MANUFACTURING MATTERS

THE CORNERSTONE OF A COMPETITIVE GREEN ECONOMY

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SUMMARY

All major political parties are committed to reviving UK economic growth. **Boosting competitiveness of the UK's manufacturing sector is central to achieving that goal.**

UK manufacturing has declined far more than other advanced economies in the G7. This matters, even for a country that rightly prides itself on its services industries. Britain has lost over one-third of its manufacturing strengths since the 1990s, making the sector much less diverse and less technologically advanced. Countries like the US and France, which are similarly services-focussed, have maintained their manufacturing strengths at 1990s levels – even as services have become more dominant within their economies.

Rebuilding the UK's manufacturing strengths can bring several benefits:

- **A more dynamic and competitive economy:** Countries with the highest economic growth potential typically have a wide and diverse set of strengths across both manufacturing and services. A manufacturing sector lacking in diversity leads to a more limited set of skills and knowledge, reducing opportunities to develop new or more competitive industries. Productivity growth in manufacturing was five times higher than in services between 1997 and 2021, and the sector is linked to two-thirds of R&D activity.
- **More economic opportunities, less regional inequality:** Manufacturing uses different skills and knowledge to the high-value services that have typically driven growth in the UK over the past few decades. It also happens in different places. The decline of manufacturing has led to fewer, worse-paid job opportunities for those with meaningful skills but without university degrees and for people who live in towns with a strong manufacturing presence.
- **Less exposure to trade shocks:** Recent crises have shown how exposed UK households' finances are to trade shocks and international supply chain disruptions. The cost-of-living crisis is partially a symptom of the UK's high import dependence for essential goods like energy. If we relied totally on imports for net zero, it would put our transition at risk. More onshore manufacturing will reduce our trade deficit and improve supply chain resilience.

The net zero transition presents a perfect opportunity to revitalise UK manufacturing. Net zero requires a significant capital investment in green products and technologies that will change the way we produce and use energy. We know the products and technologies we need to get there; the big challenge now is making and rolling them out at the pace and scale needed to meet our climate targets. There is currently a gap in the required global manufacturing capacity of green products which the UK has an opportunity to plug.

Britain already has comparative advantage in one in three green products, and these existing green strengths are scattered around the country. The UK is particularly strong in making products and components used for monitoring, measuring and analysing things, with applications in industrial decarbonisation, the electricity grid and renewable energy generation. Britain is also strong at making electric trains, essential for green transport.

The UK has good green potential – the seeds of future green sectors lie in our existing industries but they need support. The race to seize the economic upsides of net zero will likely be won by the countries that can support the industrial change needed to deliver green products. Regions in the North, Midlands, Wales and Scotland all have industrial capabilities that are well placed to branch into green manufacturing.

The UK government should adopt a 'pathfinding' economic strategy, to choose which green industries to focus on. A pathfinding economic strategy acknowledges the constraints placed on our economy by path dependencies – our economic history and current productive capabilities. However, it also acknowledges that there are still many possible paths we could take for the future, depending on choices we make today. In this report, we develop a strategic framework to help make this choice for green industries, based on the size of opportunity, our existing industrial capabilities and strategic supply chain considerations:

1. the potential size of the domestic market
2. the potential size of the global market
3. existing strengths in green manufacturing
4. green potential of existing industrial capabilities
5. supply chain resilience.

Based on this framework, we judge that Britain's immediate green manufacturing priorities should be:

- wind manufacturing
- heat pumps
- green transport.

Britain also needs to retain and decarbonise foundational manufacturing such as steel. The green transition needs a lot of metals, concrete, glass and other basic materials. Retaining and greening these industries will minimise the emissions we import and maintain thousands of jobs in the UK.

More research is needed to better understand issues around supply chain resilience – especially for the solar power sector. Solar manufacturing is highly concentrated in China – this exposes the UK and our allies to geopolitical risks and reduces the resilience of key net zero supply chains in the event of any economic shocks. More research into the solar value chain is critical in developing a clear strategy for this crucial source of renewable energy.

1. INTRODUCTION

UK economic policy has converged around three broad goals. First, the need for meaningful economic growth – poor productivity growth and chronic underinvestment have meant stagnant living standards for ordinary households since the financial crisis. Second, the need to 'level up' regions around the country – vast inequality in regional growth over the past few decades has left many places outside London and the South East with fewer opportunities. Finally, the need to reach net zero carbon emissions – economic growth over the past century has caused global heating and a climate crisis; our future prosperity depends on preserving the natural environment we rely on for our survival. Recent experience with the pandemic and war in Ukraine has highlighted that a prosperous economy also needs resilient supply chains.

These goals are highly interconnected, and we need to achieve them at the same time – the net zero transition provides an opportunity to grow the economy and bring opportunities to regions around the UK. We already know the products and technologies needed to hit net zero. The challenge we need to grapple with now is how to manufacture and supply green products at sufficient scale and pace. There is simply not enough manufacturing capacity around the world to achieve this today. Britain can and should contribute to the global effort to build green manufacturing capacity, not just for net zero but also to boost the resilience of global supply chains.

Previous work by IPPR has highlighted that the UK can become a more competitive economy by diversifying its productive capabilities. Unfortunately, unlike other G7 countries, the UK's manufacturing strengths have become much less diverse over time. This matters, even for a nation that rightly takes pride in its competitive services industries. If manufacturing slips even further behind other advanced economies, our overall competitiveness and dynamism could suffer, making it harder to grow the economy or seize the economic opportunities of net zero.

The net zero transition brings a generational opportunity for the UK to rebuild the diversity of its manufacturing strengths while paving the way to a more sustainable era of prosperity. We know that manufacturing happens in different places to services, and many of these places have seen fewer benefits from growth in recent decades as services became the focus. Nurturing and growing our manufacturing sector can bring these benefits to manufacturing-focussed places while improving our trade balance and the overall competitiveness of the UK economy.

This report fleshes out the case for building green manufacturing in the UK, and develops a framework for making strategic choices on the specific green manufacturing capabilities the UK should build. All of this is underpinned by analysis on the UK's existing manufacturing capabilities and how these relate to green industries.

2. THE UK NEEDS TO BUILD NEW STRENGTHS IN MANUFACTURING

A LESS COMPETITIVE MANUFACTURING SECTOR MEANS A LESS COMPETITIVE ECONOMY

All G7 economies have experienced a gradual decline in manufacturing as a share of economic output since the 1970s, with Asian economies picking up the slack. However, analysis by the National Institute for Economic and Social Research (see Mao et al 2023) highlights that the UK has seen the steepest decline and ended up with the lowest manufacturing share of output of all the G7 countries. On its own, this measure does not necessarily reveal a significant problem – this might have been driven by exceptional growth in service sectors rather than a decline in manufacturing, for example. Unfortunately, other data points to serious issues.

Economic diversity – the number of things an economy can produce – is a cornerstone of strong economic growth. Growth and competitiveness come from innovation, from using existing skills, tools and knowledge in new ways to make new products or to make existing products more efficiently. The more diverse an economy's capabilities, the easier it will be to branch out into new products and develop new strengths (Hausmann et al 2011).

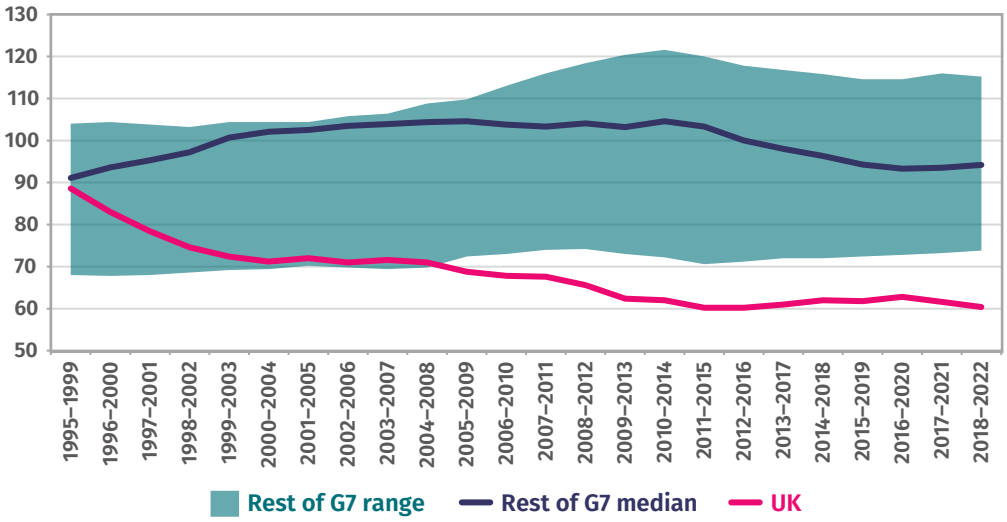
Contrary to the mainstream view in British economic policy, advanced economies like the UK are not competitive because they choose to specialise in high-value services or advanced manufacturing. In fact, advanced economies are competitive at making the most complex and valuable things because they have been successful at leveraging their diverse capabilities in new and innovative ways. They have strengths in a broad range of manufacturing and services. From a manufacturing perspective, they tend to make everything from basic commodities and agricultural produce to complex frontier technologies (Jacobs et al 2017).

Unfortunately, the UK has seen a dramatic and exceptional decline in the diversity of its manufacturing strengths. Britain's basket of competitive goods exports has shrunk by one-third since the mid-1990s while the average G7 country has added 6 per cent more goods to theirs. Even the US and France, the next lowest G7 countries in terms of manufacturing as a share of GDP, have retained the diversity of their manufacturing strengths. This is bad news for the competitiveness of the UK economy because it has fewer skills and tools to draw on for future growth.

This finding is corroborated by the Competitive Industrial Performance Index (CIP), compiled by the United Nations Industrial Development Organization (UNIDO). This is a composite measure of a country's competitiveness in manufacturing that considers, productivity, domestic production and export performance. In 1990, Britain was ranked seventh in the world for manufacturing competitiveness but had slipped to 15th by 2021, (Gasperin and Dibb 2023).

FIGURE 2.1: OVER THE PAST 30 YEARS, THE UK HAS SEEN AN EXCEPTIONAL DECLINE IN THE DIVERSITY OF ITS MANUFACTURING STRENGTHS RELATIVE TO OTHER ADVANCED ECONOMIES

Trends in export diversification (number of goods with revealed comparative advantage), UK vs G7, rolling five-year average



Source: IPPR analysis of UNCTAD revealed comparative advantage index

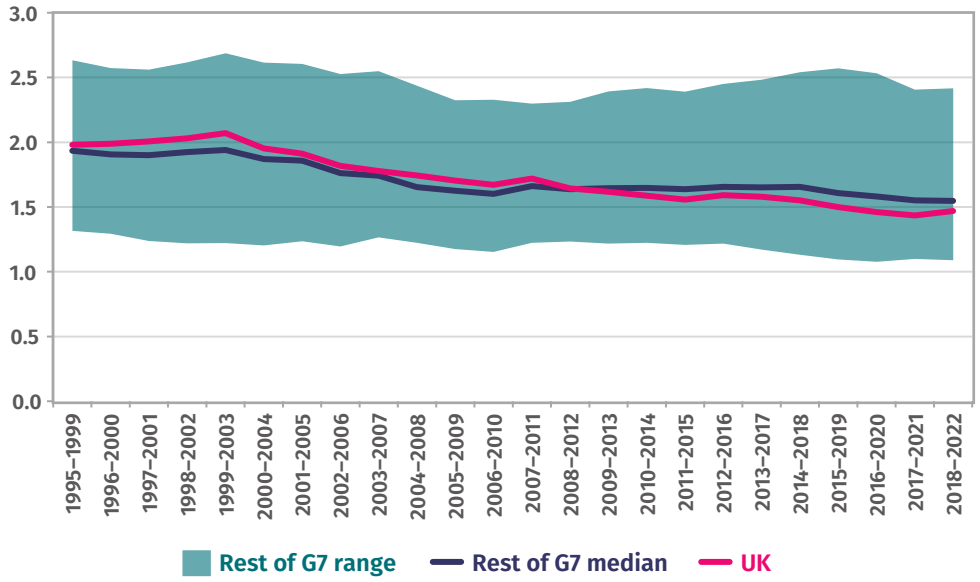
Another mark of competitiveness is the ability to make technologically complex products and components. A complex, global supply chain sits behind most goods bought by consumers. To make a smartphone you would need to gather metals, glass, computer chips, processors, circuit boards and many other things. The full range of activities to go from design to end-product, the value chain, represents income for one country or another. However, the most valuable parts of the value chain – those that generate the most income – are typically the most complicated to make, requiring highly specialist skills and tools.

Countries with more unique and technologically advanced manufacturing capabilities can develop more innovative products in the future and grow their export competitiveness (Hidalgo et al 2007). These advanced capabilities make it easier to branch out and become competitive in more valuable frontier technologies.

One measure of complexity, the Economic Complexity Index (ECI), shows that western economies have become relatively less advanced compared to the world economy, largely thanks to advances in places like South Korea, Japan and China. Of the G7, Japan and Germany have the highest scores today. The UK had the second largest drop in its ECI score in the G7, going from seventh in the world in the mid-90s to 19th. This is worse than Germany and the US, which have only declined a little, but broadly comparable to France which has dropped to 18th (albeit from a lower initial position).

FIGURE 2.2: UK MANUFACTURING IS BECOMING LESS ADVANCED RELATIVE TO COMPARABLE COUNTRIES

Rolling five-year average Economic Complexity Index, comparison between UK and the G7



Source: IPPR analysis of the Green Transition Navigator

MANUFACTURING DECLINE HAS CONTRIBUTED TO UNEQUAL GROWTH ACROSS REGIONS

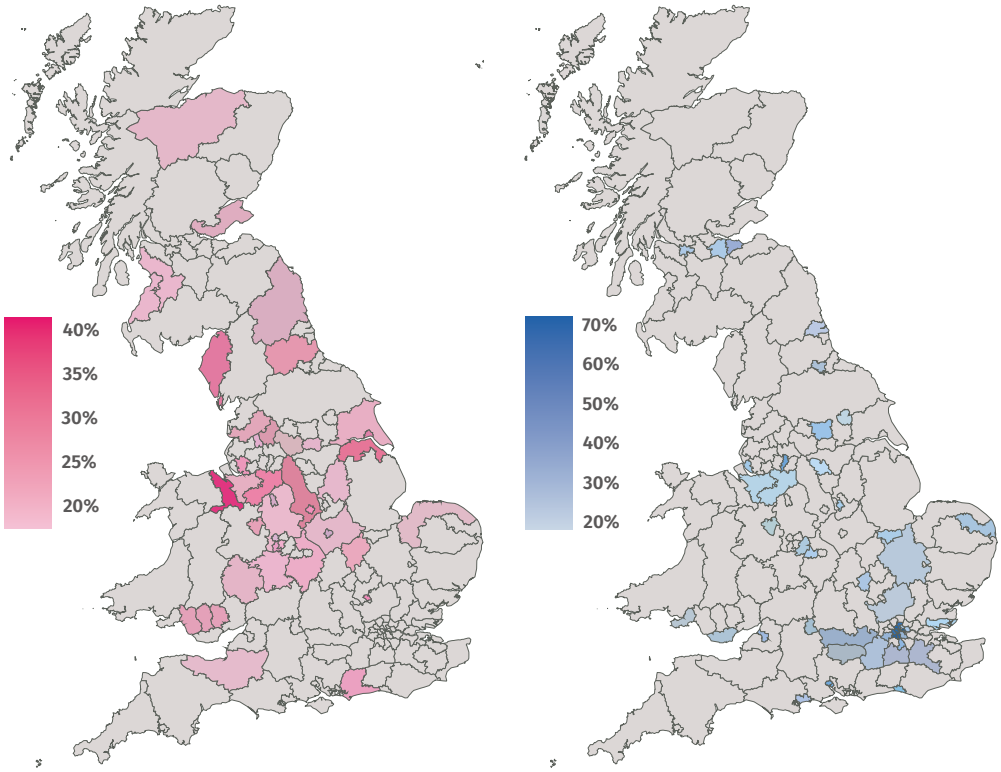
Kitson and Michie (2014) consider two competing explanations for the decline in British industry, charting its rise and fall from the late 1800s to 2010. The mainstream view is that British manufacturing declined as a natural consequence of globalisation and economic change. However, they find this to be an overly simplistic explanation. They offer evidence of a more nuanced explanation that tracks the decline of manufacturing to a set of deliberate policy and political choices made by successive governments since the 1980s.

Margaret Thatcher's 'Big Bang' reforms focussed policymakers squarely on the City of London and developing the capital as a financial services 'superpower'. To that end, Thatcher pursued monetary policy of high interest rates that benefited the City but made it significantly more expensive for capital-intensive manufacturing businesses to operate in the UK, effectively killing many factories and the stable jobs and incomes they provided.

Government bodies such as the London Docklands Development Corporation were set up to create the conditions for finance's success. Subsequent governments' focus on 'not picking winners' meant that the original winner (finance) boomed, while manufacturing-intense regions were neglected. This drove growth and prosperity in London and other urban centres such as Manchester and Edinburgh, with some benefits for towns and villages with strong transport links to these areas. For example, the South East benefited through its proximity to London. Since then, the UK has continued to rely heavily on 'tradeable services' which now account for just over half of our exports. However, the UK economy is geographically diverse – many parts of the country still have strong manufacturing bases. Allowing manufacturing to decline simply narrows the range of economic strengths and opportunities open to the regions that have developed these in the first place.

FIGURE 2.3: MANUFACTURING IS MORE PRESENT IN THE NORTH AND THE MIDLANDS COMPARED TO TRADEABLE SERVICES, WHICH ARE HIGHLY CONCENTRATED IN AND AROUND LONDON

Regions in the top quartile for manufacturing and tradeable services share of GVA



Source: IPPR analysis of ONS, 'Regional gross value added (balanced) by industry' (ONS 2023)
Note: Tradeable services are defined here as the ONS SIC Sections: Information and Communication (SIC J), Financial and Insurance Activities (SIC K) and Professional, Scientific and Technical activities (SIC M)

While the UK economy has grown overall since the start of the Big Bang reforms, areas that were specialised in manufacturing were allowed to decline. Regions with the most manufacturing presence three decades ago are sometimes classed as 'post-industrial' but they continue to be the most manufacturing-intensive regions today in terms of economic activity and still have a much higher share of manufacturing jobs than the national average (Beatty and Fothergill 2020). The difference today is that there are fewer manufacturing jobs overall, increasing these regions' reliance on lower-wage, low-productivity service industries such as hospitality. This has hollowed out the middle of the income distribution in many areas and reduced economic opportunity for people with meaningful skills but without a university education (Xu 2023).

The shift to net zero now provides an opportunity to revive the manufacturing industry. This does not mean abandoning our strengths in services – services will always be a core part of the UK economy, and manufacturing and tradeable services happen in different places and draw on different skills and resources. This is about recognising that no modern economy can exist and prosper without a strong and diversified manufacturing sector, as confirmed by international research on the subject (Andreoni and Gregory 2013; Haraguchi et al 2017). What Nicholas Kaldor explained in his 1966 Cambridge lecture on the *Causes of the Slow Rate of Economic Growth of the United Kingdom* (Kaldor 1966) remains valid today and it is constantly stressed by UNIDO in its Industrial Development

Reports (2022). Manufacturing plays a unique economic role – the sector displays increasing dynamic returns to scale that drive productivity growth – in fact manufacturing saw five times more productivity growth than services between 1997 and 2021 and accounted for two-thirds of the private sector's research and development activity (Mao et al 2023).

Britain still has the eighth largest manufacturing sector in the world in value-added terms and is the 14th largest exporter of goods (Make UK 2023). Despite the decline, the UK has preserved significant strengths in advanced manufacturing in the automotive and aerospace sector (Pourvand 2013), pharmaceuticals and, indeed, in emerging green technologies (Curran et al 2022). Industrial capacity already exists within towns across the North, Midlands, Wales and Scotland. The sector, and the regions where it can and should be found, can be a key part of a strong, green British economy. **Policymakers have a huge opportunity to deliver net zero, levelling up and economic growth by focussing their attention on green manufacturing – not one but three generational policy challenges.** The opportunity is there but it will not be easy to deliver without developing a green industrial strategy and encouraging innovative production. This means understanding the products we need for the net zero transition and how to deliver long-term economic change.

3. THE RACE TO NET ZERO IS A RACE TO RAMP UP GREEN PRODUCTION

NET ZERO IS A CHALLENGE LIKE NO OTHER

The transition to a low carbon economy is a major challenge and a shift in how our economies work. To put it bluntly, we are going to need to produce and purchase a lot of new *things*. We need to replace carbon-emitting economic activities with cleaner alternatives (eg replacing a gas power station with solar panels or a diesel car with an electric one) and we need to adapt or retrofit the things we can't replace to be more efficient (like our homes and heavy industry). From the enormous engines of an electric locomotive to the computer chips used to control a heat pump, from the materials needed to insulate an energy-efficient home to the nanometre-scale semiconductor components of a solar panel, a diverse range of manufacturing capabilities are needed. These products will directly reduce emissions when they are deployed, but they will also help people make the behavioural changes needed to reduce their carbon footprint, for example more electric public transport to help people shift away from cars.

All these new things will need to be made somewhere and by someone. With the scale of economic transition needed, it can't be taken for granted that this will happen by itself. It'll take significant and committed investment in new production facilities and equipment to build the necessary supply chains that make these new goods. When people talk about 'green growth' opportunities, they're talking about the chance to design, make and sell these goods. After years of research by scientists, policymakers and businesses across the world, we now know what most of those products are.

GREEN MANUFACTURING ENABLES THE GLOBAL NET ZERO TRANSITION

Almost all advanced economies, China and other large emerging economies such as India and Brazil are expected to accelerate their adoption of green products over the next five years (IEA 2023a). This is, in large part, because the technological and systemic changes needed to hit net zero are now relatively well understood, and becoming ever more feasible to implement for individuals, businesses and governments. Green products have become much more cost-competitive relative to fossil-fuel-based technology as key production processes for things like car batteries and large wind turbines get more efficient, as industries grow and take advantage of economies of scale. There is an enormous economic opportunity, with the global market in low-carbon goods and services estimated to be worth between £1–1.8 trillion[1] per year by 2030 (Carvalho and Fankhauser 2017).

Research by the International Energy Agency (IEA 2023a) at the global level and the Climate Change Committee (CCC 2020) in the UK both corroborate the fact that electrification and renewable electricity generation will be the core pillar of a net

1 These estimates are from 2017, and in 2017 prices – the size of the opportunity is likely to be even larger in today's value.

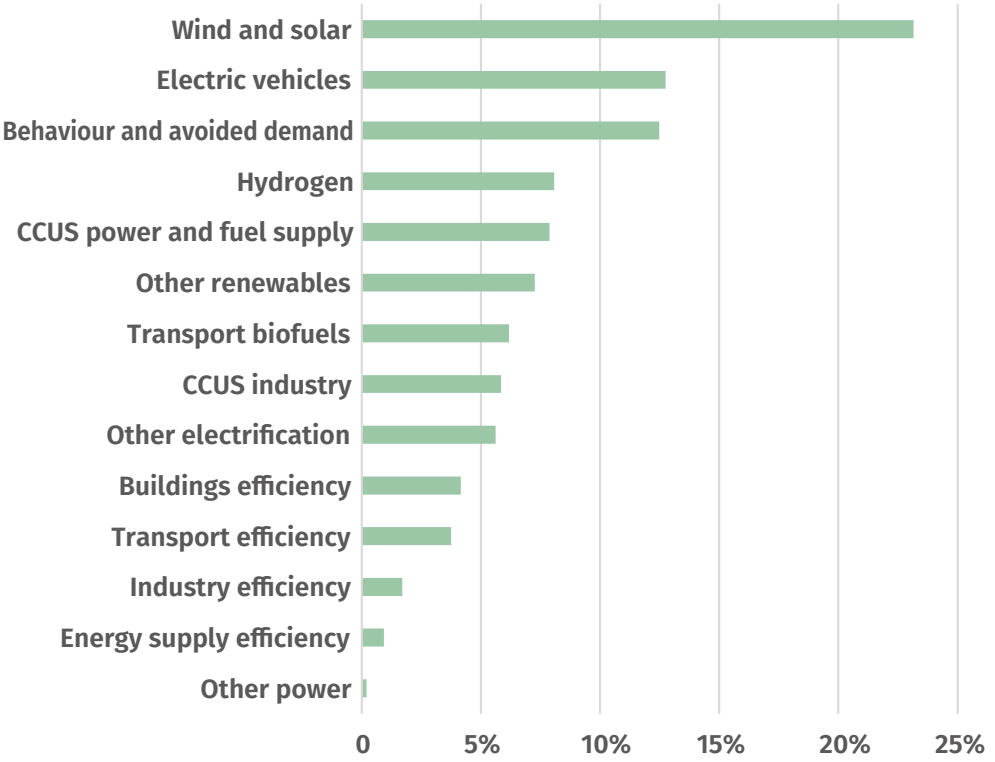
zero economy. Figure 3.1 shows how much different technologies are expected to contribute to carbon reductions in the IEA's 2050 net zero scenario. Wind turbines and solar panels are set to be the most vital products for global decarbonisation.

However, generating renewable electricity is not enough. Fossil fuels are currently embedded in our transport, buildings and commercial sectors. Decarbonising these sectors also requires the production and adoption of a wider set of green products such as electric vehicles and heat pumps.

Areas where carbon emissions are hard to avoid, such as heavy industry and long-haul aviation call for more investment in developing new green products to go from the technological demonstration stage to the commercially viable stage. For example, green hydrogen that can replace kerosene for large aeroplanes or carbon capture utilisation and storage (CCUS) for energy-intensive cement manufacturing.

FIGURE 3.1: A WIDE RANGE OF PRODUCTS, TECHNOLOGIES AND SYSTEMS ARE NEEDED FOR A NET ZERO ECONOMY

Share of CO2 emissions reductions in the IEA 2050 net zero scenario by abatement source



Source: IPPR analysis of IEA 2023a

It's not possible to deploy these green technologies without a host of more generic materials and components. Cements and metals are needed to put up wind turbines and solar panels (although these industries have high-energy intensive production processes that also need decarbonising). An expanded electricity grid needs an unprecedented amount of wires, cables, pylons, and measuring and monitoring equipment. Economic opportunities in net zero come from both making and selling green technologies and finding ways to redirect more generic products towards net zero value chains.

THE UK NEEDS TO THINK HARDER ABOUT THE RESILIENCE OF ITS GREEN SUPPLY CHAINS

The Covid-19 pandemic and Russia's invasion of Ukraine really highlighted the risks to supply chains from external shocks and geopolitics. The global semiconductor shortage perfectly illustrates the fragile nature of global supply chains under stress. Semiconductors are used as inputs to almost every piece of modern technology from iPhones to cars. Prior to the pandemic, the US had banned semiconductor sales to Huawei, the Chinese telecoms company. This resulted in the enormous firm stockpiling computer chips from non-US producers. When Covid-19 hit, demand for semiconductors surged as people bought tech to help them work from home or keep themselves entertained through lockdowns. At the same time, factories shut down to stop the spread of the virus. As economies reopened from lockdowns, demand surged once again but a shortage of manufacturing capacity and scarcity of shipping routes and lorry drivers around the world meant that there was a shortage of new cars, phones and even games consoles (Baraniuk 2021). This had a negative impact on economic growth.

A resilient economy should be able to weather the inevitable storms that come from international trade and the economic cycle – however, this episode exposed how delicate the western economies like the UK actually are. Security of supply in key goods is critical for emerging from economic and geopolitical shocks without whole industries being scarred. One of the advantages of achieving net zero is that it will reduce dependence on imports of fossil fuels, a constant source of volatility and geopolitical risk. However, the net zero economy will have to grapple with new supply chain challenges.

In a net zero economy, energy security will depend on our ability to build and replace green technologies – a different proposition to the current situation that depends on our ability to buy or replace fossil fuels. Manufacturing capacity for key renewable energy systems can ensure that the UK is prepared for any global shocks that may occur, instead of queuing up for scarce resources during a crisis. The US and EU understand this and are acting with scale and ambition to ensure that they are ahead of the curve. The US Inflation Reduction Act is creating the long-term policy conditions needed to build competitive manufacturing sectors (Murphy 2023). Building green manufacturing strengths in the UK is likely to need similar levels of strategic, patient policymaking but will help secure Britain's net zero future.

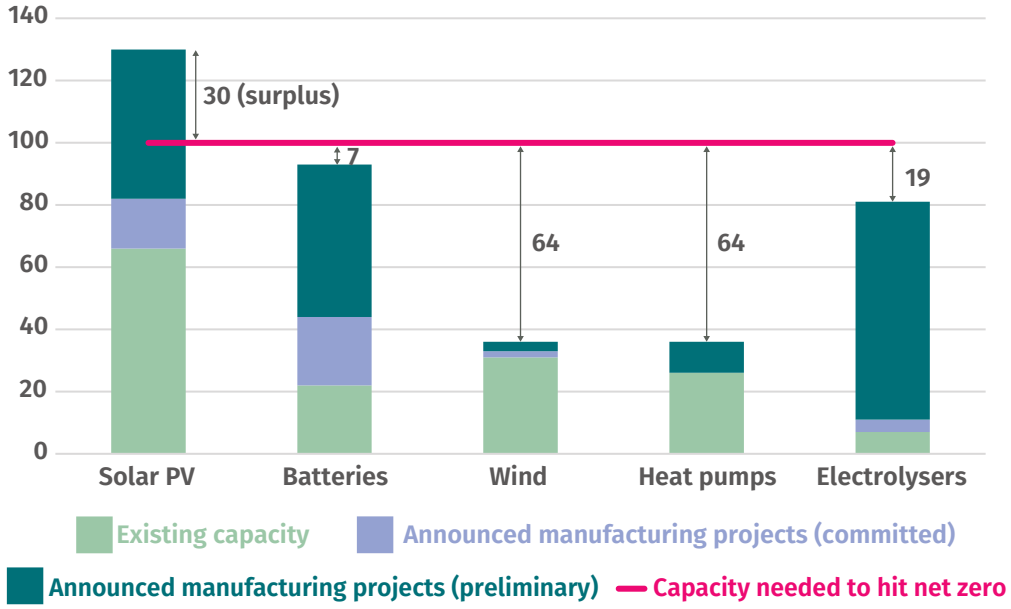
BRITAIN'S ECONOMY COULD BENEFIT FROM UNBLOCKING GLOBAL SUPPLY BOTTLENECKS IN GREEN PRODUCTS

Global manufacturing capacity in key green products has expanded rapidly in recent years, thanks mainly to a huge expansion in China, but still falls well short of the amount needed to hit net zero. There have been several announcements of new factories that are set to become operational around the world between now and 2030, meaning that some of this shortfall is likely to narrow. However, these are announced projects that may not all be completed, and some products are expected to experience a manufacturing shortfall even after announced capacity is accounted for.

According to the latest projections by the International Energy Agency (IEA), this is the case for wind turbine and heat pump manufacturing – two of the most critical products for the UK's net zero transition (IEA 2023c). Both of these products are on a trajectory to see a global shortfall of productive capacity of 64 per cent. A large amount of projected capacity in electrolysers, solar PV and batteries are also preliminary announcements, meaning that there is heightened uncertainty around whether this capacity will actually come online.

FIGURE 3.2: PROJECTIONS SHOW SIGNIFICANT SHORTAGES IN MANUFACTURING CAPACITY FOR WIND TURBINES AND HEAT PUMPS

IEA estimates of manufacturing capacity in key net zero technologies, including announced capacity that is expected to come online in the future (figures are expressed as a percentage of the total capacity needed to hit net zero and data labels show capacity shortfalls)



Source: Author's adaptation of data from IEA 2023c

By building factories to plug global supply shortages, the UK can increase progress towards net zero while seizing export and growth opportunities. Additionally, building manufacturing capacity in emerging technologies such as tidal power and green hydrogen will give the UK first-mover advantage and presents an opportunity to develop world-leading green manufacturing clusters across the country. This means good-quality, well-paying jobs around the country and a chance to revitalise neglected industrial heartlands that have been left behind thanks to Britain's rapid de-industrialisation since the 1980s.

These benefits are already becoming apparent. A snapshot analysis of the UK's current net zero economy estimated that average net zero jobs paid £10,000 more per year than the national average salary. Productivity in the net zero manufacturing sector is also an estimated 1.4 times higher than the national average. Thanks to a large presence of capital-intensive businesses in the energy and manufacturing sectors, productivity in the net zero economy in Wales, Yorkshire and the Humber, and the West Midlands is double the regional average (ECIU 2024). However, there is still a major prize to be won – IPPR's Environmental Justice Commission (EJC) estimated that the green transition can add 1.6 million jobs, spread between manufacturing, construction and services.

4. GREEN GROWTH MEANS THINKING DIFFERENTLY ABOUT PRODUCTION

All too often, processes of industrial change, creativity, innovation and investment are talked about in the abstract: there are 'green growth opportunities' and all that firms need to do is to grab them. But in practice, achieving this transition will imply knowing *how* companies change what they produce, *why* they do it, and *how* they pay for it. Government policy must be grounded in how manufacturers work, make and think. Mainstream economics has long neglected how production actually happens. For instance, innovation is treated as an exogenous input into the 'black box' of production, rather than the outcome of investments, accumulation of technological capabilities and learning processes (Dosi et al 1988). That simplified vision won't suffice for the scale of transformation needed. The race to seize the economic upsides of net zero will likely be won by the countries that can understand and shape the details of industrial change needed to deliver all the green products needed for the transition.

CHANGING WHAT WE MAKE

Successful businesses – and economies at the aggregate level – are the ones that can adapt to a changing market. Net zero is one of the most fundamental economic changes that we will experience, transitioning a system built on fossil fuels over centuries to one that is built on clean energy over decades. Often those who adapt the quickest benefit the most, but adaptation at any time is better than clinging to outdated and uncompetitive business models. Policymakers need to understand this and create the right conditions for firms and industries to evolve over time.

A company needs investment in new capital to change what it makes. This might be as small as a new mould for an existing machine, changing from shaping a metal panel for a car to a component for a plane, or it could be as large as building a whole new factory. Training to upgrade employees' skills for new production processes is another example. This capital investment can be sizeable, especially in the advanced manufacturing sectors where the UK has strengths. ASML, the world's largest manufacturer of machinery to produce semiconductors, recently released their newest chip-making machine that has a price tag of $380 million (Koc 2024).

To really adapt to new markets, this investment needs to be in highly uncertain research and development activities that allow a business to use its existing tools and expertise to shift towards a new, potentially more valuable product. Vestas, a world-leading wind turbine manufacturer, started out producing farm equipment, while Toyota started out making looms before moving into cars. When economists and policymakers bemoan the UK's low levels of business investment (Dibb and Murphy 2023), it is these exact risky, long-term, tricky decisions that they are trying to increase in quantity. It's this investment and innovation that we so desperately need more of.

This new investment and expansion takes time. There is a lag between a firm deciding it wants to make something different, getting spades in the ground, creating jobs, and new products hitting the shelves. It is for this reason that consistency and long-termism matter so much in industrial policy. Firms need to know that there will be a future market and profits opportunities at the end of this time lag to make a return on their investment. It is for this reason that the UK having 11 industrial strategies in 14 years has been so damaging, and recent policy shifts on decarbonisation targets are equally unwelcome (Alvis et al 2023).

BOX 4.1
CASE STUDY: BYD – FROM PHONE BATTERIES TO ELECTRIC VEHICLES

BYD is currently the world's largest electric vehicles producer, surpassing Tesla in the fourth quarter of 2023 by number of units sold. Founded in 1995 with just 20 employees, BYD initially focussed on manufacturing lithium-ion batteries for mobile phones. It rapidly expanded through collaborations with companies like Motorola and Nokia, diversifying into various types of electric batteries. In 2003, BYD underwent further diversification when it acquired the state-owned Xi'an Qinchuan Automobile company, subsequently rebranding it as BYD Auto. Leveraging its expertise in electric battery production, BYD Auto introduced its first plug-in hybrid vehicle, the F3DM, in 2008. In 2009, the Chinese government announced plans to purchase electric buses from BYD, and within a year, BYD Auto launched its inaugural fully electric model, the BYD e6. Besides benefiting from public procurement support, BYD's diversification and specialisation in electric vehicles were facilitated by direct government subsidies. The company now boasts the world's second-largest market share at just under 14 per cent.

PLACES AND PATH DEPENDENCE

Every place has its own unique stock of skills, knowledge and supply chain networks thanks to its unique mix of people and infrastructure and institutions. As a result, firms and industries in that area will find it easier to branch into some new industries than others. For example, China could branch into electric car manufacturing because it had expertise in battery manufacturing for mobile phones (see box 4.1). This is an example of 'path dependence' – the choices available to innovators, business leaders and policymakers are constrained by the economic setup of the place they're in. However, path dependence is not a straitjacket. It merely dictates which paths an economy can follow most easily, cheaply and quickly when market conditions change.

The economic setup that exists today is the result of choices made months, years and decades ago. The Advanced Manufacturing Research Centre (AMRC) is a great example of where choices by policymakers and businesses built on existing areas of specialism for future growth. A partnership between the High Value Manufacturing Catapult and the University of Sheffield, the AMRC built on the supply chains and skills that existed in Sheffield from its industrial metal-forming heritage but in more modern, high-value sectors. The intervention was a success and was a major driver of foreign direct investment by Boeing building a new factory in the area.

Making the right strategic choices means being open to experimentation and new modes of economic thinking. However, in the UK, successive governments

have been too narrowly focussed on areas of 'Revealed Comparative Advantage'. This concept[2] is meant to highlight where our existing strengths are, not where future potential lies. Future strengths often emerge when we leverage our existing comparative advantage in new ways. Choices to invest – or not to invest – in something now may not impact the present but could impact comparative advantage in the future.

Many people discount UK manufacturing because of our overall specialisation in services, but, as we highlighted earlier, there are plenty of places in the UK that have retained strengths in manufacturing thanks to path dependence. By thinking more strategically, we can leverage these existing capabilities to find a path to new strengths in green manufacturing.

SHIFTING TO A PATHFINDING ECONOMIC STRATEGY

Just as there are plenty of possible paths our economy *didn't* take, today's economy can develop in many different directions. Of the paths available to us some lead to a prosperous, net zero future and some don't. One path leads to us manufacturing green products in the UK and one leads to them being made elsewhere and being imported. Some paths go with the grain and build on our areas of existing specialisation and skills, and others would need more transformational shifts. From the perspective of a policymaker, some are more costly or politically feasible than others.

We broadly know the right direction we want to head in, but the challenge for policymakers is finding a path that delivers broad economic prosperity *and* environmental justice within the constraints of cost and feasibility. As we have outlined already, these vital goals can be delivered through building new strengths in green manufacturing, a sector which is already demonstrably providing better quality jobs in the very regions that need to be levelled up.

However, simply choosing 'manufacturing' is not enough. The government needs to make strategic choices about the products and technologies we choose to specialise in, drawing on a rigorous evaluation of our strengths today, the strengths a net zero Britain is likely to need and our strategic position within the global political and economic system.

For this, we can combine a mission-oriented industrial strategy with a smart specialisation approach. A mission-oriented strategy in this case means setting the goals – to deliver net zero and capture the economic upsides widely across the UK (Mazzucato 2021). From the net zero goal, we can identify the productive capacities we need to build by looking at the green products that are most important to the UK.

A smart specialisation approach is an economic strategy based on a bottom-up evaluation of skills and existing industrial capabilities, and how these could be leveraged to build productivity growth and new economic strengths in an area (Di Cotaldo et al 2020). We can use this bottom-up analytical approach to understand which productive capacities the UK already has for green products, and where the UK could leverage related skills, tools and expertise to develop new green strengths.

Adopting a pathfinding strategy means getting our top-down economic goals and our bottom-up existing specialisation to meet in the middle. It requires us to go beyond the established method of looking at revealed comparative advantage

2 Revealed Comparative Advantage attempts to measure one country's or region's strength in making something relative to another. It compares the product's share of the country's exports to the product's share of global exports. When a country making a product has a higher share of exports in that product, relative to the global average, it is said to have comparative advantage in that product.

and towards an understanding of how existing manufacturing strengths can be leveraged for green manufacturing of the future. We will base this on an assessment of the following three areas.

1. **Green strengths** – products that the UK *already* has a comparative advantage in.
2. **Green potential** – products that the UK *could* become strong at manufacturing, based on the existing manufacturing capabilities it has.
3. **Resilient foundations** – Manufacturing capabilities that *should* be developed for reasons of economic security and resilience. This includes areas where international supply chains are vulnerable due to regional concentration and geopolitical tensions.

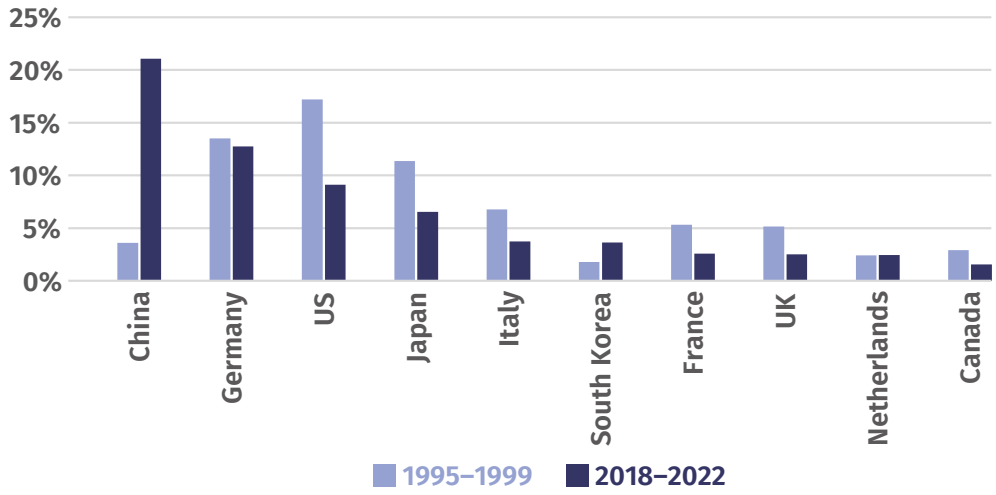
5. GREEN STRENGTHS

THE UK ALREADY HAS AREAS OF COMPETITIVE GREEN MANUFACTURING

Britain's share of global green products exports has halved since the 1990s – this was largely driven by the stratospheric rise of Chinese manufacturing, which has increased from 4 per cent to more than 20 per cent of global exports in green products in just 30 years. The UK's wider decline in manufacturing had a much lower impact on its competitiveness in green exports, where it is still the eighth largest exporter in the world.

FIGURE 5.1: THE UK IS THE EIGHTH LARGEST GREEN PRODUCT EXPORTER IN THE WORLD, BUT ITS MARKET SHARE HAS HALVED SINCE THE 1990S

Top 10 countries based on their market share in green product exports between 2018 and 2022, compared with their share of green products between 1995 and 1999



Source: The Green Transition Navigator[3]

The analysis above is based upon the green products list from Mealy and Teytelboym (2022). This list is made up of 250 products deemed to have environmentally beneficial properties by international organisations but contained products that were not necessarily relevant to the net zero transition. To assess the UK's green strengths in more detail, we narrowed their green products list to a set of 143 products that could be linked directly to technologies and value chains needed to deliver net zero.[4]

A five-year average of revealed comparative advantage from 2016–20 was used to assess the UK's competitiveness in these product codes relative to the rest of the world. This measure of comparative advantage looks at which countries have export strengths in each product by comparing the product's share of a country's

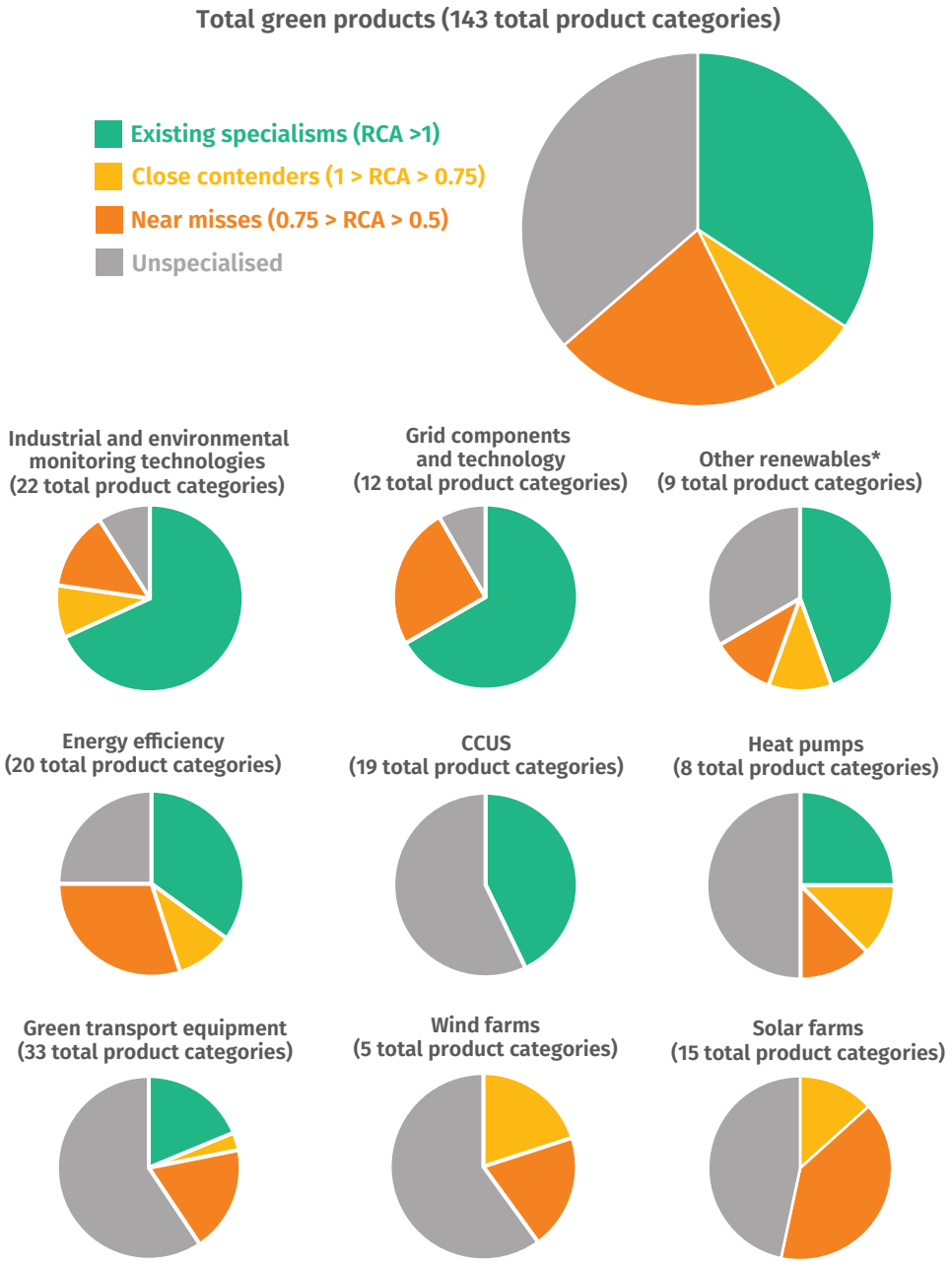
3 See https://green-transition-navigator.org/

4 Mealy and Teytelboym's list is constructed from six-digit Harmonised System (HS) product classifications, a list of more than 5,000 unique product codes.

exports with that product's share of global exports. If a country's share is above the world share, then it is assumed to have comparative advantage in that product.

FIGURE 5.2: THE UK ALREADY HAS COMPARATIVE ADVANTAGE IN OVER ONE-THIRD OF GREEN PRODUCTS

Analysis of revealed comparative advantage data for green products exported by the UK in 2016 to 2020



Source: IPPR analysis of RCA data featured in the Green Transition Navigator[5]
Note: Existing specialisms are products where RCA is greater than 1, the traditional definition of revealed comparative advantage, high potential is 0.75<RCA<1, moderate potential is 0.5<RCA<0.75, and low potential is RCA<0.5. *Other renewables are products and components used in geothermal and hydroelectric power generation.

5 See https://green-transition-navigator.org/

Britain currently has a revealed comparative advantage in 49 of the 143 goods relevant to the net zero transition, around one-third of the green products that could be identified. Within this, British manufacturers are particularly specialised at making:

- equipment used for measuring, testing and analysis of emissions and environmental indicators, with uses in industrial decarbonisation
- equipment used to control, automate and analyse activity in the electricity grid
- heat pump components – especially parts that are used to monitor and control heating systems
- some building insulation materials, such as glass fibres
- electric rail locomotives and parts for trains
- turbines that can be used in geothermal or hydroelectric energy generation.

Our list of green products can be grouped into nine 'green sectors' that roughly represent distinct areas of decarbonisation to better understand the UK's current green strengths. For example, our comparative advantage in components used for measurement, monitoring and analysis means that we have strengths in products related to industrial decarbonisation and the electricity grid.

GREEN MANUFACTURING STRENGTHS ARE SPREAD AROUND THE COUNTRY

Comparative advantage is meant to show us where products can be made at the lowest opportunity cost but national level analyses mask significant regional differences. The opportunity cost of building any manufacturing in London is very different to developing these industries in the Midlands, for example. It is likely to be very expensive to set up a battery gigafactory in London where a lot of established services firms might have to be displaced to free up land; however, it is likely to be much easier in areas like Sunderland, where facilities can be built close to existing car factories to help them produce electric vehicles.

For us to understand regions with green strengths, we need to figure out which sectors of the economy produce green products. National statistics use the Standard Industrial Classification (SIC) system for industrial analysis, so green products from the Mealy and Teytelboym list were mapped onto the manufacturing SIC sub-sectors that are most likely to produce them.[6] Most industries within the SIC system produced green and non-green products – to identify existing green manufacturing industries, we calculated the 'green intensity' of each sector's exports.[7] This is the share of a SIC subsector's export value that comes from green products.

'Other electronics and electric wires and cables' is the top green manufacturing sector – 100 per cent of the products it exports have uses within net zero supply chains. This sector primarily makes wires, cables and other components that are integral for electrification. 98 per cent of the value of exports in the railway locomotives and rolling stock sector came from electric rail locomotives or components that could be used to build electric trains – integral products for a green transport system. Sectors such as 'metal structures' and 'articles of concrete' are not typically thought of as green but produce materials and structures that are used for building renewable energy projects.[8]

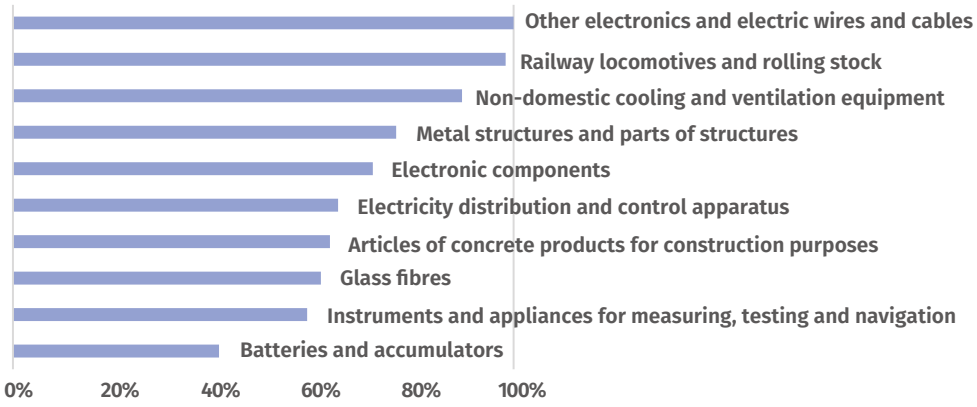
6 More details on this are included within the technical appendix.

7 Green intensity measures the share of a sector's export value that comes from green products. 100 per cent green intensity means all goods exported by the sector could be used in net zero supply chains, 0 per cent means none of the goods exported by the sector are relevant to net zero. Sectors with greater than 15 per cent of green intensity are considered green manufacturing sectors

8 For example, these sectors could produce the concrete foundations of wind turbines or the metal frames that hold solar panels in place on solar farms.

FIGURE 5.3: 32 OUT OF 221 UK MANUFACTURING SUB-SECTORS MAKE PRODUCTS THAT COULD BE USED IN NET ZERO SUPPLY CHAINS

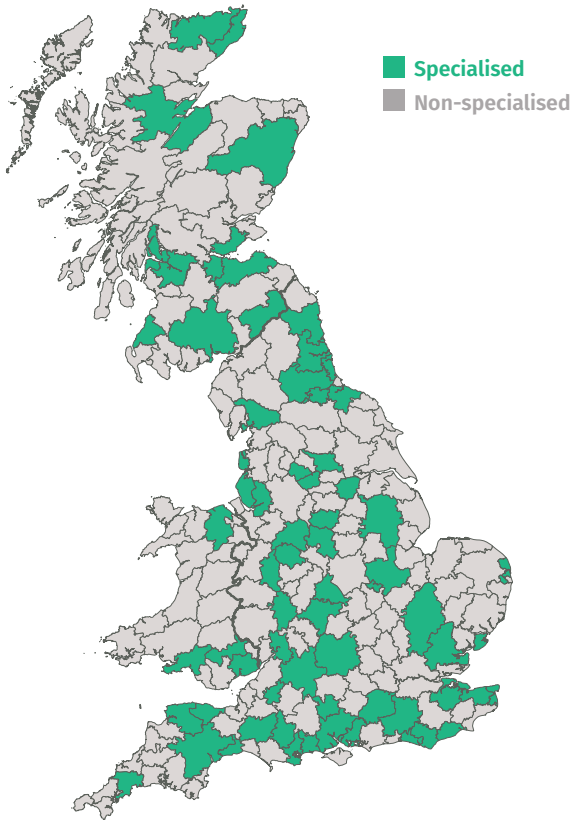
Green intensity of sectoral exports (green product exports as a share of the sector's total export value), top 10 sectors



Source: IPPR analysis of UN Comtrade data[9]

FIGURE 5.4: POCKETS OF GREEN MANUFACTURING EXIST ALL OVER GREAT BRITAIN, ESPECIALLY IN COASTAL REGIONS

Travel to work areas[10] with regional comparative advantage in green manufacturing



Source: Authors' analysis of ONS Business Registry and Employment Survey (BRES)[11]

9 See https://comtradeplus.un.org/

10 Travel to Work Area (TTWA) is the UK definition for commuting zones, a collection of wards for which at least 75 per cent of the economically active resident population works within the same area.

11 See https://www.ons.gov.uk/surveys/informationforbusinesses/businesssurveys/businessregisterandemploymentsurvey

The 32 green manufacturing sectors are scattered across the country,[12] but figure 5.4 shows that many coastal regions and around Great Britain have regional comparative advantage in green manufacturing.[13] There are also significant pockets of inland green manufacturing in the Midlands and East Anglia. The clusters identified here are areas where industrial capabilities for green product manufacturing currently exist, but a big limitation is that it is not possible to distinguish between manufacturing of products that are already being used in net zero supply chains and products that have applications within net zero supply chains but are not currently used for those purposes.

12 This analysis is for Great Britain as data was unavailable for Northern Ireland.

13 This is calculated by comparing green industries' share of employment within region to the national share of employment in green industries. Regions that are relatively specialised in green manufacturing are those that have greater employment shares than the national average, producing a value greater than 1 for this metric (more details on the formula are included in the technical appendix).

6. GREEN POTENTIAL

FINDING GREEN POTENTIAL

Looking at comparative advantage is like looking at a photo of the economy – it provides a snapshot into what the economy's strengths are right now, but not what they could look like in the future. This is because economies evolve over time and new, unexpected productive strengths could branch out from combining existing skills, tools and know-how in new ways. This branching out process is the result of decisions taken by businesses and individuals who decide to experiment with new production processes and by policymakers to offer public investment or a supportive policy environment. The concept of relatedness can be used to assess which products may be easiest to branch into.

The emergence of new strengths is path dependent – they will most likely be related to existing productive capacity. Having mapped out green industries across the UK, we identify industries that are related to green manufacturing based on regional clustering, or co-location. The more frequently industries cluster together, the more likely they are to have related production processes or links to the same supply chains or infrastructure.

BOX 6.1
CASE STUDY: FROM SHIPYARDS TO WIND TURBINE FACTORIES

The town of Bremerhaven lies on the mouth of the River Weser in North Germany. This old industrial port was a hub for shipbuilding, but with competition from more cost-competitive Asian shipyards, found itself in decline since the early 2000s. In 2005, unemployment topped 25 per cent. However, by 2011, it had a nascent offshore wind cluster that employed more people than the leftover shipbuilding industry. This cluster produces several components – nacelles, blades and substructures, while the nearby city of Bremen hosts tower manufacturers, training firms and research institutes focussing on wind energy.

State subsidies and local policy coordination provided the nutrients for this blossoming industry, but the seeds were in the workers from the shipyard. Bremerhaven beat states that offered similar subsidies because there were strong overlaps between the skills needed for wind turbine manufacturing and those used in shipbuilding. This was not a perfect one-to-one match, but the Fraunhofer Institute for Wind Energy collaborated closely with firms and training providers to offer shipyard workers training in wind manufacturing. Within two to six months, ship workers could find employment in the wind sector, and firms hired them extensively (Jaax 2015).

Finding green potential is about finding the shipbuilders that could become the wind turbine manufacturers (see box 6.1). Here, we call this *relatedness*. We measure industry relatedness between green manufacturing and ordinary (non-green) manufacturing based on an analysis of clustering following the methodology of Vanino (2022). The analysis assumes that industries that

cluster[14] together more often are related in terms of production processes implemented, inputs of production used, technologies developed, skills required, and final markets targeted (Corradini and Vanino 2021). In other words, the more frequently an ordinary industry appears alongside a green industry, the more likely it is to have *something* in common with the green industry, making it easier to branch from that ordinary industry to the green industry (shipbuilders to wind manufacturers).

This is an established methodology to identify relatedness between different industries, but we recognise that it is not perfect; it does not provide a detailed understanding of the causes of these links – it could be any combination of the factors discussed above. Green manufacturing is assessed against other manufacturing sectors only because some service industries, such as healthcare or retail, are very widespread and could result in false relatedness simply because they are found near almost every industry. It was also not possible to distinguish green and non-green service industries.

TABLE 6.1: TOP 15 MANUFACTURING SECTORS IN TERMS OF GREEN POTENTIAL

Sector name	Green relatedness score
Manufacture of communication equipment	1.36
Manufacture of other organic basic chemicals	1.27
Other non-ferrous metal production	1.24
Manufacture of magnetic and optical media	1.23
Tanning and dressing of leather; dressing and dyeing of fur	1.19
Repair and maintenance of aircraft and spacecraft	1.18
Manufacture of lime and plaster	1.17
Forging, pressing, stamping and roll-forming of metal; powder metallurgy	1.16
Manufacture of other special-purpose machinery	1.16
Manufacture of loaded electronic boards	1.16
Manufacture of central heating radiators and boilers	1.15
Manufacture of air and spacecraft and related machinery	1.15
Manufacture of other taps and valves	1.14
Manufacture of essential oils	1.13
Manufacture of coke oven products	1.13

Source: Authors' analysis

We find a range of manufacturing sub-sectors are related to green manufacturing in the UK – particularly manufacturing of electrical components and equipment. This is likely to be driven by the strong presence of products related to electrification and renewable energy generation.

Some sectors which manufacture basic materials such as metals, chemicals, and lime and plaster may be related due to green industries that manufacture materials used for building insulation and energy efficiency, and due to the inclusion of concrete and cement within renewable energy value chains.

14 Also known in the research literature as co-location or co-occurrence.

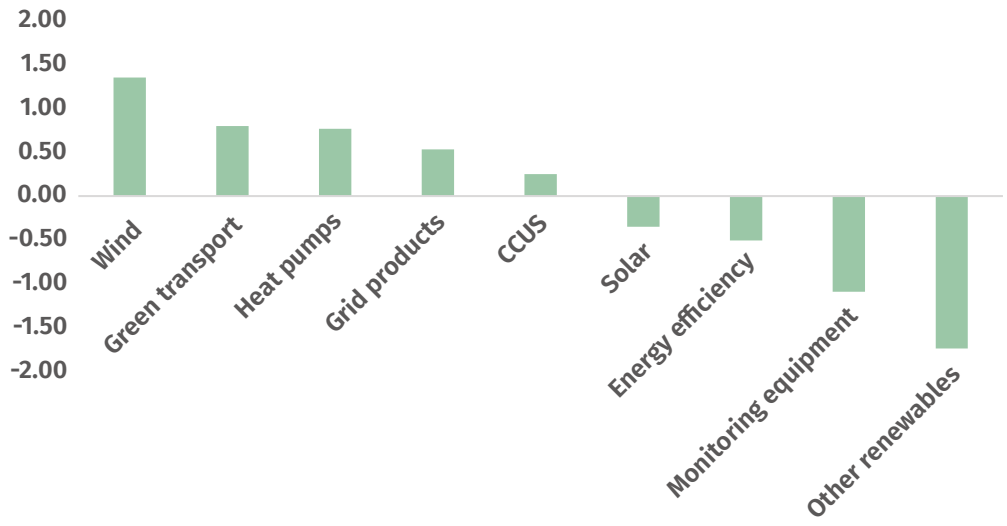
THE UK IS MORE SUITED TO DEVELOPING SOME GREEN INDUSTRIES THAN OTHERS

These scores can be calculated for the nine green manufacturing sectors we identified in the previous chapter. For example, for the wind sector, we find the SIC codes that have the highest 'wind manufacturing intensity' – the proportion of exports in products relevant to the wind sector. We then calculate a measure of green potential for the wind sector that shows how related wind manufacturing is relative to the average green industry. Green sectors with higher values are more related to the UK's existing manufacturing base, making it easier to branch into these sectors.

Figure 6.1 shows that wind manufacturing is the sector with the highest green potential. In lay terms, this shows that the manufacturing of wind turbines is the green manufacturing sector that the UK could most easily branch into given our current skills, know-how and tools. Green transport and heat pumps are also areas that the UK is more suited to developing. Grid products and carbon capture and storage (CCUS) are about average, while other green industries are not as close. The UK has existing strengths in monitoring equipment, but this sector is not as highly related to other manufacturing sectors in the UK.

FIGURE 6.1: WIND MANUFACTURING IS MARGINALLY CLOSEST TO EXISTING UK MANUFACTURING SECTORS, FOLLOWED BY GREEN TRANSPORT AND HEAT PUMPS

Normalised relatedness scores between green and ordinary manufacturing sectors in the UK



Source: Author's analysis

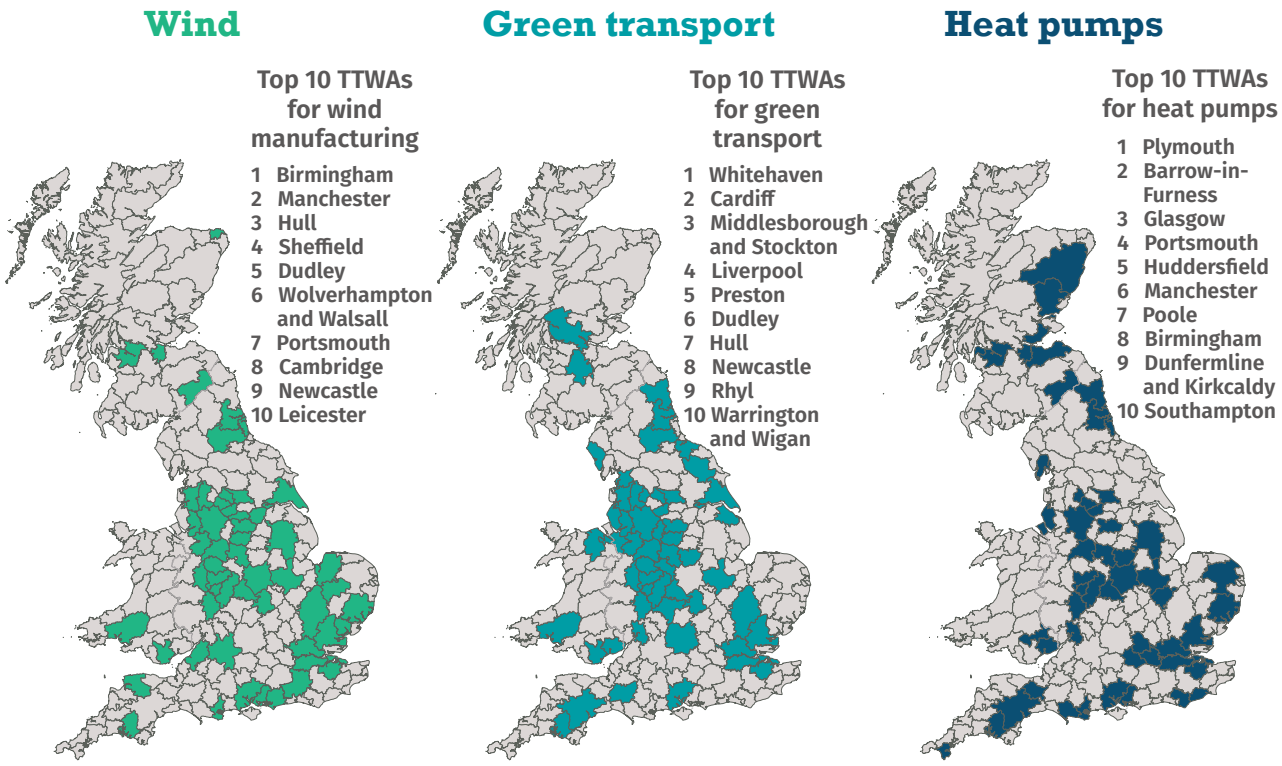
REGIONS IN THE NORTH AND MIDLANDS ARE WELL PLACED TO GROW INDUSTRIES WITH THE HIGHEST GREEN POTENTIAL

We can map employment in related industries for each green sector as an indication of the regions that are most suited to branching out into each of those sectors. We show the maps for the top three sectors in terms of green potential. The North West and West Midlands have a large presence of ordinary manufacturing that is related to the wind and green transport sectors, and some places in these regions also have high levels of employment in sectors related to heat pump manufacturing. This suggests that these regions are well placed to develop green manufacturing capacity. Many places in the coastal South East have high levels of employment related to wind manufacturing and heat pumps,

and some places in this region also have high levels of green transport-related manufacturing. Scotland has places with a presence of related manufacturing of all three of these green sectors but each green sector has a presence in a slightly separate region.

FIGURE 6.2: THE NORTH AND THE MIDLANDS ARE VERY WELL PLACED TO DEVELOP SECTORS WITH HIGH GREEN POTENTIAL

Regions in the top quartile of employment in ordinary manufacturing related to each green sector



Source: Authors' analysis

GREEN POTENTIAL AROUND GREAT BRITAIN[15]

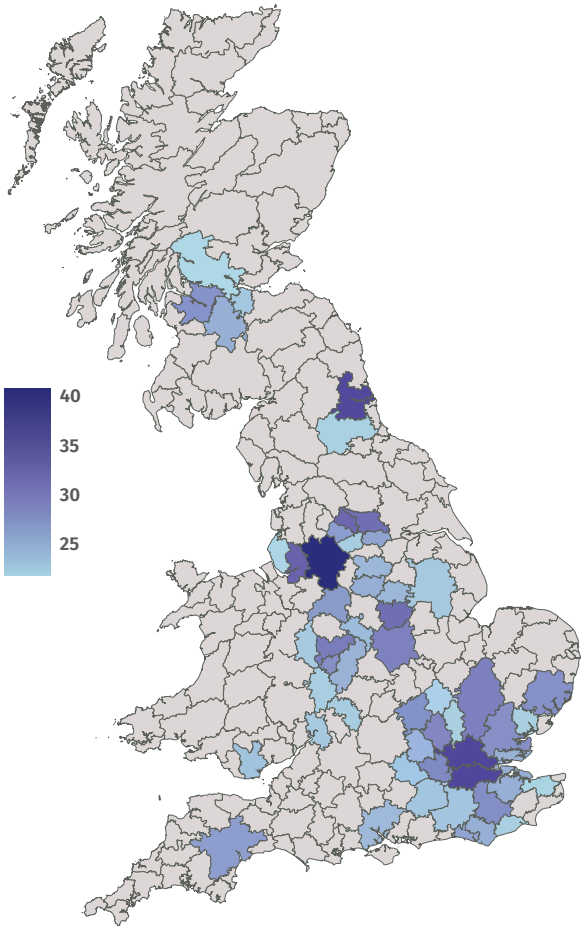
Bringing this together, we can assess regional green potential in a more general sense. This analysis uses a measure called the relatedness density, which looks at the strength of relatedness between green industries and ordinary manufacturing within a region *and* the number of green-related industries that are present.

The TTWA with the highest green potential based on relatedness density is Manchester, followed by London, Newcastle, Warrington and Wigan, and Leeds. Scottish regions Glasgow, Falkirk and Motherwell were in the top quartile of green potential as well.

15 This analysis is for Great Britain as data was unavailable for Northern Ireland.

FIGURE 6.3: THE NORTH, MIDLANDS AND THE SOUTH ALL HAVE REGIONS WITH HIGH CONCENTRATIONS OF GREEN-RELATED MANUFACTURING, ALONGSIDE SOME AREAS OF SCOTLAND

Regions in the top quartile of green relatedness density



Source: Author's analysis

Note: Green relatedness density is a measure that shows concentration of green-related manufacturing employment by region. Higher values suggest that the area has industries with higher green relatedness scores and/or a greater number of green-related industries.

7. RESILIENT FOUNDATIONS

The focus of this report is to identify growth opportunities for green manufacturing in the UK; however, this industry won't exist in isolation. Green manufacturing will need inputs from several domestic and international industries that supply the tools and materials needed to make the technology needed to hit net zero. The UK also won't be able to make every green product and will rely on trade with many countries to hit net zero. Geopolitical choices, crises or conflict could put our supply chains at risk, as the Russian invasion of Ukraine and post-pandemic disruption to global shipping have proven.

The resilience of green supply chains also depends heavily on international consensus around net zero and climate goals – geopolitical risk to supply chains could also emerge from major countries such as the US or China wavering on this commitment. For these reasons, 'friendshoring' is part of a sensible national industrial strategy where economies of scale, costs of energy or technologies do not allow investment in ramping up domestic manufacturing capacity. Friendshoring is the practice of re-routing supply chains with lower geopolitical or economic risk so that trade is less likely to be disrupted by shocks. A detailed analysis of resilience in green supply chains or an in-depth discussion of friendshoring for green manufacturing are outside the scope of this report but we discuss the broad themes below.

MATERIAL INPUTS FOR CONSTRUCTION AND DOWNSTREAM MANUFACTURING

Net zero is incredibly reliant on physical capital – this means plentiful, sustainably produced construction materials are a must. Concrete, steel and other materials are core enablers of the green transition. Steel is a particularly important industry for the UK, providing employment for thousands of people in areas around Wales and the North (Webb 2021). This is a strategically important industry for net zero, with 68 per cent of future demand expected to come from green products and infrastructure (Viisainen and Bulleid 2023). UK steel had been well placed to supply much of this additional demand but the move by Tata Steel to pivot away from virgin steel manufacturing puts this future at risk (Bulleid 2023). Steel, like other heavy industries producing materials, is extremely energy intensive and a major source of carbon emissions.

A net zero economy needs green steel, green chemicals manufacturing and others. If domestic production is substituted with imports from places with lower environmental standards, then the UK will still be contributing to global emissions and its net zero mission will be at risk. This would also destroy jobs. The introduction of a carbon border-adjustment mechanism (CBAM) within the EU and its potential implementation here is likely to level the playing field for domestic industry – gutting our productive capacity now means no chance for cleaner heavy industries to blossom and provide jobs and security of supply.

CRITICAL MINERALS

As fossil fuels get less important for our economy, critical minerals and metals are likely to become the new hot commodities. Lithium, graphite, cobalt, copper and

many other minerals will be needed in droves for batteries, electricity systems and renewable energy sources. Supply will have to come from areas with natural reserves, and that will make a net zero economy reliant on Chilean copper, Chinese rare earth metals and Australian lithium. However, the countries that do the extraction are not always the ones processing the materials. The UK does not benefit from extensive reserves of critical minerals but does have a critical minerals strategy that seeks to maximise domestic productive capabilities.

The Government has recently set up the Critical Minerals Intelligence Centre (CMIC) to deliver the strategy (DBT and DESNZ 2023). However, despite an update of the strategy last year, and the establishment of CMIC, it is still little more than a framework. The foreign affairs select committee has strongly criticised the lack of action and highlighted that the UK is lagging behind in the race to secure adequate supplies (Foreign Affairs Committee 2023). Despite the slow start, the first lithium mining project in Cornwall could signal the start of a successful new industry. Thanks in part due to equity financing from the UK Infrastructure Bank, Cornish Lithium secured funding for the first critical minerals mining facility in the UK. Britain is unlikely to ever be a major lithium exporter, but having domestic supply helps form local production networks between miners and manufacturers, boosting economic growth and improving supply chain resilience.

GREEN TECHNOLOGIES THAT ARE OVERLY CONCENTRATED IN CHINA

Some green products have highly concentrated manufacturing centres. China is by far the world's largest green product manufacturer, with the largest electric vehicles company in the world (BYD), the largest producer of electric batteries (CATL), a large wind manufacturing sector and an absolute dominance across the solar PV supply chain (IEA 2023e). While competing against China on some of these goods would be impossible for any medium-sized economy, it is still vital to ensure that geopolitical tensions do not put the UK's, nor the world's, green transition and energy security at risk.

8. THE UK'S PATH TO GREEN INDUSTRIALISATION

THE PATHFINDING FRAMEWORK FOR A GREEN INDUSTRIAL STRATEGY

A pathfinding economic strategy acknowledges the constraints placed on our economy by path dependencies – our economic history and current productive capabilities. However, it also acknowledges that there are still many possible paths we could take for the future, depending on choices we make today.

The net zero mission provides a strong signal for the industrial capabilities we will need in the future. The UK has several industrial capabilities that are relevant for this mission, but it needs to make choices about which green manufacturing sectors it specialises in. This decision must be informed by an analysis of how current industrial capabilities relate to the green strengths we need to develop, but also to the size of the opportunity – the products that provide the greatest opportunity from a domestic and international demand perspective.

We conclude that a pathfinding strategy for green industries should consider the following five pillars:

1. **The potential size of the domestic market:** This pillar should consider the UK's net zero targets and any available projections of the expected value of each green product market.
2. **The potential size of the global market:** Global product installation and deployment targets, such as those estimated by the IEA, give a sense of the overall size of the prize for each green value chain. Robust projections of market value are rare but would provide very useful information for this pillar.
3. **Existing green strengths:** Measures of revealed comparative advantage are useful for this pillar.
4. **Green potential:** This should assess the relatedness between the UK's existing productive capabilities and the green products we need to hit net zero. We measure this by looking at regional clustering between manufacturing sectors.
5. **Supply chain resilience:** This should assess the importance of the industry to the UK's overall supply chain resilience but also its strategic importance within for our net zero transition.

CHOOSING SECTORS

Wind: a priority area

The UK has been one of world's leading installers of wind turbines but has lagged behind other European countries in developing a leading wind manufacturing sector, meaning that it missed out on jobs and other economic benefits. Policy has been strong at generating domestic demand but the lack of strengths in wind manufacturing reveals a missed opportunity for the UK government (Emden et al 2023).

However, our analysis highlights that wind manufacturing is the most related green industry to the UK's existing industrial structure. Branching into this green sector is likely to be easier than others. Britain's geography and infrastructure is highly suitable for this industry with developed port

infrastructure and large swathes of coastline. The sector also benefits from institutions such as the Offshore Renewable Energy (ORE) Catapult that acts as an innovation accelerator, and a strong upstream sector focussed on developing offshore wind farms.

There is a mature domestic market for wind turbines which is likely to sustain strong demand – the government is targeting an additional 36GW of capacity in offshore wind alone as part of their push to decarbonise the power system by 2035 (DESNZ 2023). The Labour party has an even more ambitious target for an extra 41GW of offshore capacity and a target to 'more than double' onshore capacity by 20GW by 2030 (Labour Party 2024). Demand is likely to increase further if onshore wind development was given a higher priority. There is also healthy global demand: the Global Wind Energy Council (GWEC) expects an additional 1,221GW of wind energy capacity installations by 2030, a 13 per cent increase on the expected additional capacity last year (GWEC 2023). To actually be on track to hit net zero by 2050, the world would need an additional 1,743GW in 2030 (IEA 2023d).

Global manufacturing capacity is expected to fall well short of the amount needed to hit net zero, so building a domestic wind industry is vital for shoring up the UK's supply of wind turbines and could provide export opportunities in the future.

A lot of the technology used in wind energy can also be used for tidal power, which is an emerging renewable energy technology where the UK has significant innovation and production potential (Curran et al 2023).

BOX 8.1
FRANCE SHOWS THAT IT IS POSSIBLE TO QUICKLY BUILD CAPACITY IN WIND MANUFACTURING

Before 2022, France had almost no existing installed capacity in offshore wind and its 2022 national plan set a modest 3.6GW target for offshore wind by 2030, 10 times lower than the UK target for additional capacity between 2023 and 2030. At the same time, France is more specialised than the UK in every single segment of the manufacturing supply chain.

This has not always been the case: back in 2016, France's wind turbine production was valued at a mere €56.2 million, as compared to the UK's €292.6 million. However, close collaboration between the French government and leading manufacturers have resulted in a large expansion in wind manufacturing strengths in recent years. For instance, in 2022, Siemens Gamesa inaugurated the world's first factory to manufacture both nacelles and blades in the same plant at the port of Le Havre.

Heat pumps: a priority area

Heat pumps are vital for the UK's net zero transition. Britain has one of the oldest, most energy inefficient building stocks in Europe and more efficient central heating has been recognised by the government as a priority for the UK, with a target installation rate of 600,000 heat pumps each year by 2030 (BEIS Committee 2022). Installation rates have been well below this target in recent years but there are also now strong demand signals thanks to the increase in grants available for consumers through the boiler upgrade scheme (Webb et al 2020; DESNZ 2023).

International demand is difficult to assess but the IEA data suggests strong demand growth in recent years, with sales in Europe increasing 4 per cent between 2022 and 2023. However, to hit net zero, global sales need to increase by 15 per cent per year between now and 2030 (IEA 2023f). There is also a major shortfall in manufacturing

capacity. The latest projections suggest that global capacity needs to quadruple to produce enough for net zero, presenting a huge opportunity for the UK.

Our analysis shows that the UK already has some existing strengths in the heat pump value chain and ranks joint second in terms of relatedness to Britain's other manufacturing capabilities. This is backed up by the government's own research into the sector that shows many manufacturers of boilers and central heating units already produce some heat pumps. Air conditioning units use very similar components to heat pumps as well, so there is very little effort needed to repurpose existing facilities that make these goods (BEIS 2020).

Green transport: several areas of potential

Green transport covers a large set of products – zero emissions road vehicles (ZEVs), electric trains, even active travel such as bicycles. Demand for light electric road vehicles has been strong in recent years but electric cars only make up 3 per cent of cars across the country. The government has committed to banning the sale of new petrol and diesel cars by 2035, with a mandate on car manufacturers to ramp up electric vehicles as a proportion of overall sales from every year until then. The Labour party has an even more ambitious target to phase these out by 2030. This is likely to mean strong demand for electric vehicles going forward. Demand for other green transport equipment is harder to judge. Internationally, electric vehicles are expected to pick up but the largest growth in recent years has been in China, with a surge in growth of Chinese ZEV companies such as BYD.

The UK already has major strengths in automotive and aerospace manufacturing – this is the driving force behind the sector's second place ranking for relatedness. This provides an edge for Britain to develop more and greener transport manufacturing strengths in future. For car manufacturing in particular, it is essential to build battery manufacturing – without this capability our industry will be left behind in the race to build electric vehicles.

Existing strengths in green transport are mainly in electric rail locomotives and associated parts. However, strengths in other areas could be emerging already. There have already been several recent announcements of investments by car manufacturers in electric vehicles production. Tata and AESC group have also announced plans to each build a battery gigafactory (DBT 2023).

Aside from electric trains and road vehicles, the UK's existing strengths in building aeroplanes and jet engines gives us an edge in building the zero emissions planes of the future. Electrically powered flight and hydrogen jet engines maybe many years off from commercial viability, but Britain's existing cutting-edge aerospace manufacturers are well placed to bring the industry to life.

Grid products: some existing strengths but more evidence is needed

The UK has several existing strengths in grid products, particularly monitoring equipment related to analysis of electricity usage. Manufacturing sectors within this broad value chain are of a middling rank in terms of relatedness to non-green manufacturing sectors.

Domestic and international demand for such products is very likely to increase but the extent of the opportunity is uncertain since these products are in the middle of a very complicated supply chain where the final product is a network of infrastructure.

One area where there may be potential, building from the recent announcements of battery factories, could be batteries and accumulators to enhance grid storage.

Heavy industry and industrial decarbonisation: some strengths but more evidence is needed

Steel is strategically important in the UK and provides thousands of jobs across the country. A successful green transition will need lots of steel for use in construction and manufacturing, but right now the British industry is going backwards. Policymakers should ensure that we retain as much capacity as possible, particularly in green steel. More research is needed for other heavy industries in the UK.

The UK's strengths in industrial decarbonisation are not in the key products within these areas such as electrolysers for green hydrogen or CCUS. However, like the grid, the UK does have many strengths in components-related monitoring, measuring and analysing industrial emissions, and environmental variables that are useful in industrial decarbonisation and deploying CCUS systems. Both industrial monitoring equipment and CCUS are lower down on our measure of green potential as well.

These technologies are closers to the frontier than others assessed in this report, so it is not clear exactly where the opportunities lie. However, the UK is investing significantly in CCUS and should explore opportunities to make some of the components needed onshore. More research is needed here as well.

Solar: a dilemma

Solar is the most concentrated green industry from a manufacturing capacity perspective but is a key decarbonisation technology for the UK. Britain is targeting an additional 55GW of solar capacity as part of its net zero plans. However, it ranks low on green potential, and the UK has no existing manufacturing strengths here. This is the hardest area to branch into and develop a competitive sector, but, due to concentrated capacity, potential bottlenecks in Chinese supply or geopolitical disruptions would leave the UK and the world dangerously under-supplied. More research needs to be done into the extent to which friendshoring can improve supply chain resilience for solar technology and whether the UK could tap into additional manufacturing capacity that could arise from expanding industries in Europe, the US and emerging Asian economies instead of developing domestic capacity.

PATHFINDING IN AN ERA OF UNCERTAINTY

The net zero transition is an uncertain road to walk – it requires the development and deployment of new technologies, new industrial processes and new ways of managing economic and environmental change. The processes of building new economic strengths is also an uncertain one, with a great deal of patient experimentation needed to succeed. Geopolitics also provides an additional set of uncertainties. The global market for net zero is underpinned by the credibility of and adherence to national climate commitments. Shifts in geopolitics will have broad implications for net zero and our industrial prospects.

This report looks at industrial capabilities and relatedness using techniques from economic geography and draws on frameworks and methodologies from the relatively recent field of evolutionary economics. However, this still yields a relatively superficial understanding of production processes and linkages. A large part of this is due to data limitations. Existing product and sector classifications make it extremely difficult to identify production activities that are being used for net zero supply chains, let alone develop a detailed understanding of which industrial capabilities could be leveraged for green manufacturing.

Policymakers need to address these evidence gaps urgently by commissioning research, gathering new types of data and building institutions that improve

the state's capacity to maintain and develop the evidence base around production processes relevant to net zero and how these are evolving. The announcement of a 'Manufacturing Observatory' was a welcome development as part of the government's Advanced Manufacturing Plan, and such an institution could serve that purpose, providing a common evidence base for ministers across all the departments that need to collaborate to deliver net zero and build green industries.

However, the remit of the manufacturing observatory should not be limited to surveying the existing comparative advantage landscape. It should seek to proactively identify and keep a record of industrial processes that were repurposed for net zero manufacturing. The observatory should also monitor global demand and supply dynamics across key industries and the geopolitical trends that underpin them.

9. CONCLUSION

Despite decades of little support and no recognition, **the UK continues to have strengths in manufacturing, which are spread around areas of the country that were given fewer opportunities to develop during the services-led growth of recent decades**. This growth was ushered in with Thatcher's 'big bang' reforms that threw the weight of government policy behind the financial services sector and the City of London. Since then, growth has been highly unequal across regions, and the skills and know-how in our industrial heartlands are now underutilised.

The services boom helped Britain escape the doldrums of recession in the 1980s but we once again find ourselves in an era of stagnation, needing to choose a way forward. Service sectors continue to boom in urban centres but regions with a strong manufacturing presence have been allowed to decline. **It is time for the government to turn its attention towards these regions.**

Facing the incredibly challenging race to net zero, the UK needs its industrial strengths more than ever. The mission is one of significant economic transformation, requiring the deployment of billions of pounds worth of investment in physical green products every year. Production is at the heart of the net zero transition, and Britain needs the skills and ingenuity of its manufacturing clusters more than ever. **Policymakers should** be alive to this and **deliver a green industrial strategy that seeks to leverage existing strengths.**

Our assessment suggests that the immediate priorities are wind and heat pumps – these industries are core to the UK's transition to net zero and can leverage existing skills and capabilities. **Green transport is another priority area where we could seize significant growth opportunities.**

The UK might not have comparative advantage in wind manufacturing right now, but it this is a sector that can draw on our existing manufacturing capabilities. The UK already has some strengths in heat pumps and could branch out from existing manufacturing capabilities into this area relatively easily. Both these industries are currently projected to see global shortages in manufacturing capacity relative to the level needed to reach net zero. This means these sectors are a priority. The UK can leverage its existing industrial strengths to build new green transport industries, particularly electric cars and zero emissions aviation. Delivering these goals will be a challenge, and the government needs expertise and analytical capacity to succeed. But, **if we make the right choices now, Britain can grow the economy, bring opportunities to regions across the country, and build the manufacturing capacity needed to hit net zero and ensure secure green supply chains**.

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TECHNICAL APPENDIX

IDENTIFYING GREEN INDUSTRIES

We start with the green products list compiled in Mealy and Teytelboym (2022), which combines six-digit Harmonised System (HS) product codes that feature in lists of products considered environmentally beneficial by the OECD, WTO and ASEAN. HS codes are typically used for tracking international trade, but this gives us a list of products with a 'green' use-case. The original list of 250 products included products that were not directly related to delivering net zero – these codes were identified and removed, resulting in a list of 143 green products for use in the rest of our analysis. These products were often components or material inputs into a final green product, so the 143 goods were also sorted into nine categories of final green product value chains.

To identify manufacturing sectors with significant production in green products, we use trade data for UK goods exports in 2022 from the UN Comtrade database. We chose trade data because our green products list was based on HS codes, and this is the only data classified on this basis. Next, we created a list of relevant manufacturing SIC codes at the SIC4 level by gathering all manufacturing codes (within section C) and then dropping sectors from this broad list that were definitely irrelevant for manufacturing green products. These were food, drink and clothes manufacturers.

We mapped all the possible HS product codes to the remaining SIC codes through the R concordance package, which resulted in a many-to-many mapping between HS codes and SIC codes. However, there needed to be a many-to-one mapping (ie many products to one sector). This is because multiple SIC-based industries are unlikely to produce the same product, but a single industry could produce multiple products.

To achieve a many-to-one product to SIC mapping, we used cosine similarity scores between the HS and SIC descriptions to eliminate obvious incorrect matches. Then for more marginal matches, a rules-based filtering approach (for example between metal cutlery products and 'manufacture of basic metals' industry which is meant to capture more basic material inputs like steel rather than finished products). Finally, this was validated by manually looking through detailed SIC descriptions on the ONS SIC hierarchy tool for SIC codes that had unusually large amounts of matched HS product codes.

This resulted in a matched dataset with 2,804 unique HS codes mapped to 221 unique manufacturing SIC codes, and the corresponding value of UK exports of each of those HS codes. We used the export data to calculate a measure of 'green intensity' – this indicates, for each unique sector, the proportion of its total exports in 2022 that came from products with a green use-case. We then defined green industries as SIC codes with greater than 15 per cent green intensity, to eliminate sectors with very small amounts of green exports. This yielded a list of 32 green industries.

This exercise was then repeated for the nine green sector categories featured in this report. The value chain for each of the green sectors was mapped using a subset of products within the master green products list, and SIC codes that were relevant for each green sector were calculated on the basis of export intensity of products from that value chain.

ESTIMATING INDUSTRY RELATEDNESS

We estimate the relatedness between green industries and the rest of the UK's industrial structure, and the UK's regional green sectoral specialisation using employment data at the TTWA and SIC4 industry level for the period 2016–22. This is data from the Business Register and Employment Survey (BRES) sourced from the NOMIS platform. We follow the established stream of economic complexity and relatedness research (Hidalgo et al 2007; Hidalgo and Hausmann 2009; Neffke et al 2011). This methodology is based on co-occurrence analysis, considering the frequency with which industries co-locate across regions relative to all other industries, based on the Revealed Comparative Advantage (RCA) of UK TTWA industries. The assumption is that the frequency by which two industries jointly locate in the same regions can be interpreted as a sign of the strength of their relationship. First, we measure the RCA of TTWA *r* in industry *i* based on the Balassa Index (Balassa 1965; French 2017). The use of co-location to estimate industrial relatedness is an established methodology used in many studies in the fields of economic geography and economic complexity research:

$$RCA_{ir} = \frac{X_{ir} / \sum_i X_{ir}}{\sum_r X_{ir} / \sum_r \sum_i X_{ir}} > 1$$

Starting from the value of employment of industry *i* in TTWA *r* (X_{ir}), this index computes the relative share of industry *i* in the total employment of TTWA *r*, compared with the relative importance of industry *i* in the UK total employment. As a result, a TTWA *r* will have a comparative advantage in industry *i* in respect to all other TTWAs only if $RCA_{ir}>1$. Second, we measure the number of occurrences TTWA r has a joint comparative advantage both in industry i and j, relative to all other regions and industries combinations.

By applying this count of joint RCA occurrences to all possible pairs of industries, we obtain a square symmetrical matrix of co-occurrences (*C*), whose generic cell C_{ir} reports the number of times these industries have jointly RCA in the same TTWAs. This matrix of RCA co-occurrences is used to derive a measure of relatedness between industries using the cosine index S_{ij} measuring the angular separation between the vectors representing the co-occurrences of RCA for industries *i* and *j*, providing a measure of the similarity between two industries:

$$S_{ij} = \frac{\sum_r C_{ir} C_{jr}}{\sqrt{\sum_r C_{ir}^2} \sqrt{\sum_r C_{jr}^2}}$$

We then identify how green sectors are linked to the industrial structure of individual TTWAs. This help us to identify how green sectors are related to the existing industrial specialisation of a TTWA, identifying in this way which regions have the capabilities, skills and knowledge to foster these specific industries. To do so, we calculate for each TTWA *r* the relatedness density of a green industry *i* to all other sectors in the TTWA. The density of green industry *i* in TTWA *r* is derived from the relatedness S_{ij} of green industry *i* to all other sectors *j* in which the TTWA has a comparative advantage, divided by the sum of relatedness of industry *i* to all the other sectors *j* in the UK (Hidalgo et al 2007; Boschma et al 2015):

$$RD_{ir} = \frac{\sum_{j \in r, j \neq i} S_{ij}}{\sum_{j \neq i} S_{ij}} \times 100$$

Existing comparative advantages play a key role in creating the right environment for regional branching in related industries, allowing TTWAs to diversify in green sectors.

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