What role for financial supervisors in addressing environmental risks? [1]

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Abstract

A literature is rapidly developing on financial shocks originating from ecological imbalances. These shocks can be triggered by either intensified environmental policies, clean tech breakthroughs or due to the economic costs of crossing ecological boundaries. However, financial supervisors have so far given little attention to this ecological dimension. This allows systemic financial imbalances resulting from ecological pressures to build up and concentrate in financial institutions and markets. This paper sketches the ecological dimension of the prudential policy framework and illustrates the working for the case of carbon emissions.

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1. Introduction

In the run up to the climate summit in Paris, several studies show that ecological risks can turn into financial shocks (e.g. Mercer, 2011; HSBC, 2012 and 2013; Weyzig *et al*, 2014; New Climate Economy, 2014). These shocks can be triggered by either intensified environmental policies, clean tech breakthroughs or due to the economic costs of crossing ecological boundaries. If anything, the Paris Agreement has further tightened the climate ambition of restricting global warming to 2 degrees Celsius. Countries have reconfirmed the 2°C target and agreed to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels (UNFCCC, 2015).

However, financial supervisors have so far given little attention to this ecological dimension. A notable exception is the Bank of England (2015), which has put the potential impact of ecological imbalances on financial stability on the research agenda. The lack of attention for ecological risks allows financial risks to build up and concentrate in certain financial institutions and markets. Whereas several studies have documented that from a global macroeconomic perspective the costs of acting swiftly on climate change are much lower than letting the climate change or acting later (e.g. Stern, 2015; IPCC, 2014), the micro perspective is very different. Individual companies and financial institutions do often not have incentives to operate in a truly sustainable way, as environmental externalities are not priced.

The contribution of this article is twofold. Firstly, should financial supervisors target the ecological risks that are building up outside the financial system itself? We present some evidence on the potential impact of ecological risks on the financial system. Secondly, how can financial supervisors address ecological risks? We propose an outline of a policy framework for the ecological dimension of prudential supervision. The working of this framework is illustrated in the case of carbon emissions, possibly the most important ecological risk. We start with a common methodology to measure carbon related exposures across the value chain. The exposures in the full value chain include direct exposures of financial institutions themselves and the much larger indirect exposures through lending and investments. The next step is the development of a dedicated carbon stress test to examine the vulnerability of individual financial institutions to carbon related exposures. Finally, supervisors can apply prudential instruments to contain carbon related exposures.

Interestingly, some financial institutions have started to set targets to reduce the carbon emissions in their lending and investments. Financial institutions thus encourage companies to speed up the transition to a low carbon economy. This is part of a strategy towards long term value creation, as carbon related risks increase in the medium to long term.

The article is organised as follows. Section 2 indicates that financial risks increasingly originate from ecological drivers. Section 3 analyses climate change and the adverse scenario of a late and sudden transition to a low carbon economy. Next, Section 4 examines the impact of the bursting of the carbon bubble on the financial system. Section 5 discusses the appropriate role of financial supervisors with regard to the ecologically driven financial risks. A key element is the development of a common methodology to measure and disclose carbon emissions embedded

in financial firms' assets. Section 6 analyses which strategies financial firms can adopt to deal with environmental risks. Finally, Section 7 concludes.

2. Ecology and finance

The health of the ecology and that of the economy of a region or country have always been intimately linked. From the decline of the Maya empire (Diamond, 2005) to sunspots causing droughts and poor harvests, ecological shocks led to financial crises (Jevons, 1884). That is why current global ecological imbalances should also worry financiers. The overuse of the environment as a sink (CO_2, material trash) and over exploration of scarce resources (water, raw materials) result in climate change, depletion of natural resources and loss of biodiversity. These ecological imbalances develop partly linear and thus predictable, but partly (and the more so the greater the imbalance) also highly unpredictable, with sudden transitions due to tipping points and feedback loops (IPCC, 2014). In 2009, a group of 28 internationally renowned scientists identified and quantified a set of nine planetary boundaries within which humanity can continue to develop and thrive. However, they argue that three of them have already been broken: biodiversity, nitrogen cycle and climate change (Rockström *et al*, 2009).

Ecological imbalances affect the economy in a myriad of ways, many of which are of a global nature. The economic costs of environmental depletion are already significant and are set to increase. The average annual economic cost of human-induced environmental depletion was estimated at approximately $6.6 trillion in 2008, equivalent to 11 per cent of global GDP (UNEP FI, 2011). If environmentally unsustainable activity continues at this scale, the annual costs for the global economy will reach nearly $28.6 trillion by 2050, equivalent to 18 per cent of global GDP. Of this, greenhouse gas (GHG) emissions account for a large and growing share of environmental costs, rising from 69 to 73 per cent between 2008 and 2050.

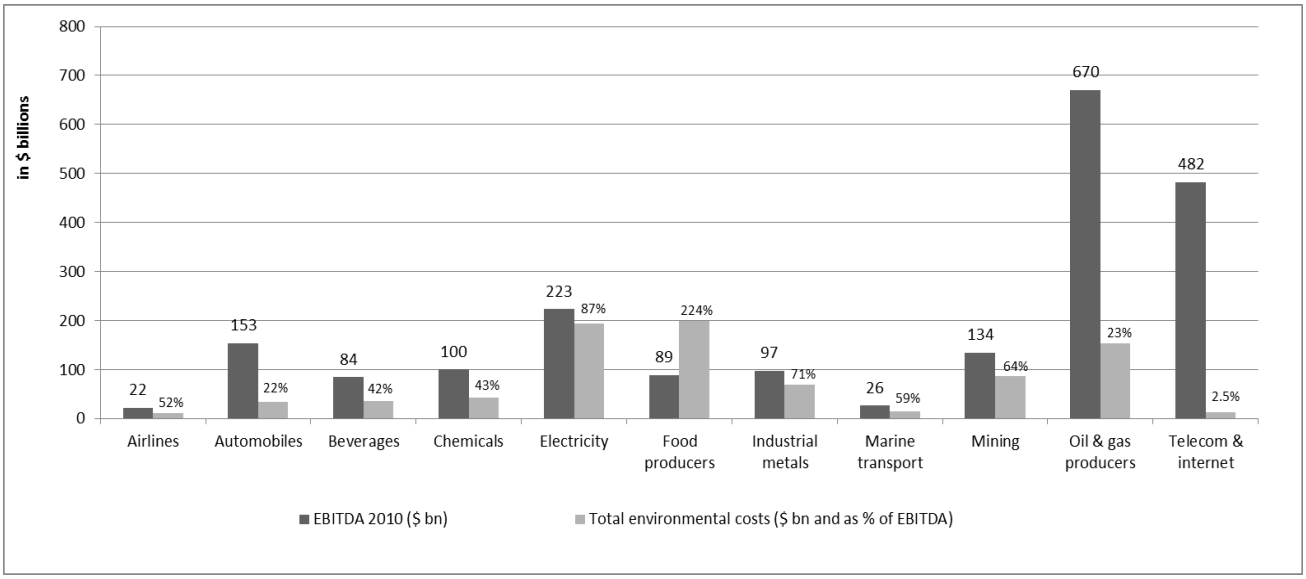
The cost of environmental damage[2] caused by 11 key industry sectors in 2010 was equivalent to 41 per cent (KPMG, 2012) to over half (UNEP FI, 2011) of their pre-tax profits (see Figure 1). Some sectors, such as food producers, would have no profits left if they had to pay the full cost of their negative environmental externalities (KPMG, 2012). The transition to a sustainable economy poses risks to the laggards, but also opportunities for the companies that are front runners. Various studies done by McKinsey for the Ellen MacArthur Foundation (2012, 2013, 2014) illustrate the potential of the circular economy for companies. These studies find net materials cost savings up to $630 billion per year on a global scale and many new jobs created.

As the financial sector is the mirror image of the real economy, it cannot be shielded from these costs (and missed opportunities) in the medium to long term. The costs of externalities are increasingly internalised through regulation and standards, market dynamics and stakeholder actions (KPMG, 2014). If environmental policies are strengthened, the price of assets that are

[2] KPMG (2012) converts 22 environmental impacts into financial value, drawing upon current environmental-economic research. They include greenhouse gases, water abstraction and waste generation. The physical totals of these inputs and outputs are converted into financial values and aggregated to achieve a total environmental cost value. The study is based on the operations of over 800 companies representing 11 sectors.

relatively dependent on the use of these now unpriced environmental services will decrease. The financial risk in the medium term is the sudden pricing of externalities and thus loss of value of stranded assets (see sections 3 and 4).

Figure 1. Negative environmental externalities (in $ bn and percentage of EBITDA; 2010)



Source: KPMG (2012)

These disruptions will have consequences for the financiers as well. Equity owners will be particularly hard hit (pension funds, insurance companies), but also lenders (banks) will suffer because the percentage of non-performing loans will rise (Weyzig *et al*, 2014). More generally, the disruptions may lead to disorderly markets (e.g. disorderly energy markets).

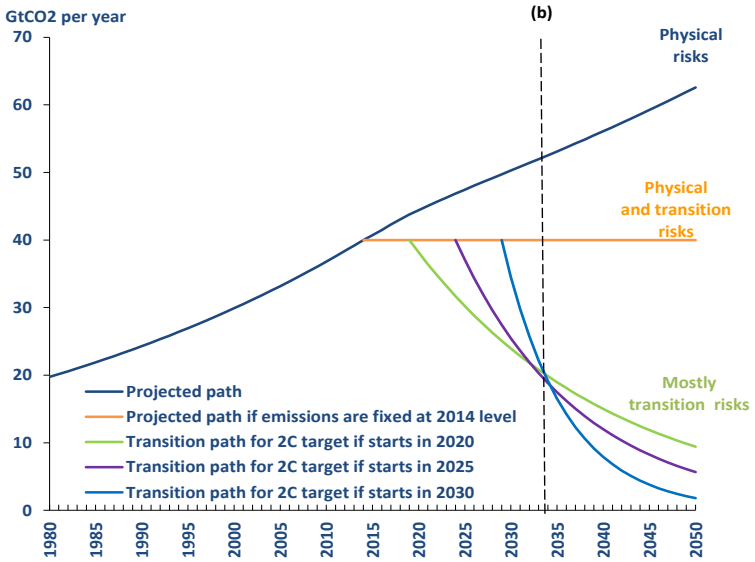
3. Adverse scenario of a late and sudden transition - the climate change example

Consensus around the United Nations Framework Convention on Climate Change (UNFCCC) has established the target of limiting the rise in global average temperatures relative to those prevailing in the pre-industrial world to 2°C. In the recent Paris Agreement, countries have reconfirmed the 2°C target and agreed to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels (UNFCCC, 2015).

This climate target is intended to limit the risk of facing catastrophic and irreversible implications from climate change reaching a tipping point (ASC, 2016). Meeting such target requires ensuring that the stock of carbon dioxide (CO_2) and other greenhouse gases (GHGs) in the atmosphere does not exceed a certain limit. The IPCC (2014) estimates that the total carbon budget amounts to 2,900 $GtCO_2$ (gigatons of CO_2) to limit global warming to 2°C with a probability of 66 per cent. About 2,050 $GtCO_2$ has already been emitted by end of 2014, leading to a remaining carbon budget of 900 $GtCO_2$ from 2015 onwards (Prudential Regulation Authority, 2015). The speed with which the limit is reached depends on the path of emissions. If current emissions are not drastically cut, the 2°C limit would be reached in less than two

decades (see Figure 2). Dietz and Stern (2015) also show the need for strong reductions in carbon emissions to limit global warming to 2° Celsius.

Figure 2. Possible trajectories of carbon emissions



Source: Prudential Regulation Authority (2015)

Uncertainty regarding the timing and speed of the required emissions reductions is high. Under the Paris agreement, many countries have made pledges to significantly reduce carbon emissions over the coming decades (UNFCCC, 2015). These pledges require substitution of renewable energy for fossil fuels, and may imply a costly transition for the global economy.

Different scenarios are possible (ASC, 2016; Weyzig et al 2014). If governments make an early start in implementing existing pledges, a "soft landing" is likely. The transition to a low-carbon economy would be gradual, allowing adequate time for the physical capital stock to be replenished and for technological progress to endogenously contribute to keep energy costs at bearable levels (Stern, 2015). However, the credibility of some existing pledges is in doubt, owing to long horizons over which reductions are promised combined with the short-term costs of immediate action. As a result, there is considerable uncertainty about whether the shift to a low carbon economy will be slow, gradual and benign – or late, abrupt and costly.

The adverse scenario is one of late adjustment, resulting in a "hard landing". In this scenario, the underlying political economy – i.e. the short term political costs of the transition, combined with the need for global coordination of emission cuts (as illustrated by Figure 3) – leads to belated and sudden implementation of constraints on the use of carbon-intensive energy. Back-loaded policy intervention will generate more severe reductions in the flow of emissions. The

"hard-landing" would be exacerbated by a lack of technological progress. The development of promising technologies – such as carbon capture, renewables, and batteries – could transform how energy is produced and stored, providing a boost to real economic activity. However, the future of technological innovation is inherently uncertain (Weitzman, 2013). Current levels of R&D of renewable energy are low, in part owing to uncertainty regarding governments' long-term environmental policies.

A late transition to a low-carbon economy would exacerbate the physical costs of climate change. Global warming, and its implications for the frequency and severity of natural catastrophes, is increasing with the stock of greenhouse gases in the atmosphere. As such, a late transition to a low carbon economy will aggravate the costs of the transition for, among others, general insurers, reinsurers and governments.

In the remainder of the paper, we analyse the impact of the adverse scenario of late adjustment on the financial system. A late and sudden adjustment may have a large impact on the value of carbon intensive assets.

4. Impact of the carbon bubble on the financial system

One of the most studied risks to the financial system stemming from ecological imbalances is the so called 'carbon bubble' (Carbon Tracker, 2011). This refers to the overvaluation of fossil fuel reserves and related assets should the world meet its stated objective of limiting climate change to 2^{o}C compared to the pre-industrial age. Meeting this target puts a limit on future carbon emissions and hence on the amount of fossil fuels that can be burned, requiring a sharp bending of the current trend (see Figure 2).

The next question is which fossil fuels should stay in the ground on order to reach these carbon emission targets. Whereas coal is highly inefficient in terms of emission per unit of energy generated, it is also geographically widespread, meaning that countries do not have to import this. Employment and security reasons may therefore lead to an overuse of coal. Ultimately, the question of which fossil fuels will be used depends also on the international climate negotiations.

If such drastic cuts in carbon emissions are needed, many existing fossil fuels will be 'stranded'. Technology plays an important, yet uncertain, role. First, new technology for Carbon Capture and Storage (CCS) may be developed. Second, new technology may make renewables more cost-efficient, which will also make fossil fuels redundant. Without CCS, McGlade and Ekins (2015) estimate that if global warming is to be kept below 2^{o} Celsius until 2050 that approximately 35% of oil reserves, 52% of gas reserves and 88% of coal reserves are unburnable (see Table 1). When using the CCS technology, the numbers are slightly lower.

Table 1. Unburnable fossil fuel reserves before 2050

	Oil		Gas		Coal	
	Billions of barrels	%	Trillions of cubic metres	%	Gigatonnes (Gt)	%
With CCS	431	33%	95	49%	819	82%
Without CCS	449	35%	100	52%	887	88%

Source: McGlade and Ekins (2015).
Note: The first column reports absolute amounts of unburnable reserves before 2050 and the second column presents unburnable reserves as percentage of current global reserves.

Private oil, gas and coal mining companies own about a quarter of fossil fuel reserves. If a large part of these reserves cannot be extracted or extraction becomes commercially unviable, the valuation of these companies and their ability to repay their debt is reduced. Equity, bond and credit exposures of EU financial institutions to firms holding fossil fuel reserves and to fossil fuel commodities are substantial. Total estimated exposures are €463 billion for banks, €342 billion for insurance companies and €256 billion for pension funds (Weyzig *et al*, 2014). Such large numbers raise serious concerns about the potential consequences of these investments if a large part of the oil, gas and coal reserves ends up stranded. Table 2 indicates that the total exposure of €1,061 billion is for 38 per cent equity financed and for 62 per cent debt financed.

Table 2. Exposures of European financial institutions to fossil fuel firms (in € bn)

	Equity	Debt	Total	As % total assets
Banks	98	365[a)]	463	1.4
Pension funds	196[b)]	60	256	5.0
Insurance	109	233	342	4.0
Total - in € bn	403	658	1,061	
- in % of total	38%	62%	100%	

Notes: a) sum of bonds (62) and loans (303); b) sum of equities (118) plus commodities (78).
Source: Weyzig *et al* (2014).

Weyzig et al (2014) estimate that the loss in the quick transition scenario, the 'low carbon breakthrough', would be:

- For the EU pension sector in the range of 2.5-3.4%, a loss of € 130-180 billion on € 5,100 of total assets.
- For banks the average loss is approximately 0.4% of total assets (€ 140 billion of losses on € 35 trillion of total assets).
- For insurance companies a loss of 1.8% of total assets (losses of € 130 billion on € 7,700 billion of total assets

Whereas these exposures -and potential losses- are large, on their own they will probably not cause a systemic crisis in a healthy economy and financial sector. However, the effect of the bursting of the carbon bubble will not be limited to the oil, gas and coal sectors alone. A sudden transition will be a shock to all sectors using fossil fuels as an input either in the production or in

the use of their products and services. There will be strong adjustments between sectors (electricity powered high speed trains versus fossil fuel jet planes) and within sectors (car manufacturers that specialise in electric cars versus heavy car manufacturers). The financial impact will therefore be much greater than the numbers here indicate.

In the adverse scenario of a sudden and late transition, the financial system could be affected by its exposure to carbon-intensive assets (i.e. real and financial assets whose value depends on the extraction or usage of fossil fuels and other carbon-intensive resources). Moreover, reduced energy supply and increased energy costs would impair macroeconomic activity, as the hard landing would force a rapid transition away from fossil fuel based energy production. These two channels could interact with other financial frictions and stimulate negative feedback loops (ASC, 2016).

While a gradual transition (i.e. the soft landing) would allow for a gradual write-down on long-term carbon intensive infrastructures and assets, a rapid transition would force more radical write-downs due to the negligible scrap value of stranded assets and not fully anticipated losses (Stern, 2015). HSBC estimates that this could result in a 50% decrease in market capitalisation for oil and gas companies, including both the risk of stranded assets and reduced demand (HSBC, 2013). Current market pricing may reflect lack of awareness of the challenges posed by climate change as well as uncertainty regarding the path of policy (ASC, 2016).

The key point is that a sudden implementation of radical environmental policies would lead to abrupt changes in asset prices, which are exacerbated by the long-term nature of the assets. The so-called 'costly trade theory' (Shleifer and Vishny, 1990 and 1997) predicts that due to the capital needs and risk of arbitrage, prices reflect much less long-term information. Therefore the mispricing of assets whose true value will only show in the longer run will be greater. Moreover, markets have difficulties in assessing and pricing future risks, such as ecological risks. Finally, fossil fuel firms and electricity utilities are to a large extent debt financed (see Table 2), exacerbating the potential financial stability impact of a sudden re-valuation of stranded assets.

5. The role of financial supervisors

5.1. Instruments for financial supervisors

From a public policy perspective, the first best option is that governments tackle ecological risks directly. Environment policies can be employed either by placing a price on the negative externalities that environmental degradation entail (e.g. a carbon tax), subsidising alternatives (e.g. renewable energy), creating a market through the government's procurement policies or using regulatory powers in standard setting.

Be that as it may. What could and should financial supervisors do about ecological risks feeding into ever larger financial risks? As a starting point, financial supervisors need to examine the vulnerabilities caused by ecologic risks. In this case a two-step process can be followed:

1. Identifying the ecological risks that give rise to the most material financial risks;

2. Mapping the financial risks that originate from these ecological risks.

A stress test is a supervisory tool to measure the vulnerability of financial institutions to certain risk factors. In this context, financial supervisors can conduct a climate stress test. Whether employed primarily as tool to uncover vulnerabilities in tranquil times or to support crisis management and resolution, a macro stress test can also help to discipline and structure thinking about financial stability among the many parties involved (the "stakeholders"). Macro stress tests can help to inform and reconcile different perspectives (Borio, Drehmann and Tsatsaronis, 2014). The ASC (2016) suggests incorporating risks associated with a "hard landing" into the macroeconomic scenarios used by supervisors in their regular stress testing of regulated financial institutions. In particular, the impact of changes is the price on non-renewable energy sources can be assessed. This macro-approach could show how an energy price shock would propagate through the global economy.

Borio, Drehmann and Tsatsaronis (2014) emphasise that it is critical to design stress tests properly, tailoring them to the specific purpose. In this case, a dedicated carbon stress test can be used to define the most pertinent systemic risks and would be adapted to the specificities of the various climate scenarios, including the "hard landing" scenario. These stress tests should allow for the long time horizon over which adverse events would occur. The methodology of dedicated carbon stress testing is still under development and will depend heavily on the assumed range of emissions pathways (ASC, 2016).

If the stress test finds that financial risks from ecological risks are material, financial supervisors can activate their supervisory instruments. The most appropriate supervisory instruments to deal with material risks related to climate change are large exposure limits and capital adequacy rules (see De Haan, Oosterloo and Schoenmaker, 2015, for an overview of supervisory instruments).

Large exposure rules provide limits to certain exposures as a percentage of total equity capital. An example is a large exposure limit of 25% on individual companies. In that way, the financial institution will not be bankrupt if the risk materialises (i.e. the company failing). In our case, large exposure limits could be applied to overall investment in carbon-intensive assets that are highly vulnerable to an abrupt transition to the low-carbon economy (ASC, 2016).

The risk-weighted capital adequacy framework aims to translate risks to appropriate capital buffers. The capital rules could be adjusted with higher risk weights based on the carbon-intensity of individual exposures in pillar 1 (ASC, 2016). Alternatively, the supervisor could apply a capital add-on in pillar 2 for banks with substantial exposures towards carbon-intensive assets. Comparing the two instruments, the use of quantitative limits (such as large exposure limits) is very intrusive, but also very powerful to reduce carbon exposures. The capital approach relies on the price mechanism to discourage investments in carbon-intensive assets.

5.2. Measuring carbon intensity

A prerequisite to conduct a dedicated carbon stress test is that financial institutions have information on the carbon-intensity or carbon-dependence of the various sectors. Moreover, it is important that financial institutions collect information in a comparable way. A common disclosure standard and a common measurement methodology is therefore important for conducting a carbon stress test, which can be used across a whole range of financial institutions to explore overexposures and concentrations in carbon intensive assets.

To this end the Financial Stability Board (FSB, 2015) has established an industry-led Task Force on Climate-related Financial Disclosures (TCFD). The Task Force will consider the physical, liability and transition risks associated with climate change and what constitutes effective financial disclosures in this area by end-2016. The FSB can built on work on carbon accounting that has been initiated since the 1997 Kyoto protocol. An NGO-business partnership has developed a standardised method for GHG accounting: The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Corporate Standard) was published in 2001, and the second edition in 2006.[3]

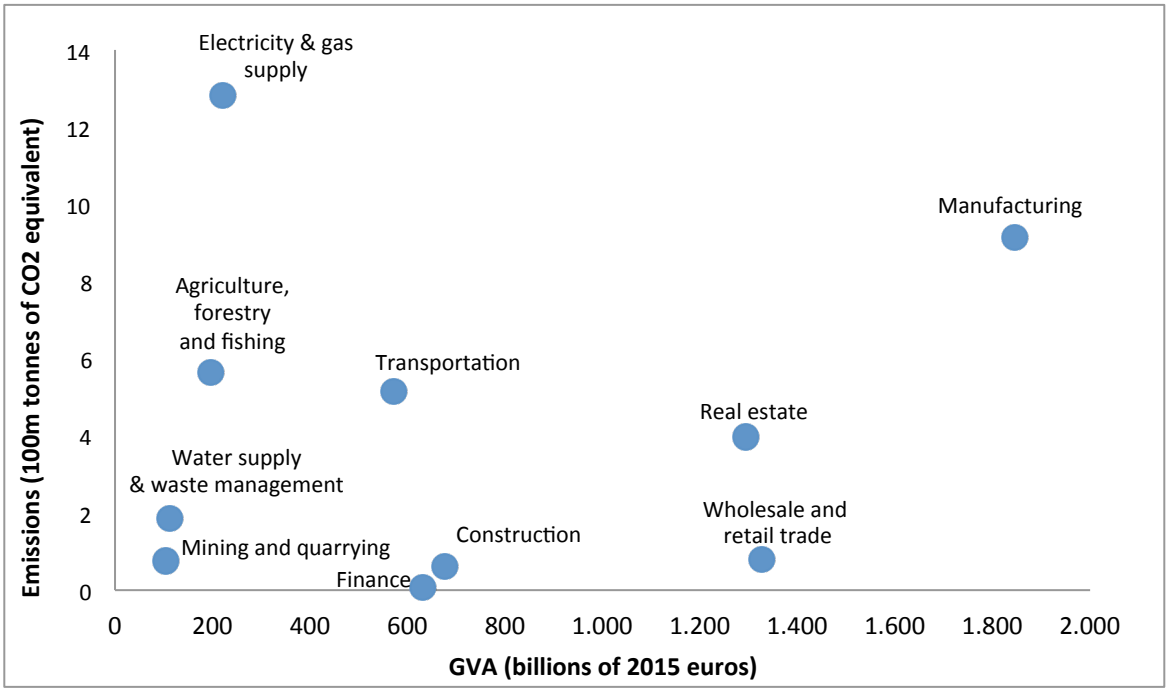
The GHG Protocol (WRI, 2015a) recognises six different greenhouse gases whose emissions are converted to CO_2 equivalents (CO_2eq) using the conversion ratios determined by the Intergovernmental Panel on Climate Change (IPCC). The GHG Protocol distinguishes between direct emissions from sources that are owned or controlled by the reporting entity and indirect emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity. The GHG Protocol further categorises these direct and indirect emissions into three scopes:

- Scope 1: All direct GHG emissions.
- Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.
- Scope 3: Other indirect emissions, the full corporate value chain emissions from the products they buy, manufacture and sell.

Figure 3 shows the GHG-emission of different economic sectors in the EU. Here we see that the financial sector itself has a very low emission of its buildings, computers etc. The real carbon exposure of the financial sector is the so-called scope 3, the indirect emissions through its investments and lending looking at the full value chain. Including scope 3 increases the emissions of banks in general with a factor 1000 (World Development Movement, 2013; Linthorst and Meindertsma, 2015). Figure 3 provides a first indication of the scope 3 emissions in loans and investments to the various sectors.

[3] In 2006, the International Organization for Standardization (ISO) adopted the Corporate Standard as the basis for its ISO 14064-I: Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals (see http://www.ghgprotocol.org/about-ghgp).

Figure 3: Greenhouse gas emissions and GVA by NACE sector, EU-27, 2011



Source: Calculations based on Eurostat data.
Notes: Real estate emissions include household heating and cooling costs.

The next step is to attribute carbon emissions to specific financial institutions or portfolios. The GHG Protocol Corporate Value Chain Standard provides guidance for reporting Scope 3 emissions including the emissions of investments. However, since 2013 a process is under way to offer more specific guidance for the financial sector (WRI, 2015b). Within the GHG Protocol standards, emission reductions are called "avoided emissions".

Carbon accounting by financial institutions is already a widespread practice. Over 120 investors with more than $10 trillion in assets under management by signing the Montreal Pledge committed to annually measure and publically disclose the carbon footprint of their investments (PRI, 2014). In France, from January 2016 onwards financial institutions are obliged to "disclose in their annual report, and make available to their beneficiaries, (…) their exposure to climate-related risks, including the GHG emissions associated with assets owned".[4]

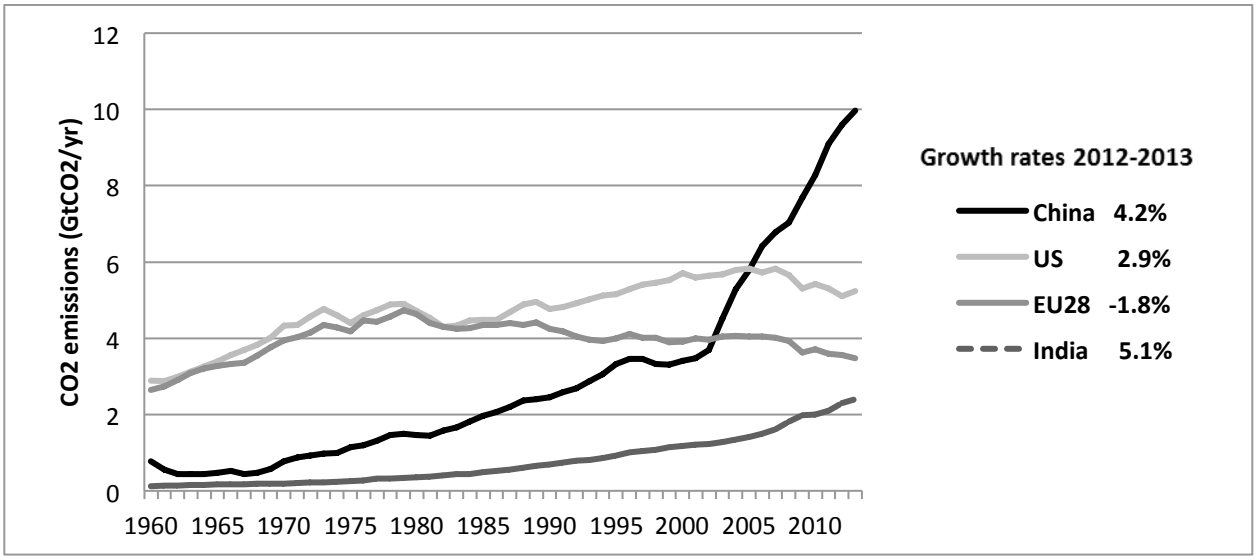
Supervisors are using these data in their supervisory work. Examples are the Climate Change Adaptation Report by the Prudential Regulation Authority (2015), the Chinese Green database (Green Finance Task Force, 2015) and the announcement of the Netherlands Bank (Elderson, 2015) that sustainability will be an explicit theme in its supervision of the pension sector.

[4] Article 173 of the French Law on the Energy Transition for Green Growth.

5.3. Institutional design

Haldane (2014) calls for international coordination in the execution of prudential supervision. That seems in particular relevant for ecological imbalances, as these pose a global financial threat. Moreover, the building up of the imbalances varies across countries, as illustrated by Figure 4, which warrants a differentiated, albeit coordinated, approach.

Figure 4. Absolute carbon emissions and growth rates China, EU, India and US, 1960-2013



Source: Global Carbon Project (2014)

The use of prudential instruments is the responsibility of financial supervisors. However, analysis is often done in conjunction with other organisations and governments. For specific environmental issues this needs to be broadened to include the academic and policy analysis in this particular field (and other stakeholders). As much of this analysis is of a global nature this could be done jointly. Several institutions might be a platform for this (the FSB, the BIS, the IMF, the G20 and several UN-supported platforms).

It is important not only to learn from each other and to do joint research, but also to judge the vulnerability of the financial sector. This can be done through the Financial Sector Assessment Program (FSAP) of the IMF. The FSAP, established in 1999, is a comprehensive and in-depth analysis of a country's financial sector. FSAP assessments are the joint responsibility of the IMF and World Bank in developing and emerging market countries and of the IMF alone in advanced economies. With ecological risks as an integral part of the financial stability assessment a common standard can be set, and guarded. The carbon stress test can thus become an integral component of the FSAP.

6. Strategies for financial firms

What can financial firms do to address ecological risks? Financial firms are increasingly adopting ESG criteria -in addition to financial and economic criteria- in their investment strategies. ESG

investing, also known as socially responsible investing (SRI), implies that investors follow minimal environmental, social and governance standards in their investment decisions. In a meta-study on the performance of SRI funds, Renneboog *et al.* (2008) report that existing studies at the portfolio level hint but do not univocally demonstrate that SRI investment funds perform worse than conventional funds. But Bauer *et al.* (2005) find little evidence that the average performance of SRI in the US and UK is different from that of conventional funds.

Financial firms can basically adopt two strategies, when adopting an ESG mandate. A first strategy is to avoid overexposures to ecological risks and follow the supervisory guidance (as discussed above). This minimal variant is a re-active strategy. A second strategy is not only to reduce carbon-intensive investments, but also to finance the transition to a low carbon economy. This latter strategy is focused on long term value creation. The impact of economic activities on the environment is typically felt in the long term. By contrast, conventional finance is mostly focused on the short term, which is reinforced by quarterly reporting of financial results (Graham *et al,* 2005). Barton and Wiseman (2014) suggest that insurance companies and pension funds, as long term investors, should engage with corporate boards to focus capital on the long term. Such a long term focus would include avoiding environmental hazards which materialise over the medium to long term as well as grasping the opportunities offered by low carbon investments which pay off in the long term.

Increasingly, financial institutions are setting targets to reduce the financed carbon emissions. By signing the Portfolio Decarbonization Coalition 25 investors with a total of $ 600 billion in assets under management pledged to gradually reduce their carbon exposure (UNEPFI, 2015). Individual financial institutions are also setting themselves carbon exposure reduction targets. The two largest Dutch pension funds PFZW and ABP respectively set themselves a reduction target of 50% and 25% before 2020 (PFZW, 2015). Allianz, a major European insurer, is another example of institutional investors with explicit climate objectives in their long term investment strategies (Allianz, 2015). Finally, Dutch ethical bank ASN set itself the target to become wholly climate neutral in 2030.

To strengthen the long term focus, we suggest to incorporate long term value creation as an objective for corporates in the corporate governance code, which is a form of soft, flexible law. A corporate governance code provides a set of best practices adopted by business associations and consists of a set of reference standards for use by any reputable company. Including long term value creation in these codes would stimulate companies and their financiers to manage and reduce environmental risks, with a pay-off in the medium to long term.

7. Conclusions

This paper has shown that ecologically driven financial risks are increasing. Several financial market imperfections make that individual financial institutions are not willing or able to effectively reduce these risks. That is why public policy has a role to play. The first best option is for governments to price these risks (e.g. carbon taxes, emission rights and caps). The earlier governments adopt climate policies, the better these risks can be contained. Nevertheless, as

these policies are currently not sufficiently implemented, systemic financial risks resulting from ecological pressures are allowed to build up and concentrate in certain financial institutions and markets, thus threatening financial stability.

Financial shocks may originate from ecological imbalances, triggered by either intensified environmental policies, technological breakthroughs (e.g. cheap renewable energy), an expectation of this in financial markets or due to the economic costs of crossing these ecological boundaries (e.g. climate change disrupting economies). To measure the full scale of environmental risks, financial institutions need to adopt a value chain approach including direct exposures of financial institutions themselves as well as indirect exposures through lending or investments in companies. Provisional estimates suggest that the impact of carbon related exposures on the financial system might be large. Following the ASC (2016), we suggest to conduct a dedicated carbon stress test to refine the measurement of exposures of individual financial institutions to an adverse scenario of a late and sudden transition to a low carbon economy. Next, we identify capital instruments (increasing risk weights) and large exposure restrictions as the most promising prudential instruments for carbon intensive assets.

More broadly, it is important to develop scenarios for the different sustainability challenges (carbon bubble, climate change, water and material shortage) that provide estimates of losses and gains for different financial instruments (equity and debt) over different economic sectors and the kind of companies within those sectors. This further research can clarify which sustainability themes are the most important from a financial stability perspective. This may also help in deciding which of the described prudential instruments are best suited for this challenge. Lastly, in order to stimulate learning and identify potential weaknesses in the supervision of the globally connected financial system, we propose that the IMF's FSAP takes this ecological dimension into account.

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