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9. Ecological Transition

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Introduction

Anthropogenic climate change caused by greenhouse gas (GHG) emissions is widely understood to be the greatest existential threat to human societies in the coming centuries. The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to coordinate a global response to the coming crisis. In 2006, the United Kingdom's "Stern Review" concluded that early action to mitigate climate change would be the most cost-effective and therefore argued for significant expenditure to address the expected geophysical, political and societal changes wrought by global warming (Stern 2006). Over the intervening decade, the 2008 Global Financial Crisis and its sequelae distracted policy makers' attention from the challenges of global environmental change. The IPCC's publication of the Special Report on Global Warming of 1.5 °C (SR15) in October 2018 has helped to galvanize public opinion and has given rise to unprecedented climate activism. SR15 made clear the scientific consensus — to halt global warming it will be necessary to achieve net zero carbon dioxide emissions by 2050. This renewed urgency has, in turn, shifted the Overton window, whereby state actors now recognize a need for immediate action.

According to the IPCC's formulation in SR15, possible responses to climate change fall into three categories: mitigation, adaptation and remediation (IPCC 2018). Mitigation is taken to mean measures to reduce carbon emissions (e.g. through decarbonization of energy and transport systems or through changes in consumption patterns) or to enhance carbon sinks (e.g. afforestation or reforestation); adaptation means measures that ameliorate the effects of climate change on human populations (e.g. ranging from flood control measures to changing land use and even relocation of cities); and

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remediation means intentional measures to counteract the effects of GHG emissions, including global warming (e.g. through stratospheric aerosol injection, cirrus cloud thinning, or space mirrors) and ocean acidification (e.g. via ocean fertilization). There are inevitable trade-offs between the costs of mitigation and those of adaptation over decadal time horizons. As the 2018 IPCC's 1.5°C SR15 states: "increasing investment in physical and social infrastructure is a key enabling condition to enhance the resilience and the adaptive capacities of societies" (IPCC 2018, p. 19). Likewise, some climate activists are concerned that the prospect of remediation (particularly the tantalizing potential of negative emissions technologies) will discourage adequate investment in mitigation, or at least complacency about the need to meet the net zero targets (Lockley and Coffman 2016).

Nevertheless, with all three responses, large-scale infrastructure investment is required, with varying degrees of involvement by state actors, multilateral organizations, other non-governmental organisations (including religious groups) and, most significantly, private capital markets. In the current climate, multilateral development banks (MDBs) have taken a leading role.

In concert with the publication of the IPCC report in October 2018, the European Investment Bank (EIB) announced in late September 2018 that it would bring all its activities into alignment with the Paris Agreement. Two months later, in December, the MDBs as a whole announced a joint framework for doing so. In the past eleven months (at the time of writing) since the publication of the SR15 report in October 2018, the scientific consensus that global warming *can* be kept to 1.5°C has weakened. There is no meaningful disagreement, however, with the conclusion that it *should* be limited to as close to 1.5°C as possible. As the report makes clear, the economic costs of adaptation rise significantly with each half degree increase, as do challenges of ensuring the inevitable adaptations are in line with other Sustainable Development Goals (SDGs). Concerns that the 1.5°C target will be missed have further catalyzed political movements in Europe such that "climate emergencies" are being declared at national, provincial and local levels. This has in turn galvanized national leaders to press for greater collaboration on decarbonization efforts.

Emmanuel Macron's determination to establish a new European Climate Bank exemplifies this trend. His efforts have prompted discussions about whether or not the European Investment Bank might play that role once the Juncker Plan (formally known as the European Fund for Strategic Investments (EFSI)) finishes. This is less surprising than it may seem to some, because the EIB's purpose is to mitigate market failure. The main criticism of the Juncker Plan by the European Commission's auditors is that a non-trivial percentage of the loans would have been made anyway. To the extent that climate change is the result of market failure (i.e. the inability of the market to internalize fully the negative externalities associated with GHGs), then there is a role for the EIB to play, particularly in helping to finance the rapid decarbonization of energy and transport which could not happen as quickly as demanded by the SR15 Report if left entirely to market forces. Whether or not the SR15's net zero target is met, there will be a critical role for infrastructure investment both in climate change mitigation and in adaptation. Institutional money managers, including those of pension funds, insurance companies, and sovereign wealth funds will undoubtedly play an important role in the low carbon transition. This is a particularly promising development because of the intergenerational risks and rewards associated with climate change mitigation and adaptation; this presents an important opportunity to renew the intergenerational social compact and to ensure intergenerational equity.

9.1. The Importance of Carbon Accounting

Most lay audiences are now familiar with the term "carbon footprint", which is a measure of the carbon dioxide emitted through a given activity, for instance in heating a house or driving a car. In response to the recent *Flygskam* (or "Flight Shame") movement in Europe, more and more air travellers are electing to "offset" the direct carbon emissions associated with their flights by purchasing voluntary carbon offsets (VCOs). Some are declining to fly, instead preferring to take voyages by train and even ship, as Greta Thunberg elected to do recently in her trip to the United States. Using "carbon footprints" to assess carbon emissions has the virtue of being relatively straightforward to do, and there are many carbon calculators available to the public to assess the carbon trade-offs around household meat consumption, energy use, transportation choices, and similar such decisions.

Unfortunately, lay audiences do not necessarily appreciate that "carbon footprints" are not the only way to assess carbon emissions. Carbon footprints focus attention on carbon produced by the *operation* of a particular asset, such as an automobile, powerplant, airplane or ship. They do not account for the carbon emitted during the *construction* of said asset, nor do they consider the carbon emitted during the *decommissioning* of the asset, both of which can often be substantial. Life-cycle assessment models which consider the carbon embedded in all phases of a product or built asset life cycle can lead to different recommendations for green investment (McDowall 2018). For example, hydropower is widely considered to be attractive because rivers are renewable, unlike fossil fuels, and the production of hydropower does not involve direct carbon emissions. However, when the construction and decommissioning phases of a hydropower project are included in the assessment, the project may be appraised differently. The cement used in the construction of hydropower dams is very carbon intensive (Mar 2009), as is the construction supply chain. By a similar token, decommissioning, when it becomes necessary, of a hydropower plant can involve considerable carbon emissions. Equally importantly, forests represent substantial natural carbon sinks. Dams that flood natural forests destroy these carbon sinks. Some hydropower projects may represent a less attractive alternative than superficially more carbon intensive alternatives. Investors need to be aware that embedded carbon is of growing concern to multilaterals, who are actively commissioning research to develop tools to assess these issues.

Some investors may question the value of accounting for embedded carbon because they worry this will lead to double-counting (a methodological error) as surely the carbon emissions produced by cement would be accounted for in that production process. While this is true on a global level, accounting merely for the carbon footprint of an infrastructure asset distorts the political economy of carbon emissions. The IPCC framework anticipates carbon emissions targets and voluntary carbon quotas; if the latter are adopted, it is necessary to consider the global value chain, as many products which are produced in one country (usually a lesser developed one) are consumed in developed countries (Meng et al 2018). Forcing the producer-nation (or assembler-nation) to take responsibility for the embedded carbon in, say, the iPhone of one of the authors, which was assembled in China (out of components made in the US, Mexico and the Philippines) and consumed in the UK would be unjust. Likewise, the embedded carbon in the production of large energy or transport mega-projects can be substantial. Most scholars agree that responsibility for those embedded carbon emissions should be borne by the beneficiaries of the infrastructure mega-project or of the goods or services so consumed. Investors, in any event, need to be aware of these debates. Ideally, infrastructure desks should have analysts who are adept at life-cycle assessment modelling, if not in doing the modelling themselves at least in understanding how these models are used in project appraisal as there are now part of statutory reporting requirements.

9.2. The Emergence of "ESG" ratings

Although there are increasingly statutory requirements to report the environmental and climate impacts of infrastructure projects, these are developing amidst a wider movement to provide a more holistic set of sustainability metrics, taking the Environmental, Social and Corporate Governance (ESG) dimensions together, as a tool for helping to internalize the positive or negative externalities of a given project. Over the second half 2019 and first quarter of 2020, the European Commission moved to procure consultancy services from a wide range of tendering parties on the development of ESG ratings. The European Commission is well aware of its leading role in green procurement in Europe, and the Commission has begun to develop tools for sustainable finance for use by the European Banking Authority. The results of this tendering process should be available in April or May 2020.

There is reason to hope that the European Commission commitment to developing sound ESG ratings can help avoid some of the criticisms that beset the Juncker Plan, while also improving infrastructure planning and promoting a shift towards a "circular" economy (Dreschel et al. 2018; Bowman 2017; Mascotto 2020), where waste is eliminated and resources continually re-used rather than exhausted (Geissdoerfer

2017). Although some critics remain sceptical, there is a growing consensus that attention to the ESG dimension of investments heightens financial performance and protects firm value (Valente and Atkinson 2019).

9.3. Mitigation: Decarbonization of Energy and Transport

There is wide agreement that it would be impossible to meet any plausible net zero target without decarbonization of energy and transport. Energy decarbonization is well underway, with some European countries (including the UK) able to go for weeks at a time without relying on coal (Ogden 2019). Taken together, decarbonization of the European energy and transport sectors is advancing rapidly and is considered achievable at current technological levels and at minimal cost, less than 1% of GDP (Capros et al. 2014).

Decarbonization of transport (also known as "electrification") is more difficult than decarbonization of energy systems, but achievable with aggressive planning efforts. Decarbonization of the food supply is also necessary, but with the exception of the role of maritime transport in the global food supply chain, largely outside the scope of this chapter.

9.3.1. Energy

As noted, decarbonization of energy systems in Europe has been underway for over a decade with impressive results (Tagliapietra 2019). Most observers urge policy makers to integrate deep decarbonization of energy into broader, cross-sector industrial strategies (Avila 2018). One particularly promising area for both policy makers and investors is renewal gas.

Renewable gas may become a leading source in the transition to zero-emission energy production, especially given its importance in promoting circular economy solutions. Its advantages are environmental as well as economic in nature. The environmental advantage is double as its production not only entails zero-emission of CO2, but also uses inputs deriving from urban, agriculture and industrial waste, contributing to decreasing their polluting effect when disposed through traditional methods. The economic advantage lies in cost savings deriving from the progressive replacement of natural gas imports. It is estimated that in 2015 the EU could produce up to 122 bcm of renewable gas per year and replace a substantial part of natural gas imports, leading to a cost saving of €138 bn annually (Ecofys 2018). However, the cost saving will not only result from the substitution of current import with domestic production, but also from the possibility to use existing infrastructure for storage and transport. Relying on existing gas grids would also make it possible to alleviate the increasing burden on electricity grids, which in the future are likely to face overloads and disruptions due to the growing share of renewables among the sources of electricity generation.

The European Union has been vigorously promoting the transition to renewable gas because of its contribution to achieving the targets of environmental policy, namely to reduce GHG emission to 30% and reach 27% of energy consumption from renewables by 2030. As a result of the incentives granted by EU policies, production of biogas in the EU has reached 18 bcm of methane equivalent in 2015, making Europe the world's greatest producer.

Despite the aforementioned environmental and economic advantages, some questions remain on the long-term economic benefits of full reliance on renewable gas. Questions particularly concern the possibility to achieve energy independence. In fact, it is estimated that a share of renewable gas, or some inputs for its production (e.g. crops), will still need to be imported.

This issue is important in view of the recent progress in the EU energy policy reforms, which envision a full transition to models based on short-term transactions in spot markets. In fact, in an energy-deprived area such as Europe, the full reliance on models based on short-term transactions is likely to increase the bargaining power of non-EU exporters, potentially threatening energy security and price affordability for consumers (Cardinale 2019). The fact that the transition to renewable gas will not guarantee energy independence suggests the need to carefully monitor the collateral changes that accompany the low carbon transition, especially for what concerns commercial relations between exporters and importers and their respective bargaining power. Moreover, it seems necessary to consider adopting a regulatory framework that includes both long- and short-term transaction models.

The relative desirability of various kinds of renewable energy remain an active research area, especially when different types of carbon accounting are used (McDowall et al. 2018). In life cycle assessment tests, wind power compares favourably to solar photovoltaics (PV). Nuclear energy at current technological levels is regarded as most desirable as an intermediate solution to wean the global energy system from fossil fuels, but nuclear is rarely considered a long-term solution (Prăvălie et al. 2018).

The ESG approach to deep decarbonization of energy has the additional virtue of encouraging co-mitigation of air pollution. While it is possible, as China has done, to reduce pollution sharply using ultra-low carbon (ULE) emissions standards (Tang et al 2019), decarbonization will also have the positive externality of improving air pollution levels (Meng et al. 2019).

In emerging markets, the calculus of deep decarbonization of energy differs somewhat, because energy security is a pressing concern, as is the need to provide reliable electricity to households and firms, against a backdrop of more extreme weather events, which can cause significant load shedding (Gannon et al. 2018). Hydropower is particularly vulnerable to these events (Ahmed et al. 2019).

In emerging markets, back-up power generation using diesel fuel is widespread, especially by export-oriented manufacturing firms (Ahmed et al. 2019). This is an area that needs further research, but preliminary studies suggest the effects can be of such a significant scale as to have the potential to change recommendations about the optimal energy mix for these countries and in any case strengthen the business case for projects that promote energy resilience in these markets (Farquharson et al. 2018). Investors, including multilaterals like the World Bank, will need to pay more attention to these issues going forward.

9.3.2. Transport

Decarbonization of transport is often taken to be synonymous with electrification, though that is by no means the entire story. First, to a greater extent than energy decarbonization, transport decarbonization will require a socio-technical transition away from family-owned autonomous vehicles towards other means of transport. This will require, in turn, significant planning challenges, which will coincide with the advent of smart cities (Zawieska and Pieriegud 2018).

Significant investment opportunities exist in the electrification space, as many European countries have already begun electrification of mass transport systems, including busses, trams and trains (Glotz-Richter and Koch 2016). Planners are increasingly requiring charging stations for electric cars in parking lots and along city streets (Thiel et al. 2010). Most households have probably already purchased their last new automobile powered solely by unleaded fuel, and most car manufacturers are relying on the growth of electric cars and hybrids to keep them in business. Consumer preferences are changing slowly but steadily in this area (Mazur et al. 2018). Electrification of transport is an active investment area for some specialist firms such as Meridiam, through their Transitions fund.

As with energy, a factor accelerating decarbonization of transport is the positive externalities associated with the reduction of automobile induced pollution, which is a grave public health threat in most countries. Pollution rates and emission rates tend to track each other; although rates of increase have slowed in recent years, tackling both will require global cooperation (Meng et al. 2019). The European approach has thus far primarily been to manage the co-mitigation of air pollution and carbon emissions in the transport sector fuel tax policies in the transport sector (Zimmer and Koch 2017). This represents an opportunity for investors, as positive externalities associated with curbing pollution can be incorporated into business cases.

The extent to which the sharing economy, notably car sharing and bike sharing, contribute to the low carbon transition is also an area of active debate (Mi and Coffman 2019). Car sharing and bike sharing have the potential to reduce both emissions and pollution, but not at all such firms behave in pro-social ways. Both planners and investors can play a role in promoting sustainable practices in this sub-sector.

Air travel is another area where decarbonization is essential, but the debate has rarely advanced beyond demand reduction, such as that encouraged by the Flight Shame movement (Pye et al. 2014). There is political momentum in many European countries (though largely not outside Europe) for taxes on frequent flyers and even the abolition of frequent flyer incentive programmes. This is one area where voluntary carbon offsetting has become particularly popular. Public attitudes to the use of biofuels in commercial aviation appear to be changing, and this could become a significant investable space (Filimonau et al. 2018).

Maritime transport remains another area where deep decarbonization is essential to meeting net zero targets. One short-term option is in the area of logistics, because fast freight is an order of magnitude more carbon-intensive than slower freight (McKinnon et al. 2016). Over the medium term, changes in fuel use (towards electrification or at least the widespread use of LNG) may be possible, but the use of biofuels is unlikely without strong financial incentives by policy makers (Balcomb et al. 2019). Fortunately, successful decarbonization of this sector would yield significant gains across the board, given the importance of maritime freight to most supply chains (Benamara et al. 2019).

9.4. Adaptation: Physical and Social Infrastructure

Adaptation to climate change is a less immediately investable space than climate mitigation, but there are opportunities to consider. Coastal flooding is the most immediate source of concern, as sea level rises are all but inevitable (Vousdoukas et al. 2018). Projects on the scale of the Dutch SEAGATE have already been undertaken in the Thames Estuary in the UK (Lumbroso and Ramsbottom 2018), and similar such projects are underway elsewhere. Not surprisingly, insurance partnerships are considered a particularly promising area (Crick et al. 2018).

Median temperature increases represent another area where adaptation is pressing, particularly as it will produce step-change increases in energy demand in vulnerable areas (Burillo et al. 2019). Retro-fitting of housing and commercial office buildings will be required, especially in countries where building stock turns over infrequently.

Climate change has profound implications for global health, but research in this area is only just gaining momentum as the share of health-related adaptation spending has risen to approximately 15% of total global adaptation spending (Watts et al. 2018).

9.5. Remediation: Negative Emissions Technologies and Climate Engineering

Remediation represents the third investable space and covers an extraordinary range of proposals and techniques. Some of them, such as reforestation and afforestation (especially in response to desertification in emerging markets) are neatly aligned with other Sustainable Development Goals. In 2014, the World Bank established a Pilot Auction Facility for Methane and Climate Mitigation to raise finance for methane capture projects by marketing tradeable put options that represented the GHG reduction potential of such projects. These facilities can be scaled up to raise finance for reforestation and afforestation in developing countries; they can even be envisioned as possible sources of finance for technological carbon dioxide removal (Lockley and Coffman 2018).

In the shorter term, carbon capture and storage/carbon capture and utilization technologies are proving helpful in the facilitation of carbon neutrality in the European iron and steel industry and in the chemical industries (Mandova et al. 2019; Kätelhön et al. 2019). Exciting work is already being done on how to optimize European supply chains for carbon storage, using a cooperative model (d'Amore 2019) and this is an area ripe for policy making (Castillo et al. 2019). At the moment, these industries represent the most realistic investable space for institutional money managers.

Also in the short term, reforestation and afforestation projects are likely to receive direct financing primarily from third sector organizations. In September 2019, the Catholic Church expressed support for climate restoration through both biological and technological means, arguing that this is a divine imperative both to protect the natural world and to mitigate the inequalities associated with climate degradation (Auza 2019).

Over the longer term, solar radiation management, while controversial, is regarded by some to be a cost-effective approach, as it is estimated to cost less than $2 bn annually (Carrington, 2018). Venture capitalists likewise see scalable technologies for carbon capture as a worthwhile target of speculative investment, especially given the involvement of state actors. Many observers, however, are concerned that the most active investors in this space are the corporate venture capital arms of oil and gas companies, as these firms try to find more sustainable business models (Lu 2019; Faran and Olsson 2018). Although most institutional investors will probably wish to avoid over-allocation to this space in the immediate future, remediation must be a part of horizon scanning.

9.6. Conclusions and Recommendations

The low carbon transition is one of the greatest challenges facing human societies. As such, climate mitigation, adaptation and remediation will all be major sources of investment opportunities, particularly for institutional investors, in the next few decades. For the moment, climate mitigation is the most important area, though adaptation and remediation will become more important over time.

Traditionally, attention has been paid most directly to carbon footprints of energy sources and transportation choices, but gradually embedded carbon is becoming an important part of the calculus. Life cycle assessment models are widely used, and infrastructure investors must be able to make sense of the recommendations they generate. More recently, the European Commission has initiated the development of ESG ratings for use by procurement authorities, the European Banking Authority, the European Investment Bank and other European agencies.

Opportunities for decarbonization of energy and transport in Europe are well-established, and appropriate to institutional investors. Emerging markets present different challenges in the energy sector than those in established markets, but projects that promote energy security and energy resilience are areas where private investors and multilaterals can cooperate. Transport decarbonization is often regarded as synonymous with electrification, but smart cities will play a role in changing consumer demand away from autonomous vehicles. The sharing economy can also play a role, subject to close monitoring by regulators. Reductions of carbon emissions and of pollution are highly correlated in both the transport and energy sectors, and are especially important in Central and Eastern Europe.

Adaptations to climate change will generally focus on flood control and accommodations to median temperature increases. This will pose challenges for both physical and social infrastructure. Remediation is comparably an emerging area, but one that will eventually be the focus of considerable interest, especially if the net zero targets are missed. Finally, this is a rapidly changing area, as the scientific consensus on the possibility of limiting Global Warming to 1.5 °C is eroding. Should 2°C or even 3°C scenarios become more likely, then adaptation and remediation strategies will become more urgent areas for investment.

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