Many countries have plans for a 'green recovery' from the pandemic. **Anna Valero** reviews 30 years of CEP research into how environmental and industrial policies can be combined to achieve economic growth that is strong, sustainable and inclusive.

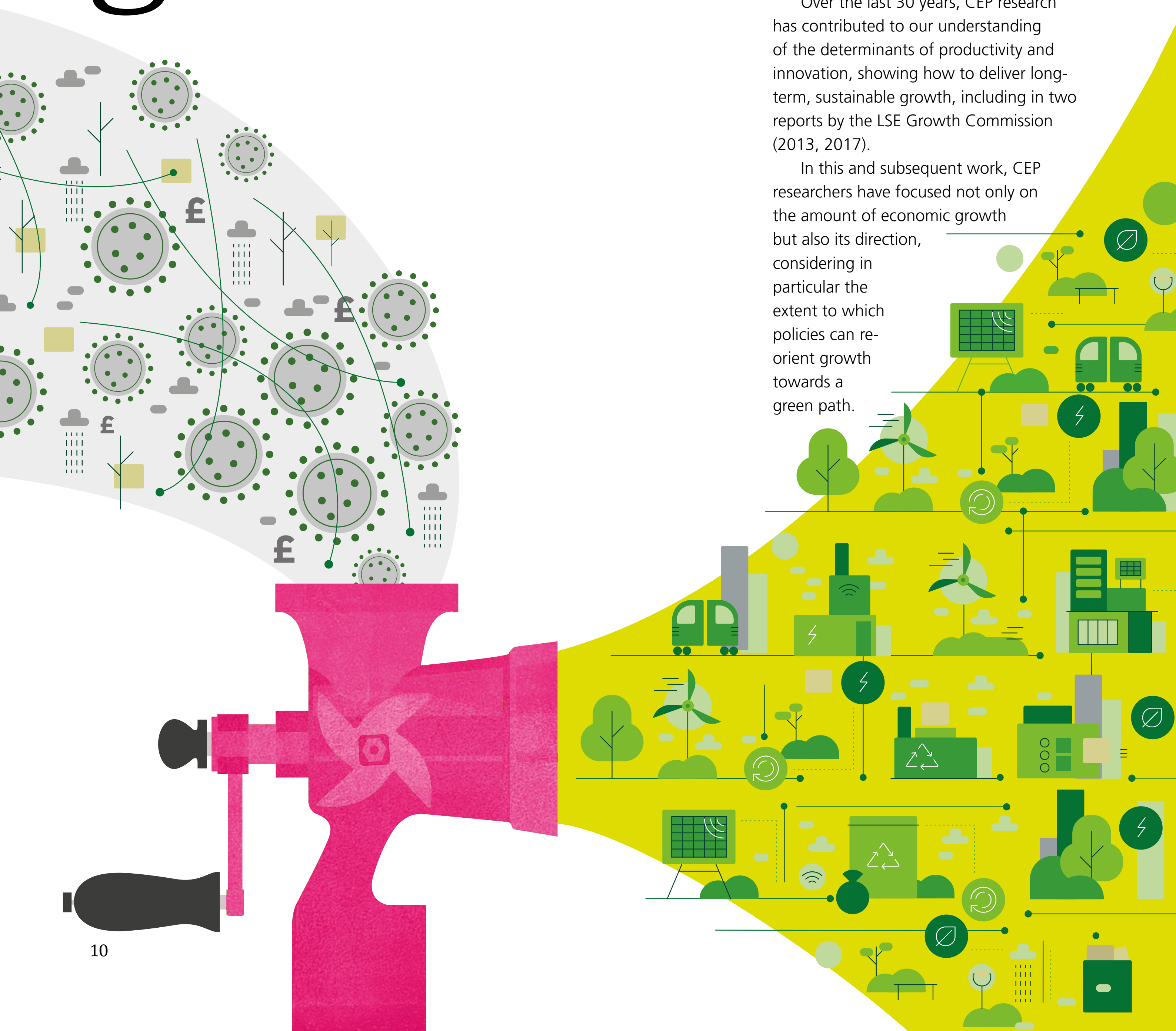
Green growth

Despite renewed international commitment, greenhouse gas emissions are reducing far too slowly to limit global warming to 'well below 2°C and preferably 1.5°C', as set out in the Paris Agreement. The Intergovernmental Panel on Climate Change has highlighted the immense dangers of going beyond 1.5°C and it is clear that action must now be accelerated to avoid catastrophic and irreversible damage.

This coming decade is critical, and choices made now on what investments to make in infrastructure, innovation and human, natural and social capital will decide whether the world is locked into systems that produce high carbon emissions or whether it re-orients to follow a low-carbon growth path.

Over the last 30 years, CEP research has contributed to our understanding of the determinants of productivity and innovation, showing how to deliver long-term, sustainable growth, including in two reports by the LSE Growth Commission (2013, 2017).

In this and subsequent work, CEP researchers have focused not only on the amount of economic growth but also its direction, considering in particular the extent to which policies can re-orient growth towards a green path.



Net zero and the recovery from Covid-19

In 2019, the UK set itself a legal target of reaching net-zero greenhouse gas emissions by 2050, hoping that the economic opportunities of becoming a greener economy would also drive prosperity. Nine months later, Covid-19 struck, creating the biggest downturn for 300 years.

CEP researchers are helping to inform policies on a green recovery with a series of reports on sustainable growth produced with colleagues at the LSE's Grantham Research Institute, underpinned by a body of research on innovation and growth.

Early in the pandemic, a CEP report highlighted the strategy, investments and policies that would enable the UK to 'build back better' from Covid-19 (Stern et al, 2020). This was followed by a review of research on innovation, growth and the transition to net-zero emissions, which summarises the evidence on the opportunities, drivers and policies for innovation-led sustainable growth (Stern and Valero, 2021). A core message is that investment in 'clean' innovation and its diffusion will be key to tackling the climate crisis and to restoring inclusive and sustainable growth.

Creative destruction – with a purpose

Innovation is the key driver of long-run productivity growth. Innovative firms that introduce new products and processes drive growth via the Schumpeterian process of 'creative destruction', which propels economic change.

In a body of work stemming from the early 1990s, economists Philippe Aghion (a CEP associate) and Peter Howitt have built this concept into models of endogenous growth. In a recent book, Aghion and his co-authors set out the evolution of the related research, including that on the environment and 'directed technical change' – which considers how technical change can be oriented towards clean innovation (Aghion et al, 2021).

A key conclusion is that with the right type of clean innovation, we can improve living standards while using fewer natural resources and cutting emissions. But the right sort of innovation will not happen at the scale and pace required without incentives, regulation, government spending and pressure from civil society.

What's more, while some industries will be created and thrive, there will also be losers. Therefore, for growth to be inclusive, policies will be needed to support those people and places that suffer from the 'destruction' in the process.

CEP research has contributed to our understanding of how to raise the amount of innovation in the economy. This is summarised in a toolkit for policy-makers (Bloom et al, 2019), which rates the evidence and benefits for policy tools such as direct grants for research and development (R&D), skilled immigration and improving human capital.

Given the urgency of tackling the climate crisis, the presence of multiple market failures and path dependencies, there is also a strong case for 'mission-based' policies that influence the direction of innovation towards clean solutions.

When private markets fail to bring about the innovation needed to tackle the climate crisis, government intervention is needed. A key justification for government support for R&D in general is the existence of knowledge spillovers. These imply that even with an effective system of intellectual property rights, private firms may underinvest in R&D as they don't capture all the financial returns on their investments.

While individual firms may hesitate, those wider benefits support the case for government investment. In fact, CEP research has found that when it comes to clean technologies, knowledge spillovers tend to be higher than those generated by their 'dirty' counterparts (Dechezleprêtre et al, 2014).

Further market failures arise when innovative firms are unable to raise finance for their innovation. To date, investments in early-stage clean technologies appear to have been generally viewed as more risky than the dirty alternatives that occupy established positions. On the diffusion side, analysis in emerging markets highlights how financial and managerial constraints hamper firms' ability to put in place clean technologies or practices (De Haas et al, 2021).

> Choices made now will decide whether the world is locked into systems that produce high carbon emissions or re-orients to a low-carbon growth path

Path dependencies in how new technologies are produced, implemented and taken up also make it hard to shift from dirty to clean technologies and sustainable growth quickly without intervention from government.

This is a key insight from the research on endogenous and directed technical change (Acemoglu et al, 2012), including research providing empirical evidence from the car industry (Aghion et al, 2016), which demonstrates how policies can direct innovation towards clean technologies and production – the direction needed to avert environmental disaster and achieve sustainable growth.

That analysis concludes that the optimal policy consists of both a carbon tax to raise the costs of emissions and direct encouragement to develop clean technologies, such as subsidies for clean R&D.

Path dependency also implies that once clean technologies are sufficiently advanced, they will benefit from their own patterns of path dependence, and so policy incentives will no longer be required.

Another implication is that delay is costly: a longer transition phase means an extended period of slower growth.

Beyond government action on the 'supply side', other key forces shape the amount and direction of firm innovation – including on the 'demand side'. Firms are more likely to invest in innovation in areas where demand is large and growing; and product market competition also shapes firm innovation.

CEP research has also shown that firms invest in cleaner innovation when facing more environmentally motivated customers, and this effect is stronger when firms face tougher competition for their customers (Aghion et al, 2020). These findings suggest that public campaigns to promote citizens' environmental responsibility are likely to be an important policy lever for stimulating clean innovation in firms.

Informing innovation and industrial policy for a green recovery

The evidence suggests that clean growth is possible with the right policy frameworks. With global demand for clean products and technologies set to increase rapidly, countries that take early action in these areas may be able to reap significant growth benefits. A key question for policy-makers is how best to target investments and design policies to promote the development of a country or region's current and potential future competitive strengths.

CEP research identifies areas where UK innovation can generate growth while also tackling the major social challenges of climate change and Covid-19 (Martin et al, 2020).

It first identifies areas where the UK has a 'revealed technological advantage' in innovation – that is, the UK's share of patents in a particular technology field is higher than the global share in that field.

Figure 1 shows that this is the case in clean energy, notably ocean and wind energy; in 'Covid core' technologies (vaccines and medical equipment); and in biotechnology and pharmaceuticals more broadly.

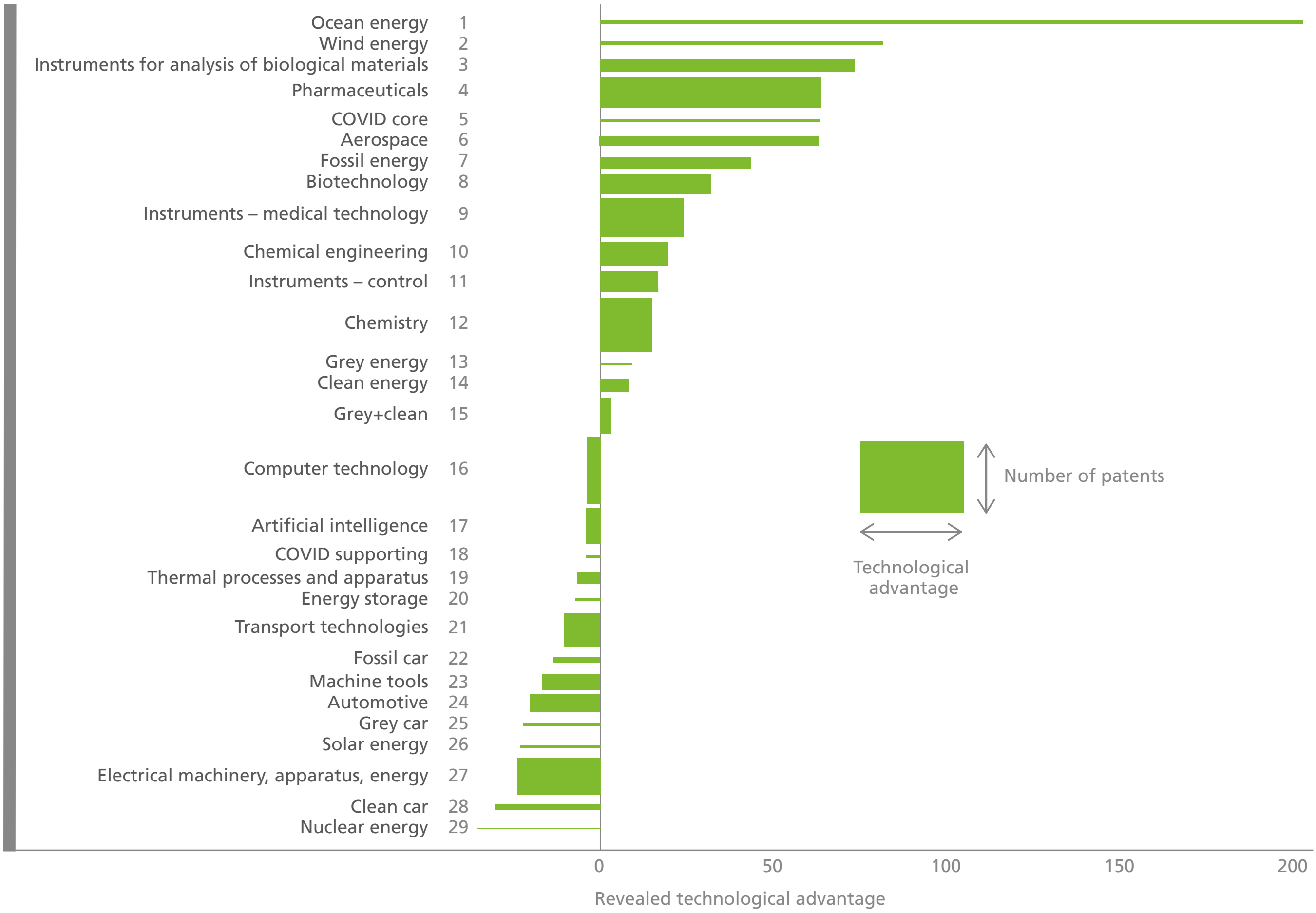
Understanding the potential economic effects of innovation support

But while the UK might have relative strengths in these areas, government support will not necessarily generate economic benefits. So the researchers set out a new methodology that estimates the national returns to public R&D subsidies for different types of technology.

This analysis demonstrates that public R&D investments in biotechnology, pharmaceuticals and 'Covid core' technologies can be expected to deliver among the highest returns of any technology area in the UK (see Figure 2). Ocean and wind energy technologies also generate relatively high returns.

Finally, the report shows that areas that specialise in Covid-related innovation tend also to be places where a large share of overall UK innovation occurs: including the

Figure 1:
UK 'revealed technological advantage' (RTA) in key areas of innovation



Note: The length of each bar on the horizontal axis shows the RTA; the width of each bar on the vertical axis reflects the number of patents in each category. RTA is defined as the share of UK's patents in a particular technology field relative to the global share of patents in that field. Analysis based on PATSTAT over the period 2005-2014.
Source: Martin et al (2020).

Delay is costly: a longer transition phase means an extended period of slower growth 'golden triangle' between London, Oxford and Cambridge, together with parts of Scotland. On the other hand, areas that specialise in clean technology are more spread out – and include the Midlands and the North of England.

Together, this evidence suggests that there could be a 'triple win' from support for clean innovations. A sustainable growth strategy could achieve net-zero emissions, improve productivity and contribute to levelling up.

What next?

Driving clean innovation in particular sectors is possible. A rich body of research identifies and analyses the key forces behind this. The challenge for researchers is to build on these models to inform structural change across the economy in the face of large-scale uncertainty.

CEP research will continue to provide evidence of policies that support firms to make the transition to net zero, while also considering the impacts of this transition on people and places in terms of jobs created and lost – helping to inform policies for future growth that is stronger, cleaner and more equitable.

This is a shortened version of CEP Insight: Green Growth, one of a series of publications outlining the history of CEP research in key areas of economics to mark the Centre's 30th anniversary, linking to all the studies mentioned here (http://cep.lse.ac.uk/_new/publications/insights/green-growth/).

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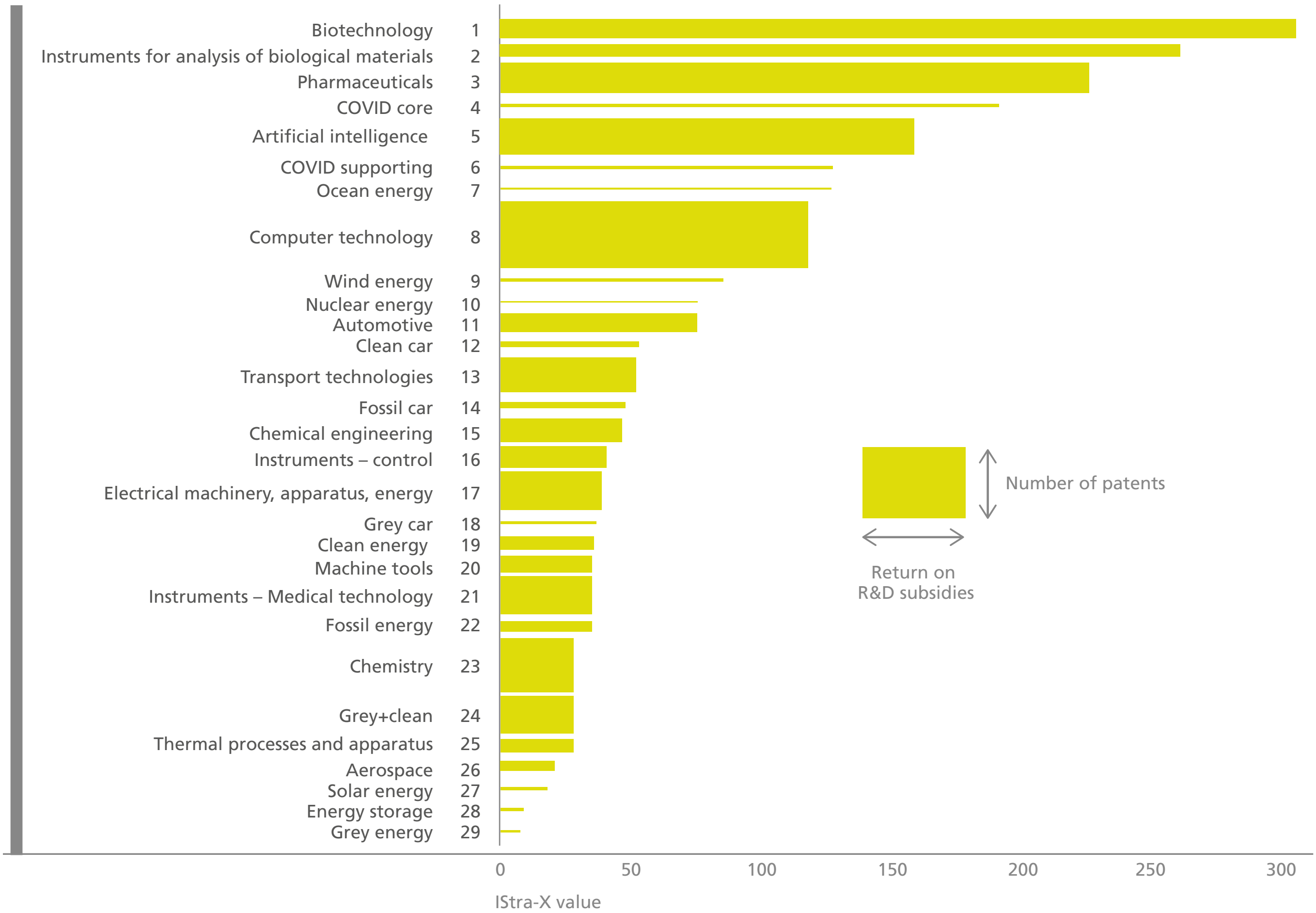
Clean innovation can improve living standards while using fewer natural resources and cutting emissions

Figure 2:
UK returns to public R&D investments across technologies, 2005 to 2014



Note: This figure reports average returns to public R&D subsidies by technology area. The calculations account for direct and indirect knowledge spillovers occurring within the UK, variations in private R&D returns, variation in R&D costs and differences in the responsiveness to subsidies between different technology areas. This is based on the 'IStra-X' indicator: the length of each bar on the horizontal axis shows the IStra-X value; the depth of each bar on the vertical axis reflects the number of patents in each category.
Source: Martin et al (2020).