Ep. 25 Productivity Puzzles podcast transcript

Greening Productivity

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BvA: Can we make the economy greener and still be productive? Or even better, can productivity help us to make the economy greener? Are green jobs more productive than non green jobs? Will green productivity help to fulfil the Paris agreements in making the world a cooler place? We're going to find out. Welcome to Productivity Puzzles.

Hello and welcome to Productivity Puzzles, your podcast series on productivity brought to you by The Productivity Institute. I'm Bart van Ark and I'm a Professor of Productivity Studies at the University of Manchester and a Director of The Productivity Institute, a UK wide research body on all things productivity in the UK and beyond.

Welcome to the May episode of Productivity Puzzles in 2023 which will be on greening productivity. There's no way around it. As we are getting increasingly confronted with the challenges of climate change, the calls to fulfil our commitment to reduce global warming to less than one and a half degree, are impacting on all of us. Whether as a consumer or working in a business or policy, the question gets personal, what can you do to make the world a cooler place?

So in this episode of Productivity Puzzles we ask the question what does climate change and a transition to a net zero emissions world mean for productivity? Are the challenges to green the economy making it even harder to raise productivity? In other words, is there a trade off, and should we be willing to give up productivity to rescue the planet? But perhaps more importantly, can productivity help to make the economy greener? Can green tech and innovation be used more productively than other technologies? Are jobs that have a lot of green characteristics more productive than those that are not? And how are we doing on green productivity in the UK? Is it part of the bigger productivity puzzle, or are we

leaving opportunities on the table which would allow Britain to strengthen its productivity performance, perhaps even to resolve some of the persistent disparities across regions in the economy?

As always, we don't shy away from the hard questions on Productivity Puzzles, but we always do it with a panel of experts who can help us to navigate through the jungle, very appropriately, of green productivity. So today we are joined first by Antoine Dechezleprêtre who is the Senior Economist at the OECD in Paris, working with the directorate for Science, Technology and Innovation. Antoine's work is on the role of innovation and technology diffusion for the green transition, looking at the impact of environmental policies on innovation, technology, adoption, carbon emissions, productivity and firm performance. And before joining the OECD Antoine was associated with the Grantham Research Institute of Climate Change and Environment at the London School of Economics.

Our second panellist is Anna Valero who's the Deputy Director of the Programme on Innovation and Diffusion, a partner project to TPI, also funded through the Productivity Programme of the Economic and Social Research Council. In her work, Anna focuses on innovation and its diffusion, the role of universities and human capital, but also on the economic opportunities from sustainable growth and a transition to net zero. Anna is a Senior Policy Fellow at the Centre for Economic Performance at the London School of Economics and an associate of the Grantham Research Institute. And recently Anna was also appointed to the Chancellor of the Exchequer's Economy Advisory Council to consult on the growth of the UK economy. Anna, welcome to the podcast.

Finally, I our third panellist is Jonatan Pinkse. Jonatan is a Professor of Strategy, Innovation and Entrepreneurship at Manchester Institute of Innovation Research at Alliance Manchester Business School. Jonatan is the lead of the research team on transitions and productivity at The Productivity Institute and his research ranges from corporate sustainability to business model innovation, social entrepreneurship and cross sector partnerships, and in recent years Jonatan has worked much on how firms make strategic decisions to adapt to climate and to transition to the net zero economy. Jonatan, great to have you on this morning.

So I'd like to start off on discussing what green economy actually is, because we often seem to talk about very different things and it's not very clearly identified. It's perhaps useful to separate between three different types of transition. First of all, there's the transition to a low zero carbon energy exploration, so basically going from fossil to non fossil, from oil, gas and coal to renewables such as solar and wind and hydro. It's debatable whether you should include nuclear in that as well. And then the second part of the transition is the adjustment that the economy is making to net zero, so making processes, products and services environmentally sustainable to create green jobs and technologies to do that.

And then the third one is the creation of the circular economy, an economy that is built on a cycle of production and consumption that is fully recyclable in terms of eradicating waste of materials. Also it quite often involves processes of societal transformation, like creation of green jobs and sustainable consumption and behaviours and fits very much in with the long term development goals of the United Nations to reduce poverty and to raise equality and equity.

Now, Antoine, for each of those levels the exploration, the adjustment, as well as the creation of a circular economy, for each of those adjustments the question rises whether the transitions will make us more or less productive, and it's not obvious at first-hand that it will make us more productive in the traditional definition of labour productivity – of total factor productivity. So what is your take on it? What will you focus on when you look at green economy and productivity and where would you put the emphasis?

AD: Yeah, thanks a lot, Bart, for having us today. So if you look at what economic theory would predict it's not so straightforward what impact on productivity you should expect from raising the ambition and stringency of environmental policies. I mean, economists traditionally think of environmental protection as a trade off where you have, on the one hand benefits to health, to biodiversity, to environmental quality more generally, but you have cost to the economy and the famous paper by Morgenstern, called *Jobs Versus the Environment*, that kind of summarises this view very strongly. The idea being that if you force companies to invest into more environmentally friendly technologies, say you impose them to install some filters on the chimney, well, this is an investment that is not going to increase your productivity, right. So it has to come at the cost of productivity enhancing investment and the impact of this would be a reduction in productivity.

Now, there is also very large literature showing that environmental policies should induce innovation, in particular in energy saving, material saving technologies, this is all part of the famous Porter hypothesis, and this will actually lead to the opposite effect so that environmental policies could via these induced innovations do some productivity improvements. There is also another very interesting kind of literature showing that improvements in air quality, for example, could raise labour productivity because people fall less ill, they are more productive while on the job, and this could also have a positive effect on productivity. So of course in theory is not so clear cut. The question becomes what does the empirical literature say, and this has been looked at by a large number of papers over the last decade including some by myself and co authors.

What the empirical literature shows is that what you should expect differs if you look at individual companies or if you get the macro economy and if you look at the short term versus the long term. What we see in the data is that when environmental policy stringency increases typically some firms

win, some firms benefit and these are typically firms that are already at the productivity frontier, they are already performing well and they have the means to adapt to these new regulations. But some other firms suffer. And these will see a reduction in their productivity. Some will also leave the market because of these policies. So you have winners and losers which at the sector or macro economy level can actually translate into very small either positive or negative effect on the economy.

On the short versus long term, what we see also is that basically environmental climate policies have transitory costs, so these potentially negative or positive effects really happen over a few years and then in the long run there's no reason to believe that a greener growth path would mean less productivity. But there can be some t transition costs, especially for some parts of the economy. That's my take of the literature.

BvA: So I think, and, Jonatan, maybe you can pick on this, what Antoine sort of hints at, and, Antoine, you'll correct me if I'm wrong, is that this in a way is just another process of creative destruction. The winners and losers, the short term and long term effects, and empirical literature will ultimately tell us how it is all going to play out. But at the same time we're dealing with a massive existential problem if you like which is climate change and therefore there is a worldwide agreement on accelerating this process much faster. So it turns from a natural process into something that's really forced by regulations and by policy and so on, which may be pushing this to another level than traditional incremental process of creative destruction. Now, I'm deliberately playing a little bit what you were saying here and I'll give you a chance to respond to it, Antoine, but, Jonatan, what's your take on this?

JP: Yes, I think I agree with that, and especially how you see the green economy, because when Antoine was talking about environmental policy a lot of those policies were to stop certain toxic pollutants coming in the sky for air quality and so forth. Climate change is a little bit different because CO2 is not necessarily toxic, so people say oh, well, it's natural, and that's the whole debate is it's man made and the whole thing. It's very much about energy with climate change, and it goes more to the core of many companies. So certain other experimental policies would only affect certain types of companies, chemical companies, for example, on the margin and there are end-of-pipe technologies, how you could solve that. When you now say you can't use your main source of energy, fossil fuels, to do your business, that's a way more existential problem. You can't just take energy out of the equation of any company. So that replacement makes it much more difficult. So this is where you see that for many companies environmental policy and, in this case, climate policy has become far more strategic than it used to be. It used to be possible to get around it.

Now for many it's simply not possible. For example, local fertilizer companies in the UK that need to use natural gas to produce their product that could not continue their business because of the gas price going up so

much, so then then should have a replacement in the net zero economy. That's not there immediately. So for them they have to shut down their business because of it. So this is where you see it is indeed a more existential problem for many companies.

BvA: So, Anna, this trade off, right, because that's the other element of here, so the trade off between the need to rescue the planet and do something about climate change versus the need to grow the economy in terms of productivity, how real is that trade off and how can we tackle this policy wise or strategically by businesses?

AV: Well, I think this is a trade off that exists in the short run. As we just heard, for some companies there is a trade off when they have to make an adjustment that's costly for them in that immediate space and time. But medium term to longer term we know there's not really a trade off because planetary health and economic health are intertwined, so I would think that these adjustment costs precisely and the need to make a system wide change that shows why policy is so important. And I tend to think about this as a process of creative destruction where we have the direction, so the directive technical change literature gives us the direction towards sustainability, but what we need is an active management of the destruction part of it, ie the displacement of workers, the displacement of firms.

I would echo what we just heard in terms of the different types of positives and potential negatives on specific firms, but the way I think about it in terms of the productivity impacts, the positive productivity impacts are kind of in three sections. So I think first of the innovation we heard from Antoine, the new technologies, which we've already seen are crossing market tipping points in many areas of renewables where the prices have come down and we actually see that they're cheaper in many cases than fossil fuels, so that implies there are growth opportunities for those companies that can develop the technologies in a superior way access growing demand.

Then there's the positive productivity impacts on resource efficiency, so we've seen very starkly that our reliance on fossil fuels has led to massively increased costs for businesses. This is bad for your profit, it's bad for your productivity. So if we can think of net zero as a way to improve resource efficiency, reducing waste in all the ways that you mentioned, and this is actually good for your productive processes, and of course here there are synergies between digitisation and net zero, if we think of digitisation as more effectively managing your processes and supply chains and your costs. And then again longer term co benefits, such as cleaner air, health outcomes from better heated homes or better cooled homes, more active travel, smart cities. All of these things are also impacts that we'd expect to be positive on workers, on our health, on our ability to get to our jobs.

So those are three positive areas on productivity. We mentioned there are adjustment costs that need to be overcome with strong policies. But really if we delay now thinking well, actually, we need our companies to focus on

productivity now then we know that the transition will be more costly over time, plus our companies in any given country you might be looking at won't have been able to access some of those innovative opportunities for growth if they haven't been focusing on that kind of transition and strategy.

BvA: How important is it to make a distinction between the productivity impact from adaptation, basically reducing the damage from climate change through productivity, and mitigation, which is to sort of seek the upside for productivity? Is that an important distinction where you think about the relationship between net zero and productivity? Jonatan.

JP: We tend to focus a lot on mitigation when we talk about net zero. Adaptation is still not talked about so much. So also from the government there's not a lot of regulation towards companies, like this is how you need to adapt, and that is partly why it is leading to problems because adaptation basically means that you need to make massive investments to be more resilient to actual impacts like a lot of flooding, extreme weather and so forth. You now see slowly companies realising oh, this is real. So, for example, energy companies in the UK over the past years have experience major impacts in the North of England. Last year they were without electricity for, what is it, two weeks. So there you see that will have huge productivity impacts if these things happen more and more because you basically can't produce anything for weeks in a row. Both the companies that deliver electricity have problems but also everyone who is relying on the electricity in this case.

So here you see that there is a bit of a problem because there is not enough signal yet from the government towards companies to do something about that, and that lack of a signal means that they tend to ignore. There's a lot of waiting and seeing. So we recently did research n that among infrastructure providers in the UK, so water companies, energy companies and so forth, and you see it was very slow realisation like oh, this is the other side of climate change and this is actually becoming real. The long term impact is no longer something for the next generation. We are now in the next generation and this is really becoming more problematic.

So I would think that the productivity impact in short term then can really be quite negative if they're not making these investments, and this is really where you see the benefits are not obvious to many so they can't basically say this is why we need to make the investment because the payoff is not clear enough, so many of the companies we looked at really deliberately said that our cost benefit analysis still says it's unclear what the benefit will be so we can't basically say this is why we make these costs and this is why we're not yet doing it. But there will be flipping points there quite soon the more this happens. So I think it's a really important topic to talk about a lot more.

AD: Just to follow up on what Jonatan was saying, one important difference in my mind between adaptation and mitigation is that except if companies are, say, very much short sighted or there are information issues you would

expect them to individually privately take action. They wouldn't, for example, take on infrastructure provision because it would be good and so on, but in general you would expect adaptation to happen in a private way with firms just looking at their cost benefit analysis, as Jonatan said. Whereas for mitigation, because climate change is a global public bad, that has to come from public policies. In that respect, because it has to come from regulation, I would then think that the trade off is clearer on the mitigation side. On the other hand we, as Jonatan said, haven't really seen much adaptation happening yet, so it's an interesting question why even the firm should do it just to maximise profit.

BvA: Okay. So we focused a lot on one side of the causal direction, on what does greening of the economy mean for productivity, but you've already hinted there's another course of direction here which is in a way a more proactive question to ask, and that is whether productivity can actually contribute to green economies. So can it help us to accelerate the transition to net zero. And that obviously gets us deeper into the question that all three of you already alluded to which is the issue of technological change and innovation. Of course there's a lot going on there at all the levels that we've been discussing. But productivity researchers are always sceptical on how much of those new shiny technologies are really coming through in terms of this is opportunities that will translate into becoming more productive and therefore cleaning production and delivery processes much faster. So, Jonatan, how do we place green technological change to innovation in the broader field of science, technology and innovation? Is it going to be an increasingly large driver of productivity growth or is it actually something more difficult to do than, for example, digital technologies or other areas of technology and therefore it may actually hold back productivity growth?

JP: It depends on what kind of innovation you look at here. As I said before, a large part of the whole greening the economy, creating a net zero economy is about energy. There you need new innovations in energy. But a lot of those have been happening for decades. So solar energy is now mature and the price is low enough so it can easily replace a lot of other fossil fuel based energy sources. Same thing with wind power. So you see real maturity there so there it can really start becoming a driver of productivity because it brings the cost even lower than fossil fuels, plus you no longer depend on all kinds of regimes in the rest of the world with all the political uncertainties. So there you can really create a more resilient economy as well.

However, energy is not just used for electricity, for example, but fossil fuels are also used as a feed stock in many industries, and there it is more difficult. You can't just say okay, I'll put a few solar panels on my factory roof and now I am green. If it's a feed stock it's an input of your chemical process then it's way more difficult because everything has to change. And then you need major investments, you need to change the way you produce. So if you, for example, want to use hydrogen for that, that sounds great, but what does it all mean? Where does hydrogen come from, what

kind of impact will it have on your production process, what kind of long term investments do you need to make. So this is a very big bet, and this is where you get the productivity trade off happening, because you can't just replace like for like the input you have, but the new type of energy resource has implications for everything you do.

The twin transition might help there as well, because the fact that there is now more and more digital also means that there is more electrification, so using hydrogen will not just be using hydrogen, it will go along with a lot of other changes. So in the end it will be very difficult to say what will be the productivity impact because it will automatically go together with the digital transition. A lot of things might go way smoother, so in that sense you can be very optimistic. But at the same time, yeah, you can be sceptical. So many new technologies have always been promised, oh, this will be the next big thing, and we've not seen it happening.

The more difficult part is when it's about materials. So a lot of innovation also needs to go into materials innovation. You need to move away from inputs that need a lot of fossil fuels. So do we need steel for everything, do we need concrete for everything? Making those changes is far more difficult. If you want to construct buildings not using concrete I wish you the best of luck finding an alternative. That will be decades. So there you see that it's a very difficult process that needs a lot of innovation with a lot of uncertainty. No one really knows what that will look like. There are many different scenarios. And this is why you see different governments making different bets, so to say. Should it be hydrogen economy, should we go for electrification, should we go for bio based economy. There's so many buzz words around, because we don't really know, and that is the typical classic tale of okay, who is going to win, what is becoming the dominant design in different industries. There's just a lot of uncertainty. There's so many factors playing a role there.

BvA: Yeah. And again sort of describes these different levels in the economy, exploration of and generation of energy adjustment, and so what you described about using materials in production processes of factories can take much longer. Anna, let me bring you in here and just please pick up on any of the topics and your thinking around innovation and how it can drive productivity and how productivity can become a force of green and growth.

AV: Yeah. So actually on that last point, can productivity growth be a key way of greening the economy, I think given in many countries we've had this slowdown in productivity since the financial crisis that has obviously been a key driver of stagnant living standards. We've then had the cost of living crisis. If we can get productivity growing again people will feel richer, firms will be making more money. It will be easier to invest and make behaviour changes we need to make for net zero. So in that sense I see improving our growth prospects and our ability to make the investments for net zero

and the changes required as going hand in hand, and ideally we'd have an agenda for both appreciating the synergies between the two.

So you talked about the shiny new technologies and the extent to which we can feel the benefits of those, and clearly there is this difference between the invention of something and its diffusion through the economy and we know from the economics literature that you need complimentary factors to be in place for a technology to be able to defuse through the economy. And this is particularly the case when it comes to skills, particularly in the case of certain green technologies which are quite complex to implement. So an example here would be, for example, heat pumps where you need the skilled engineers to actually install them in people's homes, and actually it's a lack of those skilled engineers or perhaps questions around accreditation and things that damage trust in the system and the ability to have a positive experience as a consumer.

Of course there's the key importance of complimentary infrastructure. So we've got lots of renewable projects currently in the UK, for example, which are being held back from getting into the grid because of planning delays and delays in getting the grid connections. A statistic I saw recently was that there are many projects that face ten to 15 years of delay, which is why what we do need is this kind of system wide approach. So it's thinking about the innovation, particularly in economies like the UK, like the US, other countries which are at the innovation frontier that actually are creating the new inventions that are relevant in this space. But then we need to think about the barriers to those innovations actually being commercialised and deployed at scale in the home country and more broadly as well.

You also mentioned there about clean technologies, are they in the scientific domain or more applied. I think it's a combination of both. And some of the research we're doing, we're looking at the chain of citations through academic literature into patents which is kind of a measure of an innovation being commercialised. And you see that a lot of academic research actually in fields such as material sciences, which was just discussed, ultimately gets picked up in innovations which eventually are commercialised in the clean technology space. So it's this full chain, the whole innovation process. But crucially because what we're concerned about here is actually delivering on our net zero targets and the deployment of the technologies, that's why we need to make sure we have the skills, the supporting infrastructure and everything else in place to make it happen.

BvA: So I'd like to go into a little bit more detail on some specific cases to see how this becomes concrete in practice, and we'll do that right after the break, but let's first hear about what else is happening at The Productivity Institute.

"The Productivity Institute aims to pinpoint why UK productivity has flat lined and how to create the foundations for a new era of sustained and inclusive growth. Visit our website at productivity.ac.uk to find research covering

topics such as business investment and innovation, skills and further education, foreign direct investment and trade and the transition to net zero. The Productivity Institute also investigates how levelling up and devolution can help to raise across the UK's regions and devolved nations. On our website you can find deep dives into how leaders can improve productivity within their firm or public sector organisation. While you're there sign up to our newsletters for regular updates on what productivity means for business, workers and communities as well as the latest on how productivity is measured and how it truly contributes to increased living standards and wellbeing. The Productivity Institute is a UK wide research organisation funded by the Economic and Social Research Council. The Productivity Institute, productivity together."

BvA: Welcome back to Productivity Puzzles discussing the topic of greening productivity with Antoine Dechezleprêtre, Anna Valero and Jonatan Pinkse. Now, before the break we started to talk about the important impact of technology innovation, how that drives productivity, and how productivity itself can then be a force of greening the economy. So, Jonatan, you've recently been involved with a lot of work in the construction sector, both new construction but also retrofitting, and this is a really interesting case because this is a real low productivity sector, it's a sector that is a huge amount of potential for greening in many ways, so how challenging is it to transform a sector like that from where it is now to a force of green productivity growth?

JP: Extremely challenging is what I've learned. It's a very interesting sector but very definitely changed. So the construction sector is a sector where people have worked in a certain way, well, for decades if not for hundreds of years, so the moment you say to them hey, you now have to change because you have to do this, you have to do that, then there's a lot of resistance. So the big players in the construction of houses, for example, are really taking an approach of wait and see. They will make small adjustments.

But still if you're going to buy a new house it will have a gas fired boiler most likely in it, but we know that should be a heat pump combined with solar panels. They are not going for that because they have their existing supply chains, they have existing relationships, so all such changes would mean that they need to develop new kinds of supply chains, plus the technologies will be slightly more expensive and that eats into their margin. So anything that would eat into their margin they don't want to do, more or less. And they have a monopoly on the whole system because they are really good at getting the land and then they can decide what is going to be built on it. So breaking through that deadlock is very difficult.

So we looked at a few companies that tried to do that. They tried to then change it and become more productive by going for modular housing. So modern methods of construction it is called. You'd build a house more or less in a factory where you can either build the whole house or more panels. We focused on the ones where they tried to build a whole house. So there

were three new start ups with quite a lot of investment that were trying to do this, and they're still in the process and it's a bit of a new wave. When you look at it on paper it seems to be really a good idea. It can really massively improve productivity because they are really working day by day to say okay, how can we optimise the manufacturing process in this factory so we need less people and they can do a lot more with fewer people. So it's completely towards productivity. But at the same time we found that they have to work in this existing structure with planning problems, investors that are doubtful whether it's going to deliver, delays, all kinds of issues.

So one of the three, LNG, for example, stopped its operations just last week. We really thought that was going to be the successful one. And then to many losses, a few issues here, they had a problem with mould, and then it all adds up and then the investor in this case, LNG, the company itself behind it, says, no, we're stopping it, we don't believe this is going to happen. So this is then what you see in such a sector that there are some, I would say, brave challengers but it's very, very difficult for them to change the industry because of everything around it. So while doing this study how optimistic are we about a major change there? Not so optimistic to be honest. But at the same time you will see of course the bigger players moving more into automatic installation of solar panels. They will do more with heat pumps and so forth. But it will be much lower compared to what the challengers will do. Plus the productivity improvements are not that obvious then as well.

BvA: Yeah. And what I find interesting about what you're saying here is that this kind of transition, and it goes back to what we talked earlier on in the podcast when we were looking at the incremental or system change if you like, this is a system change. A company that just does it on themselves will struggle. It might create some competitive advantage for a while, but ultimately the whole system has to change in terms of demand and supply and preferences of users and consumers, the regulatory environment behind it that drives the system change in a particular direction that I think makes it very hard to take this on a very ad hoc basis when companies are just jumping into this without seeing that system change happening.

So the other case study, Antoine, this is where I wanted to go to you because you did some work at the OECD on the automotive sector. A very different sector than construction. And look at much more from a system perspective and described how the various actors in that sort of automotive system were making this transition. So what were lessons learned from that work that you find relevant for this discussion on greening and productivity?

AD: The automotive sector is extremely interesting to look at because it's perhaps one of the best examples of the sectors that's simultaneously affected by both the green transition and the digital condition with autonomous vehicles and the like. The implications that we see in the data is that these two transitions really are very rapidly reshaping the automotive sector, and we call that the automotive ecosystem in the report because

one thing we wanted to do there is to beyond just car manufacturers and parts suppliers and look at the whole system around it which includes financial links with companies but also knowledge provisions from universities and research institutes and all the economic sectors that revolve around the core automotive sector in terms of service provision, the ICT sector and so on.

There's two things we observed. One is an increasing role for young firms. You know that small firm start ups are typically the providers of, say, more radical innovation and between the green and the digital tradition we're seeing an increasing amount of innovation that's relevant for the automotive sector coming out of these small businesses. The second thing that we're seeing is an increasing role of the ICT sector because of the role of digital technologies in cars that are built now. So this reshaping has obvious consequences for the sector itself but also for public policies. I mentioned the role of young firms. These are firms typically pretty constraint, so when you think of the green transition and the digital transition that means that entrepreneurship policies are extremely important to think about these firms need particular support as we all know. Another thing is the role of competition policies. We're seeing a lot of mergers and acquisitions between ICT and car companies which is really interesting to observe, but there's a role for competition policies.

And obviously, and we talked of innovation previously in this conversation, there's a huge role for innovation policy from governments. And this is not something that's specific to the automotive sector actually, but what we're seeing is I think a worrying focus of governments on supporting the adoption and diffusion of technologies as opposed to supporting innovation higher up the innovation chain. For example, in the last 20 years if you look at public R&D expenditure in green technologies it's completely flat. It hasn't increased as a share of GDP in two decades, which is really worrying given these new technologies, as Anna mentioned before, they are much more reliant on basic science, for example, from many scientific fields. We need I think much more support to innovation directly rather than just these demand side subsides for adoption which seem to have been the focus of public policy in that domain.

BvA: Yeah, that's very interesting, and actually it's a really nice transition to zoom in a little bit on the UK. What is government doing at the higher end of the technology chain in terms of driving innovation, new technologies first as focusing more on the diffusion? Anna, let's go to this UK case a bit more specific. You've done a lot of work on that with POID but also with the Centre for Economic Performance and the Resolution Foundation. Like in any country, it's a big policy agenda. But where would you place the UK in the scale, if you like, of driving a green transition and productivity growth at the higher end of the technology change versus the lower end but the diffusion end of the technology change?

AV: Well, I think the UK has for some time had a number of programmes in place, a number of commitments that have meant that there are areas that we've made a lot of progress. So, for example, in energy, that's a sector we've done really well in our decarbonisation. We still need to do a lot more. In other areas there's much more progress. We've talked about decarbonising the housing stock, for example. What we've done to try and analyse these questions is looked at the type of data we can compare internationally and also to disaggregated level where we can say a product or a technology is green as opposed to non green. When we look at patenting, for example, which is obviously an area that Antoine has a lot of expertise too, we look at clean patenting and we find that the UK is one of the main patentees on clean patents globally but not necessarily like the clean tech superpower that we might want it to be. I think it's within the top ten countries in terms of green patenting volumes. It accounts for about three per cent of global green patents over the 2015 to 2018 period.

But what we do to understand specialisation is a concept similar to reveal comparative advantage in trade where we look at a country's share of patenting in green versus the global share of patenting in green. We find the UK is a little bit specialised on this aggregate measure, but within that there are a number of technologies where we appear to be more specialised. So we consider these are areas of comparative strength in the UK. This is things like tidal stream, off shore wind, carbon capture usage and storage, nuclear technologies as well, biomass and bioenergy. So we've tried to explore whereabouts in the country are these pockets of specialism, and using a new methodology, trying to understand the returns to investment in innovation in different types of technologies.

So the good news is that when you look at the returns to investment in innovation in green technologies as opposed to other technologies in general, these returns appear to be quite high in the UK. So this suggests that actually the innovation we're doing in this space is generating returns in the UK. And there's also quite appealing spatial patterns here. So often we discuss the golden triangle of London, Oxford and Cambridge as being very innovation intense. What we find actually is that investments in clean innovation within those areas generate quite big spill overs to the rest of the country. Plus if you look at the rest of the country, given the patterns of specialisation, investments in clean technologies also generate good local returns.

We examine the spatial patterns using different data sets, also looking at firms that are in the green economy, also looking at high growth firms, so those firms that are attracting venture capital or growth finance. We see that although in aggregate terms a lot of that is within the more productive parts of the country, when you take measures of specialisation, so when you say okay, given the number of patents in an area, what share of those patents are green, we find those measures of specialisation are higher in less productive areas. So this gives us some hope that a lot of the specialisation relevant for net zero isn't necessarily in the parts of the

countries that have always pulled ahead on productivity. So actually if we're really supporting this with more renewed focus now, hopefully more channelling of R&D grants and the kind of innovation support that Antoine was mentioning, that this could actually generate growth for the UK but also more regionally balanced growth for the UK.

BvA: Yes. I agree. The only thing where I would be a bit doubtful for a UK prospect is currently almost like the arms race between the US, the EU and China for developing this green economy. With the Inflation Reduction Act President Biden has made major investments in green technology. The EU is trying to respond to that. When we talk about cars or anything electric that comes from China they're really moving in that direction. And now you see that the UK because of Brexit is actually a relatively small player, so they just can't do the same thing of massive investments across the board. You have to specialise, as Anna said. You need specialisation. Because you simply don't have the same amount of resources. You can't play that same game anymore than when they used to be part of the EU.

So this is where I'm a little bit worried that to make such a bet will it be CCS? Well, really carbon capture storage, the UK seems to be betting on it. Other countries are a bit more hesitant there. And that could be a massive failure. It has been a failure beforehand, and then you've just wasted a lot, it has crowded out all kind of investment space from other directions. So I'm not always as hopeful when I look at the kind of political choices that are being made in this country of which parts of the green economy need to become successful.

AD: Yeah. I mean, I think there are obviously now lots of headwinds to this story. As you say, we've erected new trade barriers with Europe. There's an increasingly competitive environment internationally with subsidies. And I think it's generally acknowledged that we can't compete in terms of scale, in terms of the subsidies. But what we can do is perhaps build on our regulatory environment, create stronger regulatory incentives combined with more targeted financial support in areas where we do actually have underlying capabilities and excellence, which we do in a number of areas in the UK, so that we can actually have this as part of a smart green industrial strategy.

I think the alternative to doing that and saying okay, well, now that other countries have really started doubling down on this that suggests we can't do anything. I think that would be a shame for the UK's growth story and for our net zero story, because, as I said, the data shows there are a number of strengths here which are our innovative strengths. We have high growth firms around the country operating in this space, we should try and address some of the barriers to growth for such firms that we can address. Antoine mentioned credit constraints which is a key issue for high growth firms. Often in the UK this growth stage or the scaling up stage has proved difficult. So there are targeted things that policy makers can do to try and improve our chances in a more competitive world.

BvA: Antoine, looking a little bit indeed outside in from the OECD to the UK, there is this big question around the importance of international coordination in many respects including innovation and tech policy. So when you look at this how important is it for countries to engage internationally in coordinating tech and innovation policies to be successful both at the top end of technological change as well as at the lower end of diffusion and an adoption of these technologies?

AD: To be honest, I don't see a huge role for international cooperation on R&D specifically. Just because of the tension between competition and coordination in that respect. Green technologies in the green economy, they will be key assets. It's proven very difficult for countries to collaborate on R&D specifically. There are a couple of examples out there like nuclear fusion which hasn't delivered much in the few decades. I see an important role for at least coordination and agreeing jointly, for example, on raising public support to demonstration projects, for example, which, first, they are critically important but also you don't want to duplicate effort so there is of course an important role for coordination there, and more generally there's probably some role for coordinating efforts and making sure everybody's looking in the same direction. But that shouldn't only happen on the R&D side but also on emissions reduction more generally and coordinating on price signals is also important. Making sure everybody's moving towards some meaningful carbon pricing at the same time.

And I'm saying this because I wanted to react to what Jonatan mentioned before on the failure of CCS project, which is very true, but I think what that hints at is also a failure of policy consistency, because what happened ten years ago is a massive amount of public subsidies was put on CCS projects, but there was no meaningful carbon price. So why would a company add private money to this subsidy if there is zero economic reasons to use carbon capture at the end of the day. So I think that policy coherence is extremely important.

Now, back to the collaboration on innovation, I see a bigger role for collaboration on international diffusion of technology more than creation. Creation will still happen in the few countries that do have the knowledge and capacity to do this. We should keep in mind that the vast majority of future emissions growth is going to come from emerging economies, developing countries, and so there is perhaps a bigger role in terms of international collaboration on international technology diffusion and making sure that these new technologies will flow very rapidly to those countries that are building up their capital and making sure that their emissions are reduced very quickly.

BvA: Jonatan.

JP: Yeah, to briefly respond to that. I agree that diffusion is pretty important, and this is where international collaboration will become an important part.

What you're basically seeing is that you need to develop new kinds of global value chains, and this is where I'm a bit sceptic about the role of the UK, because if you try to set up a new global value chain why would you then have part of that in the UK when there are these trade barriers now? So this is where you see a lot of potential investors saying we're not too sure about the role of the UK in this right now, because you need to move a lot of stuff round and every time there is a barrier there it's not going to be helpful. So for these new global value chains will the UK be a part of that? That's really an empirical question. We have to see how that pans out in the coming years with all the new investments coming in from abroad into Europe more generally.

BvA: Anna, do you want to wrap this up and take it back to the UK and then we'll finish?

AV: Yeah. I'd say that's a reason why we shouldn't be seeking to diverge on all regulations but rather to make sure that we're aligned on key regulations and at least be able to minimise non tariff barriers, as you say. And particularly if there are new standards in Europe for certain technologies we should seek that we produce technologies to meet those standards so that we can actually meet demand from European countries. To wrap up, I think that this is a major technological change that is coming globally where we already see certain countries with a number of capabilities and specialisms which are either directly relevant or kind of adjacent to where things are going, so it seems smart that any country developing some sort of industrial policy and industrial strategy should be trying to make the most out of those. I think rather than accept the fate that we have a number of barriers to that we should be seeking to remove some of the barriers.

BvA: Yeah. That's a really good wrap up and difficult to summarise in a better way. But what I do feel when I listen to the three of you is that you're all cautiously positive about things changing but you do recognise how systemic this change is and that it is a very subtle balance between competition on the one hand, particularly at the high end of developing new technologies where competition is good for innovation, we all know that. But on the other hand when it comes to diffusion of these technologies this is a major driver of making the adoption of green technology more productive collaboration both within nations but also internationally it's going to be very important as well. So that's a really good take away from this discussion.

Anna, Jonatan, Antoine, thanks very much for scratching the surface on this topic but also taking a couple of deep dives, and I'm sure this is a topic that we will be coming back on Productivity Puzzles. We will make a link to some of the work of our panellists and some other references which you can find in the show notes of the podcast, or you can just go to our website, productivity.ac.uk, and look up the podcast page on Productivity Puzzles. Thank you very much.

AV: Thank you very much, Bart.

JP: Thank you, Bart.

AD: Thanks a lot, Bart, and keep up the good work.

BvA: Our next episode of Productivity Puzzles for June will be on artificial intelligence. A lot has been said and written about what generative AI will mean for digital tech, innovation, jobs and society. The rise of Chat GPT has suddenly made clear to all of us the disruptive effects of this new technology for better or for worse. But what will AI do for productivity? Will it be the game changer that some predict it might be? Or might it be the same story again, much hype but little visible effects in terms of aggregate productivity? We'll discuss it in our June podcast and I can already tell you that Professor Erik Brynjolfsson from Stanford University who's a leading authority on digital technology will be joining the panel for this broadcast.

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