environment Working Paper 331. London: London School of Economics and Political Science. <http://www.lse.ac.uk/GranthamInstitute/publication/green-revenues-profitability-and-market-valuation-evidence-from-a-global-firm-level-dataset/>
- Kruse T, Mohnen M and Sato M (2020b) *Are financial markets aligned with climate action? New evidence from the Paris Agreement*. Centre for Climate Change Economics and Policy Working Paper 364/Grantham Research Institute on Climate Change and the Environment Working Paper 333. London: London School of Economics and Political Science. <http://www.lse.ac.uk/GranthamInstitute/publication/are-financial-markets-aligned-with-climate-action-new-evidence-from-the-paris-agreement/>
- OECD (2020) *Green growth in countries and territories*. <https://www.oecd.org/greengrowth/greengrowthincountriesandterritories.htm>
- Palmer K, Oates W E, Portney P R (1995) Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm? *Journal of Economic Perspectives* 9(4):119–132
- Polzin F (2017) Mobilizing private finance for low-carbon innovation – a systematic review of barriers and solutions. *Renewable and Sustainable Energy Reviews* 77:525–535
- Porter M E, van der Linde C (1995) Toward a New Conception of the Environment-Competitiveness Relationship. *The Journal of Economic Perspectives* 9(4):97–118
- United Nations (2015) Paris Agreement on climate change. https://unfccc.int/sites/default/files/english_paris_agreement.pdf
- Rydge J, Martin R, Valero A (2018) *Sustainable Growth in the UK: Seizing opportunities from technology and the transition to a low-carbon economy*. London: Grantham Research Institute on Climate Change and the Environment. <http://www.lse.ac.uk/GranthamInstitute/publication/sustainablegrowth/>
- Unsworth S, Valero A, Martin R, Verhoeven D (2020) *Seizing sustainable growth opportunities from zero emissions passenger vehicles in the UK*. London: Grantham Research Institute on Climate Change and the Environment and Centre for Economic Performance, London School of Economics and Political Science. <http://www.lse.ac.uk/GranthamInstitute/publication/seizing-sustainable-growth-opportunities-from-zero-emission-passenger-vehicles-in-the-uk/>