The misplaced expectations from climate disclosure initiatives

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The financial sector's response to pressures around climate change has emphasised the role of disclosure, notably through the recommendations of the Financial Stability Board's Task Force on Climate-related Financial Disclosures. This Perspective examines two dimensions of the expectations behind transparency and disclosure initiatives: the belief that disinvestment is driven by disclosure; and that investment 'switches' from high to low-carbon assets. We warn about the risk of disappointment from inflated expectations about what transparency can really deliver and suggests some areas that research and public policy should examine to mobilise the required capital to meet the climate goals.

Aligning private sector finance with the Paris goals is crucial to achieving deep decarbonisation[1]. The international effort spearheaded by Mark Carney has focused on disclosure initiatives as the main route to influence private capital allocation towards low-carbon assets[2]. Following Carney's speech, the Financial Stability Board argued that transparency on climate risks and their potential financial impact on the asset holdings of financial market participants, would enable markets to efficiently align their response to climate change. The FSB thus established the industry-based Task Force on Climate-Related Financial Disclosure (TCFD) to develop a consistent climate disclosure framework to support financial decision-making[3]. Fully implementing the resulting TCFD recommendations on disclosure to establish transparency across the financial system, is now a prime goal of policy, financial regulation and industry efforts in the climate finance arena.

Examples at international level include the 'TCFD Pilot Projects' launched by the UNEP Finance Initiative[4]; the recommendations promoted by the Network for Greening the Financial System[5] and recent developments supported by the European Commission, such as the EU taxonomy[6], along with the EU green bond standard[7], climate benchmarks and ESG disclosures[8]. Various initiatives also proliferated at the national level. The French government sets requirements for investors to report on the carbon intensity of their portfolios, exposure to climate-related risks and contribution to mitigating climate change under Article 173-VI of the Energy Transition Law. The People's Bank of China together with six other major Chinese regulatory agencies, have introduced a mandatory environmental disclosure regime for listed companies and bond issuers[9]; while more recently the Bank of England has published its climate-related financial guidelines to manage the risks from climate change across its entire operations[10]; and New Zealand has announced requirements to make climate risk reporting mandatory for banks, asset managers and insurers[11]. As a result of these developments, a growing number of companies worldwide have been implementing standard practice in climate risk management and reporting[12].

The implicit assumption behind disclosure is that exposing climate-related risks and opportunities to global scrutiny for all the main financial actors will cause investors (i) to move away from carbon-intensive assets to reduce risks and (ii) to re-direct capital to low-carbon opportunities to benefit from the enhanced market (as shown in the stated objectives of the main disclosure initiatives, such as the TFCD[3] and the EU taxonomy[6]). Whether made explicit or not, this assumption is rooted in the 'efficient markets hypothesis'[13,14] applied to climate finance[15]. The expectation that transparency can move large volumes of climate finance from high to low-carbon resides in the belief that market participants will respond 'rationally' to information – climate related-financial disclosure – and will change investment outlays. Given enough time for information to become available and credible, markets will align to provide the necessary climate investment.

Though disclosure initiatives are quite nascent and more time is needed before a full assessment, some limitations have started to emerge. The voluntary nature of disclosure requirements[16], along with the lack of reporting standards and comparable measures on climate risks seem to undermine their effectiveness[17,18,19]. Recent evidence also shows the limited effectiveness of climate-related financial disclosure in companies' assessments of adaptation impacts[20] and in their potential application to the public sector[21]. More fundamental issues suggest that risk transparency may not be enough to trigger a step change in investment decision making[15,22]. A major challenge to investors is the timeframe over which climate risks will materialize compared to their traditional investment horizon (1 to 5 years)[2,15,23,24]. Investment portfolios' typical turnover is about 1-2 years[25], and the horizon of financial analysis does not usually exceed 3-5 years[26], while most asset managers' incentives are based on an annual performance[27]. Moreover, at the employee level, portfolio managers are benchmarked on much shorter-term performance, such as quarterly or monthly[26]. Most climate-related risks are thus way beyond these investment time horizons[28,29]. In a comprehensive survey collecting 436 responses from institutional investors, climate risks were indeed ranked extremely low in comparison to other investment risks[23].

Even when investors may consider climate-related risks potentially relevant on their time horizons, other factors could deter action. They might be sceptical about the political prospects for strong action[15]; they may hope that negative emission technologies will enable their assets to emit as projected[15]; or they may anticipate compensation, to ensure a smooth transition and ameliorate political backlash[30]. The main risk behind the disclosure narrative is thus the implicit exemption of the finance sector itself from the need for more radical actions beyond transparency leading to long-term systemic changes.

This Perspective examines two dimensions of the expectations behind transparency and current disclosure initiatives: i) the belief that disinvestment is driven by disclosure and ii) that investment 'switches' from high to low carbon assets' (other dimensions of disclosure, such as physical risks, are not analysed in this work). First, we argue that transparency does not seem the main driver behind divestment; market returns and future outlook better explain current investment trends in the sector. Second, there is no reason to believe that transparency on its own will be sufficient to encourage capital into low-carbon investment, as high and low-carbon technologies are diverse asset classes and there is not a self-contained "energy investment system". An implicit assumption of disclosure is to treat fossil fuels and low-carbon investments as similar assets, hence as long as transparency enables markets to appropriately value energy assets, capital will naturally switch towards the less risky assets within the same investment category. We argue that most low-carbon assets form very different asset classes with their own set of characteristics. As disclosure initiatives do not play a key role in reallocating more capital towards low-carbon assets, we suggest three areas that research and public policy should examine to that end, namely boundaries of the financial system, interface between policy and financial elements, and investments in developing countries.

Role of industry returns and future expectations.

The fossil fuel sector is under growing pressure from governments, climate-conscious investors and public opinion to decarbonise. Since the Paris Agreement and the start of the divestment movement - a student activist-led initiative that emerged in the early 2010s

– fossil fuel companies increasingly became more scrutinized by their shareholders and the target of environmental campaign groups. On one hand, shareholders have started to use the annual general meetings - the yearly meetings of a company's shareholders and its board of directors - to raise climate resolutions. Such climate resolutions call for greater transparency and climate-related disclosure, the setting of emissions reduction targets and more climate-aligned strategies[31]. On the other hand, the divestment movement has grown rapidly, with hundreds of fossil fuel divestment campaigns globally and becoming extremely popular on public and social media[32,33]. According to recent estimates, more than 1,200 financial institutions holding approximately $14 trillion of assets, are supporting climate-related pledges calling for divesting from or stopping finance for fossil fuel-related activities[34].

Despite these rising pledges, increased investor engagement and spread of the divestment movement, the tangible financial impact on fossil fuel finance and emissions reduction remains insignificant[32,35,36]. Only a small portion of investors will divest their fossil fuel holdings, and divested shares will be bought by other investors[32,33]. Criticisms of divestment point to its largely symbolic nature and the potential diversion of attention from the systemic nature of the problem, which requires coherent and co-ordinated climate action[32,33,35]. At a systemic level, the necessary scale to significantly impact the supply of finance to high carbon sectors thus does not exist. On the contrary, recent estimates show that fossil fuel financing from the world's largest investment banks has been increasing in the last five years, despite their announcements and reports on disclosure[37]. More indirect impacts seem to be linked to the stigmatisation of the industry, the increasing social awareness and the public discourse shift[32,33,35,38], rather than transparency *per se*.

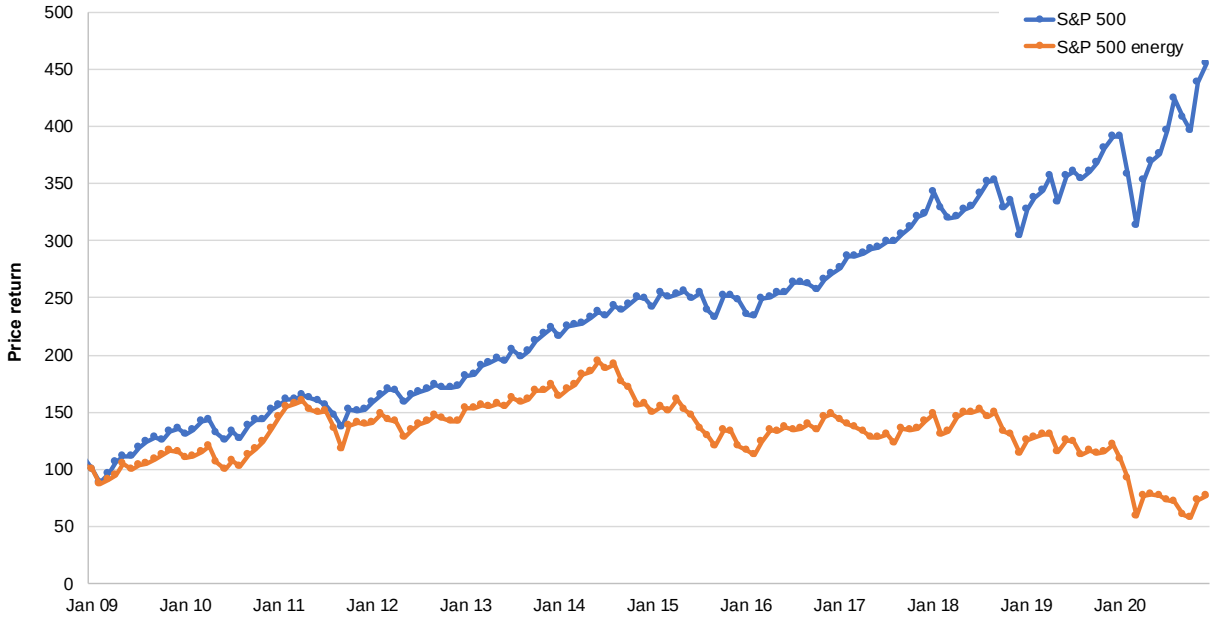
A much more significant trend is underway. Notwithstanding continued debt investment by the banking sector whose objective is to ensure debt recovery[37], equity returns in the fossil fuel industry are less attractive compared to the past. They have been declining for a number of years and current market returns do not seem to repeat previous performance. The Standard and Poor (S&P) 500 Index and the Morgan Stanley Capital International (MSCI) Europe Index, which track the performance of the large-capitalization

traded companies in the US and Europe respectively, are illustrative of the declining importance of the fossil fuel industry over the last four decades. Both indexes are often treated as a proxy for describing the overall health of the stock market, as their trend and composition reflect sectors' returns, thereby providing an indication of where financial opportunities lie. We focus on the S&P 500 and MSCI Europe indexes to track the energy sector performance as they capture the main private sector fossil fuel companies globally (nationalised oil companies are not subject to private investment dynamics and divestment pressure). For instance, the S&P 500 includes Exxon Mobil, Chevron and ConocoPhillips among others; while top energy constituents in the MSCI Europe are Total, Royal Dutch Shell, BP, ENI, Neste, Repsol and Equinor.

Fossil fuel companies have had declining weights in these indexes' composition registering a 90% decrease since the 1980s to 2020[39], as their market value growth has underperformed that of other market sectors. The fossil fuel sector has lagged in particular in the US by a wide margin, where the overall index performance was more than double the energy sector returns in the last ten years (figure 1). From 2014 to 2018, the 43 biggest stand-alone US oil companies lost more than $90 billion in market capitalization, triggering investors' exit from the sector[40]. A similar trend is observed in Europe, where returns of the index overall have exceeded those in the fossil fuel sector by approximately 40% between 2009 and 2020 (figure 2). Most sectors in both indexes have surpassed the oil and gas industry based on companies' performance and future growth potential[39].

Recently, more comprehensive studies comparing financial performances of investment portfolios with and without fossil fuel stocks show indeed that returns are either higher or not compromised when selecting a fossil fuel free-portfolio[41,42,43]. Risk-adjusted returns - stock returns considering how much risk has to be borne to achieve the return - over the last forty years (1973-2016) show that fossil fuel companies have underperformed the broad market as the substantial systematic risk associated with the fossil fuel industry offsets the above-market returns[41,42]. Such trends are observed both in the US market[42] and globally[41].

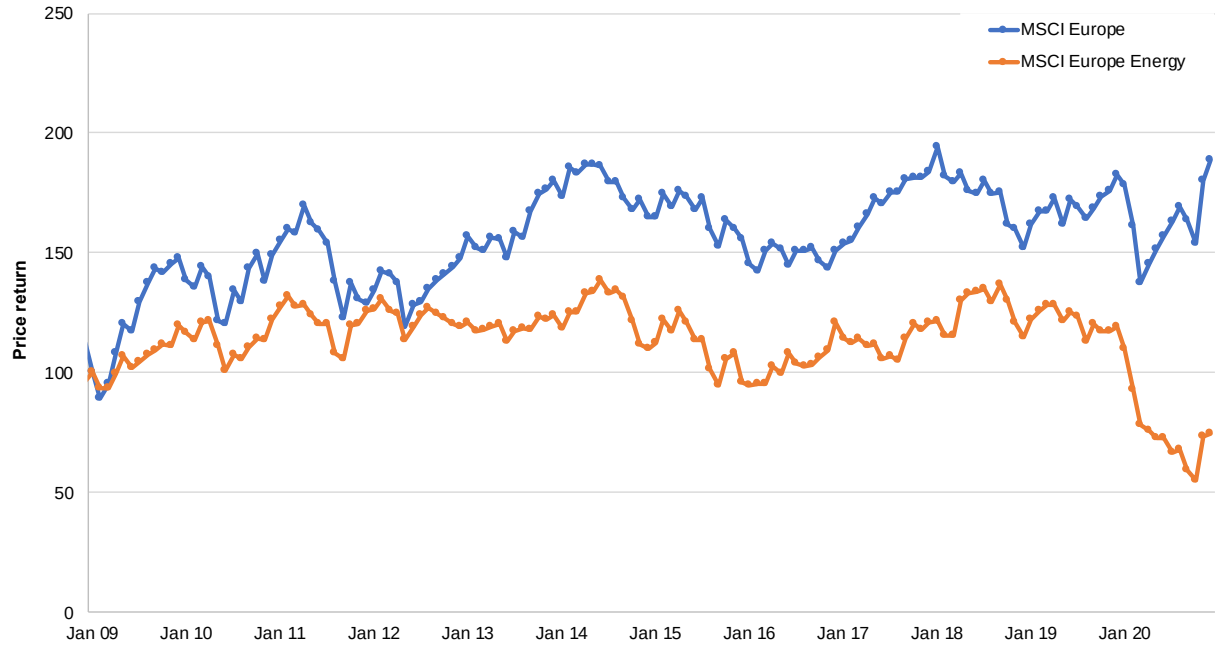
Figure 1: S&P 500 vs S&P 500 Energy sector performance (2009-2020)



Source: Bloomberg (2021)

The S&P 500 Energy index comprises those companies included in the S&P 500 that are classified as members of the GICS® energy sector, namely Integrated Oil and Gas, Oil & Gas Equipment & Service, Oil & Gas Exploration & Production, Oil & Gas Refining & Marketing, Oil & Gas Storage and Transportation based in the US. Please note the Energy sector is included in the S&P 500 index and accounts for about 2.8% of its composition[39].

Figure 2: MSCI Europe vs MSCI Europe Energy sector performance (2009-2020)



Source: Bloomberg (2021)

The MSCI Europe Energy index comprises those companies included in the MSCI Europe that are classified as members of the GICS® energy sector, namely Integrated Oil and Gas, Oil & Gas Equipment & Service, Oil & Gas Exploration & Production, Oil & Gas Refining & Marketing, Oil & Gas Storage and Transportation based in Europe. Please note the Energy sector is included in the MSCI Europe index and accounts for about 4.8% of its composition[39].

Historically, the fossil fuel industry has been a sector with high market returns (until recently) and high volatility[44,45,46]. Oil super cycles enabled oil prices to vastly exceed production costs, resulting in high market returns for mainstream investors (the last super-cycle peaked in 2008-10). At the same time, inherent supply and demand factors linked to the market structure and the resource itself, resulted in high volatility for the sector[47]. OPEC remains dominant in terms of long-term reserves (75%)[48], while the advent of unconventional oil production in the US (accounting for 63% of total US crude oil production in 2019), made the US the world's single oil producer[49]. The higher cost of offshore and shale production, combined with uncertainties arising from the dependence of prices on production agreements spanning OPEC and Russia, may be more important than climate concerns in making the industry less attractive to investors.

Climate change mitigation does add an extra layer of uncertainty, further increasing the sector's volatility and reducing its risk-adjusted returns. Meeting the climate targets requires that most of the world's fossil fuel reserves will remain in the ground[50], implying that fossil fuel assets will significantly reduce their value – potentially with sudden changes in market valuation[52,53,54] (e.g. Shell and BP slashed the value of their assets by $15-$22 billion and $18 billion, respectively[51]). Disclosure initiatives aim to reduce this risk by providing transparency to the investor community. On the other hand, speculative investors hoping for 'a return to high returns', in reality, monitor the state of OPEC-Russia relations and the OPEC quarterly decisions on oil production quotas. Thus, investment decisions concerning fossil fuel industry are more likely to be impacted by the fundamentals of the sector and investor expectations around climate policy, not the results of CO_2 transparency or the pinpricks of disinvestment.

Finally, there is extensive evidence that investors are strongly influenced by their established networks, relationships, dominant practices and assumptions[15,55,56]. Fossil fuel companies are a standard part of most major investor portfolios; debt repayments have rarely been at risk, and dividends hardly ever interrupted until 2020.

The transfer myth from fossil to renewable investments.

In principle therefore, transparency and divestment hoping to stimulate a large-scale move from high to low-carbon sources should be ‘pushing at an open door’. However, even if enhanced transparency on the holding of risky assets may reduce the attractiveness of fossil fuels investment, there seems to be little apparent link between disclosure initiatives and capital flows from high to low-carbon investment. We take the case of fossil fuels and renewable assets to show that there is not an "energy investment system" where capital moves easily from one technology towards the other.

One key reason lies in the different company profiles. Over the last decades, the fossil fuel sector reached a strong consolidation where a few players led the market development (e.g. Chevron, Exxon Mobil) along with national oil companies (e.g. Saudi Aramco, Qatar Petroleum). Looking at its history, before 1960 the oil industry was almost entirely dominated by its “Majors” (namely Exxon, Shell, BP, Chevron, Texaco, Gulf and Mobil). The “Seven Sisters” controlled the whole oil supply chain from extraction to use[57] and ensured the balance of oil supply and demand globally via joint ownership, production-sharing agreements and other business models with local operating companies, such as those in the Middle East[58]. Despite many changes over time (e.g. OPEC influence and emergence of powerful state-owned oil companies), the oil sector has always had few key players leading its development. Such a consolidated structure has historically created value for the sector through cost reduction along the value chain, asset acquisition to support fast growth and strong negotiation power in contractual relationships. These aspects significantly improved the returns on invested capital and consequently the value for shareholders[59], and resulted in a supportive financial ecosystem used to dealing in huge scales through major institutions.

Conversely, the renewables industry, despite growing over time[60], remains a fragmented sector missing its “majors”. In the first decade of 2000s, the renewables industry expanded rapidly and some specialised companies started to emerge. To mention a few, in the solar market, First Solar and Sunpower emerged in the US, Suntech in China, Sharp in Japan, Centrosolar and Q-Cells in Germany; while in the wind sector Iberdrola

and Gamesa expanded in Spain, Vestas in Denmark, Siemens and RePower in Germany, General Electric in the US, Suzlon in India, and Sinovel and Goldwind in China[61,62]. In the following years, many such companies and new ones continued to experience rapid growth, but renewable energy remains a young industry with a less integrated supply chain and characterised by many participants often specialised in just one technology and on a single geographic market[63]. At the moment, it is not clear whether the renewable companies will support their growth through consolidation or the industry will remain fragmented among a larger number of small to midsize companies.

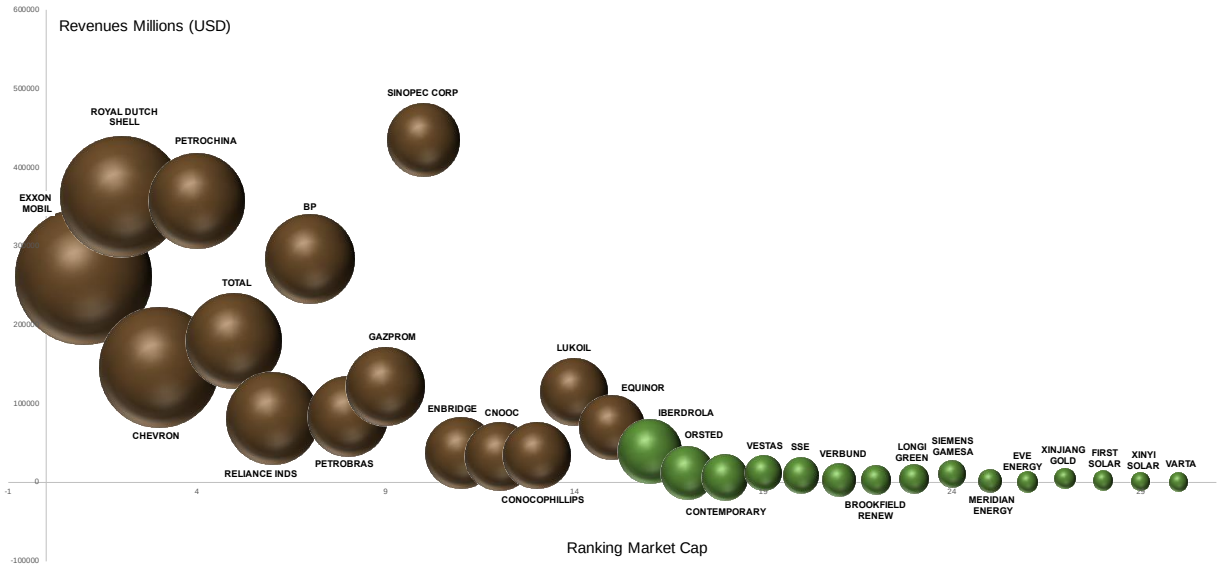
Such differences partly reflect the nature of the assets. As the supply of solar and wind is inherently more widely distributed at global level than oil reserves, renewables are more sensitive to local conditions than fossil fuel assets. This means that renewable energy typically is not an internationally traded commodity like oil, and hence international investors are exposed to currency risk rather than having a major currency for trading (e.g. US dollars). In addition, they are potentially more affected by regulatory risks, as their revenue streams and thus their attractiveness to investors, depends highly on the energy policy framework in place at the time[64,65,66,67].

Overall, the lack of consolidation in the green sector makes it less attractive to investors. Strong consolidation would allow the whole sector to become more resilient to potential cyclicality across markets and economic or policy shocks in individual geographies. Our on-going analyses on the solar finance market shows that many investors and renewable developers held only a handful of generating assets in their portfolio over the last 20 years to exploit the temporary support schemes in place - with the drawback that eventual policy changes would impact companies' survival. Smaller companies are more sensitive to any policy or market changes and unable to absorb potential losses in their balance sheets or through project-financing structures. Currently, only few renewable actors (e.g. Enel, Iberdrola) have leveraged economies of scale and expertise globally across several renewable technologies, hence being in a strong position to address sectoral challenges[68]. Consolidation processes can also have the advantage to lower the cost of

finance and improve capital access for renewable assets, where most of the project cost is upfront[60].

These different company profiles are reflected in the lower market capitalization and revenue levels of renewable players compared to fossil fuel companies (Figure 3). These indicators are widely used to compare companies' values and incomes, and assess their ability to attract investment. The market capitalization is the aggregate valuation of the company based on its outstanding stock and share price, capturing company reputation, expectations of growth potential and public sentiment; while the total revenues show a company's income resulting from its business activities and thus represents the money flowing into a company.

Figure 3: Top public fossil fuel and renewables companies by market capitalization in USD Billions (2019)



Source: Authors' calculation based on Bloomberg data (Bloomberg 2020c)

The selected companies are based on Bloomberg global classification of oil and gas, renewables and power generation companies ranked by market capitalization. As some of these companies operate in both fossil fuel and renewable space (e.g. Orsted, Iberdrola), they have been assigned to the sector where most of their energy activities belong based on authors' analysis. The bubble size reflects companies' market capitalization on 31/12/2019 in USD Billions, where red bubbles represent fossil fuel companies and green ones denote the renewables players. The X axis reports the ranking of the companies based on their market capitalization (1 to 30), while the Y axis shows the revenue levels in USD Millions in 2019 (12 months). We applied a free float > 25% criterion to our sample to exclude mainly state-owned companies (e.g. Saudi Aramco) and report companies relevant to private investors. The free float threshold indicates shares that can be traded on the market, other than the restricted shares held by company insiders or controlling investors (e.g. government). All companies' values are reported in the Supplementary Information.

There is a substantial gap between the market capitalization and revenues of the oil and gas companies, and renewables companies (Figure 3). At the end of 2019, Exxon Mobil

was the most valuable private fossil fuel listed company[69], valuing slightly less than 300 billion dollars. The final three ranked renewable companies have roughly a market value which is ten times smaller than the value of the lowest ranked fossil fuel company. Similar trends emerge with regards to companies' revenues. While companies' market values may change quickly over time, such indicators are important to capture the difference in the order of magnitude between the two sectors since they affect companies' ability to attract funds (high levels of market capitalization are positively associated with greater investments[70]).

The different company profiles of the two industries have implications on investments that assets may attract. For the last decades, fossil fuel assets represented the major target of investments in capital markets, receiving stable and large contributions from institutional funds[37,71]. On the contrary, the market for renewable energy companies has low liquidity to attract large asset managers, asset owners and institutional funds[72]. As most institutional investors and asset managers apply liquidity criteria on their investment holdings, the majority of renewable assets on the market would not be considered eligible investments due to their small size (e.g. outstanding shares) and daily traded volume[72]. Additionally, the market for renewable securities is quite limited compared to the fossil fuel one, in terms of the number of companies, hence investors' investment choices are very bounded. Donovan et al.[72] suggest that mainstream investors only screen companies worth at least $200 million (market capitalization), while companies having a value below this threshold are usually not included in their assessment, which is the case for most renewable companies. Finally, renewable companies have only recently been able to raise capital from public investors with the first few companies going through their initial public offerings between 2006 and 2008, thus having a relatively short trading history[61,62] and being treated as a developing asset class[72]. These data suggest that while the fossil fuel sector has been able to attract steady and relevant flows from key participants in the stock market, this is not yet the case for renewables.

Additionally, most energy assets (both fossil fuel and renewables) are financed on corporate balance sheets[60,73], despite an increased share of project finance deployed for

renewable projects (in 2019 project finance accounted for 35% of the renewable energy asset finance compared to 16% in 2004[73]); this further worsens the availability of capital for renewable assets as renewable companies have generally smaller balance sheets than fossil fuel counterparts.

The crucial differences between the structure of the two industries and investment implications suggest that as far as financial markets are concerned these assets are quite different in the eyes of most investors, and are not substitutes. Low-carbon assets should then be treated as a specific asset class having its own challenges and unique characteristics, to understand what actions are needed to enhance investment. Even if investors start to incorporate climate risks in their decision-making process and do not find fossil fuel assets attractive anymore as a consequence of the disclosure movement, they have several investment options. Capital could simply exit the energy sector to other sectors like IT and pharmaceuticals, rather than flowing to low-carbon assets. Disclosure in itself does not account for any of the aforementioned aspects and it is unlikely to play a dominant role to facilitate the capital switch between fossil fuel and renewable sectors.

Reorientation of policy focus.

Disclosure initiatives are having little influence in driving a potential large-scale reallocation of capital from high to low-carbon assets to align the energy system with the needs of a more sustainable economy. The current policy focus on transparency alone may risk diverting the attention from some key areas that would need to be better understood to mobilise more capital towards low-carbon investment. We suggest three areas that research and public policy should examine in the climate finance domain and provide examples of actions that may be considered.

Boundaries of the financial system

The financial sector has historically funded and is highly exposed to high carbon[15,37]. Battiston et al.[71] estimate that it has even broader exposure to climate-policy-relevant sectors (e.g. fossil-fuels, utilities, energy-intensive industries) reaching roughly 45% of

their portfolio. Breaking such path dependence, linked to behavioural, institutional and market lock-in mechanisms[15,74,75], implies that a variety of market participants would need to redirect their capital into low-carbon assets. Investors differ on many dimensions, such as their capital base, preferences, expertise, expectations, time horizons and risk appetite[76,77,78]; they also face varying market barriers and have different financial and non-financial incentive structures[79,80]. For instance, feed-in tariffs that are based on premiums over wholesale price benchmarks increase the revenue risk compared to fixed-price tariffs and may inhibit risk-sensitive investors (such as pension funds or insurance companies) while being acceptable to energy actors that are naturally suited to manage this risk. Similarly, adaptive policy elements (such as feed-in tariffs that change based on prevailing costs) might improve the effectiveness and cost-efficiency of policies but will hinder the participation of actors that prefer fixed income streams from renewable projects (such as bank-led project financing). As a result, different investors have historically been attracted and deterred by different policies having a common intent to support low-carbon investment[77]. Moreover, different investor groups get involved at different stages of low-carbon technology development and their temporal dynamics drive the growth of renewable industries[76,78]. A systemic understanding of investment dynamics and policy impacts is thus needed to target appropriate investor groups based on their heterogeneous preferences and investment drivers to mobilise capital. A 'potent' ecosystem (e.g. mature renewable technologies, conducive policy environments, stable long-term outlook) may lead to the emergence of novel actors such as renewable energy investment funds, which are hybrid energy and financial actors acting as investors and creators of alternative energy assets. Similar opportunities may arise when investigating co-investment patterns and induced investment effects. For instance, understanding how to best utilise international public climate finance to leverage more private capital flows[81,82] and the role of the banking sector in influencing entrepreneurial and institutional investor activity in renewables[83], are aspects largely unexplored.

Interface between policy and financial elements

Over the last two decades, public policy has experimented with different mechanisms and design features, along with policy mixes, to support the energy transition[84,85,86]. However,

the current climate policy setting still lacks a broader integration of the finance dimension into policy design such that it captures all positive synergies. Further exploration of how financial policies[87,88,89] could be integrated with other public levers, such as monetary, fiscal and macro-prudential policy, is needed to align different policies with climate goals. A recent initiative considered by the European Parliament and Commission[90], includes the introduction of a green supporting factor (GSF) on bank capital reserve requirements. A GSF allows to lower the risk weights applied to low-carbon loans and investments, thereby reducing banks' capital ratios for these particular assets and increasing their overall leverage. Along these lines, the introduction of climate considerations into monetary policy would directly impact central banks' asset purchases, such as the quantitative easing programme[91]. This would be especially relevant considering that most Central Banks' corporate asset purchase remains biased towards high-carbon industries and misaligned with climate goals[91]. Additionally, fiscal instruments have been used extensively to disincentivise high carbon activities (e.g. carbon prices) and support low-carbon technologies (e.g. public investments, grants, tax credits)[66]. While some of these initiatives are return enhancing at a project level and aimed at project developers and operators, their impact in inducing broader financial participation in low-carbon industries has been limited. There is much potential to make them more appealing for diverse financial investors, for instance making tax credits transferable (from project companies to third parties) would draw large corporations that wish to avail of the tax benefits to low carbon assets. For structural changes, there is also a need to ensure that wider public expenditure achieves environmental co-benefits and is directed to low carbon activities. Green budgeting frameworks and tools, for example, assess the impact of budgetary measures on environmental objectives and can help to direct investment, expenditure and taxes towards government's green agenda. More research and policy efforts taking a sustainability transition perspective triggered by financial elements[92] can thus help to directly impact investment in specific assets/sectors, stimulate different financial market participants and affect path dependency.

Capital flows in developing countries

A just and inclusive energy transition requires that low-carbon technologies and climate finance are channelled into diverse countries globally, particularly in low-income and vulnerable economies, to achieve climate and sustainable development goals. The inherent capacity to mobilize capital differs between countries and seems strictly linked to the local enabling environments and associated perceived risks[93,94,95]. The integration and consolidation of the oil sector have historically helped to overcome investment risk considerations in uncertain contexts, supporting its development through codified standards and financing structures[74]. In contrast, low carbon technologies still lack formalised and specialised investment channels, particularly in developing countries, where political, regulatory and macroeconomic instability increase investment risks and thus make it more difficult to invest even in low risk technologies. These factors have an immediate consequence on the financing conditions of the projects which would need to secure sufficient access to capital and at competitive rates[96,97]. Indeed, whereas in effect the oil majors can underwrite their own risks, in many poorer developing countries, such as those in Africa, attracting private money from capital markets is challenged by the high return investors expect for perceived risks - making unviable many projects which in principle would be economically attractive in other contexts. Innovative and international action is needed to create financing channels that enable better management and diversification of risks to attract diverse private capital, reduce costs and create sustainable international financial structures. Matthäus and Mehling[98] propose a multilateral guarantee mechanism to reduce renewables financing costs with potential savings reaching $1.5 trillion globally by 2030. More research is needed to assess the viability and implications of potential policy schemes targeting low-carbon investment in developing countries, where a narrative for climate finance is still missing except from the need for more public support. These regions represent the areas of the world with a high financing need and for which the transition will be more expensive given the significant financing cost associated with the local context[99]. A “climate investment trap” may arise for developing economies when climate-related investments remain chronically insufficient[99].

To conclude, in this Perspective we show why disclosure is an insufficient response to the challenge of redirecting capital to low-carbon assets by probing some limitations of its assumptions. Whilst the decadal trend to declining market returns in the fossil fuel assets are making the industry less attractive to investors, there seems to be little apparent link between disclosure initiatives and capital flows from high to low-carbon investment. The investment system behind low-carbon assets is tailored around specific characteristics of these assets and a true understanding of its key components and dynamics is essential to re-allocate more capital towards them. More in-depth analyses of the patterns underlying the emergence of low-carbon investment systems are needed; and more research should focus on the complex interactions between financial market participants and their expectations, local contexts and policy elements to accelerate the pace and scale of climate investment. Some sectoral aspects (e.g. company profiles) remain a challenge for renewables. They could be eventually overcome by the scale up of green financial channels, such as green bonds and exchange traded funds, which currently represent niches in the financial market, but could be perceived as an appropriate way of "piggybacking" low-carbon assets into existing investment structures familiar to investors. Overall, such sectoral aspects will largely be contingent on the development of the industry and whether renewable players will be able to leverage economies of scale and expertise globally across several low-carbon technologies. In addition to its own efforts to generate persistent cost reductions, market returns and attract broader financial market investment, low-carbon industries will rely on long-term climate policy signals, as well as a redesigned financial system with mechanisms better adapted to the low-carbon transition. Disclosure initiatives on their own mainly respond to the need to protect the financial system from climate-related risks by ensuring financial stability, rather than making financial flows consistent with climate goals. As disclosure initiatives are not a central plank of capital reallocation, they should be considered as at best one of several equally important measures to support the low-carbon transition rather than the main policy tool.

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Competing interests

The authors declare no competing interests.