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LIMITING GLOBAL WARMING TO 2°C: A CARBON STRESS TEST OF THE DUTCH FINANCIAL SECTOR

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All errors are the responsibility of the author.

Abstract

Recent breakthroughs in the policy environment of climate change shifted the paradigm for companies engaged in the fossil fuel value chain. Policy "shocks" with respect to the regulation and pricing of carbon emissions may accelerate the carbon transition, thereby causing harm to those companies whose business model is still centred around oil, gas and coal.

The financial sector is exposed to the fossil fuel industry primarily via equity holdings, bonds and loans. Using a DCF analysis based on the 450 Scenario of the International Energy Agency and a pricing formula for bonds, a carbon stress test is applied to determine the expected loss for the vast majority of Dutch banks, insurers and pension funds. While the direct fossil fuel portfolio losses seem manageable, policymakers need to require more carbon related data disclosure for all carbon intensive industries in order to improve the comprehensiveness of carbon stress tests.

Keywords: *stress test, climate change, financial sector*

List of abbreviations

Phrase	Definition
450S	450 Scenario
ABP	National Civil Pension Fund (NL)
CCS	carbon capture and storage
CET 1	Common Equity Tier 1
CPI	Climate Policy Initiative
CPS	Current Policy Scenario
DCF	Discounted Cash Flow
DNB	De Nederlandsche Bank / Dutch National Bank
ESRB	European Systemic Risk Board
EUR	Euro (European monetary unit)
EV	electric vehicle
FTSE	Financial Times Stock Exchange
GHG	greenhouse gas emissions
Gt	giga tonnes
ICAAP	Internal Capital Adequacy Assessment Process
ICBC	Industrial and Commercial Bank of China
IEA	International Energy Association
IPE	Investment & Pension Europe
IPCC	Intergovernmental Penal on Climate Change
LTO	low tight oil
OECD	Organisation for Economic Cooperation and Development
PFZW	Stichting Pensioenfonds Zorg and Welzijn
PMT	Pensioensfonds Metaal en Techniek
PPM	parts per million
S&P 500	Standard & Poor's 500
TCF	trade commodity finance
UNFCC	United Nations Framework Convention on Climate Change
USD	United States Dollar

1. Introduction

Although the IPCC (1995) already indicated strong scientific evidence that climate change is caused by human activities in 1995, this has become overwhelming scientific consensus in the 21st century (Oreskes, 2004; Alley et al, 2003). It is this scientific consensus and its daunting implications on future generations that have made 195 governments from all over the world agree to an unprecedented climate change agreement in December 2015 (UNFCC, 2015). The Paris Agreement aims to curb the rise in global warming below 2°C above pre-industrial levels. However, this target remains only realistic if governments align their economic and environmental policy accordingly by implementing carbon-pricing mechanisms, including a carbon tax or a cap-and-trade policy that limits the amount of greenhouse gases (GHG) that may be emitted. Therefore, the current uncertainty related to climate change politics is not about the *if*, but how and when the transition will be implemented.

While it has been shown that postponing climate change action will be far costlier from an economic point of view; inaction would be equivalent to losing at least 5% of global GDP each year (Stern, 2007). Yet, some companies would have to suffer more losses in the short term, leading to potential destabilisations across the economy.

In a world with tighter carbon regulation, more natural resources would have to stay in the ground and remain "unburnable." This would have most adverse implications for companies engaged in the oil and gas industry with the highest marginal extraction cost. In other words, most affected are companies at the high end of the industry cost curve that tend to be most carbon intensive. The reason for this is that high-cost sources of production, such as deep-water, oil sands or low tight oil (LTO) require a higher energy intensity in the extraction process. These companies are primarily private multinational integrated oil companies. (Lewis et al, 2014)

This paper simulates the implications of a stricter environmental regulation by applying a 2°C scenario of the International Energy Agency (IEA) on the valuation of stocks, bonds and loans from multinational integrated oil companies. Since the financial sector is exposed to this development by stock, bond and loan holdings of fossil fuel companies, a "carbon shock" is applied to the portfolio of the largest Dutch banks, insurers and pension funds. Stocks are valued according to a DCF model, whereas bonds and loans are valued according to a readjustment in recovery rates and probability of default. The most affected asset class is stocks, followed by bonds and loans. Pension funds have the highest exposure to transition risk because of significant stock holdings in their portfolios. The overall risks for Dutch financial institutions seem manageable, but need to be observed more closely in order to make more accurate judgments about the expected future losses.

The first part of the paper starts with a literature review and the explanation of crucial concepts, including "carbon budget," "carbon bubble," and "stranded assets." Chapter three discusses stress testing in general and the emerging field of climate stress testing in particular. Chapter four introduces the data about the carbon exposure of Dutch financial institutions before the methodology of the stress test is laid out in chapter five. Chapter six states the results of the stress test for banks, insurers and pension funds. The discussion and methodological limitations are presented in chapter seven and eight, respectively.

2. Literature Review

The financial sector will be affected by direct and indirect effects of climate change. Physical impacts of climate change are likely to affect insurance companies directly via the increase of acute risk and chronic risk. Acute risk manifests itself in the form of extreme weather events such as hurricanes, floods or tropical cyclones and is predicted to occur more often and with higher intensity (IPCC, 2014). Additionally, an increase in global warming is predicted to be accompanied by long-term structural shifts in climate patterns that may cause sea level rise or chronic heat waves. A case study about flood risks in the Netherlands by the Dutch National Bank (DNB, 2017a) finds three distinctive impacts on the financial sector: first, through direct exposure to commercial and residential buildings in affected areas, secondly through downward valuations of Dutch sovereign bonds and thirdly through secondary effects, such as lower economic growth or higher borrowing and lending costs for Dutch assets. In one adverse flood risk scenario, losses amount to EUR 60 billion to the Dutch economy, according to a scenario by the Dutch National Bank (2017).

The indirect effects of climate change on the financial sector are mainly related to the transition to a lower-carbon economy, implying extensive policy, legal, technology, and market changes in order to address mitigation and adaption requirements. Depending on the speed and smoothness of adjustment of the transition, such risk factors may pose varying levels of risk to the institutions if they are being held responsible for climate change in their role as financers (DNB, 2016). Although courts have so far restricted the claims for affected parties, a single legal decision may set a precedent for liability. It is expected that insurers are most exposed to potential liability risks as providers of liability coverage to companies engaged in the fossil fuel sector (Actuaries Institute, 2016).

2.1 The concept of "carbon budget," "carbon bubble" and "stranded assets"

Since this paper focuses on the transition risks of climate change, that is, a policy "shock" on the financial sector related to climate change regulation, some concepts need more clarification. In this context, "climate risk" can be interpreted as "carbon risk" because a more stringent climate change policy essentially implies a higher price on GHGs (The Climate Institute, 2015).

The negotiated agreement at the Paris climate conference in 2015 aims to curb the rise in global temperature "well below 2°C" of global warming until 2100 (UNFCCC, 2015). Nevertheless, just using the already listed reserves of coal, oil and gas on the world's stock markets in the next 40 years would cause global warming to rise beyond 2°C (Carbon Tracker Initiative, 2013). This would assume the unrealistic scenario that no new fossil fuel resources are explored and burned during the period. It is also not taking into account that two thirds of proven reserves is held by privately or state-owned companies. In other words, the world's "carbon budget", the maximum amount of carbon emissions that may still be emitted under a two degree scenario, is quickly running out. Researchers estimate that only a fraction of the proven reserves of listed companies can be used unmitigated.[1]

Despite the evidence, current valuations of most companies involved in the carbon extraction value chain appear to be based on the assumption that all reserves will be fully exploited (Boston Common Asset Management, 2014). The promise of extracting explored assets is the key determinant of a firm's value that is engaged in the natural resources extraction segment. An analysis by McKinsey and the Carbon Trust (2008) estimated that more than 50% of the value of a publicly listed oil and gas company resides in the values of cash flows to be generated in year 11 and onwards. Thus, applying a transition scenario towards a low carbon economy implies a necessity to write off many "stranded assets" in the coal, oil and gas sector. By this metric, most companies in this sector appear to be significantly overvalued by the market. Although some price corrections have already taken place in recent years, most notably reflected by the drop in equity value among coal companies, new climate policies have not yet had a decisive impact on the stock prices of fossil fuel producers (DNB, 2016).

[1] That is, only 900 GtCO2 of the total 1541 GtCO2 until 2050, and only another 75 GtCO2 until 2100 (Carbon Tracker Initiative, 2013). The World Resources Institute (2015) estimates that two thirds of currently proven coal, oil and gas reserves would have to remain in the ground. McGlade and Elkins (2015) estimate that under a two degree global warming scenario, 33% of current oil reserves, 49% of gas reserves and 82% of coal reserves are unusable.

Research by the ESRB (2016) concludes that current market pricing reflects a lack of awareness of the challenges related to climate change, including widespread uncertainty regarding the path of policy.[2]

Stranded carbon intensive assets can be rendered "unburnable" and form the basis of a "carbon bubble" in the financial sector (Baron & Fischer, 2015). Estimating a precise number for the amount of stranded assets leads to a wide divergence across various sources. According to the IEA's 2°C compatible 450 scenario, USD 304 billion of stranded assets "will not recover all or part of their investment during the time that they are operational" by 2035 (IEA, 2014).[3] A study by the Climate Policy Initiative (2014) estimates stranded assets as the difference in net value of output in a 2°C scenarios as opposed to a hypothetical business as usual scenario. This includes foregone revenues due to a combination of lower volume and prices of fossil fuels. According to their research, until 2035 stranded assets in power generation amount to USD 50 billion and in the coal and gas sector to USD 600 billion and USD 400 billion, respectively (CPI, 2014). In a similar study, Lewis et al (2014), assuming the IEA 450 scenario, find that oil, gas and coal companies could lose USD 28 trillion in revenue over the next 20 years compared with baseline projections. Just the oil industry alone would face a 21% reduction in sales revenue.

The substantial difference boils down to the different definition of assets: the IEA applies a narrower definition and assumes assets as physical capital without taking into account any foregone revenues (IEA, 2014). It should further be mentioned that the estimates by the IEA and CPI are based on a relatively smooth low-carbon transition, also assuming technological progress for carbon capture and storage (CCS).

There are two important factors that could trigger a less orderly transition. First, an unanticipated breakthrough in low-carbon technologies that leads to more rapid cost decreases of technologies such as renewable energy, electricity storage or electric vehicles (Baron & Fischer, 2015).

[2] Some of the largest multinationals in the oil and gas extraction business admitted that their business strategy is based on a 4°C global warming scenario (Macalister, 2015) (Davidson, 2017). Other peers, such as Exxon Mobil and Chevron argued prior to the multilateral Paris Agreement that climate change action is unlikely to occur and thus will not affect their business (Exxon Mobil, 2014).

[3] The largest stranded share of USD 180 billion is allocated in the upstream oil and gas investments, followed by USD 120 billion for new fossil fuel capacity in the power sector and just USD 4 billion in the coal mining sector, since most of the initial investment cost have already been recovered. Because state-owned companies own the majority of oil and gas reserves worldwide, they are predicted to be most affected (Mitchell, Marcel, & Mitchell, 2015).

Second, while future scenarios assume smooth evolutions in energy prices, sudden price movements could potentially interfere with such scenarios. Energy prices have the potential to react imminently and strongly to the economic environment and shifts in supply and demand. In June 2014, the oil price stood at USD 105 per barrel and fell to USD 45 in September 2015. The current situation poses a dilemma for the oil and gas industry: while low prices render many explored projects unprofitable, a price increase further incentivises the research and development activities for green alternative technologies (Mitchell et al, 2015).

Even if the discussed write offs for stranded assets would follow an orderly energy transition and occur over a longer time period, it will almost inevitably pose shocks to the world economy, especially once investors lose confidence and start divesting the affected asset classes. Clerk et al (2016) find that while the first-order impact of financial sector losses on carbon intensive assets seems manageable, the initial shock could trigger negative feedback loops due to information spillovers. In fact, recent macroeconomic modelling estimates that major stock markets might plunge by 15% - 20% after markets would correctly price assets according to a two degrees global warming scenario (CISL, 2015).

In this paper divestment is defined as “the action or process of selling off subsidiary business interest or investments” (Stevenson, 2010) triggered by risks related to climate change. Ansar et al (2013) analyse the impact of investor’s divestment outflows from fossil fuel companies, which could quickly lead to stigmatisation, a higher uncertainty that such firms are able to convert its reserves into positive cash flows, financing problems and a lower intrinsic value of a stock. As predicted in the report, coal companies characterised by larger fossil fuel emissions than companies in the oil and gas sector are particularly vulnerable of being stigmatised as “scapegoats” for climate change. The recent global divestment movement directed against coal companies shows how rapid divestment movements can gain momentum when public campaigns are effectively carried out (Ayling & Gunningham, 2017).[4]

However, the risk of divestment may not be limited to the fossil fuel industry. In a similar fashion, financial institutions are facing reputational risks if customers and other stakeholders raise concerns about certain exposures. This may further contribute to a shift of investor’s appetite away from carbon intensive assets.

[4] After Bank of America announced in May 2015 that it intends to reduce its financial exposure to the coal sector, other major financial institutions, such as Crédit Agricole, Citibank and Allianz followed suit (Batten, Sowerbutts, & Tanaka, 2016).

2.2 Transition risks for banks, pension funds and insurers

Given the described transition risks, banks are primarily affected through the exposure of bonds and loans to counterparties in sectors characterised by high fossil fuel abatement, including but not limited to the fossil fuel industry, electricity production, heavy industry, agriculture, real estate and transport (French Treasury, 2015). In order to assess the transition risks banks are facing, it is thus necessary to identify the sectorial exposures most sensitive to the transition. Some of the European national banking authorities have recently started to analyse the scope of their financial carbon exposure: research by the Dutch National Bank (2016) finds that 11% of total assets in the balance sheets of the three largest banks is tied to carbon-intensive sectors. For the major French banks, the exposure amounts to almost 13% (French Treasury, 2015).

The portfolios of pension funds are vulnerable through the direct exposure to transition risks mainly via listed equity holdings of companies in fossil fuel intense sectors, and to a lesser extent, bond holdings. Since institutional investors tend to invest in equity via main stock exchange indices, the exposure to carbon bubble risk of an equity portfolio depends on the selected index (Weyzig, Kuepper, van Gelder, & van Tilburg, 2014). The weight of the fossil fuel sector (including oil, gas and coal) in the major stock exchanges ranges from approximately less than 10% in the French Euronext, 11% in the US S&P 500 index to more than 20% in the London Stock Exchange (Carbon Tracker Initiative, 2011). By the end of March 2016, the oil and gas sector alone accounted for 12.5% of the FTSE 100 index in London (Batten et al, 2016).

Research by Mercer (2015) concludes that the traditional approach of institutional investors to strategically allocate assets over different classes, i.e. equity, bonds and real estate, is not effective when hedging against a carbon bubble because climate change risk affects these asset classes at the same time. It will be more important to focus instead on the risk within each asset class, for example low-carbon and high-carbon listed equities.

The transition to a low carbon economy is likely to affect both the asset and liability side of insurance companies' balance sheets (Prudential Regulation Authority, 2015). If business activity in carbon-intensive sectors will be reduced, this would negatively affect insurers' liabilities via a decrease in insurance premiums. The current share of the energy sector for the UK general insurance industry is estimated to be around 4% (PRA, 2015).

On the asset side, insurer's investment portfolios are likely to be negatively impacted by mispriced carbon-intensive assets with broad implications for both life and general insurers.

The financial authority of the UK estimates a 5% exposure of total life insurance and a 2.2% of total non-life assets to the energy sector, with most investments in bonds rather than equities (PRA,2015). Overall, the PRA concludes that transition risks for insurers are manageable; nevertheless, life insurers will be most affected due to the nature of the relatively long-term horizon of their investments.

3. Stress Testing

As a supervisory tool, a stress test serves to measure the extent of vulnerability of financial institutions to certain pre-specified risk factors. It is intended to provide an indication how much capital might be necessary to absorb potential losses as a consequence of a large shock (Basel Committee on Banking Supervision, 2009).

In the context of global warming as a consequence of climate change, this paper employs a stress test based on the carbon exposure of the Dutch financial system, including major banks, insurance companies and pension funds.

3.1 Linking traditional stress testing to a climate change stress test

Stress testing can be conducted for two ends: either for macro- or micro-prudential purposes. Macro-prudential stress tests are employed in order to assess the impact of an adverse macroeconomic shock scenario on the financial system as a whole, whereas micro-prudential stress tests intend to measure the financial resilience of individual institutions (DNB, 2017b). Despite the recent pressure of institutional investors for more disclosure of climate change related risk, no individual financial institution has yet conducted a climate change stress test (Flood, 2017).

Furthermore, two types of stress tests are most commonly applied in the context of the Internal Capital Adequacy Assessment Process (ICAAP) of the Committee of European Banking Supervisors (2006): scenario tests and sensitivity analysis. Sensitivity analysis only evaluates the impact of an individual risk driver on an institution's financial robustness. In contrast, scenario analysis is a more complex approach, characterised by multiple and simultaneously moving risk drivers, such as long- and short term interest rates, inflation, GDP growth, unemployment, real estate prices or equity indices (DNB, 2017b).

Selecting the specific model for the stress test may start with events that challenge the viability of the bank, so called "tail events." As the current paradigm of best practice states, scenarios should be applied that are "severe, yet plausible:" severe enough to have an impact yet plausible enough to be taken seriously (Quagliarello, 2009). To take an earthquake analogy: how severe and long is the earthquake, and how solid does the fundament of the house still have to be once the earthquake has stopped?

The Advisory Scientific Committee of the European Systemic Risk Board (ESRB, 2016) suggests that the most severe systemic risk for the EU financial system lies in a late and sudden adaption of climate change regulation, the so-called "hard landing" scenario. The underlying assumption for a transition scenario is not *if* there will be stricter climate change regulation but *when*.

The reasons why many stakeholders around the issue have not placed much importance on climate change as a shock scenario are twofold. First of all, behavioural biases play a role: human beings tend to be biased against correctly assessing the impact of low probabilities events on one variable, and even more so if it comes to a portfolio with many correlated exposures (Tversky & Kahneman, 1974). Hence, it is difficult to intuitively grasp the impact of an adverse shock on unidentified risk factors and the wider financial system.

Secondly, transition risk is usually not regarded as a shock but rather as a long process with various policy steps towards a low carbon economy. However, this must not be the case, as the sudden regulation of tobacco in the US or nuclear energy in Germany has shown.[5]

For a common top-down stress test framework, the credit risk exposures of a bank play a major role. Such exposures are generally related to a bank's lending portfolio: in times of economic stress, higher unemployment implies that more households will fail to meet their mortgage re-payments. Similarly, more bankrupt firms default on their loans. As a consequence, banks will incur more losses and need to write off assets on their balance sheet on a larger scale (impairment) (DNB, 2017a).

Additionally, the predefined risk drivers of a stress test also affect market risk exposure. If stock markets lose substantial value, all financial institutions that are exposed to equity investments are facing impairments and value adjustments (Henry & Kok, 2013).

[5] The US government was able to take action decisively and rapidly, despite the existence of a strong lobby (Saloojee & Dagli, 2000). In the context of energy and environment politics, the German government initiated a sudden energy transition ("Energiewende") in the aftermath of the Fukushima catastrophe in 2011 (Smedley, 2013). As a consequence, an immediate phase out of almost all German nuclear power plants was mandated, causing billions of stranded nuclear assets and shockwaves for the valuation of German utilities. RWE and EON, the largest utility provider in Germany, lost billions of its market value in the course of a few days (Meinke, 2011).

The climate stress test applied in this paper also focuses on credit and market risk exposure. Specifically, the carbon intensive exposures are analysed with respect to each asset class. Credit risk for banks materialises if carbon intensive companies in the oil, gas and coal sector will be unable to meet their credit obligations. All financial institutions are exposed to market risk via equity holdings of companies in the carbon intensive sectors; this will lead to impairments as a result of value adjustments of those companies on the stock exchange.

The last step and ultimate goal of a stress test is to assess whether the financial institutions still possess sufficient liquid capital to absorb the losses. In order to do so, the amount of core capital is weighted against a pre-defined threshold of risk-weighted assets. For example, the European Banking Authority (2014) recommends a threshold value at a core capital ratio of 5.5% (Common Equity Tier 1 ratio or CET 1 ratio). Core capital, usually referred to as "Tier 1 capital," is the most important parameter to measure a bank's resilience against adverse shocks because it has the highest loss absorbing capacity (DNB, 2017b). Tier 1 capital must predominantly consist of common stock and retained earnings (European Actuarial Consultative Group, 2013).

A similar approach is valid for insurers. For insurers located in the EU, the unique regulatory framework on which capital requirements for insurers rests is called Solvency II. The solvency ratio under Solvency II bases eligible own funds against required capital and needs to be higher than 99.5%. Similar to the banking sector, such own funds need to be mostly (80%) made up of tier 1 capital, and the remaining share of tier 2 and tier 3 capital. The required capital depends on the risk exposure of the portfolio of the insurer, where equities are heavier weighted than government bonds. (DNB, 2016)

However, in a stress scenario the core capital of a financial institution is negatively affected by the change in net income due to impairments and a decreased value of investments, among other factors. This effect remains the same, irrespective if the shock is caused by carbon transition risk or a structural break in the business cycle.

Lastly, the outcome of every stress test is strongly contingent on both the chosen scenario and modelling assumptions (DNB, 2017b). The contextual element of a stress test is therefore critical to bear in mind.

3.2 Climate change stress testing

The academic field of climate change risk for financial stability is relatively new. The Industrial and Commercial Bank of China contributed to the theoretical approach of financial stress testing based on environmental factors on credit risks of banks (ICBC, 2016). Weyzig et al (2014) investigate carbon exposures of EU financial institutions and emphasise the need for a "carbon stress test." Applying a network analysis of the exposures of financial actors in the EU to cli- mate-relevant sectors, Battiston et al (2017) find that although direct exposures are small, combined exposures are substantial and amplified via financial counterparties. The analysis in this paper does not take into account second order effects, which most likely understates the implications of the stress test. Second order effects are part of a "cause-effect" chain triggered by an external shock that has an impact on key economic and financial variables responding endogenously to the scenario (Miller, 2006).

In a stress test related framework, the World Resources Institute (2015) suggests how to evaluate the financial impact of carbon asset risk on the financial portfolio level. An example of an applied scenario-based approach on the portfolio-level risk assessment is Mercer's (2015) "Investing in a Time of Climate Change" that integrates four climate scenarios and four climate risk factors into an investment modelling process along traditional assumptions and input factors. The impact of climate change on portfolio returns, asset classes and industry sectors is modelled for a 35-year timeframe (2015 – 2050). The study concludes that despite a moderate long-term impact of climate risks on a diversified portfolio, short-term transition risks are severe for the coal, oil and utilities sector.

The Cambridge Institute for Sustainable Leadership (2015) analyses the climate change impact on economic growth and investment portfolios using a common macroeconomic general equilibrium model with three distinctive climate scenarios over a five-year period (2015 – 2020). The model predicts strong repercussions on the economy in the short to medium term.

4. The Data

Company input data for the five largest integrated oil and gas producers in the world by revenue (Exxon Mobil, Shell, BP, ConocoPhillips and Total) was retrieved from Bloomberg and publicly available financial statements. The predictions used in the analysis of the paper are based on the International Energy Agency's[6] (IEA) Current Policy Scenario and the 450 Scenario. Data for capital expenditure projections are based on the work of Accenture (2016). The six largest pension funds in the Netherlands were retrieved from a ranking by Investment Pension Europe that was published in September 2016 (IPE, 2016). Wherever data was only

[6] The International Energy Agency (IEA) is an intergovernmental organisation founded 1973 by the OECD member countries as a response to the oil crisis 1973. Ever since, it publishes a yearly World Energy Outlook about relevant energy trends and predictions for multiple scenarios.

exhibited in Euro, the data was converted to USD based on the exchange rate on 1 January 2018 to stay coherent throughout the analysis.

For an analysis of the Dutch financial sector's exposure to high-carbon assets, aggregate data for the three largest banks, six insurers and six pension funds were provided by the Dutch National Bank (DNB). These institutions comprise together 75% of the cumulative balance sheet total of the Dutch financial sector. The initial survey by the DNB was held at the beginning of 2016. The data on the specific exposure of each asset class to the fossil fuel industry relates to the entire value chain of oil, gas and coal companies, meaning that downstream extraction companies are included as well as suppliers, service providers and related infrastructure (e.g. pipe- lines). (DNB, 2017a)

The total carbon asset exposure of the Dutch financial sector by asset class and industries

Although this paper only investigates the consequences of the carbon asset exposure to the fossil fuel industry, this is not the only sector that may be affected by a carbon bubble. The following sectors also carry significant carbon asset risks: traditional power generation, chemical industry, construction materials, metal and mining, paper and lumber, transport (air, road and maritime) as well as agriculture and food.

Figure 1 illustrates the exposure to fossil fuel intensive assets by industry. Financial institutions are most exposed to the fossil fuel sector (3.2%), followed by agriculture and food (2.8%) and transport (1.8%). The total exposure expressed as the sum of all carbon intensive industries exposure amounts to 10.7%.

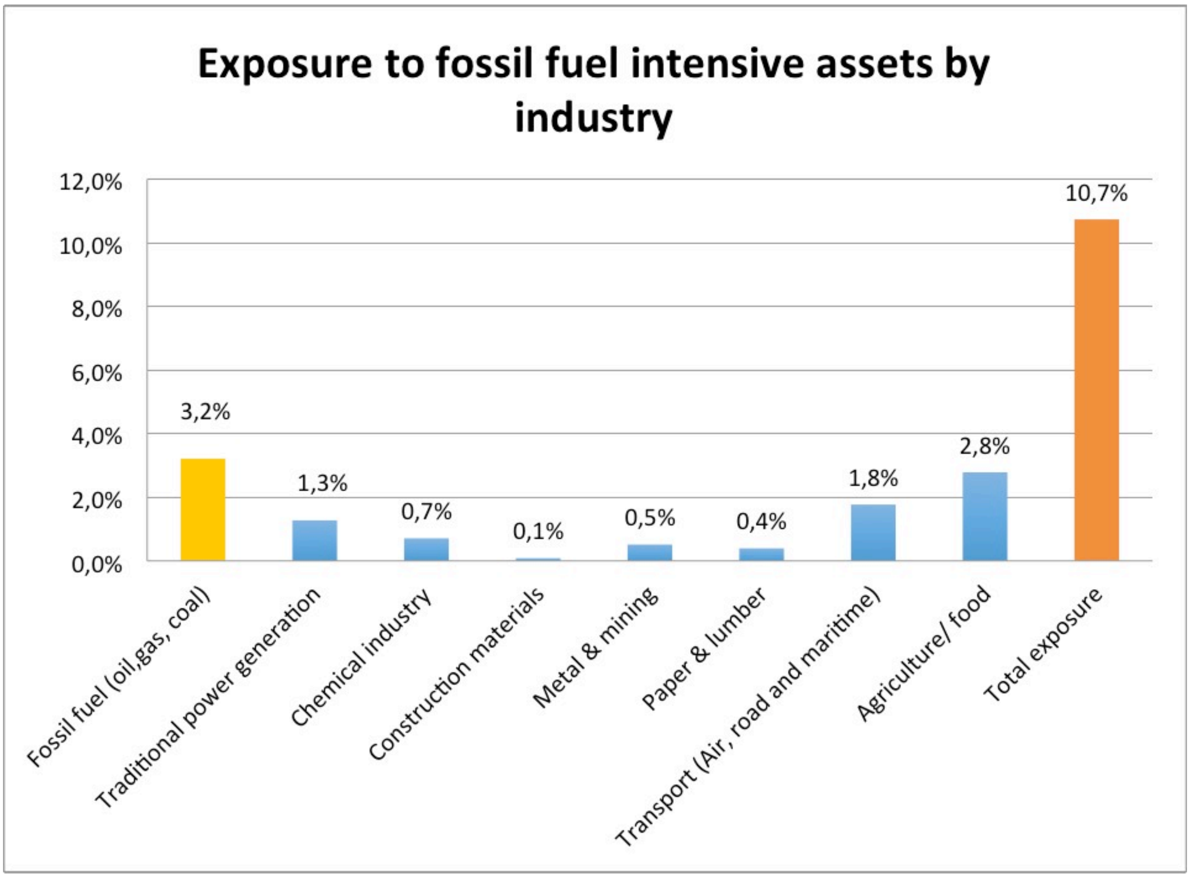

Figure 1: Exposure to fossil fuel intensive assets by industry (expressed as percentage of total assets)

The exposure per asset class is exhibited in Figure 2. Loans are in relation to other assets most exposed to carbon asset risk: 13.1% of all loans are loans from fossil fuel intensive sectors. The second most exposed asset class is stocks with 9.9%, followed by alternative investments with 7.1% and bonds with 6.8% exposure. The average exposure per asset class is 9.2%.

To conclude, the overall exposure levels per industry and asset class become significant when added together. While investigating specifically the fossil fuel sector (oil, gas and coal) can only give a partial result in case of a shock, it is likely that exposures of that magnitude to other carbon intensive sectors will also have repercussions on the balance sheets of financial institutions.

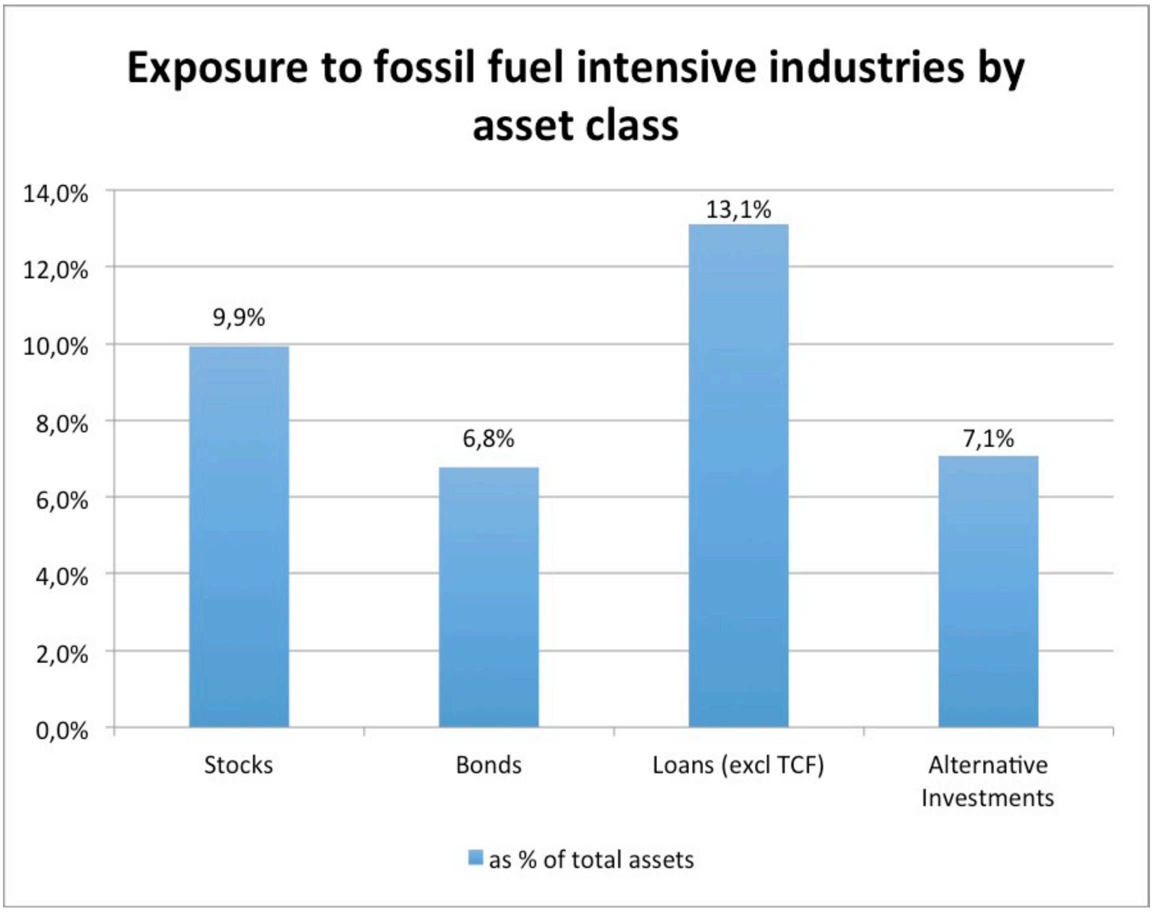

Figure 2: Exposure to fossil fuel intensive sectors by asset class (expressed as percentage of total assets

Among the three largest financial sectors in the Netherlands, the banking industry holds more than half of total assets (56%), followed by pension funds (26.6%) and insurers (17.4%) (Figure 3).

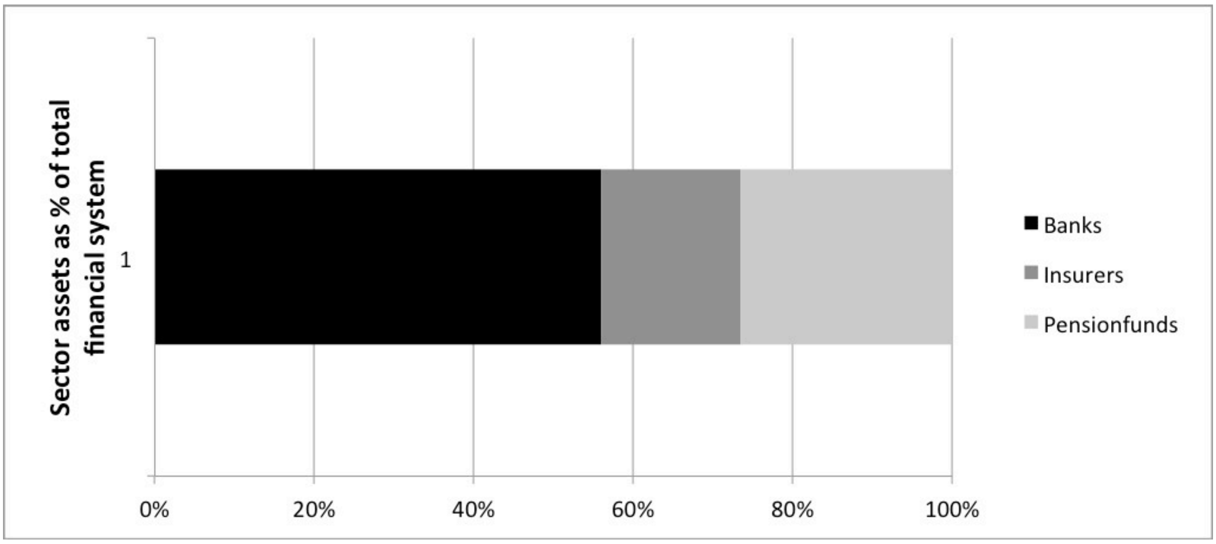

Figure 3: Distribution of total assets among the three major financial sectors

As can be seen by looking at Figure 4 (overview about relative exposures), the portfolio composition for fossil fuel assets differs substantially among the three financial sectors. Banks act almost exclusively as issuers of loans, with zero holdings of any stocks. The total exposure amounts to USD 48.8bn, equivalent to almost 3% of total assets.

With a total exposure of less than 2% (USD 9.9bn), insurers exhibit the lowest vulnerability among the three main sectors. Yet, the large exposure to bonds stands out: more than 70% of all fossil fuel producers' assets are bond holdings. The remaining amount is mainly covered by equities. (Figure 4)

Pension funds have the largest exposure relative to their total assets: about 5.4% (USD 42.5bn) are allocated to the sector. The largest share is composed of commodities (2.1%), equity holdings (1.9%) and other assets (0.7%). "Other assets" are made up of alternative investments (private equity, hedge funds and infrastructure investments) and are not part of the analysis because of the wide range of asset classes. (Figure 4)

Both the magnitude and the given asset composition of pension funds make them the most vulnerable financial sector to potential shocks. However, the nature of a more flexible portfolio of pension funds means that they may adjust their investment strategy more rapidly than banks or insurers (DNB, 2016).

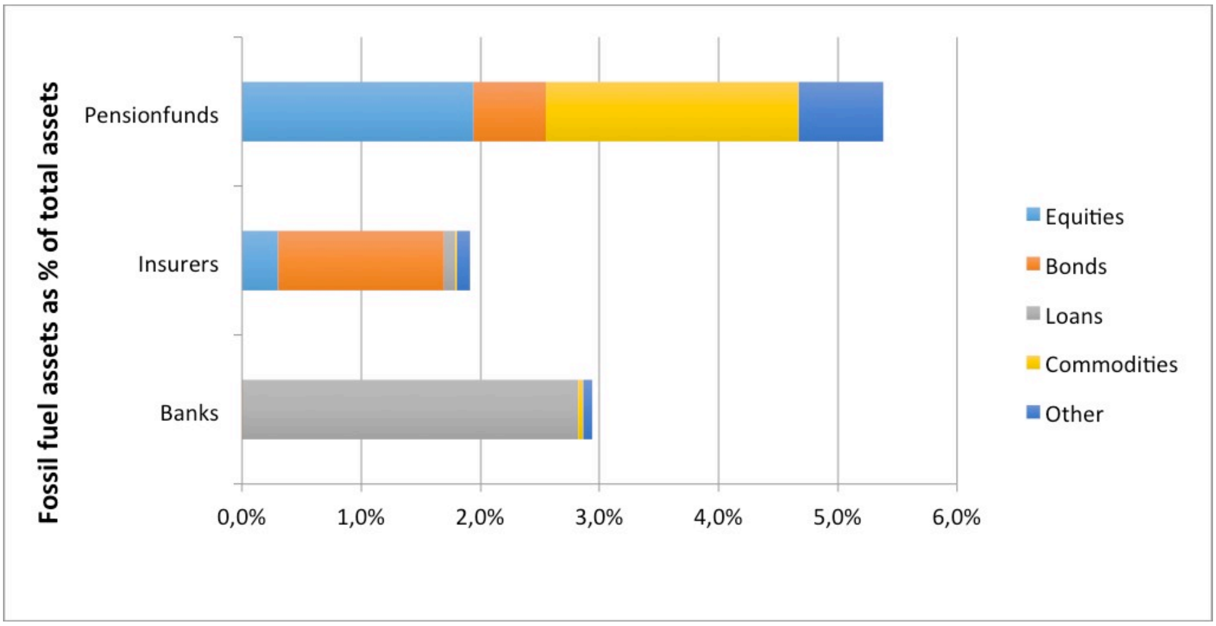

Figure 4: Overview of fossil fuel exposure of each financial sector

"Note: 'Loans' consist of traditional corporate loans and trade finance to parties engaged in fossil fuel trading. 'Equities' consist of investments in equities, equity funds and derivatives. 'Bonds' consist of corporate bonds and bonds issued by sate-owned companies. 'Commodities' consist of direct investments in commodities, futures contracts and fund investments in commodities. 'Other' consist primarily of investments in private equity, hedge funds and public/private infrastructure investments." (DNB, 2016)

5. Methodology

Testing transition risks for the Dutch financial system starts with the exposure data of banks, insurers and pension funds. Specifically, exposures to the oil and gas industry are analyzed in detail, as the carbon transition poses the most severe risk to firms directly involved in the fossil fuel value chain (Lewis et al, 2014). The first part of the analysis employs a discounted cash flow (DCF) model to calculate the loss in value of fossil fuel stocks for financial portfolios of each respective financial sector. In the second part, the affected bonds and loans of fossil fuel companies are readjusted according to the expected loss formula by Ramaswamy (2004).

As the aim of the paper is to measure the impact of climate change risk in the form of a "policy shock" on the financial industry, the shock scenario applied follows directly the 450 scenario by the IEA (2016). Based on Meinshausen et al (2009), the carbon budget of the world is set to 1,440Gt of GHG until 2050 in order to have a 50% chance to limit the rise in global temperature to 2°C above preindustrial levels. However, for the long-term temperature to stay below 2°C, the IEA assumes to reduce carbon concentration to 450 ppm (IEA, 2014).

This implies a gradual reduction in fossil fuel consumption. In contrast, the Current Policy

Scenario serves as a benchmark against which the 450 Scenario is stressed. It includes only those policies that have been enacted by mid-2016 (IEA, 2016).

The impact of both scenarios can be investigated by the means of a discounted cash flow (DCF) analysis. The DCF is a common company valuation methodology where future cash flows are discounted by the weighted average cost of capital of the firm (combined cost of debt and cost of equity). Since one particular firm has limited representativeness of a whole sector, the average financials of the five largest integrated oil and gas firms are merged for the purposes of this research to create a new artificial company. Cash flows are projected for a five-year horizon 2018 – 2022. The cash flow of the last year is taken as the base to calculate the present value of the terminal value.

The most crucial input variables for a DCF analysis of a multinational oil company are revenue growth, capital expenditure development and the discount rate. Revenue growth determines principally the magnitude of future cash flows. The IEA (2016) provides sophisticated estimates for future oil demand and price trajectories according to each scenario. For simplicity, it is assumed that the sum of the compounded annual growth rates for oil demand and price predict revenues of oil multinationals proportionally on a linear scale (Table 1). This assumption is based on the analysis of Granli (2009) who studied the impact of oil price changes on share prices of oil and gas companies in the period between 1990 and 2007. The author concludes that share prices of integrated energy companies can be well explained by changes in oil prices.

While the predictions for the period 2016 – 2020 do not differ considerably between the scenarios, in the long term the demand for oil is predicted to diverge substantially between the Current Policies Scenario (CPS) and the 450 Scenario (Appendix 1). For the 450 Scenario, oil production is reduced by 10.5% between 2020 and 2030, whereas under the CPS oil production increases by 10.1% in the same time period (IEA, 2016). Furthermore, the oil price increases significantly slower under the 450 Scenario than under the CPS between 2020 and 2030 (1.7% vs 5.0%, respectively) (Appendix 2).

The 450 scenario: a policy "shock"

The 450 Scenario by the IEA limits global warming to 2°C until 2100 (equivalent to 450 parts per million CO2), as a consequence of the Paris Agreement in 2015. Since national governments tend to be slow to pass laws into action after such an agreement, a shock only occurs around the year 2020 when carbon pricing mechanisms are adopted on a global scale, first in the power generation and industry sectors, later also extended to the transport sector. It is assumed that OECD countries will initiate the transition, implementing a carbon price of USD 130/t in 2030 and USD 140/t until 2040. Other major non-OECD countries, such as China and Russia, are assumed to follow suit with carbon prices rising slightly below OECD countries' level in 2040. Additionally, fossil fuel subsidies are expected to have been eliminated until 2040, except in the Middle East. (IEA, 2016)

Thanks to the widespread adoption of carbon pricing mechanisms around the world, low carbon technologies are expected to gain momentum. Specifically, variable renewable energies (wind and solar), carbon capture and storage (CCS) and alternative fuel vehicles (EVs) would stand to gain (IEA, 2016).

Despite the fact that this would be a policy response unseen of in the history of climate change policy, it does not seem too unrealistic if the multilateral climate change agreement in Paris is to be taken seriously. As a result, the IEA (2016) estimates that USD 304bn of stranded assets would not at all or only partially recover their investment during their operational lifespan. The 450 Scenario is only based on a 50% chance of limiting global warming to 2°C.

As companies in the fossil fuel extraction sector are characterised by considerable spending in machinery and equipment, capital expenditure projections also form an important part in the valuation of those companies (Guilford, O'Connor, & Cutler, 201). The results of the analysis for capital expenditure projections are based on work by Accenture (2016). Following the demand projections by the IEA for each scenario, capital expenditure rises significantly in the CPS and decreases slightly in the 450 scenario as of 2020. The weighted average cost of capital is assumed to remain stable for the future.

The second part of the analysis includes the valuation of bonds and loans under the same scenarios. Bonds and loans are only treated differently in the calculation of the loss on default due to different recovery rates. According to Ramaswamy (2004), the expected loss for a corporate bond portfolio can be calculated with the following formula:

$$EL = NE\,x\,PD\,x\,LD$$

where

EL = expected loss

NE = nominal exposure

PD = probability of default

LD = loss on default

Furthermore, the loss on default is calculated by:

$$LD = P_{dirty} - RR$$

where

P_{dirty} = dirty price of the bond

RR = recovery rate

Although there is evidence that the dirty price of a bond is negatively correlated with the probability of default, for simplicity most credit risk models assume an independent relationship between the two parameters (Ramaswamy, 2004). Therefore, the dirty price will be equal to one.

The two main variables that are affected by the stress test are the probability of default and the recovery rate. First, the probability of default increases with the rate of change of the difference of DCF valuations between the scenarios. The base rate is taken from a report by S&P (2016), an international rating agency, that estimates the default rate of the energy and natural resource sector at 6,5% in 2015.

The average recovery rate measures the share of a defaulted debt instrument that can be recovered. For the year 2010, Moody's (2011), an international rating agency, calculated the average corporate debt recovery rates measured by post-default trading prices. First lien bank loans recovered on average 72.3% of its value, whereas senior secured bonds recovered only 54.7%. For the sake of the stress test, these recovery rates are then subtracted by 16.5% (50% x 33%). This is because of the findings by McKinsey and the Carbon Trust (2008) and McGlade and Elkins (2015). The former estimated that more than 50% of the value of a publicly listed oil and gas company resides in the values of cash flows to be generated in year 11 onwards. The latter estimated that 33% of all proven oil reserves cannot be extracted from the ground under the 2 degree scenario.

Since loans and bonds are both affected by the result of the DCF valuation (via the probability of default) and lower recovery rates, it is assumed that the value of both asset classes will decrease significantly in the 450 Scenario. Such an impact can be compared to a rating change in the international bond market, which is applied in the course of a transformational event, e.g. a "structural change to the industry or competitive environment," according to S&P (2013). Moody's (2017) expressed its concerns over "significant credit risks from the carbon transition" in a special report about the environmental risks of the oil and gas industry.

6. Results

The projection of future cash flows for the artificial oil and gas company under the 450 Scenario assumes a revenue growth rate of 16.8% between 2016 and 2020 (mainly driven by a rising oil price), subsequently flattening out to 0.9% from 2021 onwards. Capital expenditure decreases slightly in anticipation of reduced demand by 1.3% of the yearly growth rate. The total valuation expressed by the discounted future cash flows adds up to USD 97.6bn.

In contrast, under the CPS the revenues of the company grow at a similar level in the short term (17.5%) and then stay at a relatively high level of 4.2%, as derived from the IEA (2016) projections for 2030 by the formula of the compounded annual interest. The growth rate of capital expenditure is increasing by 0.4% per annum. Hence, the final value is USD 134.8bn, or 27.6% higher than in the 450 Scenario.

Sensitivity analysis

Figures 5 and 6 exhibit the sensitivity to changes in the weighted average cost of capital, the growth rate of capital expenditure as well as the aggregate price and demand change of oil in the DCF analysis. The sensitivity analysis only refers to the 450 Scenario, as similar outcomes for the CPS render a second sensitivity analysis for each scenario unnecessary. In this model, the weighted average cost of capital does not seem to be a major determinant of the final value of the company: on average, a 2% change in the cost of capital influenced the final enterprise value by 0.14% (Figure 5). However, changing the aggregated price and demand of oil does change the projected enterprise value substantially. A 5% change of the weighted average cost of capital leads, on average, to a 7% change in enterprise value (Figure 5 and 6). This is not a surprising finding, as the revenue projection of a company in the DCF is one of the most crucial predictors of the final value.

The valuation seems especially sensitive to small changes in the growth rate of capital expenditure: the average impact of an additional 1% change in the growth rate of capital expenditure is a -10% change in enterprise value. This relationship is negative because a higher capital expenditure presses the free cash flow down. It should also be noted that the capital expenditure is one of the major expenses for oil and gas companies, since it is on average among the five largest oil and gas producers in the dataset equivalent to more than 11% of sales revenue. Therefore, small changes that are assumed to stick to perpetuity have a large impact.

Sensitivity analysis: Implied enterprise value
oil aggregate price & demand change in growth

		-10%	-5%	0%	5%	10%
	4,0%	84.388,2	90.440,1	97.366,9	102.799,0	109.107,2
	2,0%	84.463,6	90.516,9	97.455,0	102.878,4	109.188,0
WACC change	0,0%	84.541,1	90.595,8	97.572,0	102.960,0	109.271,0
	-2,0%	84.620,6	90.676,7	97.647,6	103.043,8	109.356,2
	-4,0%	84.702,4	90.759,9	97.852,2	103.129,9	109.443,7

Figure 5: Sensitivity analysis WACC and aggregate oil price & demand change in growth

Sensitivity analysis: Implied enterprise value
oil aggregate price & demand change in growth

		-10%	-5%	0%	5%	10%
	2,0%	64.936,0	70.990,7	77.130,1	83.355,0	89.665,9
	1,0%	74.918,8	80.973,5	87.112,9	93.337,7	99.648,7
Capex change in growth rate	0,0%	84.541,1	90.595,8	97.572,0	102.960,0	109.271,0
	-1,0%	93.813,1	99.867,8	106.007,2	112.232,0	118.543,0
	-2,0%	102.744,8	108.799,5	114.938,9	121.163,8	127.474,7

Figure 6: Sensitivity analysis capex change in growth rate and aggregate oil price & demand change in growth

The second part of the analysis deals with the potential losses for bonds and loans. Due to higher seniority, the expected losses for loans are lower than for bonds. In the 450S, the impairments of loans amount to 3,7%, whereas 5.1% of bonds are affected.

6.1 Banks

As banks do not hold equities and only a negligible share of bonds of fossil fuel producers, they are impacted almost exclusively by the impairments in loans. Based on the analysis these losses amount to 5.4% of all fossil fuel related loans and approximately 0.2% of total assets (Figure 4 and 9). Despite the relatively little exposure to fossil fuel assets, banks suffer the second greatest loss among all three financial sectors in total terms: USD1.7bn (Figure 10). Assuming that all banks have an equally large share of fossil fuel loans in their balance sheet, the average loss per institution amounts to USD 482m.

Thanks to strong CET 1 ratios of ING (12.6%), Rabobank (13.7 %) and ABN (16.4%), the potential losses as a result of fossil fuel exposure may be absorbed without causing major turbulences for the balance sheets of the banks (ING, 2017; Rabobank, 2017; ABN, 2017). These data were retrieved from the banks' respective balance sheet as on 31-12-2016. ING is only affected by 0.2%, Rabobank by 0.2% and ABN has 0.5% of fossil fuel loan impairments (Figure 7). The differences can be explained by the different magnitude of the balance sheets; hence equal losses are more easily absorbed by a larger capital buffer of CET 1 capital (in this case by the largest bank ING). After accounting for the losses, all banks are still far above the suggested threshold value of 5.5% of CET 1 capital ratio by the European Banking Authority (2016).

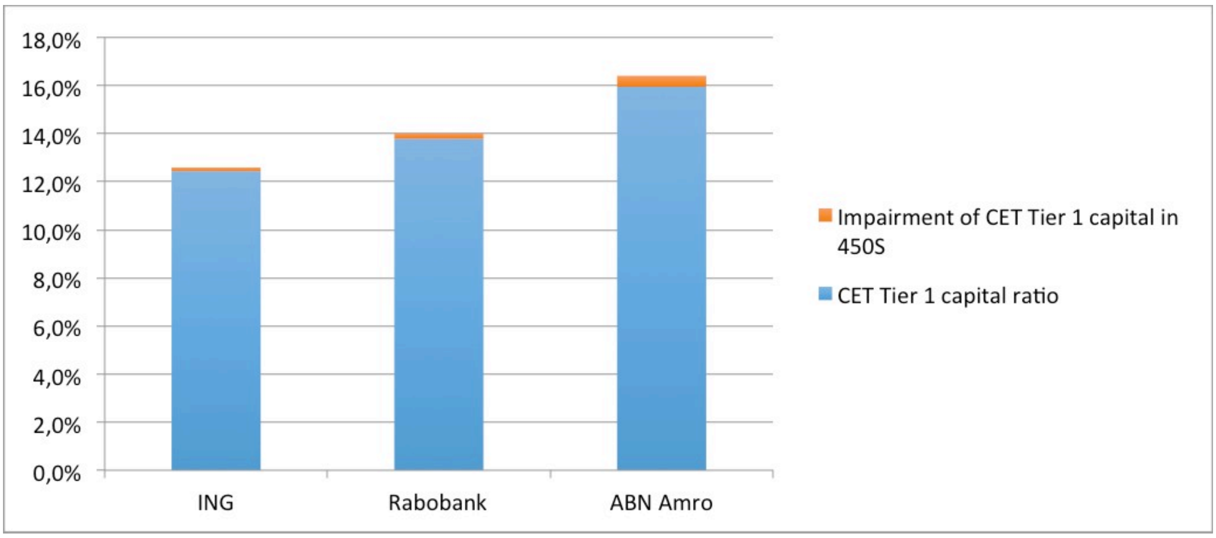

Figure 7: CET 1 ratios of the three largest banks after the impairment for losses with respect to bad fossil fuel loans.

6.2 Insurers

Insurers are the principal holder of fossil fuel bonds among the three financial sectors (1.4% of total assets). In addition, they are exposed to fossil fuel equities (0.3%) and to a negligible amount of loans and other fossil fuel assets (0.1% each) (Figure 4). However, due to the relatively greater impact of equity losses (28.5%) vs losses of bonds (5.1%) and loans (3.7%), the share of fossil fuel losses with respect to total assets is almost equal (0.1% each). In total, insurers lose approximately USD 815m in the 450 Scenario (Figure 9).

Due to limited public financial data availability regarding most of the Dutch insurers, the impact on an individual institution can only be shown by the example of Achmea. At the end of 2016, Achmea constituted by far the largest insurance company in the Netherlands with a market share of 25% (Verbond van Verzekeraars, 2016). Achmea had eligible own funds worth USD 10bn and required capital of USD 5.5bn, implying a solvency ratio of 180.5% (Achmea, 2017). After deducting the expected loss of USD 204m, the capital ratio diminishes by 3.7% to 176.8%, still far exceeding the required rate of 100%. Assuming the remaining insurers have similar capital buffers as Achmea, the loss related to fossil fuel assets does not seem to jeopardise the financial stability of the insurance sector.

6.3 Pension Funds

Pension funds suffer the highest aggregate losses, both in total and relative to total assets of USD 790bn (0.6% or USD 4.5bn) among the three financial sectors, mainly because 2% of total assets are made up of fossil fuel equities (Figure 4 and 9). Equity losses amount to 0.6% of total assets while bond losses are negligible (0.03%). Potential losses of other assets on the portfolio of pension funds are not included in the analysis of the stress test.

ABP as the largest institution in the Netherlands (50.6% market share among the largest six pension funds) and the second largest institution in Europe with own funds worth USD 492bn incurs the highest losses of USD 2.7bn. The smallest pension fund in the sample, ING pension fund, has only 3.4% market share among the largest institutions and incurs losses of USD 180m (relative to own funds worth USD 32.7bn).

Figure 8 exhibits the carbon asset related losses after the stress test. The average funding ratio among the six largest pension funds is 105.4% as of 31-01-2018. This puts them above the statutory minimum required funding ratio of 104.2% recommended by the DNB (2017c). However, the high funding ratio of bpfBOUW distracts the fact that actually three of the largest six Dutch pension funds fall below the minimum required funding ratio: PFZW (103,0%), PMT (102,5%) and ING (95,5%). After distributing the losses of USD 4.5bn according to weight of the pension funds' assets, the losses lower the funding ratio between 0.5% (ING) and 0.7% (bpfBOUW).

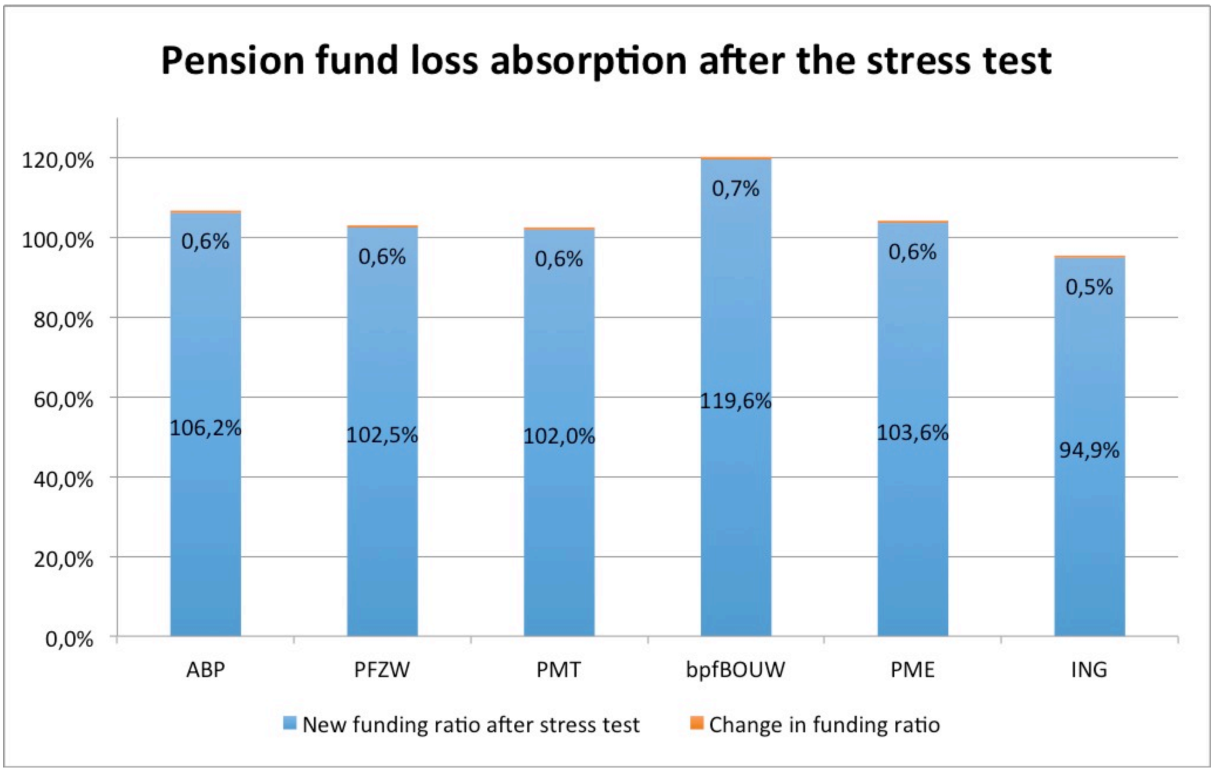

Figure 8: the six largest pension fund's loss absorption after the stress test

Yet, the average funding ratio of the six pension funds stays above the minimum required funding ratio (104.8%). Even if pension funds had to absorb higher losses than in this scenario, they would still be the most flexible financial institution to adjust to challenging market environments. Generally, pension funds can do four things to recover from financial distress: cut benefits, raise contributions from its members, postpone annual index-linking (automatic mechanism that increases according to wages and price levels) and increase investment returns. These measures may be required by the regulatory body when pension funds are below the minimum required funding ratio for five years. DNB (2017d) found that pension funds in the Netherlands rely almost exclusively on achieving surplus returns on their investments to eliminate their deficit. While the stress test does not cause the pension funds to get into financial trouble, it reveals the vulnerability with respect to its funding ratios towards macroeconomic shocks.

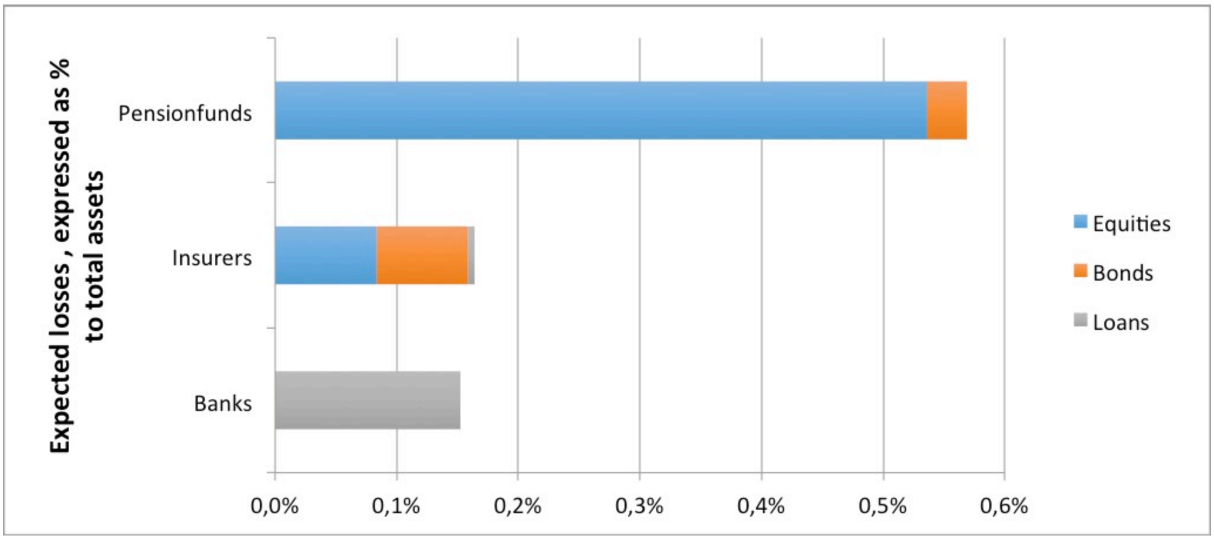

Figure 9: Expected fossil fuel portfolio losses expressed as a share to total assets

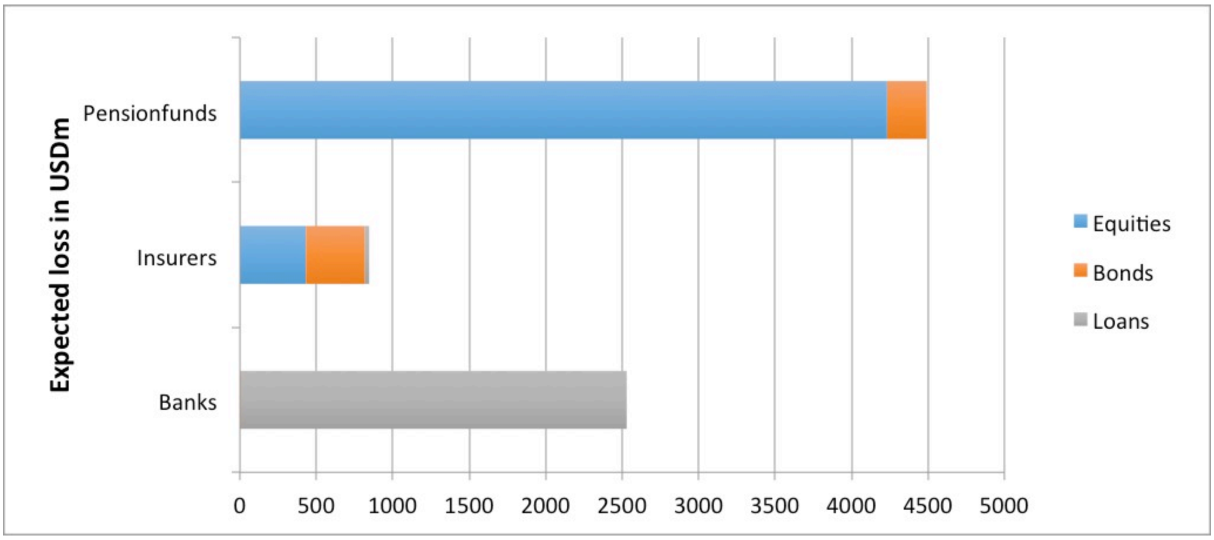

Figure 10: Expected portfolio losses expressed in USDm

7. Discussion

At first sight, the results of the carbon stress test seem to allow for a clear conclusion: the Dutch financial sectors are able to withstand a carbon policy shock (450S) induced by government regulation. The expected losses for banks and insurers are not close to jeopardise the capital buffers of the sectors. The portfolios of pension funds are the most vulnerable; low capital buffers could potentially lead to severe portfolio losses triggered by a carbon policy shock.

However, this does not imply that individual institutions with below average sector capital buffers are as secure against losses as large institutions like ING or Achmea. Smaller institutions with larger fossil fuel asset exposure and lower capital buffers are the most vulnerable in the advent of a policy shock. Since this stress test analyses only on the sector level, future stress test should take into account exposures on the institutional level. For this to happen, financial institutions will have to require more carbon related information from companies they are financing in order to perform a proper risk assessment. Specifically, knowledge about the carbon intensity of a firms' inputs and technologies would enable a better quantification of potential effects, as suggested by ESRB (2016).

Although the results do not imply an imminent risk that threats the underlying financial stability in the short term, policy makers should nevertheless be aware of carbon policy related shocks to the fossil fuel industry that have the potential to contage the financial sector as well. Since contagion happens via exposure to assets of the fossil fuel sector, several regulatory means seem possible to limit the severity of the impact of carbon asset risk.

First of all, institutions could be disincentivised to hold assets of carbon intensive firms by implementing capital surcharges based on the carbon intensity of individual exposures. Another idea would be to cap the overall exposure of institutions by applying exposure limits to the overall investment in carbon intensive assets that will be most vulnerable to a sudden transition to a low carbon economy (ESRB, 2016).

Thirdly, the promotion of long term best practice investment strategies for institutional investors could lead to a paradigm shift in the way carbon risk is taken more seriously as an important investment criteria. Possible application strategies include promoting low carbon indices or joint exclusion criteria. Some major institutional investors have already started to implement carbon related exclusion criteria (Black Rock, 2016). This also increases the pressure on carbon intensive firms to reduce investments in potentially stranded assets (Weyzig et al, 2014). The European Commission is considering recalibrating capital requirements for banks by introducing a "green supporting factor." The approach is focusing on supporting green investments rather than requiring additional capital requirements for investment in carbon intensive assets (European Commission, 2018).

Additionally, financial institutions should not make the mistake to point at their stable capital buffers and ignore carbon asset risk in future risk assessments. Too many known and less obvious variables are involved that may trigger a black swan event (Taleb, 2007). For example, advances in clean technologies are rapidly advancing, thereby contributing to the acceleration of the energy transition (IRENA, 2017); by the same magnitude, other external shocks may cause sudden energy price movements that may alter the speed and smoothness of the transition. This is to say that a potential shock does not have to come from government legislation but might as well be brought about by innovations in the private sector. Large-scale battery storage and electric vehicles have the potential to reduce drastically oil demand in the future (Kittner, Lill, & Kammen, 2017). Future stress tests should take these developments into account.

8. Methodological limitations

The DCF valuation methodology is commonly applied to value an individual firm. Although the five largest oil and gas multinationals have a substantial amount of market share, it neglects the fact that the fossil fuel sector is made up of many smaller and more specialised firms. Those firms are likely to exhibit more volatile cash flows, making it more difficult to project cash flows into the future. To at least partly compensate for the bias of taking larger firms, the bond valuation takes into account the probability of default rate for the entire oil industry.

Another assumption made in the DCF is that future revenue is contingent on the oil price and demand development. However, the trend to more diversification in the industry means that this relationship will weaken in the future. On the other hand, since the price of gas is strongly correlated to the price of oil, it still seems fair to assume that the oil price and demand is the major determinant of future revenues (Villar & Joutz, 2006).

In this paper, only the exposure of the financial sector to the oil, gas and coal industry is analysed. Nevertheless, other fossil fuel intensive sectors, such as utilities, chemical or the transport sector would also be substantially affected by the introduction of a carbon price. This would add further "stress" on the portfolios of financial institutions and should be considered by future carbon stress tests.

The valuation of bonds assumes the same probability of default and dirty price for the entire portfolio of fossil fuel bonds. Yet, in practice the portfolios of banks, insurers and pension funds consist of bonds with varying degrees of length and yield to maturity. Due to the fact that the available aggregate data does not reveal any details about the maturity levels of bonds, no further breakdown was applied.

Lastly, the result may be underestimated because second order effects were ignored as a potential consequence of the policy shock in this analysis.

9. Conclusion

The paper investigates the consequences of a carbon policy shock in the form of carbon pricing for the fossil fuel sector on the portfolio of banks, insurers and pension funds in the Netherlands. The shock is simulated by applying the 450 Scenario by the International Energy Agency that limits global warming to 2°C until 2100. Thanks to strong capital buffers, the financial stability of Dutch banks and insurers is not jeopardised in the event of losses in the fossil fuel portfolio. On average, banks lose USD 482m, equivalent to a 0.3% diminishment of their common equity tier 1 capital. The example of Achmea, the largest insurer in the Netherlands, illustrates that a 3.8% deduction does not have a significant impact on the capital ratio (still far exceeding the minimum required rate). The case is different for pension funds, however. Pension funds are by far the most vulnerable financial sector to transition risk because their portfolio is exposed to 1.9% of fossil fuel equities. Additionally, three out of the six largest pension funds already score below the minimum required funding ratio of 104.2% before the stress test is conducted. Hence, even the relatively little reduction (on average 0.6%) of the funding ratio exposes the financially weak position of the pension fund sector. Fortunately, pension funds are better able to overcome financial distress than banks or insurers.

While the results of the climate stress test indicate that no financial turbulences are to be expected if the OECD governments were to implement decisive carbon pricing schemes in the next years, the mere fact that one fossil fuel intensive sector can already lead to substantial losses for selected asset classes should serve as a warning to the financial sector. Most likely, further research that takes into account all relevant carbon intensive sectors will find a more dramatic impact on financial stability.

Regulators who understand the possible repercussions of the carbon bubble have various tools at their disposal to limit its impact. Ideas put forward by scholars range from disincentivising investment into carbon intensive firms to setting exposure limits to the overall investment in carbon intensive assets.

Although climate change stress testing has yet to become fully institutionalised by regulators, the growing importance and speed of transition to a world with less GHG emissions implies that climate stress tests for the financial system are here to stay.

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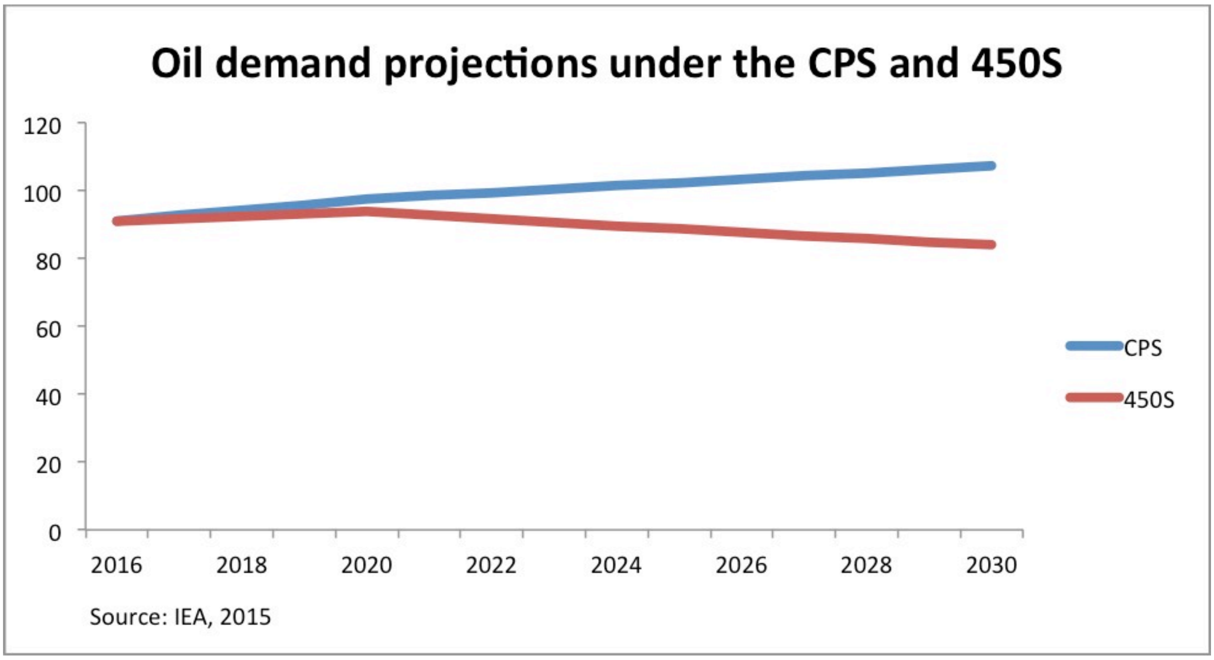
Table 1

Scenario	2016	2020	2030	CAGR ** 2016 – 2020	CAGR 2020 – 2030
CPS					
price in USD per barrel	43	80	130		
price % increase		*86.0%*	*62.5%*	*16.8%*	*5.0%*
demand mb/d	91	97.5	107.3		
production % increase		*7.1%*	*10.1%*	*1.7%*	*1.0%*
sum price increase and production increase				*18.5%*	*5.9%*
NPS					
price in USD per barrel	43	80	113		
price % increase		*86.0%*	*41.3%*	*16.8%*	*3.5%*
demand mb/d	91		107.2*		
production % increase			*17.8%*	*0.7%**	*0.7%*
sum price increase and production increase				*17.5%*	*4.2%*
450S					
price in USD per barrel	43	78	95		
price % increase				*16.1%*	*1.7%*
demand mb/d	91	93.7	83.9		
production % increase		*3.0%*	*-10.5%*	0.7%	-1.1%
sum price increase and production increase				*16.8%*	*0.6%*

** 2030 figure not available, therefore 2040 projection taken to compute CAGR*
*** CAGR = compounded annual growth rate. Formula:*
(ending value/beginning value)^(1/n) - 1

Appendix 1



Appendix 2