Accounting Forum xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Accounting Forum

journal homepage: www.elsevier.com/locate/accfor

Accounting for decarbonisation and reducing capital at risk in the S&P500

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ARTICLE INFO

Keywords:
Climate change
Decarbonisation
Financial institutions
S&P500 carbon-financial risk

ABSTRACT

This article accounts for carbon emissions in the S&P 500 and explores the extent to which capital is at risk from decarbonising value chains. At a global level it is proving difficult to decouple carbon emissions from GDP growth. Top-down legal and regulatory arrangements envisaged by the Kyoto Protocol are practically redundant given inconsistent political commitment to mitigating global climate change and promoting sustainability. The United Nations Environment Programme (UNEP) and European Commission (EC) are promoting the role of financial markets and financial institutions as drivers of behavioural change mobilising capital allocations to decarbonise corporate activity.

1. Introduction

Since signing the Kyoto Protocol in 1997 international climate conferences such as Montreal 2005, Copenhagen 2009 and Paris 2015 national governments have moved towards setting long-term goals to control the increase in Greenhouse Gas Emissions (GHG) and their carbon equivalent to levels that are designed to arrest the increase in global average temperatures to levels that are below 2 °C above pre-industrial levels. At the Paris climate conference (COP21) in December 2015 Governments agreed:

> a long-term goal of keeping the increase in global average temperature to well below 2 °C above pre-industrial levels; to aim to limit the increase to 1.5 °C, since this would significantly reduce risks and the impacts of climate change; on the need for global emissions to peak as soon as possible, recognising that this will take longer for developing countries; to undertake rapid reductions thereafter in accordance with the best available science (European Commission, 2018a).

According to a carbon footprint briefing note issued by ShareAction and TruCost, ‘global emissions would have to fall by about 60% by 2050 to limit the increase in average temperature to less than 2 °C (3.6 °F) above pre-industrial levels. Over the last 40 years, CO2 emissions have continually risen and only stalling following major economic crises.’ (ShareAction and Trucost, 2015).

Table 1 reveals that, although carbon emissions intensity has fallen from 0.48 tons of carbon per $1000 of global GDP in 1990–0.32 tons in 2016, it is that case that GDP has grown at a faster rate thereby increasing overall global emissions from 22 billion to 36 billion tons of carbon equivalent emissions annually. The world’s major industrial and industrialising economies have not found a way of decoupling carbon emissions from economic growth and carbon emission concentrations in the atmosphere have increased

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https://doi.org/10.1016/j.accfor.2018.01.004
Received 19 January 2018; Accepted 21 January 2018
0155-9982/

Table 1
Global carbon emissions in relation to GDP and atmospheric concentrations.
Sources: For carbon emissions parts per million in atmosphere as at Jan 1st of these years. (Tans, Keeling, & Dlugokencky, 2018). For data on total global carbon emissions in relation to GDP. (European Commission, 2017a).

	1990	2000	2010	2016
Tons of carbon/1000$ of GDP	0.48	0.41	0.37	0.32
Total CO2 emissions bill tons	22.5	25.6	33.6	35.8
CO2 parts per mill in atmosphere	355.0	370.6	388.7	402.5

from 355 to over 400 parts per million.

Since the Kyoto Protocol was signed in 1997 the idea that a top down legalistic regulatory model would provide the authority to establish a unified global political commitment to reducing carbon emissions has been progressively undermined and global carbon emissions continued to increase. Rather than a top down legal and regulatory approach attention is now focusing on the contribution of financial markets and financial institutions. Specifically, how financial markets or governing financial institutions could be employed to modify corporate behaviour and decarbonise economic development. This approach is now being advocated by the United Nations Environment Programme (UNEP) and European Commission (EC). New financial markets such as carbon cap and trade have been tested out in Europe and to some extent in the US but with limited impact on carbon emissions. The broader alternative, and which is the focus of this paper, is the contribution of financial institutions (FIs) and how their power over capital allocations (debt and equity) could promote decarbonisation. FI's could progressively direct capital from more to less carbon intensive business models because there is a risk attached to investing in carbon intensive activities. Carbon intensive business activity could, for example, be subjected to adverse regulatory and technical changes that could lead to 'stranded assets' or a 'carbon bubble' that would put invested capital at risk.

Whilst there has been a steady increase in our understanding of climate change from a scientific-environmental risk perspective, for example, the increase in volatile climatic events (Sneed, 2017), the challenge has been to translate this understanding of risk into meaningful behavioural changes within corporations. Specifically this would involve companies that are carbon intensive moving on to a less carbon intensive trajectory so as to secure absolute reductions in global carbon emissions. Connecting the science of climate risk arising from carbon emissions to changes in corporate behaviour is, as we have noted, not an easy task but recent policies have centred on encouraging new financial markets to trade in carbon off-set credits and of encouraging financial institutions (FIs) to change their asset allocation behaviour away from more to less carbon intensive investment portfolios.

With regards to financial market interventions the European Union Emissions Trading System (EUETS), the world's largest carbon cap and trade system, was launched in 2005 and the UK Government believed that:

> The EU Emissions Trading System (EU ETS), the world's largest cap and trade system, should remain the cornerstone of EU energy and climate change policy. The EU ETS demonstrates Europe's ambition to act as a global leader in the fight against climate change through the delivery of a functional and effective carbon market. The continued success of EU ETS is vital in helping the EU to meet its 2030 and 2050 targets at least cost, and in laying the foundations of a global carbon market (United Kingdom Government, 2014)

The EU ETS operates on the basis of what is termed a 'cap and trade' principle. Within the EU a target is set for the overall volume of greenhouse gases that can be emitted by energy power plants, industry and other sectors covered by a cap on carbon emissions set at EU level. Within this overall cap some companies may be under target and so obtain allowances which they can trade with other companies/sectors that are above their targets (European Commission, 2016)

Chart 1 reveals that the price of carbon traded is volatile and peaked at 30 Euro before falling into a range of 3–5 Euro. A fundamental problem is that this cap and trade trading system has failed to impose meaningful caps on the emissions of Europe's most carbon-intensive industries (Friends of the Earth Europe, 2010). In addition and according to a Sandbag report (2017):

> The EU ETS has hit a new record of 3 billion tons of surplus EUAs (EU Allowances), including both volumes available to the market and those destined for the MSR (Market Stability Reserve). This record surplus and accompanying low carbon prices suggests that the EU ETS has failed as a policy (Sandbag, 2017).

A research report produced by the Grantham Institute for climate change is more positive but finds that it is difficult to separate out the impact of the ETS market for carbon and the recession in Europe which also contributed to reducing emissions (MuÛls, Colmer, Martin, & Wagner, 2016). However, according to the European Commission climate action website the surplus of trading credits risks undermining the orderly functioning of the carbon market. In the longer term it could also affect the ability of the ETS to meet more demanding emission reduction targets cost-effectively (European Commission, 2018b).

The lack of support for the EU ETS is nicely summed up in a recent European Commission (2017b) report which observes that there is a considerable gap between the shadow price for carbon emissions employed by the European Investment bank (EIB) of €32/tCO2 and so-called market price of less than €5 euro. This low 'price' for carbon emissions obscures the difference between assets that are carbon efficient and those which are not.

> The absence of a financially material carbon price prevents investors from differentiating carbon-intensive assets from carbon-efficient assets in their economic reasoning. The EU emissions trading system (ETS) price of carbon for a DEC17 EUA is currently

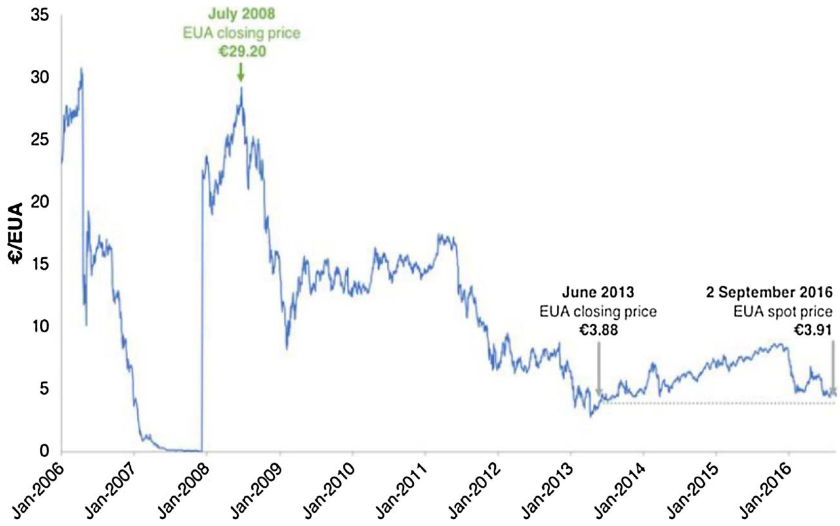

Chart 1. Trading price of carbon on European ETS.
Source: MacDonald (2016)

about €5. The EIB, by comparison, uses a shadow cost of carbon of €32/tCO2 today, rising €1 each year to €45/tCO2 in 2030 (European Commission, 2017b)

In the US one of the most enduring cap-and-trade carbon off-set markets is the Regional Greenhouse Gas Initiative (RGGI), operating in nine Northeastern states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. These states collectively obtain revenue from the auction of carbon credits but according to a 2016 report from the Congressional Research Service (CRS) found that, as a group, the total CO2 emissions from the nine RGGI states account for approximately 7% of U.S. CO2 emissions (and 16% of U.S. gross domestic product) and aggregate emissions rank in the top 20 among all nations. But from a practical standpoint, the RGGI programmes contribution to directly reducing the global accumulation of GHG emissions in the atmosphere is arguably negligible (Congressional Research Service, 2017). Although states such as California's cap and trade scheme covers about 85% of emissions in the state and is designed to reduce emissions to 1990 levels by 2020 it too seems not to have impacted on aggregate emissions (St-Louis & Millard-Ball, 2015)

The alternative to a 'market' based cap and trade approach to reducing carbon emissions would involve encouraging Financial Institutions (FIs) to modify their investment behaviour, that is, allocate capital away from more to less carbon intensive portfolios. And, it is with this approach to decarbonisation, and how this is framed, that informs the basis of this article. Specifically, it is argued that a change in investment strategy by FIs is required, that is, carbon intensive assets present increased value at risk due to possible changes in regulation and threats from new technology. These changes could limit the extraction and use of carbon and hence damage the return on capital for the FIs that have positions in these business models. This might then lead on to FIs facing exposure from so-called 'stranded assets' or a 'carbon bubble' (see WRI-UNEP, 2015, European Commission, 2017b).

For example, if a large quantity of fossil fuel resources cannot be extracted and used to produce energy (whether because of policy, market or other carbon-related constraints), companies whose business is principally focused on such activities could be negatively impacted, both operationally and financially. The implications for fossil fuel commodity prices are crucial in any asset valuation scenario for such companies. This concept is referred to as 'operator carbon risk' and affects carbon-intensive companies and asset operators. Further, this possibility of value at risk from carbon intensive asset classes has led to a broader discussion about whether financial intermediaries, such as commercial and investment banks, and broader investors, are thoroughly integrating considerations of operator carbon risk when evaluating, pricing, and financing carbon intensive assets and companies (Fulton & Weber, 2012)

For example, the Carbon Tracker Initiative reviews the extent to which meeting a 2 °C global warming target would render some energy assets at risk because extracting reserves would prove to be uneconomic.

> Investors have recognised the value of companies considering a range of scenarios, including a 2 °C scenario, by supporting initiatives and resolutions which ask companies to report on the implications of this future for their business…. Mark Carney, the FSB(Financial Stability Board) chair stated that a carbon budget consistent with a 2 °C target "would render the vast majority of reserves 'stranded'–oil, gas and coal that will be literally un-burnable without expensive carbon capture technology, which itself alters fossil fuel economics" (Carbon Tracker, 2017).

Whilst a European Commission sponsored report suggests that while Europe's investors have been leading the decarbonisation of investment portfolios, the combined exposure of their equity portfolio to carbon-intensive sectors remains large [45–47%] (European Commission, 2017b). In contrast the concern, expressed by others, is that carbon risk may not be modifying investor and analyst's behaviour in a way that progressively mitigates climate change risk (Campbell & Slack, 2011; Harmes, 2011; Pattberg, 2012) and that this delay could lead to a so-called ‘carbon bubble’ effect.

> The carbon bubble poses risks to the financial sector because financial institutions have large exposures to oil, gas and coal mining companies through equity, bond, and loan portfolios (Weyzig, Kuepper, van Gelder, & van Tilburg, 2014)

The prospect of a ‘carbon bubble shock’ or ‘stranded asset values’ relates to the volatility and extent of valuation changes if carbon intensive sectors are not able to extract and utilise carbon so as to generate a financial return on capital invested. The WRI-UNEP-commissioned report ‘Carbon Asset Risk’ observes that industry sectors that rely on high levels of carbon emissions, such as those involved in energy supply and materials extraction and processing, may find that their carbon reserves cannot be employed ‘whether because of policy, market, or other carbon-related constraints’ (WRI-UNEP, 2015). This will have a negative impact on the valuation of these sectors and this has led on to a broader debate about whether financial institutions are taking into account carbon risk in the allocation of their capital stack, that is debt and equity positions.

Al Gore in a Wall Street Journal article noted that ‘this is exactly what is happening with the sub-prime carbon asset bubble: It is still growing because most market participants are mistakenly treating carbon risk as an uncertainty, and are thus failing to incorporate it in investment analyses. By overlooking a known material-risk factor, investors are exposing their portfolios to an externality that should be integrated into the capital allocation process (Gore & Blood, 2013). Policy responses that are required to comply with a 2° rise in global average temperatures would impact negatively on sectors that rely upon the extraction of and burning of carbon to generate energy. According to Comerford and Spiganti (2015) “It is not only the equity of companies that is exposed to this, the quality of the debt they have issued is also exposed and there will be defaults and ratings downgrades” (Comerford & Spiganti, 2015)

According to Ritchie & Dowlatabadi, (2015) the idea of a carbon bubble has not only gained traction in financial markets but investors are now ‘incorporating stranded asset risk’ into their outlooks. It is argued that a growing number of institutions are committing to divest from carbon intensive industry sectors to avoid a carbon bubble. The possibility of a carbon bubble and how it might force investors to divesting these assets is regularly cited by climate campaigners as being of a benefit to society (Ritchie & Dowlatabadi, 2015). Moreover, incorporating carbon risk into portfolio allocations might encourage a more rapid exit from carbon intensive business models. For example, John Fullerton, a former managing director at JP Morgan is reported as stating that the market value of 2795 gigatons of carbon missions are worth about $27 trillion and if 80 per cent of it were to be kept underground, you’d be writing off $20 trillion in assets (McKibben, 2012).

Dieter Helm (2015) has alternatively argued that this notion of ‘stranded assets’ and ‘asset bubble’ from carbon risk is deceptively too simple and argues that what matters is the price of oil, gas and coal and how prices coupled to a discount rate impact on the valuation of a reporting entity’s assets. Helm observes that:

> The great mistake the stranded asset lobby make is to believe that they have come up with a way to mobilise private investors and institutions to do the decarbonisation for them. They think that disinvestment will be a profit maximising strategy. Hence their job is to educate private investors as to how best to make more money. In the process they anticipate that the cost of capital to fossil fuel companies will go up, hence starving them of investment (Helm, 2015).

Dieter Helm makes an important observation about constructing an understanding of carbon-financial risk using concepts such as stranded assets’ and/or a ‘carbon bubble’. This, Helm argues, is rather too simple an understanding about how carbon emissions intensity informs the costs of capital (risk) and thereby capital allocation(s) and return on capital for investors. In this paper we agree with Helm’s observation about the framing being rather too simple. To set about constructing a more sophisticated critical argument about carbon emissions and financial risk we set up two key questions to be answered. Firstly have financial institutions reduced their capital stacks (debt and equity) in more carbon intensive business models in the S&P500? Secondly, would a disorderly retreat of capital from carbon intensive business models make financial sense in the context of wider interconnectedness between business models within value chains?

In this paper we employ carbon emissions data disclosed by the Carbon Disclosure Project (CDP) for the S&P 500 group of companies and match these emissions data with reported revenues, earnings, and capitalisation. Using these matched carbon and financial data for firms listed in the S&P 500 over the period 2008–2014, we can then engage with two key questions we have set for our analysis: are ‘financial institutions’ re-allocating capital away from carbon emissions-intensive sectors to less intensive sectors? And, secondly, is it possible to re-frame carbon-asset risk into a more nuanced understanding of business models that are embedded in a more complex physical and financial value chain than that presented by the protagonists of: stranded assets or carbon bubble?

Mark Carney, Governor of the Bank of England, observed in 2015 that:

> An old adage is that which is measured can be managed [and] information about the carbon intensity of investments allows investors to assess risks to companies’ business models and to express their views in the market’ (Carney, 2015).

And in the same speech Carney observes that how carbon emissions are measured should be consistent–in scope and objective across the relevant industries and sectors (Carney, 2015). There is also the additional challenge that what is measured and disclosed by companies about their carbon emissions may also change over a period of time because, as Lohmann (2009) observes, there are considerable problems controlling the boundary of a company (Haslam, Butlin, Anderson, Malamatenios, & Lehman, 2014). Whilst there are additional problems associated with encouraging disclosures (de Aguiar & Bebbington, 2014) if these are voluntary rather than a regulatory obligation.

There are considerable challenges and health warnings attached to translating carbon arising from different greenhouse gases into a company based measure (Andrew & Cortese, 2011). For the purpose of the investigation about carbon-asset risk in the S&P 500 constituent group of companies we employ information on carbon emissions collected by CDP, formerly known as the Carbon Disclosure Project. CDP supports companies in terms of technical advice on how to measure their GHG emissions and how to convert these into a C02 equivalent. CDP collects C02 equivalent data from companies and these are allocated into what are known as Scope 1, 2 and 3 emissions categories. Scope 1 carbon emissions are from operations that are owned or controlled by the reporting company whilst scope 2 emissions are indirect emissions from the generation of purchased or acquired electricity, steam, heat or cooling consumed by the reporting company. Scope 3 emissions include upstream and downstream value chain emissions and are an optional reporting category in the Corporate Standard (World Resources Institute and World Business Council for Sustainable Development, 2001). In this paper we have obtained S&P 500 group company disclosures for their scope 1 and 2 carbon emissions and identify 313 companies out of the S&P 500 that disclose carbon emissions and matching key financial operating data over the period from 2008 to 2014.

In the following section we review the trajectory of US carbon emissions at an aggregate level and across key industry sectors before turning to review carbon-financial performance of business models in the S&P 500 group of 313 companies

2. Accounting for US carbon emissions

The direction for aggregate global carbon emissions has consistently been on an upwards trajectory and in an earlier period the trend added an additional 3–4 billion tons of carbon dioxide emissions every 10 years carbon emissions this has accelerated in recent decades with aggregate C02 emissions increasing at the rate of 8 billion tons over the period 2000–2010. And, in just 4 years from 2010 to 14, the global increase has been an additional 3 billion tons. A major driver of this growth in carbon emissions has been that arising from China's rapid economic growth which has added 6 billion tons to annual global carbon emissions since the year 2000. In contrast data for US and EU carbon emissions reveals slight reductions in recent years, for example, since 2008 the US reported carbon emissions are down roughly 6 percent (see Chart 2).

If we break down the analysis of US CO2 emissions by economic/industry sector (see Table 2) we find that whilst shares remain quite steady it is the case that roughly 80 percent of carbon emissions are from three industry sectors: electricity generation, transportation and industry. However there are limitations attached to measuring and reporting carbon emissions using industry sectors as the unit of analysis. One problem is that economic sectors are not made up of firms but establishments and another challenge is that the legal reporting/disclosure unit of analysis for carbon emissions are company's not individual firms.

The motivation for locating economic activity into a system of industrial classification is one that is driven by 'economists' and their need to understand how the structure of an economy is evolving and how this informs policy initiatives.

> A good classification system …need(s) to reflect the current structure of the economy in order to assist analysis of important changes. … It is often remarked that the structure of the economy provides a kind of snapshot view of the economy at one time, which implies that times series will show how the structure changes' (Economic Classification Policy Committee, 1993)

There have been a number of general criticisms about locating economic activity into industry classifications and using these to then describe the structure of the economy. The first of these relates to the way in which the firm, as a unit of account, is deconstructed into its 'establishments' which are then classified into an industry sector. These establishments are located into an industry sector using information about their 'dominant' or primary supply-side characteristics. This process of deconstructing the firm into establishments erases the identity of the firm.

> An establishment is classified to an industry when its primary activity meets the definition for that industry. Because establishments may perform more than one activity, it is necessary to determine procedures for identifying the primary activity of the establishment (United States Department of Budget Management, 1999).

A second problem with this process of classification concerns the use of the supply-side characteristics alone to locate establishments into an industry sector because this loses the identity of outputs and demand side characteristics.

In this paper we employ information using companies listed in the S&P 500 and here there is a different twist on how reporting

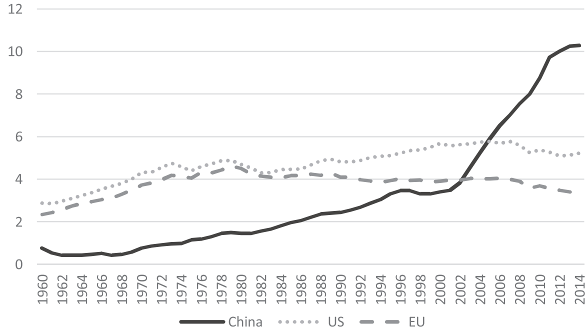

Chart 2. CO2 emissions: China, US and European Union 1960–2014 (bill tons).
Source: The World Bank (2018)

Table 2
US Economic sector share of carbon emissions 1990–2014.
Source: WorldAtlas (2017)

Economic Sector	1990	2000	2010	2014
Electricity generation	29.2	32.2	32.9	30.3
Transportation	24.2	26.5	26.2	26.3
Industry	25.3	21.8	20.0	21.3
Agriculture	8.8	8.0	9.0	9.1
Commercial	6.5	5.6	6.1	6.6
Residential	5.4	5.3	5.2	5.7
U.S. territories	0.5	0.6	0.6	0.7
Total	100.0	100.0	100.0	100.0

entities rather than enterprises are allocated to industry sectors. The S&P 500 constituent list employs the S&P500/MSCI Global Industry Classification Standard (GICS) classification assigns companies to a single GICS sub-industry 'according to the definition of its principal business activity as determined by Standard & Poor's and *MSCI*. Revenues and earnings are a significant factor in defining principal business activity' (Morgan Stanley Capital International and Standard and Poor's, 2012)

> A company is assigned a classification at each of the four levels of GICS; however, a company may only belong to one group at any level. The classification is generally determined by the business activity that generates a majority of the company's revenues and/or earnings.

The S&P methodology for locating companies into an industry integrates into its methodology a market-oriented perspective which takes into account that production and services are comingled within companies.

> The GICS methodology for defining industries remains profoundly rooted in the microstructure of industries, but has shifted towards a market-oriented perspective. For example, in today's economy, drawing the line between goods and services is increasingly difficult and arbitrary, as almost all goods are sold with a service. Thus, the distinction between consumer goods and services has been replaced by the more market-oriented sectors of "Consumer Discretionary" and "Consumer Staples" which both contain goods and services sub-industries (Morgan Stanley Capital International and Standard and Poor's, 2012)

Companies are classified into their respective industry sector using their annual reports and financial statements but other sources of information including investment research reports and other industry information are also employed to support classification. The S&P 500 GICS methodology for allocating companies into industry sectors employs material financials (revenues and earnings) to allocate a company to an industry sector. It is also a more flexible and adaptive approach because new GICS can be created if and when a group of companies have significantly different activity characteristics but also material sales and earnings profiles that can be employed to locate these firms into the new industry sector classification.

Using the company as the unit of analysis is significant for two reasons the first of these is that the carbon emissions disclosed by a company transcend industry sectors. For example, General Motors (the company) manufactures cars and components, but also provides financial services and invests in car retailing and distribution networks all of which contribute to its carbon emissions profile as scope 1 and 2 disclosures. The second benefit of using companies as the unit of analysis is that, as reporting entities, they will disclose operating financials, balance sheet assets and liabilities and be given market valuations by analysts. These financial dimensions of a reporting entity will have a corresponding physical carbon emissions disclosure.

2.1. Carbon emissions intensity in the S&P 500

Our analysis focuses on 313 companies listed in the S&P 500 constituent list for which we have disclosed carbon emissions and also matching financial data for the period 2008–2014. Some of the S&P 500 group listed in 2008 will not be listed continuously during the period 2008 up to 2014 due to mergers and acquisitions or a company previously listed may alternatively have gone into insolvency and bankruptcy.

Table 3 reveals that for the period 2008–2014 this group of 313 firms consistently disclosing their carbon emissions and listed in the S&P500 constituent list have not managed to reduce their overall carbon emissions. This group of companies accounts for 2 billion tons of carbon emissions on an annual basis and this is equivalent to roughly 40 percent of aggregate US carbon emissions. For this group of companies the amount of sales revenue and cash earnings extracted from one tonne of carbon has increased by 20 percent and 60 percent respectively. However, the amount of capital employed (debt and equity) relative to carbon emissions for this group of 313 companies increased by roughly 25 percent. For the average company in the S&P313 group the amount of carbon required to generate earnings has reduced but capital employed relative to carbon emissions increased.

2.2. Mapping carbon emissions and capital intensity in the S&P 500

In this section we split our analysis of the S&P313 group of companies into carbon intensive 'generating' business models and those that we describe as carbon 'dependent' business models. This analysis is employed to first investigate the extent to which

Table 3
Carbon emissions S&P 313 2008–2014.
Source: CDP public datasets (https://data.cdp.net/browse) and also authors' own investigations.

	Carbon Emissions (bill tons)
2008	2.055
2009	2.056
2010	2.072
2011	2.126
2012	2.074
2013	2.095
2014	2.039

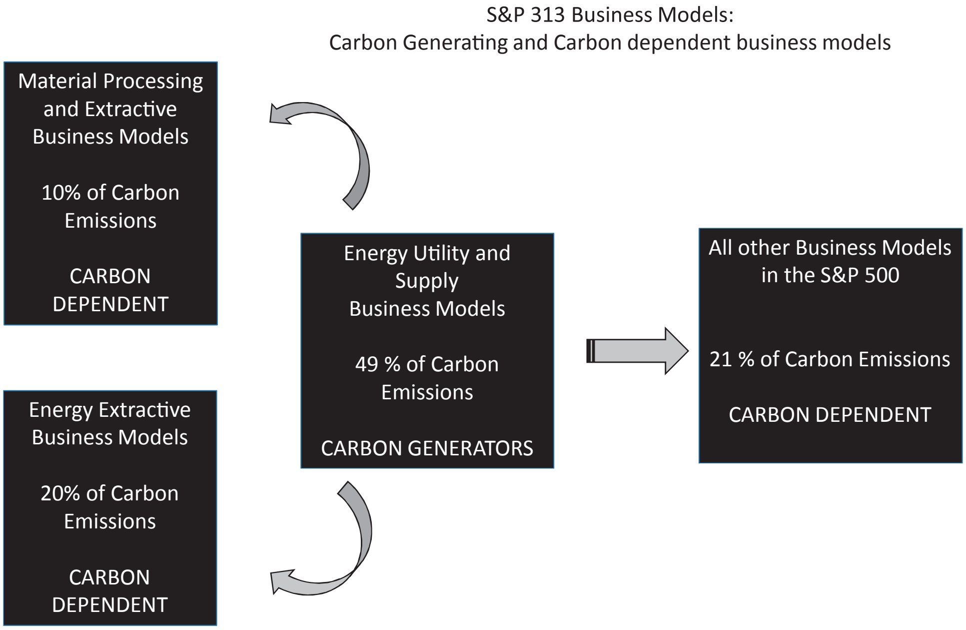

Fig. 1. S&P 313 Business Models: Carbon Generating and Carbon dependent business models.
Notes: the shares of carbon emissions are the average for all companies in these business models covering the period 2008–2014
Source: Authors

investors have migrated their capital stack (debt and equity) from carbon intensive business models over the period 2008–2014. And secondly to construct an alternative understanding about carbon 'generating' and carbon 'dependent' business models within a more complex physical and financial value chain.

Using the S&P313 group of companies we split these into a range of business models: Energy Utility, Materials Processing, Materials Extractive and all others. This framing is employed to broadly set out a value chain that maps out business models that are carbon generators and those that are carbon dependent. Although we note that these defining arrangements do not represent clear boundaries because some materials extractive and processing companies will have invested in their own power-plant capacity. Fig. 1 below describes the carbon value chain using the concept of carbon generating and carbon dependent business models.

In the middle of Fig. 1 we have the energy utilities that supply energy from converting different types of input from coal, nuclear, oil, gas and renewables. Our flow diagram indicates that the materials processing and energy extractive business models are carbon dependent in terms of requiring energy supply. However these business models may also have invested in their own power plants that generate carbon emissions. On the right we have all other predominantly carbon dependent business models that use energy and also require inputs from the materials processing and to some extent energy extractive business models. The purpose of Fig. 1 is to broadly separate out business models that are carbon generators and carbon dependent and to estimate their share of total carbon emissions in the S&P313 group of companies.

The framework presented in Fig. 1 is a physical carbon emissions representation of the value chain and this can be supplemented by including: operating and balance sheet financials for these business models which contain allocated companies. In Fig. 2 we reproduce the physical share of carbon emissions by business model but add in to the analysis their share of capital employed.[1]

[1] Capital employed is: Short and Long-run debt plus total shareholder equity which is paid in capital, additional capital paid in and retained earnings reserves after

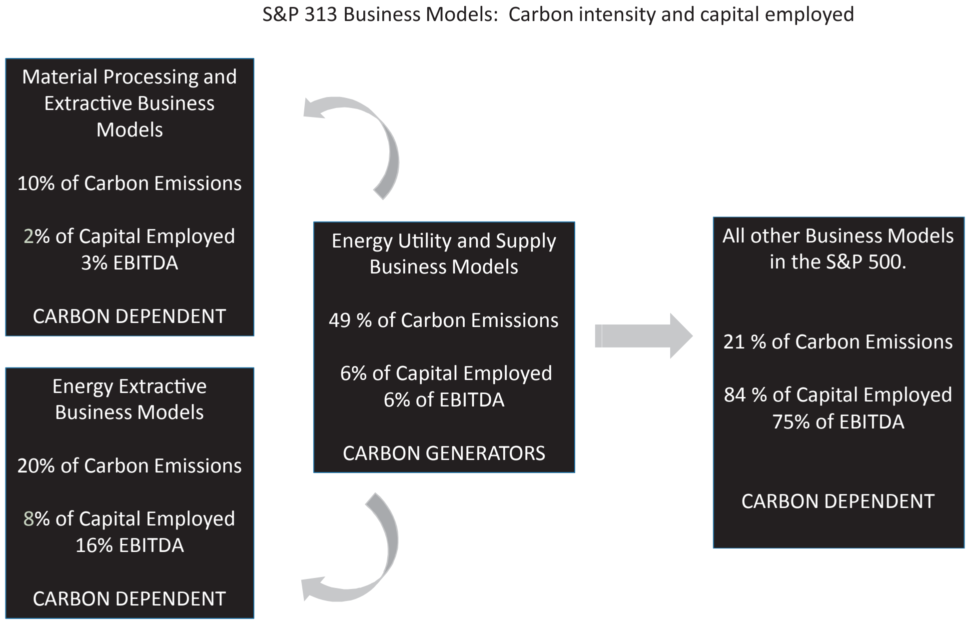

Fig. 2. S&P 313 Business Models: Carbon intensity and capital employed.
Notes: the shares of carbon emissions are the average for all companies in these business models covering the period 2008–2014. Capital employed is: Short and Long-run debt plus total shareholder equity which is paid in capital, additional capital paid in and retained earnings reserves after adjustments for changes in comprehensive income.
Source: Authors

Table 4
Capital stack in carbon intensive business models in S&P 313.
Source: Thomson Reuters and author datasets.

	Total capital employed in carbon intensive business models $ trillion	Total capital employed in less carbon intensive business models $ trillion
2008	1.2	8.4
2009	1.3	8.9
2010	1.5	9.4
2011	1.6	9.5
2012	1.7	9.8
2013	1.8	10.4
2014	1.9	10.4
Change	0.7	2.0

When then share of capital employed is included, for the various carbon generating and dependent business models, we find that the carbon intensive business models: energy utilities, materials processing and energy extractive account for approximately 80 percent of carbon emissions but just 16 percent of capital employed (debt and equity). All other business models to the right in Fig. 2 account for roughly 20 percent of carbon emissions but 84 percent of capital employed.

However, over a period of time (2008–2014) we find that financial institutions do continue to provide increasing amounts of capital (as debt and equity) to carbon intensive business models in the S&P 500 although the absolute increase in funding is less than that provided to other less carbon intensive business models (see Table 4). During this period the increase in capital employed in carbon intensive business models increased by $0.7 trillion and in the less carbon intensive business models it is roughly $2 trillion. Our analysis reveals that financial institutions do continue to provide capital to carbon intensive business models and have not yet evacuated their positions in the expectation of a carbon 'bubble' or 'stranded assets'. We believe that it makes sense for financial institutions to maintain a steady and reliable supply of energy and energy intensive processed raw materials to downstream activities. This is because the capital invested by financial institutions spans a more complex interdependent physical and financial value chain. That is, downstream business models to the right in Fig. 2, whilst less carbon intensive (but still carbon dependent) are able to convert a relatively low dependency on carbon emissions into substantial financial leverage and market value added (MVA) for investors and pension funds.

(*footnote continued*)
adjustments for changes in comprehensive income.

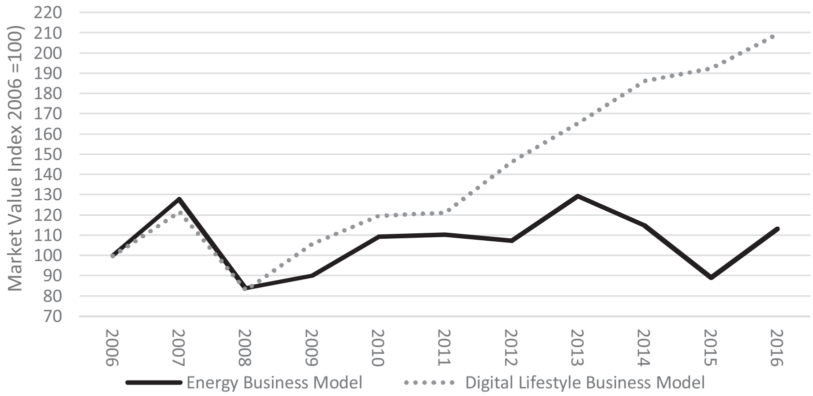

Chart 3. Energy and Digital Lifestyle Business Model: Market Value Index.
Source: Thomson Reuters and Author datasets

In the S&P 313 group of companies the digital lifestyle business model (DLBM) includes all companies that are involved in the provision of hardware, software applications and internet facilitation services. This broadly defined business model contains a group of companies that had a market value of roughly $1 trillion in 2006 and roughly equivalent to the S&P 500 energy utility business model (see Chart 3). By the year 2014 the market value of companies contained in the DLBM had increased to $3.5 trillion whilst the market value of companies in the energy business model remained at 2006 levels of roughly $1 trillion. Although the DLBM only accounts for an average and steady 2.6 percent of the S&P 313 total carbon emissions over the period 2008–2014 its share of total S&P 500 market value increased from 6 to 18 percent.

The implications of this analysis are that downstream high value business models require inputs in the form of energy and materials that have been extracted and/or processed by business models that embody high levels of carbon emissions but represent a relatively low level of value at risk both in terms of the share capital employed and market value of the S&P 313 group. The physical-financial interdependency between upstream and downstream business models complicates matters. A disturbance to energy supply or raw material processing capacity could arise if financial institutions redirected their capital stacks in a disorderly way. If such a disorganised exit from carbon intensive upstream business models were to take place this would have ramifications for downstream business models which generate significant financial leverage from their relatively low physical carbon dependency.

Financial institutions are managing investment portfolios that overlap a range of business models ranging from those that are high carbon generators but capital light to those that are less carbon dependent but generate higher financial returns on capital. The conclusion we come to from this analysis is that financial institutions should be encouraged to maintain investment in carbon intensive business models but fund innovation(s) and infrastructure to reduce carbon emissions from energy and materials processing business models. For example, investing in energy efficiency; smart electricity distribution systems; CO2 capture utilization and disposal; energy storage and conservation, especially batteries; and increasing the uptake of CO2 by the terrestrial biosphere. This is essential because financial institutions need to, on the one hand, secure the flow of energy and processed materials to business models further downstream that can deliver the financial leverage necessary to underwrite pension funds.

3. Policy implications and discussions

There has been a shift in emphasis regarding the policy interventions for moderating the impact of climate change since the Kyoto agreement was signed in 1997. A top down legalistic and regulatory approach is no longer politically practical given the resistance emerging in America at a federal level to reducing carbon emissions and mitigating climate change. The alternative now being adopted by global institutions such as WRI-UNEP and the European Commission is to consider how financial markets and institutional could modify corporate behaviour. That is, establish carbon cap and trade markets that set a floor above which carbon emissions cannot increase and trade surplus and deficit credits in a market and/or encourage institutional investors to allocate capital away from carbon intensive business models.

Given the practical difficulty of establishing cap and trade markets for carbon emissions and also the fact that global carbon emissions have continued to rise. We propose that financial institutions engage, as global governing institutions, directly in different business models to influence how capital (both debt and equity) is allocated to reduce carbon intensity. Using the S&P313 group of companies we develop a framework of analysis that locates companies into broadly defined business models (Haslam et al., 2014). The objective is to reveal the extent to which financial institutions are evacuating from carbon intensive business models in terms of their debt and shareholder equity positions. We find that financial institutions continue to invest capital into carbon intensive business models but that this investment is not reducing carbon emissions. That is, financial institutions although increasing their financial commitment to carbon intensive business model are, either not engaging with companies to ensure that capital is committed to innovations that reduce carbon emissions or, are not tracking the carbon emissions embedded in their investment portfolios (see also European Commission, 2017b).

A second purpose of our analysis reveals the complexity embedded in the physical and financial relationships that exist between business models within a value chain. We find that upstream business models are high carbon generating but operating with a relatively low share of capital employed. Downstream business models that are dependent upon energy and processed raw materials are less carbon intensive in terms of their share of overall carbon emissions but account for a substantial proportion of the S&P500 capital stack (debt and equity). For example the digital lifestyle business model accounts for roughly 2–3 percent of S&P313 carbon emissions but 18 percent of S&P 500 market value in 2014. These carbon light but financially leveraged business models depend upon a secure supply of energy and processed materials from upstream carbon intensive business models.

Financial institutions cannot easily evacuate from carbon intensive business models because there is a lock-in effect because physical outputs from these business models are inputs into high value creating downstream business models. There is an opportunity for financial institutions to take a more holistic approach to their portfolios one that recognises and incorporates this physical-financial interdependency into their decision making. This would involve investors providing finance that is guided by a combined social and economic imperative: sustainable decarbonised growth and stability in asset pricing. The first of these would involve financial institutions taking responsibility for funding society's long-term needs for innovation and infrastructure that enables a reduction in carbon emissions from carbon intensive business models. The second imperative is that financial institutions secure financial stability by taking a more holistic view of their investment portfolios that comingle carbon generating and carbon dependent business models that are not mutually exclusive but physically and financially interdependent.

Acknowledgements

We would like to thank participants at the European Parliament conference 'Driving down Greenhouse Gases: The 2050 Energy Transition Roadmap for the Paris Agreement' November 2017 for useful and constructive comments on earlier drafts of this paper.

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