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Green Financial Perspectives

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Proceeds of the Central European Scientific Conference on Green Finance and Sustainable Development, October 2020

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Foreword

This unique selection of articles in this publication is intended to provide the reader with a thematic overview on the Central European Scientific Conference on Green Finance and Sustainable Development, held online, October 13, 2020. The event proved the conviction of its organizers and participants that actions on sustainability can be furthered based on a strengthened dialogue built on the results of well-communicated scientific research. It is all the more important, as it is widely agreed, that the role of institutions, in particular that of the central banks, is pivotal in greening the financial system, i.e. pursuing shifting savings towards greener investments.

The conference was organized by the Department of Geography, Geoeconomy and Sustainable Development (GGFF) of the Corvinus University of Budapest (CUB) and the Green Program of the Central Bank of Hungary (MNB). CUB, with a curriculum focused on economics and other social sciences, considers sustainability high on its agenda, and GGFF is strongly committed to endorsing the issue of sustainability in education and academic research. While the conference addressed the issue of sustainability primarily from the perspective of finance, it attracted over 120 participants, about 30% internationally, including scholars, students and policy representatives. With 26 presentations in six thematic sections, it also well complemented the concurrent Central European Green Finance Conference, an outreach event of the Central Banks and Supervisors Network for Greening the Financial Sysem (NGFS), organized in Budapest by the Central Bank of Hungary (MNB) and the European Bank for Reconstruction and Development.

The conference, beyond those thematic subjects usually covered by similar events, gave floor to perspectives from various geographic regions, too, including the Middle-East, Central-Asia and Japan. This versatile approach may well highlight the role and potential of Central European institutions in the global scientific discourse on sustainability.

This publication presents eleven selected articles in two thematic chapters. The chapter titled Institutions and Instruments is focused on the role of institutions, among them the central banks, as well as various financial instruments designed to pursue sustainability at the micro-level, such as corporate reporting on environmental, social and governance performance (ESG), the pricing of carbon, and performance of stock exchange listed shares etc.. The wealth perspective is presented as a framework that offers a comprehensive approach to the issue of sustainability. Articles in the second chapter provide climate and sustainability insights at the macro level in the regions of Central-Asia, the Middle-East and Europe.

The organizers of the conference and editors of this publication appreciate and give thanks to all participants for their contributions.

Géza Salamin

Head of the Department of Geography Geoeconomy and Sustainable Development

Contents

Chapter I: Institutions, instruments

The role of central banks in mitigating CO_2 emissions

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Abstract

The financial sector in general has a very crucial role to play in financing the transition to a carbon-neutral economy. Banks can contribute through lending, or by maintaining a well-functioning financial market to channel money towards green investments. As a main actor in the financial sector, central banks may take several climate change-related aspects into account in monetary policies. However, the central bank's first and priority objective, namely price stability, cannot be compromised. The paper introduces the main fields where financial risk can arise because of increases in CO_2 emissions and examines the potential of central banks to assist in CO_2 mitigation. The main thesis of the paper can be expressed as follows: the role of today's central banks is changing as they take into account climate-related risk and aim at mitigating CO_2 emissions in order to maintain financial stability. With this changed role, central banks may reduce climate risk and negative externalities in relation to the environment. This paper examines the topic based on scientific articles and reveals that central banks can contribute to creating a greener economy

Keywords: Central bank; Climate-related risk; CO_2, financial system; GHG emissions; Green bonds; Low carbon economy; Monetary policy; Transition; Quantitative easing

1. Introduction

Addressing the threat of climate change requires a major shift in how financial resources are allocated. Moving to a greener economy requires a massive and sustained investment effort. Incentives should be created to encourage investors to direct their money into green assets instead of fossil fuel industries. The main problem is that investors are interested in short-term profit and do not take into account the long-term impacts of irresponsible capital allocation. It has been strongly emphasized that without the involvement of central banks, a green transition cannot happen. The private sector is not able to change fast enough, and the lack of green investment is a market failure that should be corrected by the public sector (*The ECB Podcast, 2020*).

In recent years, financial stability has also become a main target of central banks, and climate change is a threat to the former in the way that it increases risk in the financial system. There are three different related policy goals: maintaining price and financial stability and supporting wider economic objectives. The role and responsibility of central banks may change, and the third goal could potentially include sustainability targets. However, central banks' main targets – namely, financial and price stability, should not be compromised in order to fulfil the goals of sustainability (*UN Paper, 2017*).

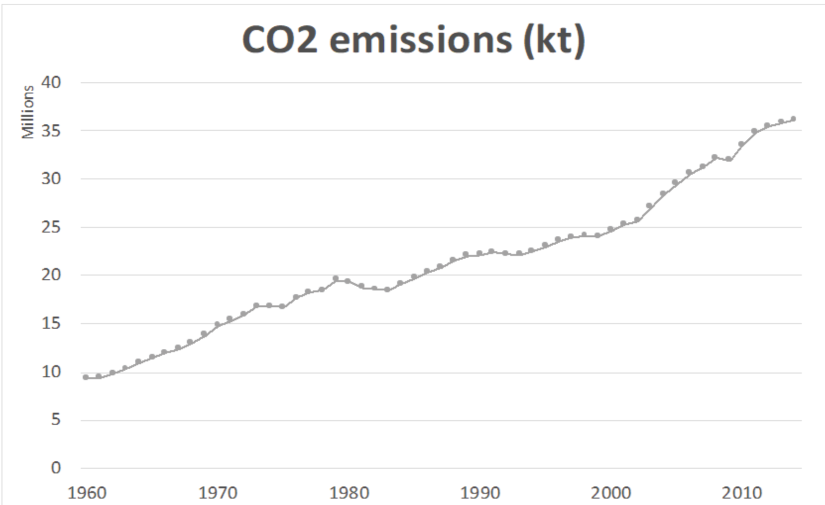
A range of policy instruments have been analysed in scientific papers that could be implemented by central banks to contribute to a greener economy. The aim of this paper is to identify the nexus between climate change and central banks, and the potential of central banks to mitigate CO_2 emissions, thereby contributing to the creation of a greener economy. The first part of the paper is devoted to describing the importance of CO_2 emission mitigation and to identifying the main sources of emissions. In the next section, the climate-related financial risks that arise from emissions and global warming are discussed. After that, the role of central banks is introduced. In the last part, the potential tools of central banks in this regard are presented.

2. Trends and main sources of CO2 emissions

The greenhouse gases, or GHG emissions, generated by human activity in recent centuries have initiated several processes and resulted in the phenomenon called climate change. Since the economy and population are predicted to continue to grow, emissions from fossil fuels will further increase CO_2 if there is no transition to a greener economy. Between 2000 and 2010, annual GHG emissions grew on average by 2.2% per year, while between 1970 and 2000 the figure was only 1.3% per year. In the history of mankind, GHG emissions have never been higher than in the previous decade. As at the global scale, carbon dioxide amounts to 65% of greenhouse gases emitted by human activities, this paper focuses only on the mitigation of CO_2 emissions. According to the IPCC report, half of the cumulative anthropogenic carbon dioxide emissions between 1750 and 2010 occurred in the last 40 years (*IPCC, 2014*).

While in recent years several breakthroughs have been achieved, including the Paris Agreement and issuance of green assets, and a lot of mitigation policies have been applied globally, human intervention has not succeeded in slowing down the increase in emissions, or, consequently, global warming. Current emissions of CO_2 will determine the rise in the average temperature for roughly the next 20 years, independent of future policy decisions (*Matus, 2019*). Figure 1 below illustrates global annual CO_2 emissions (measured in kt), which mainly stem from the burning of fossil fuels. Based on this evidence, it is crucial to take action immediately, because global warming will accelerate further in the forthcoming years.

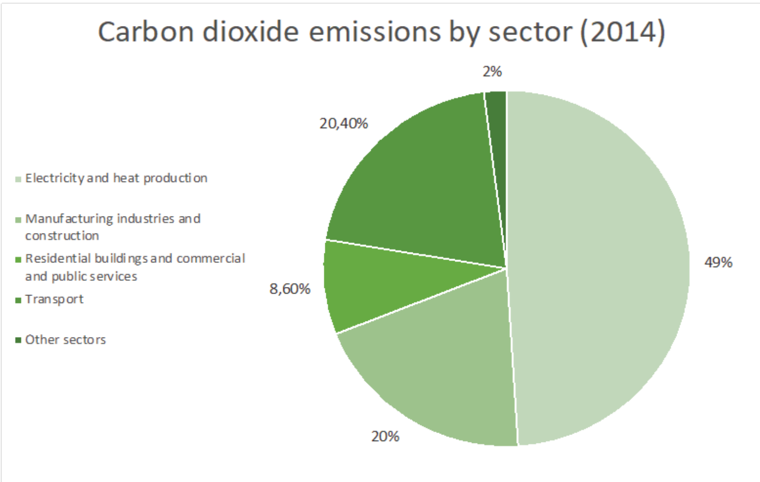
Figure 1: CO2 emissions (kt)



Source: The World Bank

The largest sources of carbon dioxide emissions from human activities globally are related to the following sectors, as presented in Figure 2. Roughly half of CO_2 emissions are caused by electricity and heat production. This sector includes emissions from the public utilities of publicly and privately owned companies, but also other energy industries like petroleum refineries, and coal mining. The category 'Transport' and 'Manufacturing industries and construction' makes nearly the same contribution to CO_2 emissions. Besides these sectors, residential buildings (emissions from fuel combustion in households), commercial and public services are significant contributors (*The World Bank, 2020*).

Figure 2: Carbon dioxide emissions by sector in 2014.



Source: The World Bank

To create a sustainable economy, first the effective mitigation of climate change (and evidently, of carbon emissions) is needed, which depends on adequate financial resources and investments. In the scientific literature, the expression 'climate finance' is used to describe this need. The Paris Agreement is one of the greatest achievements of recent years, and its target (keeping the global temperature rise to below 2°C this century) is not feasible without appropriate climate finance (*Ryszawska, 2016*).

Monetary and fiscal policy has a leading role in assisting in resource allocation in accordance with climate finance. The latter can influence the value creation process of company management. As the appropriate regulations take effect, and these entities show commitment, the price and value of CO_2 can be determined by consulting and accounting firms, investment banks, and other market participants. In this way, CO_2 might become a significant factor in security pricing, credit risk valuation, and project assessments, thus companies may include it into their value creation process (*Csapi & Fojtik, 2009*).

Besides monetary policy tools, there are several opportunities for contributing to the valuation and mitigation of CO_2 emissions. Some of these include carbon pricing (quotas, cap-and-trade systems) and feed-in tariffs. However, taxing energy use is politically sensitive and might lead to socio-political instability (*Matikainen, Campiglio & Zenghelis, 2017*). This paper focuses only on monetary policies as part of climate finance.

3. Climate (financial) risks and their impact on the economy

As previously discussed, CO_2 emissions have a direct impact on the environment, but they also have indirect impacts on the economy and society as well. This section is devoted to introducing the financial risks related to climate change and their threat to the economy. There are three types of risks distinguished by the Bank of England: physical risk, transitional risk, and liability risk (*Bank of England, 2015*).

Physical risk is related to direct impacts on the environment. Physical risk can take the form of severe events such as floods and devastating storms, but it means also acute risk like heat waves and wildfires. Furthermore, chronic risks are also caused by gradual change, such as droughts or rising sea levels (*The ECB Podcast, 2020*). Sea-level rise could displace millions of people. This could generate high costs for mankind and lead to social and political conflict if it leads to refugee crises (*The Economist Intelligence Unit, 2015*). The main impacts on the economy are resource shortages caused by interruptions in supply chains, increased food prices because of devastated crops, and losses due to increases in the cost of insurance and the consequence of greater uncertainty. From the macroeconomic perspective, these extreme weather events mean a negative supply shock that has an effect on outputs and prices. Furthermore, these factors might influence core inflation through increasing the prices of raw materials, food, and energy (*Bank of England, 2015*).

As natural disasters became more frequent, insurance companies have also begun to incorporate increased risk into their pricing. Furthermore, they are now emphasizing the existence of a so-called 'protection gap'. This term stands for the phenomenon that some climate change-related events, mostly disasters, can occur very frequently and will be too costly to insure. This factors further increases uncertainty and future losses (*Pandurics & Szalai, 2017*).

On the one hand, this material risk can lead to financial instability and damage to the real economy, as systematic risk may arise in the financial system. On the other hand, the direct impact of climate change on food and energy prices undermines price stability (*UN, 2017*).

The second type of climate risk, namely transitional risk, arises from the re-pricing of the high-carbon sector's assets, which are mainly held by pension funds and insurance companies. For the shift to a low-carbon economy, the required activities, climate change-related policies, and regulations may have harmful effects on the economy and the financial system. The value of assets of certain industries (those introduced earlier as the main polluters) would drop in the case of a rapid transition that involves a preference for green assets, resulting in losses for the investors that hold the former. Unemployment could also rise because of the sudden end to the manufacture of particular products of some industries (*Matikainen, Campiglio & Zenghelis, 2017*). However, there is also a risk factor if the reduction of carbon emissions is delayed, because the cost of stabilising the climate later might be higher (*Bartók, 2019*). Thus, adjustment to a lower-carbon economy should happen at the appropriate pace. This type of risk can be managed better if carbon-intensive assets are not mispriced (*Bank of England, 2015*).

The third climate-related financial risk, called liability risk, arises from the fact that banks and insurance companies might have to provide compensation for damages stemming from operations they are currently financing. After damage from climate-related risk (physical or transitional), legal action might be taken, and if these institutions are found responsible, they could face major claims for related losses (*Bank of England, 2015*).

Based on Arthur Pigou's theory (explained in his book *The Economics of Welfare*), pollution is one of the negative externalities that results in lower social welfare (*Bartók, 2019:85-99*). It is often discussed that environment-related factors are not integrated into financial management and they are not priced in the right way (*Bank of England, 2015*). In order to correct this market failure, fiscal and monetary policies should be implemented. In the following parts of the paper, an analysis is provided of central banks' liability related to emissions and climate change. An introduction is also given to the monetary toolbox that might provide solutions for mitigating CO_2 emissions.

4. The role and mandate of central banks

The purpose of this part is to define central banks' mandate in general and to discuss the role of climate change in their targets. While the main target of central bank is price stability, and it is often argued that environmental sustainability is outside of central banks' main scope of issues, central banks have the potential to help reduce emissions. Since the Financial Crisis of 2007–08, new monetary policy tools have appeared, and price stability is no longer the sole target of central banks as it was in the 1980s and 1990s (*Bartók, 2019:93*). The crisis has shown that, despite price stability, imbalances might occur in the financial system and this can be harmful for the economy.

However, the hierarchy of these targets is often discussed. Financial instability might occur even if price stability is preserved (as occurred during the financial crisis), but price stability cannot be maintained without financial stability. This means that a trade-off exists in the short-term, and that inflation targets cannot be upheld in order to maintain financial stability. However, in the long term, these two targets may be fulfilled jointly (*Bihari, 2019*).

In Hungary, the primary objective of the central bank is to achieve and maintain price stability, but financial stability is also defined by the Central Bank Act. Financial stability means that the financial system is in a condition that is resistant to economic shocks and fulfils its basic functions such as acting as intermediaries of financial funds, the management of risks, and the arrangement of payments (*MNB, 2020*). In accordance with its commitment towards a more sustainable economy, the Hungarian Central Bank published a 'Green Program' and is currently creating a portfolio of green securities (*Világgazdaság, 2019*).

Although stretching central banks' mandates might create risk, addressing climate-change-related risks is necessary in order to avoid financial instability, which is clearly one consequence of increasing CO_2 emissions. Research by The Economist (*2015*) – which estimated the value at risk (VaR) to 2100 as a result of climate change to the total global stock of manageable assets – has shown that if the worst case scenario of 6 °C of warming happens, the present value loss could be US$13.8trn. This is around 10% of global manageable financial assets.

As earlier discussed, climate change will have an impact on the financial system if the customers of financial institutions – i.e. households and firms – become insolvent mainly due to the impact of physical damage. There is a high uncertainty about the likelihood and magnitude of global warming to cause these events, while the consequences for banks may trigger instability in the financial system. Thus, climate change risks can lead to financial instability and central banks have to address these issues in order to meet their targets. Central banks should assess and manage climate-change-related risks and mitigate systemic risk by identifying system-wide vulnerabilities.

5. Monetary tools and their mechanism

There are different tools at the disposal of central banks which might reduce CO2 emissions and green the economy, and this part is devoted to introducing them. As the latter can effectively influence the investment decisions of financial market actors, central banks might be able to promote green investment (*Bartók, 2019:*96).

First, through macroprudential regulations central banks could reduce those investments which are not carbon neutral. As was shown in the first part of this paper, some sectors contribute more to CO_2 emissions. By giving a higher risk rating to or defining credit ceilings for the companies of these sectors, the related investments could be reduced, and the most polluting activities would not obtain favourable loans (*UN, 2017*).

Besides this, through disclosure requirements for capital market actors about climate impact, mispricing could be avoided, and transparency would be enhanced (*Bartók, 2019*). Central banks could ensure that commercial banks incorporate climate risk into their risk management procedures and pricing policies, and that they set aside appropriate capital against the risk stemming from their operations.

One task of central banks is performing stress tests, which should also have a climate component. There are three areas where risk can arise. First, climate events can directly have an impact on assets. Mining, farming, or other industrial activities may become impossible, and their assets might depreciate. Second, existing climate policies may have a future impact and they must be priced correctly. Finally, the impact of future policies should be taken into account as well. For instance, a carbon tax might be applied, causing oil reserves to decline in value, and large write downs might be recorded by financial intermediaries. A climate-related stress test assesses the resilience of financial system as a whole and that of financial institutions individually in case of an adverse shock (*Brunnermeier & Landau, 2020*).

5.1. Quantitative easing

In recent articles, it has been discussed how so-called quantitative easing could sufficiently facilitate the transition to a greener economy. The following section clarifies the concept of non-conventional monetary policy and quantitative easing.

Conventional monetary policies are the set of instruments that have been at central banks' disposal since the beginning. They include the setting of an overnight interest rate target in the interbank money market, and the adjustment of money supply through open market operations. When the central bank changes the very short-term interest rate, this affects the whole yield curve. If expectations about inflation are anchored, long-term real interest rates are also influenced by the decisions of central banks (*Pál, 2018*). In normal times, liquidity conditions in money markets are effectively managed with these measures and the primary target (price stability) of the central bank is achieved. However, central banks have additional tools, and these have become more frequently applied since the Financial Crisis of 2007–08. If there is market failure or a shortage of liquidity, these tools might be more effective than conventional measures (*Krekó et al. 2012*). These non-conventional instruments directly aim at modifying the cost and availability of external finance sources for financial institutions and non-financial companies, but also for households. Such external funds can be loans, equities, and bonds. These may ease financial conditions – for instance, by providing extra liquidity to banks or reducing the spread between different forms of external financing by modifying the size and composition of their balance sheets (*Smaghi, 2009*). In the case of green assets, unconventional policies have the potential to reduce prices compared to 'brown' assets, because the former assets are still traded at a premium.

Quantitative easing is an unconventional measure that has gradually become more popular in the latest years. It has mainly been employed when deflationary pressures were present and there was a zero lower bound for interest rates. It aims at expanding the size of central banks' balance sheets through asset purchasing, thus central banks can indirectly lower interest rates for riskier assets. Usually, the latter purchase long-term government bonds from banks and other financial institutions via open market operations. Due to increased demand, prices will be higher and yields lower. As government bonds are considered benchmarks, the interest rate of other investments is expected to decrease as well (Smaghi, 2009).

5.2. Green assets

To stimulate the market for green investment, central banks could purchase green bonds within the framework of quantitative easing. Green bonds are financial instruments with fixed interest and long maturity, designed to raise debt finance to fund climate-friendly investment. The main idea behind them is the mitigation of the climate crisis. These assets are issued by sovereigns, supranational institutions, development banks (for instance EIB, AfDB) and by corporations (*Mihálovits & Tapaszti, 2018*). Their popularity in recent years is due to the fact that more and more stock exchanges require so-called ESG reports (*Czwick, 2020*). However, investors are also increasingly interested in the non-financial risks of companies and demand Environmental, Social and Governance reports (*Broughton & Sardon, 2020*). These reports are second-party opinions that evaluate how a company's products and services are contributing to sustainable development in the areas of the environment (impact on nature), society (relationship with employees, working conditions) and governance (in relation to company leadership) and how efficiently companies are managing their resources (*Nordea, 2020*).

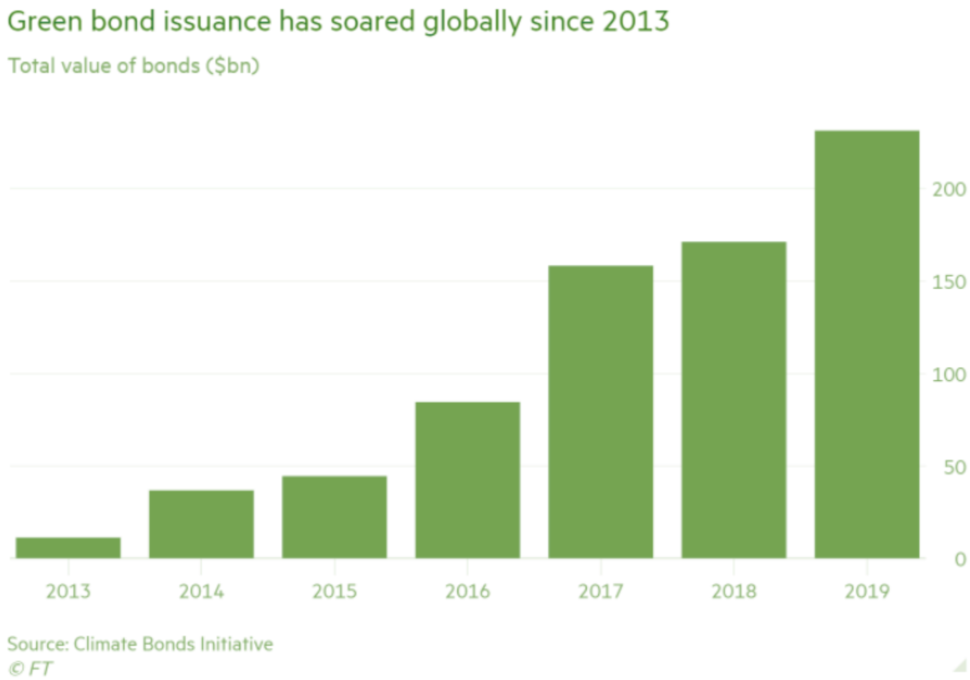
As part of quantitative easing, central banks can purchase green assets. An analysis has shown that green corporate QE programmes may have a positive impact and are able to reduce climate-related risk. If a central bank buys green bonds, the demand for such bonds goes up and this results in a higher price and lower yield. This lower yield reduces the cost of borrowing for firms (which do not rely on bank lending) and increases green investment. Furthermore, the yield of these assets declines relative to that of conventional bonds. The higher capital allocation to green assets helps to improve energy efficiency and decreases CO_2 emissions. This model has some simplifications, and while green QE programmes are not able to prevent global warming by themselves, they can contribute to reducing the temperature increase (*Dafermos, Nikolaidi & Galanis, 2018*).

Besides showing an example and including green securities in their portfolio, central banks could encourage other financial institutions to issue and invest in green assets by providing surveillance and regulation for banks related to green bonds. According to a survey among EU central banks, 50% of respondents have green bonds in their reserve (*Mihálovits & Tapaszti, 2018*).

Beside green bonds, there is a new asset on the capital market called the 'transition' bond. These assets allow companies from brown industries to become greener without meeting the requirements for a green label. The problem of greenwashing can arise as polluting companies may issue such bonds only in the expectation that this will boost their reputation without any change in business practices. However, the former might represent one asset that helps with greening the economy. The establishment of a common framework is necessary to make these instruments as credible as green bonds are (*Gross & Stubbington, 2020*).

Despite the very promising tendency in recent years (Figure 3 shows that the value of green bonds is increasing every year), green bonds still represent a minor part of the bond market, as only 0.2% of all bonds have a green label globally. Barriers related to the green QE programme are the following: the liquidity of these assets is still low due to the small market, and central banks are typically conservative regarding new assets and do not want to take the risk of using them (*Mihálovits & Tapaszti, 2018*).

Figure 3: Green bond issuance



Source: Financial Times

Beyond the tools previously mentioned, green differentiated capital requirements could be applied by central banks based on environmental impact after the climate risk connected to their lending is analysed and assessed. This measure would encourage banks to shift from speculative lending to green investment lending. For green activities, less capital requirements and more favourable regimes might be defined. Since central banks have to decide about and can influence the allocation of credit, they could become subject to lobbying pressure from interest groups (*Brunnermeier & Landau, 2020*). Green differentiated capital requirements would be an effective complementary measure, beside green QE programmes, for reducing CO_2 emissions (*Dafermos, Nikolaidi & Galanis, 2018*).

6. Conclusion

This paper has shown that the role of central banks is changing because of the increase in climate risks connected to CO_2 emissions. Central banks have the potential to encourage long-term, carbon-neutral investment, thus helping green the economy. The toolkit of central banks could be utilized in an efficient way to internalise the negative externalities related to CO_2

pollution and avoid financial instability in the economy. Even though monetary policy by itself is not able to stop climate change, it can influence the creation and allocation of credit and capital. Climate-related risks might have harmful effects on the financial system and central banks have to address these issues. However, central banks should be very careful with new assets and with their exposure to various forms of political pressure because their primary targets (price and financial stability) cannot be compromised.

Bibliography

Bank of England (2015). The impact of climate change on the UK insurance sector. *Prudential Regulation Authority*. London

Bartók, L. (2019). Válaszok a klímaváltozás kérdésére a fiskális és monetáris politika oldaláról. *Polgári Szemle*, 15. évf. 4-6. szám, 2019, 85-99.

Bihari, P. (2019). Szempontok a jegybank mandátumának újragondolásához. *Közgazdasági Szemle*. LXVI. ÉVF., 2019. December, 1241-1256.

Smaghi, L. B. (2009). Conventional and unconventional monetary policy. Speech at the Center for Monetary and Banking Studies, Geneva, 28.

Broughton, K. & Sardon, M. (2020). Coronavirus Pandemic Could Elevate ESG Factors. *The Wall Street Journal*. Retrieved May 25, 2020, from https://www.wsj.com/articles/coronavirus-pandemic-could-elevate-esg-factors-11585167518

Brunnermeier, M. K. & Landau, J-P. (2020). Central banks and climate change. *Vox, CEPR Policy Portal*. Retrieved June 3, 2020, from https://voxeu.org/article/central-banks-and-climate-change

Csapi, V. & Fojtik, J. (2009). Pénzügyi szolgáltatások az éghajlatváltozás tükrében: elérhető kockázatmenedzselési eszközök. *A szolgáltatások világa*. JATEPress, Szeged, 440-453.

Czwick, D. (2020). Válság idején felülteljesítik a piacokat az ESG-termékek. *Világgazdaság*. Retrieved June 3, 2020, from https://www.vg.hu/penzugy/penzugyi-hirek/valsag-idejen-felulteljesitik-a-piacokat-az-esg-termekek-2-2278341/

Dafermos, Y., Nikolaidi, M., & Galanis, G. (2018). Climate change, financial stability and monetary policy. Ecological Economics, 152, 219-234.

Gross, A. & Stubbington, T. (2020). The 'transition' bonds bridging the gap between green and brown. *Financial Times*. Retrieved June 6, 2020, from https://www.ft.com/content/ff2b3e88-21b0-11ea-92da-f0c92e957a96

IPCC (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Krekó, J., Balogh, Cs., Lehmann, K., Mátrai, R., Pulai, Gy. & Vonnák, B. (2012). Nemkonvencionális jegybanki eszközök alkalmazásának nemzetközi tapasztalatai és hazai lehetőségei. *MNB-Tanulmányok* 100.

Matikainen, S., Campiglio, E. & Zenghelis, D. (2017). The climate impact of quantitative easing.

Matus, J. (2019). Globális trendek és kockázatok a 21. Században – a második évtized. *Nemzet és Biztonság*. 2019/1. Szám, 20–41.

Mihálovits, Zs. & Tapaszti, A. (2018). Zöldkötvény, a fenntartható fejlődést támogató pánzügyi instrumentum. *Pénzügyi Szemle*. 2018/3

MNB (2020). Monetáris politika. Retrieved May 29, 2020, from https://www.mnb.hu/monetaris-politika

MNB (2020). Pénzügyi stabilitás. Retrieved May 29, 2020, from https://www.mnb.hu/penzugyi-stabilitas

Nordea (2020). What is ESG. Retrieved June 3, 2020, from https://www.nordea.com/en/sustainability/sustainable-business/what-is-esg/

Pál, T. (2018). Az európai mennyiségi lazítás jellemzői és perspektívái. *Köz-Gazdaság*. Budapest, 2018/4. 138-167.

Pandurics, A. & Szalai, P. (2017). A klímaváltozás hatása a biztosítási szektorra. *Hitelintézeti Szemle*. 16. évf. 1. szám, 2017. március, 92–118. o.

Ryszawska, B. (2016). Sustainability transition need sustainable finance. *Copernican Journal of Finance & Accounting*. 5(1), 185–194.

The ECB Podcast (2020). Climate change and the role of central banks. Retrieved May 25, 2020, from https://open.spotify.com/episode/2DtotEbmZKdmJXJwRme43f?si=olXzNL61QQOEFd1b8UX_YQ

The Economist Intelligence Unit (2015). The Cost of Inaction: Recognising the Value at Risk from Climate Change.

The World Bank (2020). CO2 emissions (kt). Retrieved June 6, 2020, from https://data.worldbank.org/indicator/EN.ATM.CO2E.KT

The World Bank (2020). World Development Indicators: Carbon dioxide emissions by sector. Retrieved June 6, 2020, from http://wdi.worldbank.org/table/3.10#

UN (2017). On the role of central banks in enhancing green finance.

Világgazdaság (2019). Már környezetvédelemmel is foglalkozik a jegybank. *Világgazdaság* Retrieved June 3, 2020, from https://www.vg.hu/penzugy/penzugyi-hirek/mar-kornyezetvedelemmel-is-foglalkozik-a-jegybank-1583894/

ESG-rated stock performance under Covid-19 An empirical study of Warsaw-Stock-Exchange-listed companies

Bogusław Bławat,[1] Marek Dietl,[2] Tomasz Wiśniewski,[3]

Abstract

Investors, lenders, and asset managers worldwide require private and public companies to measure their **E**nvironment, **S**ociety, and **G**overnance performance. Even entrant retail investors are aware of the abbreviation **ESG**. The majority of large global asset managers are committed to full ESG integration in their investment processes. The incorporation of ESG measures has been perceived to make investment portfolios more sustainable – i.e., increasing immunity to short-term shocks. In this paper, we evaluate the performance of ESG-rated stocks listed on the GPW Warsaw Stock Exchange. We investigate the role of ESG factors for both return and volatility, while controlling for industry and financial variables. In contrast to various pieces of earlier research, we find that the ESG score is positively related to return/risk ratios. The fundamental question of correlation versus causation remains open.

Keywords: stock performance, ESG, WSE, Covid-19.

1 Introduction and literature review

Sherwood and Pollard (2018), in the history-based introduction to their recent textbook, sought the roots of so-called "responsible investment" in religious beliefs. For Christians, Jews, and Muslims, their respective holy scripts influenced and constrained the choice of "asset allocations." The Holy Bible alone has over 2300 verses devoted to the issue of money. Therefore, it is not surprising that the industrial revolution and rise of capitalism increased the desire to make the use of capital compliant with religious teachings. Early Jews and Christians started to distinguish "sin stocks." Suppliers of addictive and health-harming products or war-related companies were black-listed by major religious groups. By the end of the nineteenth century, Christian and Islamic investment had become somehow defined – some industries were excluded from the investment universe.

At the turn of the nineteenth and twentieth century, investors gradually became more interested in what we today call Corporate Social Responsibility (CSR) and Social Responsible Investing (SRI) (Renneboog et al., 2008). Scheuth (2003) explains that the 1950s and 1960s witnessed significant developments in CSR and SRI in the USA. In a nutshell, social pressure resulted in both a change of attitudes and discourse – from contemplating the necessity of

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measuring non-financial performance to considering how the measurement of CSR performance should be evaluated.

The early 1990s brought about other essential developments in responsible investment. The latter became an asset class of its own. The first indices that incorporated social factors were launched.[4] Over a decade later, the term ESG was used for the first time. It was coined by the authors of the United Nations report on Principles of Responsible Investment. Fourteen years later, we can safely claim that all major players in the investment industry have since subscribed to the basic principles; however, we still lack widely accepted operational definitions and taxonomies (Mooney, 2020). Further discussion of that issue is beyond the scope of this paper. The following subchapter covers the current status of ESG investments worldwide. Next, we share up-to-date statistics about ESG investments, focusing on "ESG-intensive" stock performance. We summarize the chapter by reporting on selected contributions related to the impact of the first wave of the Covid-19 crisis on publicly traded equities in the context of ESG.

1.1 The immunity of equities to the Covid-19 crisis

The unprecedentedly strong reaction of share prices worldwide to the Covid-19 pandemic in March 2020 encouraged researchers to look for the factors that made some stocks more immune to the coronavirus crisis. The expected "suspects" were pre-Covid financial strength and ESG scores (Mooney, 2020).

The most comprehensive study we are aware of is that of Ding et al. (2020). The authors base their findings on a large dataset of over 6000 companies from 56 economies. They incorporate a broad range of parameters from five areas: finance, supply chain, corporate social responsibility, corporate governance, and investor base, i.e., shareholding structure. ESG performance was broken down into three parameters, including CSR score and CSR strategy. Those five variables were evaluated against twenty-one other parameters that present a fair overview of the importance of ESG scores on stock performance during Covid-19.

From our perspective, the most relevant finding is that past investments in CSR (represented by the variable CSR Score) were statistically significant at a 5% significance level in all model specifications. However, the importance of financial strength before the crisis and limited exposure to the international supply chain was more critical than CSR.

Another study that covered a cross-section of countries was presented in the Harvard Business School working paper series (Cheema-Fox et al., 2020). The research is focused on ESG factors and Covid-19. The authors use data from Truvalue Labs. The data on ESG sentiment in relation to public companies was gathered automatically using machine learning and natural language processing techniques in eleven languages. Company self-evaluations were avoided. The relatively sophisticated research approach yielded some interesting insights into the impact of sentiment around supply chains, human resources, and products as regards stock performance.[5] In part of the research, ESG scores were also included. Scores by Sustainalytics were not significant for stock returns, but MSCI ESG ratings were associated with 1.2% higher returns.[6]

There are also interesting contributions at the country level. Let us present just three of them. Takahashi and Yamada (2020) looked at Japanese public companies – specifically, their ownership

[4] To the best of our knowledge, the first one was the KLD Domini 400 social index, which has been calculated since 1990.

[5] Control variables were key economic and financial indicators.

[6] The authors analyzed companies of over USD 1 bn valuation. The ESG score was available for 600 companies spread across 47 countries, so the findings may be appropriately generalized.

structure, globalization of their value chains, and ESG. Those parameters were controlled for beta, size, liquidity, and momentum. ESG was included in two ways: (1) the Refinitiv ESG score, and (2) holdings of ESG-focused investment funds. The authors demonstrate a statistically significant relationship between excess returns and ESG score, but the presence of ESG funds in the investor base was positive for stock performance.

Similar results were reported by Broadstock et al. (2020). The latter found that portfolios consisting of stocks with high ESG scores outperformed other portfolios made up from China's CSI300 index. The authors use ESG data provided by SynTao Green Finance and control for variables like leverage and size. Their modeling includes industry-fixed effects. The authors offer an interesting decomposition of the ESG score. Environmental and Governance factors improve returns, and Social factors adversely affect portfolio performance.

The above-mentioned results were not confirmed by Folger-Laronde et al. (2020). The authors used a different portfolio approach by selecting environmental scores ("eco-funds") of Exchange Traded Funds (ETFs). Their findings are that high E-scores did not make ETFs more resilient to the Covid-19 crisis.

Demers et al. (2020) conducted an extensive comparison of market-based models with and without incorporation of ESG scores. The authors restricted their sample to US companies, but gathered a wide range of data. They built models around time-series covering the Global Financial Crisis, and tested them out-of-sample during the Covid-19 crisis. Their findings suggest that ESG scores do not significantly contribute to explaining stock performance compared to market-data based models. ESG-intensive stocks tend to underperform their peers when a wide range of accounting and financial data is controlled for.

Completely different findings were offered in Albuquerque et al. (2020). The authors analyzed US stocks in the first quarter of 2020. They found that Environmental and Social scores positively influenced both returns and trading volumes, and negatively (i.e. reduced) stock volatility. In many respects, we follow a similar approach in this paper.

A brief overview of the literature on ESG scores and stock resilience to the Covid-19 crisis shows a mixed picture. It seems that even excellent ESG performance is not a guarantee of the sustainability of an investment portfolio. It is not surprising thus that "ESG falls down the investment agenda," as the Financial Times reported (Telman, 2020).

1.2 Environment Society Governance (ESG)

The concept of SRI has, as with notions of corporate social responsibility (CSR) and philanthropy, a much longer history than the term Environment, Social, and Governance (ESG). The inclusion of social considerations and restrictions into investment decisions has occurred since the nineteenth century, especially among faith-based organizations. The approach gained momentum due to historical events, such as the Vietnam War, and social concerns (such as civil rights, the environment, and women's rights) were increasingly included in politically active individuals' investment decisions. Some decades later, SRI efforts specifically targeted investments in relation to South Africa's period of apartheid, and countries involved in the arms trade (such as Sudan), leading, for example, to the creation of Ethical Investment Research Services Ltd. (EIRISix) in London, which was set up to provide independent research for churches, charities and NGOs to help them make informed and responsible investment decisions (Khan, 2019).

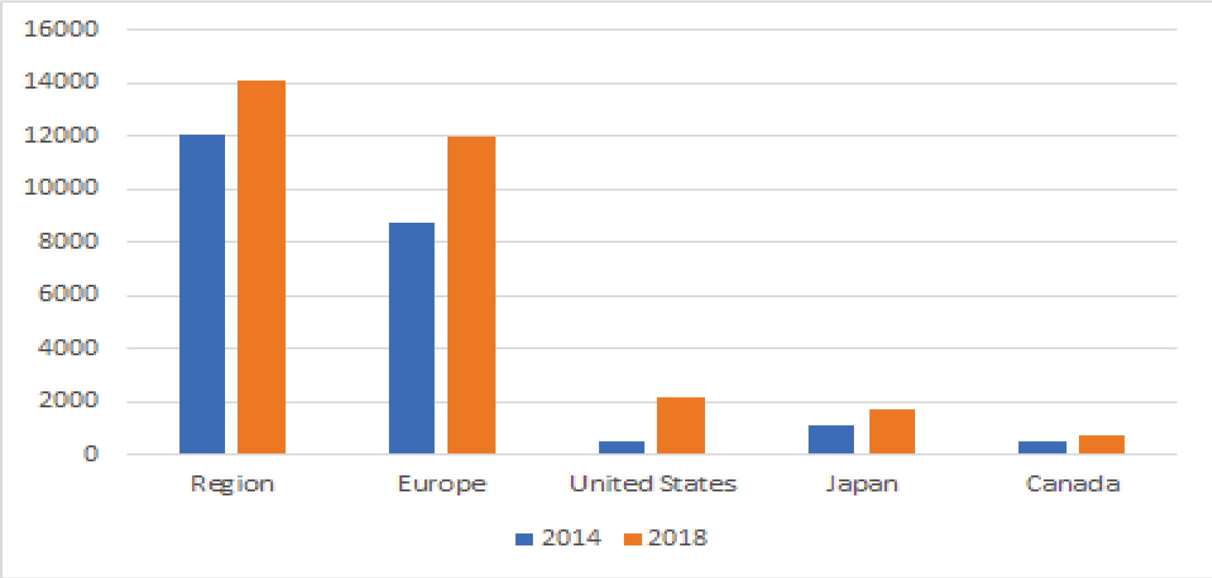
The term ESG first appeared in the United Nations Global Compact (Global Compact) report entitled "Who Cares Wins – Connecting Financial Markets to a Changing World" in 2004, for which the former UN Secretary-General invited a group of financial institutions "to develop guidelines and recommendations on how to better integrate environmental, social and corporate governance issues in asset management, securities brokerage services, and associated research functions." The final report was endorsed by a group of 20 financial institutions, including large banks (such as BNP Paribas, HSBC, and Morgan Stanley), asset owners (including Allianz SE and Aviva PLC), asset managers (such as Henderson Global Investors), and other stakeholders (such as Innovest).

The United Nations Environmental Program's Finance Initiative's (UNEP-FI) "Freshfield Report," released only one year later (in 2005), provided the first evidence of the financial relevance of ESG issues and discussed at length fiduciary duty in relation to the use of ESG information in investment decisions. In practice, management consulting firms and investors widely use ESG scores as a relevant measure for understanding a firm's overall CSR performance. ESG essentially evaluates a firm's environmental, social, and corporate governance practices and combines the accounts of these practices. A firm's ecological performance indicates its effort to reduce resource consumption and emissions. A firm's social performance measures, its respect for human rights, the quality of employment, product responsibility, and community relations. Finally, a firm's corporate governance performance indicates the rights and obligations of the management within a governance structure (Eccles & Stroehle, 2018).

The two reports are seen as the foundation of the UN-backed Principles of Responsible Investment (PRI), which was launched in 2006 and has attracted global financial institutions as signatories that collectively represent more than $89 trillion in assets. The growth of the number of signatories of the PRI is a barometer of the growing awareness of ESG issues among investors and their inclusion in investment decisions. As the increase in demand for ESG data has spurred the creation and growth of an entire industry of ESG data vendors in a relatively short period, those looking to use ESG data for the first time may find it challenging to navigate the wide range of offers available in the ESG data market.

According to the Global Sustainable Investment Alliance, sustainable investment assets under management in the five major markets stood at $30.7 trillion at the start of 2018 – a 34% increase in two years. In all regions except Europe, the market share of sustainable investing has also grown. Responsible investment now commands a sizable proportion of professionally managed assets in each region, ranging from 18% in Japan to 63% in Australia and New Zealand. Sustainable investing constitutes a significant force in global financial markets. From 2016 to 2018, the fastest-growing region in this respect was Japan, followed by Australia/New Zealand and Canada. The latter regions were also the three fastest growing in the previous two-year period. The largest three areas – based on the value of their sustainable investment assets – were Europe, the United States, and Japan. In Europe, total assets committed to sustainable and responsible investment strategies grew by 11% from 2016 to 2018 to reach €12.3 trillion ($14.1 trillion). Nonetheless, their share of the overall market declined from 53% to 49% of total professionally managed assets. The slight drop may be due to a move towards applying stricter standards and definitions. Although exclusionary screens remain the dominant strategy (at €9.5 trillion), this figure is down from the €10.2 trillion reported under this strategy in 2016 (Global Sustainable Investment Alliance, 2018).

Figure 1. Global Sustainable Investing Assets 2014-2018, data in billions of US dollars.



Source: Global Sustainable Investment Review

The ecosystem of organizations that provide ESG data is vast, and the products that are offered range from a wide variety of overall rating scores (sometimes including sub-dimensions), ratings of specific issue areas, overall rankings of companies based on specific scores, as well as services that provide evaluations of companies' ESG performance. According to the Global Initiative for Sustainability Ratings, over 100 organizations collect data, analyze, and rate or rank company ESG performance today. These organizations' origins can be traced back to the late 1970s, when sustainability issues first became part of the considerations of the capital market, often driven by NGOs. The latter sought to inform investors about companies' involvement in controversial issues, such as nuclear weapons development or apartheid in South Africa. One of the agencies that operates in the ESG scoring services market is Sustainalytics, which was created in 2009 from a merger of several research and rating organizations. In 2012, Sustainalytics entered the Asian market with an office in Singapore. In 2016, Morningstar acquired 40% of Sustainalytics, and in 2020 the rest of its shares.

ESG and stock performance

ESG investment refers to financial investment evaluated using three performance criteria, and is intended to support sustainable long-term economic and business development. Related international efforts, including the Paris Agreement to address climate change and the United Nations Sustainable Development Goals, together with the growing market demand for sustainable development, have driven the evolution of ESG investment. Investors have allocated their ESG investment mostly in equities and bonds, among other asset classes. Since the launch of the first ESG index in the US in 1990, ESG and ESG-related indices have become increasingly popular ways of meeting the growing appetite of investors for ESG investment.

Over the past three decades, ESG equity indices have evolved to cover global markets beyond the US and adopt different investment strategies.

According to the last survey of Hong Kong Stock Exchange investment return and volatility, the risk-return performance of ESG indices in many cases was similar to that of their parent indices for different investment horizons and under various market conditions. Some ESG indices, mainly regional ESG ones, had better returns and/or lower volatility than their parent indices during the same period of time. In other words, in many cases, ESG indices have tended to have similar, if not better, risk-return performance than their parent indices (HKEX, 2020).

These empirical findings may imply that individual ESG indices may have specific characteristics that contribute to their outperforming their parent indices that would not be expected to be present across the whole spectrum of ESG indices. As such constituents of ESG indices' companies are regarded to lead to better ESG performance, the potential outperformance of ESG indices relative to their parent indices may be associated with better corporate financial performance and/or higher investor valuation. ESG indices with differing ESG investment strategies in other markets could represent alternative investment choices with potentially better returns for global investors. By and large the empirical findings support the claim that ESG investment does not necessarily involve sacrificing financial returns – and may even increase them – while pursuing a policy of ethical investment.

2. Empirical study

2.1 ESG on the Warsaw Stock Exchange (GPW)

WSE has been involved in activities related to sustainable investments since the early 2000s, involving the field of Corporate Governance regulations and sustainability indices.

Best Practices for WSE-Listed Companies are related to a tradition of the Polish corporate governance movement, whose first formalized work was the collection of principles called "Best Practices in Public Companies 2002," developed by market experts and institutions connected with the financial market, with significant opinion-forming influence and the executive role played by the Best Practice Committee. This led to the passing of a code of corporate governance principles for further implementation by the WSE, which supported the dynamic propagation of principles with practical applications.

Modifications to the Best Practices made in 2016 were designed to ensure continued coverage of issues covered by the previous version of the corporate governance principles. To address comments raised by recipients of the Best Practice award, several existing principles were clarified. In specific areas key to corporate governance, the requirements became more enforceable. New issues previously not covered by the corporate governance principles for listed companies were added.

The detailed provisions of the Best Practice follow the "comply or explain" approach. Consistent non-compliance with a principle or an incidental breach requires a company to report immediately. It should be noted that companies' explanations of the reasons for and circumstances of non-compliance should be sufficiently exhaustive to represent a truthful explanation of the incidence of non-compliance and to allow for an assessment of the company's position regarding compliance with the principles of the Best Practice. The modifications approved by the Warsaw Stock Exchange aim to improve the quality of listed companies in relation to corporate governance standards. Compliance with corporate governance principles is voluntary. The transparent structure of the Best Practice, which avoids excessive barriers by ensuring that most of the principles are worded to allow for flexible implementation, and frequently refers to the principle of adequacy, should support the broadest implementation of this best practice code across the widest group of share issuers.

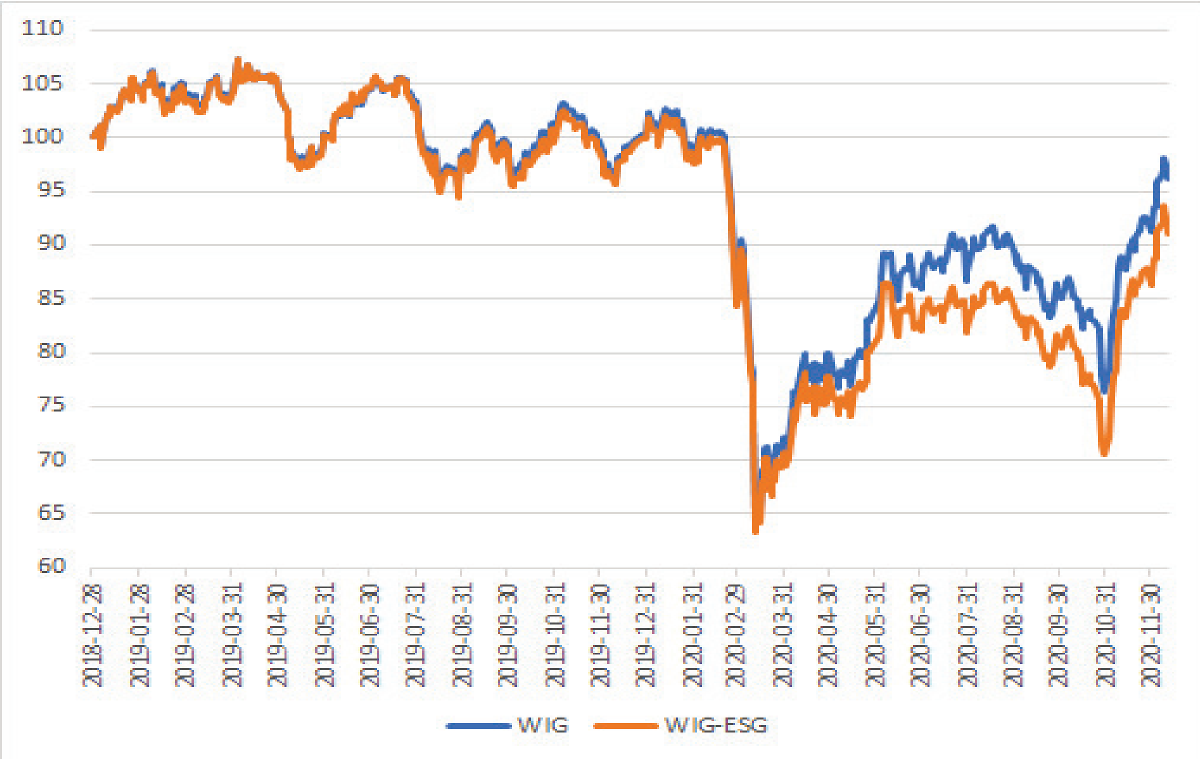
The WSE has launched two indices: RESPECTIndex in 2009, and WIG-ESG ten years later. The RESPECT Index concept, which was calculated to the end of 2019, was a follow-up to the Warsaw Stock Exchange measures that led to the creation of the first CSR index in Central and Eastern Europe.

The RESPECT Index company classification process was divided into three phases. Phase I aimed to identify companies with the highest liquidity, meaning that they were the companies incorporated into the following indices: WIG20, mWIG40, and sWIG80. Phase II included the evaluation of the corporate governance practice of companies, as well as information and investor relations governance, undertaken by the Warsaw Stock Exchange in collaboration with the Polish Association of Listed Companies on the grounds of publicly available reports published by the companies on their websites. In Phase III, an assessment was made of companies' maturity in terms of the social responsibility dimension in their operations on the grounds of questionnaires completed by companies, which were then audited independently. The deliverables of Phase III laid the foundations for preparing the final list of companies for inclusion in the RESPECT Index (Wiśniewski, 2010). In 2019, the RESPECT Index was replaced by the new WIG-ESG index.

The WIG-ESG index has been calculated since 3 September 2019 and includes the largest companies listed on the WSE. Weighting in the index depends on market capitalization, free float, trading volume, and ESG score. The ESG score is provided by Sustainalytics. Their reports determine the scoring based on publicly available information published by companies. The following data is analyzed: annual reports of companies, reports containing non-financial data, and information provided on websites. The Sustainalytics methodology assesses ESG risk; i.e., it measures the industry's exposure to specific risks related to ESG criteria and assesses how a given company manages these risks. Global companies that calculate indices and institutions that invest in international capital markets use Sustainalytics. In the ESG ranking, companies can achieve between 0 and 100 points. The lower the number of points, the better the company adheres to socially responsible business principles. Companies are ranked according to the points mentioned above, and classified into five groups. Depending on their classification into a specific group, the number of free-float shares of a given index participant is limited – from 0% (for companies from the first group) to 40% (for companies from the fifth group).

Shares of companies in the index also depend on the level of application of corporate governance principles contained in the "Best Practices of WSE Listed Companies 2016." Based on companies' published statements in this regard, the WSE awards companies weightings depending on the number of principles they apply and the quality of published statements. In the case of the Best Practices ranking, companies are classified into four groups, and their share is limited by an additional 0 to 15% depending on the assignment into a specific group. Also, the share of one company in the index may not exceed 10%, and the total share of companies, each of which exceeds 5%, may not exceed 40%. The index's methodology provides for the adjustment of the list of participants by removing existing members or adding other companies to replace them.

Figure 2. Performance of WIG and WIG-ESG indices (normalized, 100 at end of December 2018)



Source: Warsaw Stock Exchange data.

The base value of the WIG-ESG index was set on 28 December 2018 at the level of 10,000 points. This is a total return index, and thus when calculated it accounts for both the prices of underlying shares and dividend income. The index is calculated continuously at one-minute intervals. The index opening value is published after the session opening when the session transaction allows for the valuation of at least 65% of the index portfolio capitalization. The index closing value is broadcast once the session has been closed.

2.2 Sample and method

The data we used in our study consist of three subsets: ESG scores of 59 companies listed on the Warsaw Stock Exchange, stock exchange data, and companies' financial data. The time range of the data cover the entire year 2019, and the period from February to August 2020. The latter period, which starts with the COVID outbreak, coincides with the first wave of the epidemic.

The four ESG variables are:

1. ESG Risk Score
2. Overall Exposure Score
3. Overall Management Score
4. ESG Risk Rank Universe.

To control for the financial situation, and, in particular, the impact of results achieved in 2019 on companies’ ability to sustain their performance in the COVID period, we selected five control variables:

1. EBITA 2019
2. Total Debt to Total Assets 2019

3. Cash Flow to Net Income 2019
4. Pre-Tax Income 2019
5. Sustainable Growth Rate of 2019.

The last of the control variables was calculated as follows:

*Sustainable Growth Rate 2019 = Return on Common Equity * (1-(Dividend Payment Ratio/100))*

In the modeling process, we decided to start with the linear model. This decision resulted from the desire to observe the differences between 2019 and the COVID period using the same exogenous variables, and produce a more straightforward interpretation of their behavior.

2.3 Model and results

To examine the influence of individual factors on selected measures of company behavior in both analyzed periods, we chose six endogenous variables:

1. Stock rate of return
2. Percentage point distance from main stock exchange index
3. Percentage point distance from respective sectoral indices
4. Percentage point distance from sectoral indices excluding banks
5. Stock price volatility
6. Stock price volatility compared to volatility of sectoral indices

Table 1 presents the model estimation results for both periods under analysis.

Table1: Linear model coefficients

Variable	Return								Volatility			
	%		pp distance to WIG		pp distance to sectoral index		pp distance to sectoral index (no banks)				sectoral distance	
	2019	COVID	2019	COVID	2019	COVID	2019	COVID	2019	COVID	2019	COVID
Intercept	112.84	135.88*	112.59	96.51	67.08	-155.49	62.63	-64.63	20.8*	29.56	49.02	11.99
	(72.7)	(74.42)	(72.7)	(73.33)	(188.6)	(205.54)	(190.28)	(201.12)	(11.07)	(19.5)	(194.26)	(103.99)
ESG Risk Score	-6.91	-10.32	-6.91	-5.36	-4.61	23.01	-5.13	13.24	0.66	1.23	-8.06	1.55
	(7.16)	(7.33)	(7.16)	(7.22)	(18.84)	(20.53)	(19.01)	(20.09)	(1.09)	(1.92)	(19.41)	(10.39)
Overall Exposure Score	6.02	9.34	6.02	7.08	4.3	-11.37	4.24	-6.92	-0.43	-0.58	3.69	-2.21
	(5.9)	(6.04)	(5.9)	(5.95)	(11.08)	(12.07)	(11.18)	(11.81)	(0.9)	(1.58)	(11.41)	(6.11)
Overall Management Score	-3.28	-5.21*	-3.28	-4.15	-2.55	2.67	-2.4	0.72	0.26	0.2	-1.03	1.26
	(2.68)	(2.74)	(2.68)	(2.7)	(4.76)	(5.19)	(4.8)	(5.08)	(0.41)	(0.72)	(4.9)	(2.63)
ESG Risk Rank Universe	-0.84	-0.67	-0.84	-1.15	-0.38	-2.03	-0.12	-1.1	0.01	-0.06	1.39	0.36
	(1.02)	(1.05)	(1.02)	(1.03)	(2.01)	(2.19)	(2.01)	(2.13)	(0.16)	(0.27)	(2.07)	(1.11)
Sustainable Growth Rate	0.13	1.06*	0.13	0.56	-1.27	0.51	-1.08	1.17	0.11	0.44*	-0.77	0.69
	(0.55)	(0.56)	(0.55)	(0.55)	(0.81)	(0.89)	(0.8)	(0.84)	(0.08)	(0.15)	(0.84)	(0.45)
EBITA	-0.99	1.19	-0.99	1.59	-0.62	1.27	-0.71	1.6	0.05	-0.24	0.39	-0.23
	(1.47)	(1.5)	(1.47)	(1.48)	(2.12)	(2.31)	(2.14)	(2.26)	(0.22)	(0.39)	(2.18)	(1.17)
Total Debt/Total Assets	-0.26	-1.19	-0.26	-1.29**	-1.05	-0.85	-0.78	-0.39	-0.13	0.12	-0.11	0.47
	(0.5)	(0.51)	(0.5)	(0.5)	(0.86)	(0.94)	(0.83)	(0.88)	(0.08)	(0.13)	(0.89)	(0.48)
Cash Flow/Net Income	2.72	-0.16**	2.72	-0.4	0.35	-1.81	0.14	-2.41	0.19	-0.05	-1.14	0.09
	(1.88)	(1.92)	(1.88)	(1.9)	(2.42)	(2.64)	(2.44)	(2.57)	(0.29)	(0.5)	(2.49)	(1.34)
Pretax Income	2.28	-2.32	2.28	-2.85	2.33	-1.92	2.32	-2.56	-0.16	0.23	-0.35	0.47
	(2.67)	(2.74)	(2.67)	(2.7)	(3.64)	(3.97)	(3.67)	(3.88)	(0.41)	(0.72)	(3.75)	(2.01)
Adj. R-squared	0.12	0.41	0.12	0.34	-0.21	0.18	-0.28	0.29	0.02	0.21	0.02	-0.61

*Source: Authors. Standard errors are shown in brackets. Confidence level: ** 5%, * 10%.*

When assessing the model's ability to explain individual endogenous variables, it should be emphasized that long-term models are not the best tool for predicting the behavior of financial markets – we kept this fact in mind. We focused our efforts not so much on building the most accurate model, but more on finding out to what extent ESG factors can explain individual variances in endogenous variables.

In most cases, ESG factors better explain the behavior of shares in the COVID period than in 2019. For example, the variance of returns in 2019 was 12%, and during the COVID period 41%. Sometimes – as for example when comparing individual company returns with sectoral returns – the predictive power of the 2019 model is inferior to the simple average of the data.

In addition to the linear model, we examined how ESG companies behave compared to the broad WIG index. It turned out that, on average, companies in 2019 performed 1% better than the WIG index, while during the first period of COVID, this difference increased to 3.2%. We also examined how excluding the financial sector – which suffered very strongly due to very low base interest rates – from these calculations would affect the comparison of ESG company returns with the broad market index. It turned out that for 2019 this advantage dropped to 0.12%, while in the COVID period, it increased to 9.1%.

3. Summary and Discussion

The picture that emerges from our study results shows the significant impact of ESG indicators on a given company's ability to survive in the global crisis caused by the COVID epidemic. As exogenous variables, these indices explain 18 to 41% of the variance in the rates of return. For comparison, in 2019 this capacity was a maximum of 12%. There is a significant difference between WIG-ESG and WIG companies, which is due to the advantage of companies that follow the principles of corporate governance, social responsibility, and environmental protection. This advantage is also visible in the higher average return rates they created for investors during the COVID period. Undoubtedly, from the perspective of investment funds, this may be an essential criterion for selecting companies for an investment portfolio. Greater resistance to global crises is indeed a particular feature of ESG-compliant companies.

The research method we chose does not provide answers to all the emerging questions. One of the former is the issue of the role of individual ESG factors in explaining endogenous variables. Large standard errors do not allow for an unambiguous answer, even if the signs of the coefficients we obtained are consistent with the model's assumptions. Our attempts to reduce the model through the stepwise selection of variables reduced the problem of standard errors, but did not give a consistent indication as to the behavior of the sign of the coefficient. In a following study, it seems that it would be necessary to decompose individual ESG variables into the components of a given scoring, and thus identify those which are critical from the point of view of modeling a given company's behavior.

Conclusions

In recent years, the implementation of ESG factors in the evaluation of company performance has been observed. Stakeholders and especially shareholders have stimulated changes in attitudes and reporting. More and more corporations are incorporating ESG parameters into their business models. Without doubt, ESG has become mainstream within the investment industry. Stock exchanges and other index providers commenced calculation of ESG-related indices over 20 years ago. Currently, investors are offered a wide range of ESG-compliant products in emerging and developed capital markets. The GPW Warsaw Stock Exchange introduced the first index of socially responsible companies, RESPECT, in 2009, which in 2019 was replaced by the new WIG-ESG index.

The purpose of our analysis was to verify the differences between the rates of return and volatility of the share prices of companies deemed responsible and included in the WIG-ESG index against other WSE-listed companies in the WIG index. The research was conducted using data in two periods: in 2019, and during the first period of the COVID epidemic, from February to August 2020. As a result of the study, the following research hypotheses were verified:

I. ESG factors are significantly correlated to the rates of return and volatility of prices of companies from the WIG-ESG index in both periods that were analyzed.
II. Listed companies included in WIG-ESG index outperformed their peers (in terms of rates of return) and their stocks were characterized by lower volatility during the first phase of the COVID-19 epidemic.

The literature offers a mixed picture about the importance of ESG factors in relation to resilience to the COVID-19 pandemic. Our findings suggest that ESG-intensive stocks were more immune to recent market shocks.

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Bibliography

Albuquerque, R. A., Koskinen, Y. J., Yang, S., & Zhang, C. (2020). Love in the Time of COVID-19: The Resiliency of Environmental and Social Stocks. *CEPR Discussion Paper* No. DP14661. https://ssrn.com/abstract=3594293.

Broadstock D. C., Kalok C., Louis T. W. C, & Xiaowei W. (2020). The role of ESG performance during times of financial crisis: Evidence from COVID-19 in China. *Finance Research Letters*, 101716. https://doi.org/10.1016/j.frl.2020.101716.

Cheema-Fox, A., LaPerla, B. R., Serafeim, G., & Wang, H. (2020, September 23). Corporate Resilience and Response During COVID-19. *Harvard Business School Accounting & Management Unit Working Paper* No. 20-108. http://dx.doi.org/10.2139/ssrn.3578167.

Ching Y. H., Gerba F., & Toste T. H. (2014). Scoring Sustainability Reports using GRI indicators: A Study based on ISE and FTSE4Good Price Indexes. *Journal Management Research*, 6(3), 27-48.

Demers, E., Hendrikse, J., Joos, Ph., & Lev, B. I. (2020, August 17). ESG Didn't Immunize Stocks Against the COVID-19 Market Crash. NYU Stern School of Business. http://dx.doi.org/10.2139/ssrn.3675920

Ding, W., Levine, R., Lin Ch., & Xie W., (2020). Corporate Immunity to the COVID-19 Pandemic, NBER Working Paper 27055. https://www.nber.org/papers/w27055.

Eccles, R., & Stroehle, J., (2018). Exploring Social Origins in the Construction of ESG Metrics. https://www.esginvesting.co.uk/wp-content/uploads/2019/07/Judith-Stoehle.pdf.

Folger-Laronde, Z., Sep P., Leah F. & Amr ElA. (2020). ESG ratings and financial performance of exchange-traded funds during the COVID-19 pandemic. *Journal of Sustainable Finance & Investment*. DOI: 10.1080/20430795.2020.1782814.

Global Susttainable Investment Alliance, (2018). Global Sustainable Investment Review 2018, http://www.gsi-alliance.org/wp-content/uploads/2019/03/GSIR_Review2018.3.28.pdf?utm_source=.

HKEX (2020). Performance of ESG Equity Indices Versus Traditional Equity Indices, November 2020. https://www.hkex.com.hk/-/media/HKEX-Market/News/Research-Reports/HKEx-Research-Papers/2020/CCEO_ESGEqIdx_202011_e.pdf.

Khan, M., (2019). Corporate Governance, ESG, and Stock Returns around the World. *Financial Analysts Journal*, 75(4), 103-123.

Mooney, A. (2020, October 20). BlackRock pushes for global ESG standards, *Financial Times*.

Renneboog, L., Horst, J. T., & Zhang, C. (2008). Socially responsible investments: Institutional aspects, performance, and investor behavior, *Journal of Banking & Finance*, 32(9). https://doi.org/10.1016/j.jbankfin.2007.12.039.

Sherwood, M. W., Pollard, J., (2018). *Responsible Investing: An Introduction to Environmental, Social, and Governance Investments*. Routledge.

Schueth, S. (2003). Socially Responsible Investing in the United States. *Journal of Business Ethics* 43, 189–194. https://doi.org/10.1023/A:1022981828869

Takahashi, H., & Yamada, K. (2020). When the Japanese Stock Market Meets COVID-19: Impact of Ownership, China and US Exposure, and ESG Channels. http://dx.doi.org/10.2139/ssrn.3577424.

Telman, K., (2020, November 18). ESG falls down the investment agenda. *Financial Times*.

Wiśniewski T. K. (2010). Indeks RESPECTIndex jako inicjatywa Giełdy Papierów Wartościowych w procesie tworzenia zasad CSR na polskim rynku kapitałowym. *Zeszyty Naukowe Polityki Europejskie, Finanse i Marketing*, 4(53).

Yoon B., Hwan L. J., & Byun R., (2018). Does ESG Performance Enhance Firm Value? Evidence from Korea. *Sustainability*, 1

Environmental, Social, and Governance (ESG) Scores in the Service of Financial Stability for the European Banking System

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Abstract

The financial stability of the banking system depends mainly on the resilience of the banking system, which can be estimated with traditional variables like the ratio of non-performing loans, capital adequacy ratios, and other balance-sheet-related approaches that represent robustness (like ROA). This paper aims to test how the capital adequacy ratio can be estimated better with the implementation of different ESG scores (total and environmental only).

Since the ESG score can be an appropriate proxy variable for capturing the non-financial 'soft skills' of a bank, it can be used to approximate the ethical standards of a bank in the long run. This paper uses an annual set of 247 banks from the European Economic Area between 2002 and 2018 (source of data: Refinitiv database) to test our theoretical model, employing a standard unbalanced panel and a quantile panel regression in Eviews. The latter approach provides better insight into the assumed differences between banks with high and low capital adequacy ratios. Our results support the hypothesis that the ESG score could be useful for capturing a specific, financially more resilient market segment.

Keywords: ESG, financial stability, quantile regression, non-financial reporting

JEL code: E44, G21, O44, Q56, M40

1. Introduction

One of the emerging global trends in the past few decades has been the focus on aspects of sustainability in the field of the economy, even in the financial sector. Various corporate sustainability movements (e.g. triple bottom line, CSR, green economy, etc.) differ in their names but have the same goal of incorporating environmental (E), social (S), and governance (G) aspects into the activities of economic actors (Tóth, 2019). In the present study, the term 'green finance' is used to mean that all financial institutions consider not only economic efficiency but also sustainable development in their operations and in their strategies (Pintér & Deutsch, 2012). ESG information refers to the three central factors involved in measuring the sustainability and societal impact of a company.

Companies communicate their contribution to sustainability to their stakeholders in the form of non-financial reports (e.g. integrated reports, sustainability reports, CSR reports, ESG reports, etc.) whose evaluation is a resource and time-consuming task. In relation to its nature, the information received from ESG reports can be either qualitative or quantitative, which may cause difficulties with interpretation for stakeholders. This problem has led to the rise of sustainability rating agencies or ESG rating agencies – following the example of credit rating agencies, which are already well known in financial markets. These rating agencies, based on company reports and using different methodologies, award ESG scores, thus quantifying qualitative data.

Banks have a dual role: as users of reports on the one hand, and as reporters on the other. As lenders and investors, they collect non-financial (e.g. ESG) information, and measure different risk types based on company reports. We divide the motivating factors and incentives into two groups: mandatory elements, like regulations; and voluntary ones, like stakeholders' information needs. As reporting entities, banks are subject to regulations, but also to the expectations of stakeholders, institutions, etc. Mandatory incentives are regulations: for example, EU Directive 2014/95/EU, which requires the publication of non-financial reports for certain large undertakings of public interest in the European Union from financial year 2017, or EU Directive 2013/34/EU, which defines banks as public interest entities. Apart from regulations, other factors, including voluntary incentives, also influence the reporting behaviour of these institutions – for example, the non-regulated information needs of stakeholders, UN Sustainable Development Goals (SDGs), Science Based Target Initiatives (SBTIs), Principles for Responsible Banking, etc.

2. Theoretical Background

Why do companies publish ESG information? Several theories have emerged in relation to corporate disclosure (Lakatos, 2013), of which the following theories can be best linked to the publication of ESG information (Ortas et al., 2015).

Stakeholder theory deals with social actors that are affected by companies. According to the theory, when determining the scope of information to be disclosed, companies seek to serve the information needs of stakeholders (An et al., 2011). Stakeholder demand for information has a direct and indirect impact on companies' ESG disclosure practices. Employees and investors may even request various sustainability-related information directly (via phone or e-mail, etc.), or indirectly (investors influence disclosure practices through rating agencies).

Most authors connect legitimacy theory to the disclosure of ESG information (Ortas et al., 2015). According to the theory of organizational legitimacy, an organization can only operate within a framework that is established by members of society (Pereira Eugénio et al., 2013). The theory, therefore, is based on preconceptions about society and social relations, and suggests that managers should communicate information that influences users' perceptions of their organizations (Cormier & Gordon, 2001).

According to signalling theory, in order to eliminate information asymmetry and make their businesses more attractive, firms provide information to stakeholders that indicates that they are better than their peers (An et al., 2011; Campbell et al., 2001; Shehata, 2014). There are a number of ways to present a positive image of a company, one of the most effective of which is to disclose positive financial and non-financial information to stakeholders (An et al., 2011; Watson et al., 2002). Of course, a company will only adhere to the above practice if expenditure on signalling is less than the increase in revenue thereby generated (Szántó, 2009).

According to agency theory, divergent goals and information asymmetry lead to mutual distrust between the principal and the agent (Kaliczka & Naffa, 2010). Such relationships exist between managers and owners, between creditors and shareholders, and between management and employees (Jensen & Meckling, 1976). Reports are compiled by managers (agents) on the basis of which owners (principals) evaluate their performance in the given year (Jensen – Meckling 1976; Lakatos 2009; Mohl 2013). In this relationship, the managers of a company have an information advantage, and owners cannot accurately evaluate decisions that are made. The agent – i.e., the manager – can take advantage of the fact that their action is not observable, thus putting their own personal interests first (Barako, 2007). The conflicting interests of the two parties generate agency costs, and additional residual losses can occur if managers seek to maximize their own well-being in contrast to following owners' decisions (Jensen & Meckling, 1976, Shehata 2014).

From the above theories, it can be seen that the disclosure of ESG information can affect profitability, either by reducing agency costs or by providing more attractive investment opportunities, thus reducing the cost of capital for companies.

ESG disclosure-related investigations usually examine the motivation for the ESG disclosure, or the effect of the ESG disclosure on profitability and efficiency. Such research is presented in Table 1.

Table 1: Literature background of our investigation

Study	Aim of the research	Sample	Examined period	Method	Findings
Buallay, (2019)	Examine the relationship between profitability and ESG disclosure.	235 banks	2007-2016	linear regression	ESG disclosures have a positive impact on ROA and TQ. CSR disclosures have a negative impact on ROA and TQ. Corporate governance disclosure negatively affects ROA and ROE, and positively affects ROA.
Tommaso & Thornton, (2020)	ESG impact on risk-taking and bank value	European banks	2007-2018	linear regression	High ESG scores are also associated with a reduction in bank value. High ESG scores are associated with a modest reduction in risk-taking.
Ortas et al., (2015)	Financial factors' impact on company environment sustainability reporting	3931 companies from 51 industry	2010	quantile regression	Company size has a positive impact on reporting. Companies with higher leverage tend to provide more voluntary information. R&D spending is correlated positively with environmental reporting. Market return and capitalization have a positive effect on reporting.
Dell'Atti et al., (2017)	Test the relationship between sustainable behavior, firm reputation, and economic performance.	75 large international banks	2008-2012	Principle Component Analysis, multiple linear regression models.	Positive relationship between reputation and social performance, while reputation has a negative relationship with environmental and governance performance.
Birindelli et al., (2018)	Impact of a critical mass of female directors on ESG performance.	Banks from Europe and USA	2011-2016	panel regression	Bank sustainability performance is found to be positively associated with women on the board of directors, board size, CSR committee, and bank size. The relationship between women on the board of directors and a bank's ESG performance is an inverted U-shape. Gender-balanced boards positively impact a bank's performance.

Source: Authors' construction

Buallay (2019) found that ESG disclosure has a positive impact on ROA and TQ. In a very recent article, Tommaso & Thornton (2020) state that high ESG scores are associated with a reduction in bank value, and with a modest reduction in risk-taking.

Ortas et al. (2015) found that company size has a positive impact on ESG reporting. Companies with higher leverage tend to provide more voluntary information. R&D spending is correlated positively with environmental reporting. Market return and capitalization have a positive effect on reporting.

In Dell'Atti et al. (2017) we can read that there is a positive relation between reputation and social performance, while reputation has a negative relationship with environmental and governance performance.

According to Birindelli et al. (2018), bank sustainability performance is found to be positively associated with women on the board of directors, board size, the existence of a CSR committee, and bank size. The relationship between women on the board of directors and a bank's ESG performance is an inverted U-shape. Gender-balanced boards positively impact a bank's performance.

3. Theoretical model

Banking is based on the lending of allocated external capital (which can be assumed to be a deposit, bond, interbank-market debt, or other liability), where losses are limited by shock-absorbent tier one and two capital. Later capital adequacy standards were reinforced by the Basel Accords during recent decades, such as that regulatory capital requirements should keep up with owners' profit expectations (otherwise they should pursue other alternate investments), while profitability is a factor of economies of scale – but size determines the level of the supervisory authority in Banking Union countries. The quality of lending or solvency can depend on internal management competencies and external conjuncture variables. Therefore, we can assume that capital adequacy will depend on the following relationship among the above-mentioned variables (1).

$$capital\ adequacy = f(profit, size, management, solvency, shocks) \quad (1)$$

To operationalize the aforementioned set of relationships into a theoretical model (2), this paper employs the Capital Adequacy (as a percentage of total capital, CA_t) ratio as an independent variable (while its previous *t-1* value was added to the model to avoid autocorrelation in the residual), while profitability will be represented by Return on Assets (ROA_t), size by value of total assets (TA_t), while management resilience is proxied by the Environmental, Social, and Governance (ESG_t) scores and solvency is represented by the proportion of non-performing loans (NPL_t). It is worth mentioning that only the ESG_t ratio can be considered a forward-looking variable, since the others are determined by decisions made in the past. External shocks are represented by dummy variables: regulatory regime changes like the implementation of Basel 2 regulations ($dummy_{basel2}$), institutional regime changes like Eurozone-membership ($dummy_{ez}$), and conjunctural shock like recessions in the Eurozone ($dummy_{ez_{recession}}$) or in the US ($dummy_{us_{recession}}$) were added.

$$\Delta\big(\ln(CA_t)\big) = \omega + \beta_1\, \Delta(\ln(CA_{t-1})) + \beta_2\, \Delta(ln(ROA_t\ ) + \beta_3\, \Delta(ln(TA_t) + \beta_4\, \Delta(\ln\,(ESG_t)) + \beta_5\, \Delta(\ln\,(NPL_t)) + \beta_6\, dummy_{basel2} + \beta_7\, dummy_{ez} + \beta_8\, dummy_{ez_{recession}} + \beta_9 dummy_{us_{recession}} + \varepsilon_t \quad (2)$$

Intuition would suggest that we can anticipate the following results: Capital Adequacy will increase in case of increased profitability ($\beta_2 > 0$), growth in the balance sheet ($\beta_3 > 0$), if operations are guided by better established internal standards ($\beta_4 > 0$), and if losses on lending decrease ($\beta_5 < 0$).

4. Data and methods

4.1. Data

This paper analyses all 247 European banks whose data was made available in the Refinitiv Eikon database between 2002 and 2018. The only criteria for acceptance in the sample was that the latter had to report in one of the countries of the European Economic Area, creating unbalanced panel data.

Table 2 indicates that all the time series meet the input requirements for linear regressions: they are similarly scaled, their expected value is near to zero, and they lack a unit root. However, their distribution is not normal, since it shows excess kurtosis or 'fat-tails'. This result supports the later implementation of the quantile regression model.

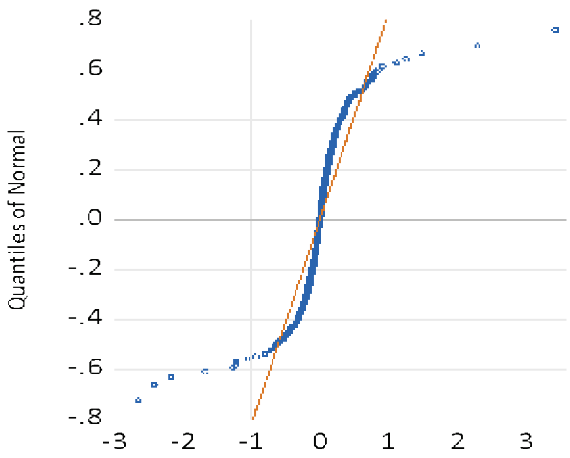
Table 2.: Descriptive statistics

	D(LN_CA)	D(LN_ROA)	D(LN_TA)	D(LN_ESG)	D(LN_NPL)
Mean	0.0341	0.0061	-0.0033	0.0176	-0.0002
Median	0.0242	0.0032	0.0069	0.0106	-0.0148
Maximum	0.8012	4.3766	9.2355	0.6733	1.3176
Minimum	-0.3562	-4.3638	-9.1479	-0.6312	-1.2540
Std. deviation	0.1330	1.0377	1.0084	0.0962	0.3198
Skewness	1.0343	0.1570	-1.2549	0.5954	-0.0182
Kurtosis	7.5360	7.3954	78.7642	15.7598	6.9601
Normal dist.: Jarque-Bera-stat.	422.5209	330.1145	97690.7900	2791.9380	266.6182
p	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*
No. of observations	408	408	408	408	408
Unit root: Im, Pesaran & Shin W-stat	-13,8031	-34,0422	-94,0126	-11,6013	-5,8620
p	*0,0000*	*0,0000*	*0,0000*	*0,0000*	*0,0000*

Source: Authors' edition, using Eviews 11

During the later defined quantile analysis, we analyse how the different changes in the Capital Adequacy ratio affect the theoretical model's behaviour. Figure 1. shows the fat-tailed nature of the ratio that supports the use of quantile regression.

Figure 1.: The QQ-plot of the logarithmic change of the Capital Adequacy ratio



Source: Authors' edition, using Eviews 11

4.2. Methods

Quantile models are based on quantiles of the conditional distribution of the response variable and are expressed as functions of observed covariates. While classical linear regression assumes that grouped data means fall on some linear surface, and the parameters can be estimated on this basis. Least squares regression offers a model: $\min_{\mu \in \Re} \sum_{i=1}^{n} (y_i - \mu)^2$ for the random y and μ unconditional population mean. The quantile regression follows a similar approach for conditional quantile functions: the scalar μ is replaced by a parametric function and $\xi(x_i, \beta)$ estimates of the conditional expectation function with a $\rho_\tau(.)$ absolute value function that yields the τth sample quantile as its solution: $\min_{\beta \in \Re^p} \sum_{i=1}^{n} \rho_\tau(y_i - \xi(x_i, \beta))$ (Koenker & Hallock, 2001).

For panel data, according to Lamarche (2010), it is necessary to employ the classical Gaussian random effects model first (3):

$$y = X\beta + Z\alpha + u \tag{3}$$

where Z is an "incidence matrix" of dummy variables, and α and u are independent random vectors. The parameter of primary interest β can be estimated by two alternative (fixed and random effect) models. Because the error term u is assumed to be mean zero and orthogonal to the independent variables, the conditional mean function of the unobserved effects model is: $\mathbb{E}(y_{i,t} | x_{i,t}, \alpha_i) = x'_{i,t}\beta + \alpha_i$, where $y_{i,t}$ is the response, $x_{i,t}$ is the vector of covariates, and α_i is an individual fixed effect. For quantile panel regression, it is necessary to use an analogous conditional quantile model: $QY_{i,t}(\tau_j | x_{i,t}, \alpha_i) = x'_{i,t}\beta(\tau_j) + \alpha_i$ for all quantiles τ_j in the interval (0, 1). The individual effect is assumed not to represent a distributional shift, since this is unrealistic in the case of a small number of individual observations. Therefore, the individual specific effect i will be the pure location shift effect on the conditional quantiles of the response. It is necessary to test slope equality across quantiles to show that linear models can generate inadequate conclusions for specific quantiles since there is a link between the explanatory and dependent variables. Therefore, coefficients of the estimated quantiles are valid for cases of $p<0.1$. There is also a test for symmetry between quantiles to check the heterogeneous impact of the explanatory variables, which suggests major discrepancies when comparing the upper and lower tails of the distribution (Škrinjarić, 2018).

The research for this paper employed an OLS panel regression to backtest the results of the quantile regressions.

5. Results

The estimated conventional OLS panel regression and the median result of the quantile regression results are presented in Table 3. This shows that only changes in the ESG ratio contributed to the near-median development of capital adequacy, meaning an improving ESG ratio contributed to the achievement of higher capital adequacy ratios. Meanwhile, the introduction of the Basel 2 regulations had an obvious impact on the increase in capital adequacy ratios. Both diagnostic requirements are met, since both the Symmetric Quantiles (Wald) Test and the Quantile Slope Equality (Wald) Test proved to be significant – meaning that it is worth analysing quantiles and there are significant differences between the two sides of the data change distribution.

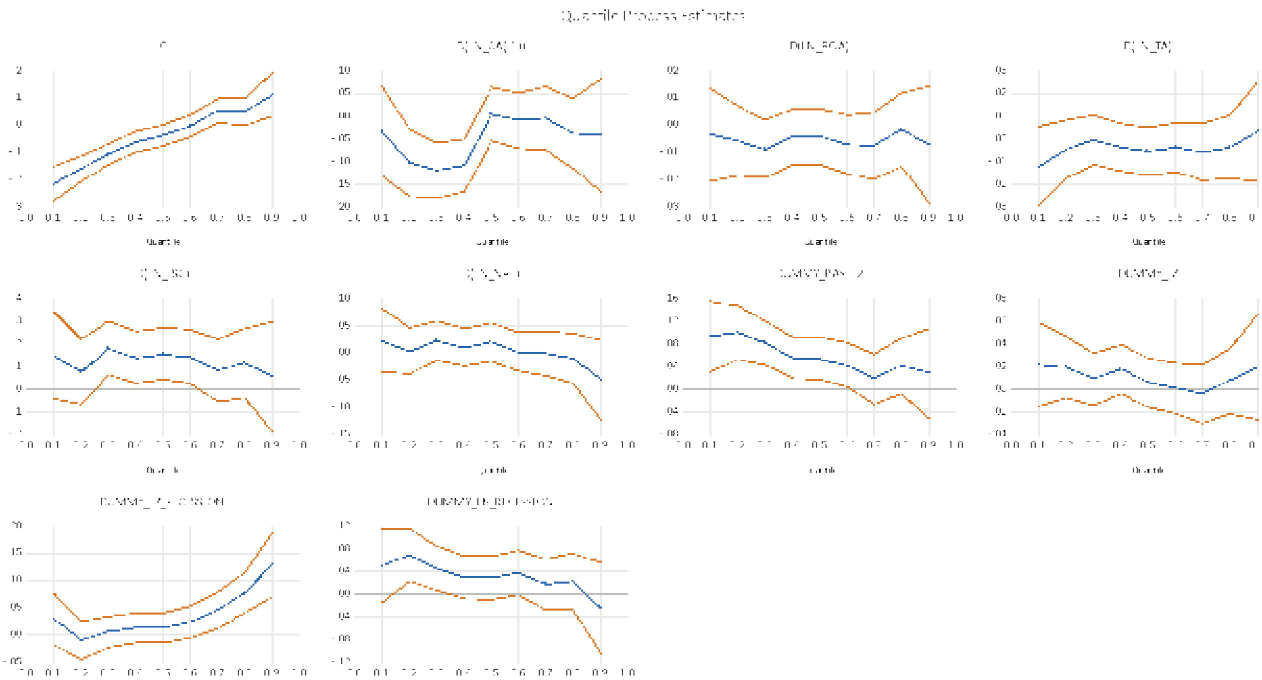
Table 3.: Results, based on the Panel Least Squares and the Median Quantile Regression

Modell	Panel Least Squares		Quantile Regression (Median) (Ordinary (IID) Standard Errors & Covariance)	
	Coefficient	Prob.	Coefficient	Prob.
C	-0.0323	0.1741	-0.0366	0.1127
D(LN_CA(-1))	-0.0040	0.9146	0.0047	0.8966
D(LN_ROA)	-0.0099	0.1261	-0.0039	0.5280
D(LN_TA)	-0.0046	0.4860	-0.0052	0.4124
D(LN_ESG)	0.1346	0.0622	0.1566	0.0253
D(LN_NPL)	-0.0077	0.7223	0.0212	0.3143
DUMMY_BASEL2	0.0454	0.0545	0.0541	0.0181
DUMMY_EZ	0.0166	0.2267	0.0061	0.6448
DUMMY_EZ_RECESSION	0.0521	0.0032	0.0140	0.4129
DUMMY_US_RECESSION	0.0189	0.4274	0.0292	0.2062
Durbin-Watson stat	2.2370			
R-squared	0.0661			
Pseudo R-squared			0.0363	
S.E. of regression	0.1323		0.1341	
Symmetric Quantiles (Wald) Test			18.7809	0.0431
Quantile Slope Equality (Wald) Test			27.8402	0.0645

Source: Authors' edition, using Eviews 11

Focusing on the deciles of the Capital Adequacy changes (see Figure 2), none of the variables made a significant contribution, except for the ESG-rate changes in-between the 30-60% deciles not too far from the median. This means that extreme changes in the Capital Adequacy ratio can be triggered by exogenous shocks, but not by model variables. However, under nominal circumstances, the improvement of ESG rates can contribute to further stability.

Figure 2.: Quantile regression results for each decile



Source: Authors' construction using Eviews 11б.

6. Conclusion

A resilient banking system is a fundamental component of financial stability. Our research tested the hypothesis that a higher environmental, social, and governance (ESG) score may strengthen a bank, proxied by the capital adequacy ratio. We utilized a sample of 247 financial institutions from the European Economic Area, covering the period between 2002 and 2018, as provided by the Refinitiv database.

Our quantile regression results suggest that the ESG score is a significant contributor to a bank's capital adequacy. The higher the ESG score, the higher the capital adequacy ratio. Our results imply that banks should be encouraged either by regulation or by stakeholders to achieve higher ESG scores in order to maintain higher capital adequacy, which may contribute to greater financial stability.

An interesting issue for further research would be analysing the sub-indices of the ESG score separately to reveal whether the different parts of the ESG (i.e. environmental, social, or governance) ratings affect capital adequacy in different ways. Results could also be compared to those for other prominent countries – for example, the United States and Japan.

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Bibliography

An, Y., Davey, H., & Eggleton, I. R. C. (2011). Towards a comprehensive theoretical framework for voluntary IC disclosure. *Journal of Intellectual Capital*, *12*(4), 571–585. https://doi.org/10.1108/14691931111181733

Barako, D. G. (2007). Determinants of voluntary disclosures in Kenyan companies annual reports. *African Journal of Business Management*, *1*(5). https://doi.org/10.5897/AJBM.9000203

Birindelli, G., Dell'Atti, S., Iannuzzi, A. P., & Savioli, M. (2018). Composition and Activity of the Board of Directors: Impact on ESG Performance in the Banking System. *Sustainability*, *10*(12), 4699. https://doi.org/10.3390/su10124699

Buallay, A. (2019). Is sustainability reporting (ESG) associated with performance? Evidence from the European banking sector. *Management of Environmental Quality: An International Journal*, *30*(1), 98–115. https://doi.org/10.1108/MEQ-12-2017-0149

Campbell, D., Shrives, P., & Bohmbach-Saager, H. (2001). Voluntary Disclosure of Mission Statements in Corporate Annual Reports: Signaling What and To Whom? *Business and Society Review*, *106*(1), 65–87. https://doi.org/10.1111/0045-3609.00102

Cormier, D., & Gordon, I. M. (2001). An examination of social and environmental reporting strategies. *Accounting, Auditing & Accountability Journal*, *14*(5), 587–617. https://doi.org/10.1108/EUM0000000006264

Dell'Atti, S., Trotta, A., Iannuzzi, A. P., & Demaria, F. (2017). Corporate Social Responsibility Engagement as a Determinant of Bank Reputation: An Empirical Analysis. *Corporate Social Responsibility and Environmental Management*, *24*(6), 589–605. https://doi.org/10.1002/csr.1430

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, *3*(4), 305–360. https://doi.org/10.1016/0304-405X(76)90026-X

Kaliczka N., & Naffa H. (2010). Természetes jelzések a megbízó-ügynök koalíció jövedelmének hitelesítésében. *Vezetéstudomány - Budapest Management Review*, *41*(4), 45–54. http://unipub.lib.uni-corvinus.hu/2783/

Koenker, R., & Hallock, K. F. (2001). Quantile Regression. *Journal of Economic Perspectives*, *15*(4), 143–156. https://doi.org/10.1257/jep.15.4.143

Lakatos, L. P. (2009). *A számvitel szabályozása, és a pénzügyi kimutatások hasznosságának megítélése*.

Lakatos L. P. (2013). A számviteli érdekhordozói elmé- letek evolúciója és a szabályozás. *Vezetéstudomány - Budapest Management Review*, *XLIV*(5), 13.

Lamarche, C. (2010). Robust penalized quantile regression estimation for panel data. *Journal of Econometrics*, *157*(2), 396–408. https://doi.org/10.1016/j.jeconom.2010.03.042

Mohl G. (2013). A kockázat szerepe a könyvvizsgálatban = The role of risk in external audits. *Vezetéstudomány - Budapest Management Review*, *44*(10), 50–62. http://unipub.lib.uni-corvinus.hu/1356/

Ortas, E., Gallego-Alvarez, I., & Etxeberria, I. Á. (2015). Financial Factors Influencing the Quality of Corporate Social Responsibility and Environmental Management Disclosure: A

Quantile Regression Approach. *Corporate Social Responsibility and Environmental Management*, *22*(6), 362–380. https://doi.org/10.1002/csr.1351

Pereira Eugénio, T., Costa Lourenço, I., & Morais, A. I. (2013). Sustainability strategies of the company TimorL: Extending the applicability of legitimacy theory. *Management of Environmental Quality: An International Journal*, *24*(5), 570–582. https://doi.org/10.1108/MEQ-03-2011-0017

Pintér É., & Deutsch N. (2012). A fenntartható fejlődés elvei és azok érvényre jutása a banki gyakorlatban II. rész (The principles of sustainable development and their realization in the banking practice II. part). *Vezetéstudomány - Budapest Management Review*, *43*(1), 57–63. http://unipub.lib.uni-corvinus.hu/2079/

Shehata, N. F. (2014). Theories and Determinants of Voluntary Disclosure. *Accounting and Finance Research*, *3*(1). https://doi.org/10.5430/afr.v3n1p18

Škrinjarić, T. (2018). Revisiting Herding Investment Behavior on the Zagreb Stock Exchange: A Quantile Regression Approach. *Econometric Research in Finance*, *3*(2), 119–162. https://doi.org/10.33119/ERFIN.2018.3.2.3

Szántó Z. (2009). Kontraszelekció és erkölcsi kockázat a politikában. Vázlat az információs aszimmetria közgazdaságtani fogalmainak politikatudományi alkalmazhatóságáról (Negative selection and moral risk in politics. An outline of the usefulness to political science of the economic concept of information asymmetry). *Közgazdasági Szemle*, *56*(6), 563–571. http://www.kszemle.hu/tartalom/cikk.php?id=1104

Tommaso, C. D., & Thornton, J. (2020). Do ESG scores effect bank risk taking and value? Evidence from European banks. *Corporate Social Responsibility and Environmental Management*, *27*(5), 2286–2298. https://doi.org/10.1002/csr.1964

Tóth, G. (2019). Circular Economy and its Comparison with 14 Other Business Sustainability Movements. *Resources*, *8*(4), 159. https://doi.org/10.3390/resources8040159

Watson, A., Shrives, P., & Marston, C. (2002). VOLUNTARY DISCLOSURE OF ACCOUNTING RATIOS IN THE UK. *The British Accounting Review*, *34*(4), 289–313. https://doi.org/10.1006/bare.2002.0213

Are climate-change-related projections incorporated into mortgage characteristics?

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Keywords: climate change, mortgage, non-bank, interest rate

Mortgage lenders are far from immune to the risks of climate change. Most importantly, climate-change-related physical destruction, impacts to local economies and demographic shifts, government measures, in addition to expectations and perceptions about the latter factors, can affect house prices – and the respective default rates. In addition, in some countries – such as the US – repayment willingness has also been shown to be strongly related to house prices (Ghosh, 2015). A slowdown in local economies, a decline in the health of residents, or a change in expectations thereof, could also increase defaults. Climate change is one of the most pressing problems of our day. Scientists have made a number of assertions with high confidence, including that mean temperatures will rise and hot spells will increase across all three dimensions: frequency, duration and magnitude (Collins et al., 2013).

In principle, concerned lenders have a menu of options regarding how to react to the latter, including adjusting loan terms. We are the first, to our knowledge, to investigate the relationship between climate *projections* and mortgage lending characteristics – primarily interest rates, but also loan terms. One strand of related studies has examined whether the impact of climate change, mainly through sea-level rise, is capitalised in real estate – providing mixed evidence. Other studies document mortgage lenders' reactions as climate-change-related risk becomes more salient due to, for example, natural catastrophes or abnormal weather. Also, to our knowledge we are the first to use temperature projections from the downscaled version of global climate models – the collaborative effort of a number of climate scientist teams worldwide that are used in the UN's reports – in a study in the area of finance.

Using loan-level data pertaining to close to two million US mortgages and the aforementioned global climate models, we find that the projected increase in the number of hot days in the coming decades has an effect on local mortgage characteristics. Results indicate a statistically highly significant impact, suggesting higher interest rates and shorter loan terms in areas more exposed to the changing climate, after controlling for macroeconomic, borrower and loan characteristics, local housing market risks, lender competition, and lender effects. In our baseline specification, the impact of a projected additional day with maximum temperatures above 90°F is 0.06bps on the rate spread. Comparing an area with no projected increase in the number of hot days with an area for which the average of 32 days' rise is projected, this effect alone corresponds to a two basis points difference (0.06*32) in the rate spread. Rate spreads are higher still in areas where the number of hot days is projected to be extreme. The probability of a loan term that is shorter than the standard 30 years rises by approximately 1 percentage point to 5.4% if the projected increase in the number of hot days is at the 75th percentile (40.4 days) rather than at the

25th percentile (24.5 days), assuming other variables are held at their means. The observed relationships are driven by lenders with a wide geographical focus and non-banks.

At a financial system level, a key question is the extent to which financial markets are pricing climate risks properly – i.e. anticipating risk events and efficiently discounting them. The better markets are at pricing risk today, the lower the probability of extreme price movements and bankruptcies in the future. There is widespread belief that financial market participants are still underestimating risks (e.g. Duan and Li, 2019), leading to financial stability concerns (Carney, 2015). In this respect, the results of our study are welcome. Importantly, though, our study does not seek to recommend the optimal level of rate spreads or loan terms with respect to the risk of global warming. The results of our study may also help guide supervisory efforts: in aggregate, banks do not appear to be factoring in increases in hot days in their rate spreads, and rate spreads on mortgages from lenders with a greater geographical concentration also react less to the climate variable.

References:

Carney, M., 2015. Breaking the Tragedy of the Horizon – climate change and financial stability. Speech given at Lloyd's of London 29, pp. 220-230.

Collins, M., Knutti, R., Arblaster, J., Dufresne, J.-L., Fichefet, T., Friedlingstein, P., Gao, X., Gutowski, W.J., Johns, T., Krinner, G., Shongwe, M., Tebaldi, C., Weaver, A.J. and Wehner, M., 2013. Long-term Climate Change: Projections, Commitments and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Duan, T. and Li, F. W., 2019. Climate Change Concerns and Mortgage Lending. Working Paper. Available at http://dx.doi.org/10.2139/ssrn.3449696 (accessed 15 August 2020).

Ghosh, A., 2015. Banking-industry specific and regional economic determinants of non-performing loans: Evidence from US states. *Journal of Financial Stability*, 20, pp. 93-104.

Carbon pricing – theory versus practice

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Abstract

Putting a price on carbon emissions has gained a lot of attention in recent years as a policy tool with the potential to reduce greenhouse gas emissions in an effective and economically efficient way. While setting a global uniform carbon price – considered by many economists to be the most promising strategy against climate change – continues to appear unrealistic, a growing number of countries and regions have introduced their own carbon-pricing schemes in the form of taxes or quota trading systems, and the further expansion of such schemes is expected. However, considerations about political feasibility and economic consequences may result in a considerable gap between these real-world carbon prices and economists' recommendations.

Theoretical carbon price estimates are also constantly evolving due to advances in scientific as well as economic modelling, but continue to suffer from considerable uncertainty. There are two widely used approaches for calculating a carbon price. First is the social cost of carbon that is calculated based on estimates of future damages from climate change, while the second approach is to calculate a shadow price based on the cost of achieving emission reductions consistent with a policy target. Based on these approaches, some countries have established official carbon values to support policy analysis and decision making.

The goal of this paper is to examine the current state of play regarding theoretical carbon price estimates and to compare the range of values with carbon prices used in public decision making and prices applied in actual carbon pricing schemes. Results show that, while values used for decision-support purposes broadly correspond with the mid-range of theoretical estimates, prices seen in actual carbon tax or ETS schemes continue to fall far short.

Keywords: climate policy, carbon price, social cost of carbon, shadow price of carbon, carbon tax, emissions trading systems

1. Introduction

In recent years, the pricing of carbon emissions has emerged as an important element of the toolbox in the fight against climate change. This is in accordance with the broader scientific and policy interest in the economic valuation of ecosystem services and environmental impacts. Establishing monetary values for pollutant emissions can be useful in a variety of ways. It can help policymakers measure the cost of mitigation measures against their expected benefits; and the former may also be directly imposed on economic actors to internalize the environmental damage associated with their activities and thereby create appropriate motivation for their reduction. However, in the case of pollutants such as greenhouse gases – which are global in nature, come from a wide variety of sources and lead to various effects that are highly complex and are expected to span many decades or even centuries – establishing a per-unit value[7] that is both theoretically sound and practically applicable is a considerable challenge.

Therefore, today we can observe the coexistence of various approaches to carbon pricing, with the range of recommended or used values differing considerably within, as well as between these approaches. For the purposes of this paper, we distinguish between four basic types of carbon price:

1. Theoretical values recommended by climate economists
2. Values used by some countries in public decision-making (for policy evaluation or investment appraisal purposes)
3. Carbon prices actually levied on economic actors in various jurisdictions (in the form of taxes or quota trading systems)
4. Internal carbon prices used by some companies as a voluntary environmental management tool

The goal of this paper is to examine the range of actual values recommended or used today under the above approaches (excluding the fourth type, as this paper does not address issues of corporate environmental management). Particularly, we aim to analyze the relationship between theoretical and real-world carbon prices; i.e., how the prices applied in public decision-making and environmental policy measure up to the recommendations of climate economists.

This paper is structured as follows: first, we present the theoretical discussions surrounding the calculation of a carbon price and the range of values resulting from the different approaches and model parameters. Second, we discuss the official values adopted by certain countries for the purpose of supporting public decision making, and finally, we report on the prices applied in actual carbon pricing schemes around the world today. Finally, we present our conclusions based on the comparison of the various values.

2. Theoretical approaches to carbon pricing

From a theoretical perspective, two basic approaches exist to establishing a carbon price (Hartje et al. 2015). The first one relies on the estimation of the future damages from climate change and uses this to calculate the marginal cost of an additional unit of CO_2 emitted today, known as the social cost of carbon (SCC). The alternative possibility is to start with a predetermined goal for climate change mitigation and calculate the unit cost of emission reductions consistent with that goal – this is known as the shadow price of carbon (SPC). From these two, the SCC approach can be considered the more theoretically sound, as it is in line with the fundamental principle of environmental economics that the optimum level of pollution abatement can be achieved by quantifying and internalizing the amount of external damage caused by pollution. This, however, assumes that environmental and economic goods are wholly substitutable, a proposition that is not universally accepted (Neumayer 1999).

Furthermore, as we will see below, in the case of climate change, quantifying damage is fraught with a number of methodological difficulties as well as ethical dilemmas that has led some (including the IPCC) to abandon the SCC approach and calculate carbon prices based on the SPC

[7] Carbon prices are usually given for tonnes of CO_2-equivalents (where other greenhouse gases can be converted into CO_2-equivalents according to their relative global warming potential).

– which, while still leading to a wide range of possible estimates, nevertheless substantially reduces the uncertainty inherent in establishing the SPC. In the following, we present the basics of these two approaches and some concrete value estimates proposed by climate economists.

2.1 The social cost of carbon

Calculating the SCC involves many steps and requires complex modeling of natural (climatic and ecological) as well as economic and technological processes.

First, it is necessary to predict how global greenhouse gas emissions will evolve in the future, through modeling expected economic and technological development.

The second question is how the temperature will change as a result of the above-described emissions.[8] Answering this question is far from straightforward, due to the need to understand many natural processes (including feedback loops such as melting ice or increased evaporation and changes in the capacity of natural carbon sinks such as the oceans and the biosphere) that significantly influence the degree of global warming, and at present our ability to model these is limited. Because of this uncertainty, climate models usually provide a range of estimates for the likely temperature increase, in relation to which it must be noted that especially the higher end of these estimates – the worst-case climate scenario – is very difficult to determine. In practice, this means that there is small but non-negligible likelihood (around 5-10%) that the future temperature increase and the resulting damage will be significantly higher than generally expected. Additional factors that are difficult to estimate but have an important impact on the damages resulting from climate change are the speed of the temperature increase and the changes that it will result in on a regional scale.

The next step in the modelling involves estimating the economic effects resulting from the expected climatic changes, which are usually described in the form of separate damage functions for various economic sectors. Current models mostly focus on estimating market impacts (such as changes in heating and cooling costs, production losses in agriculture, or damage due to extreme weather events) and some non-market impacts such as health damage. At the same time, other important effects, such as biodiversity loss, ocean acidification, or indirect impacts such as conflicts and migration are not taken into account because of the difficulty of their monetary valuation. Another problem is that empirical data only exist for a relatively small range of temperatures above which the validity of the damage functions cannot be tested (Hartje et al. 2015).

Finally, such damages must be summed up and converted into present values. This involves making decisions that are fundamentally ethical in nature, meaning that, unlike the above issues, uncertainty cannot be reduced in line with developments in scientific knowledge and methodology. The first of the former is the question of equity weighting, which must be considered when adding up damages that occur in different parts of the globe. This issue arises because the dollar value of equivalent damages in poor countries is less than in the developed world, but may (due to lower consumption levels and the decreasing marginal utility of consumption) nevertheless lead to a greater loss of welfare. Therefore, some economists recommend that, instead of simply summing up damage estimates regardless of where they occur, greater weight should be attached to damages that occur in developing countries. Because most damage is expected to occur precisely in these poor countries, the application of equity

[8] A key factor here is the so-called climate sensitivity parameter, which means the temperature increase associated with a doubling of the concentration of atmospheric greenhouse gases.

weighting can greatly increase the overall damage estimate, and therefore the SCC (Fankhauser et al. 1997).

Last, converting future damages into present values involves discounting, and the choice of the discount rate to be applied is perhaps the greatest source of disagreement among climate economists. Because the damages resulting from climate change are expected to extend far into the future, the choice of discount rate has a decisive impact on the present value of the damage estimates and can fundamentally influence the value of the SCC and the policy recommendations resulting from the analysis. On one side of the debate, economists, most prominently W. A. Nordhaus, argue that climate-change mitigation investments must compete with and therefore be evaluated according to the same standards as any other welfare-increasing investment – thus the discount rate that is applied must correspond to real market rates of return (that is, around 4-5%) (Nordhaus 2007). Others hold that such a devaluing of future generations' interests is ethically unacceptable and recommend the use of a lower social discount rate in relation to climate change. This can be justified by the fact that regular market rates do not reflect external effects and are highly sensitive to the situation of the economy – indeed, climate change itself may have such a negative impact on future growth rates that it renders estimates based on current growth prospects inapplicable. The most widely known supporter of this position is Nicholas Stern, who applied a discount rate of 1.4% overall in his famous review about the economic impacts of climate change (Stern 2008).

To date, several models have been created that undertake the complex process described above and provide estimates for the SCC and can also be used to test the impact of various assumptions and model parameters on the latter's value. The most widely used of these so-called integrated assessment models (IAMs) are DICE (the Dynamic Integrated Climate-Economy Model) created by Nordhaus (who received the Nobel Prize in economics in 2018 for his work), FUND (the Climate Framework for Uncertainty, Negotiation and Distribution) created by Anthoff and Tol, and the PAGE model (Policy Analysis of the Greenhouse Effect) created by C. Hope, which was also used in the calculations for the Stern Review.

Regarding the SCC, the central estimate of the models (provided by their creators) is as follows:

- DICE: 9.5 USD for 2005 (Nordhaus 2007) and 37.3 USD for 2020 (Nordhaus 2017)
- PAGE: 100 USD for 2009 (Hope, 2011)
- FUND: 6.6 USD for 2010 (in 1995 USD) (Waldhoff et al. 2014)

As can be seen above, the values are not directly comparable because of the different base years. It is important to note that in all models the SCC increases with time above and beyond inflation, because it is assumed that as climate change progresses, so will the damage associated with emitting additional units of GHGs. Nevertheless, it is clear that the differences between the results of the models are substantial. The main reason for the relatively low values published by Nordhaus is the high discount rate (5.5% in the 2007 estimate, reduced to 4.25% in the 2017 calculation) – Nordhaus provides the results of calculations from the DICE model that apply different discount rates, with a 3% rate leading to a carbon price of 87 USD, and the discounting method used in the Stern Review leading to 266.5 USD for 2020 (Nordhaus 2017) – highlighting the importance of the choice of discount rate. The PAGE and FUND models both apply discount rates between the two "extremes" suggested by Nordhaus and Stern – the high values of the PAGE model are primarily the result of the use of equity weighting, while the low value produced by the FUND model can be explained by optimistic assumptions regarding the effect of carbon fertilization (the positive impact that higher atmospheric CO_2 concentrations may have on plant growth) and the level of adaptation-related investment undertaken globally to reduce damage from climate change (Ackerman and Munitz 2016).

It is important to note that the values discussed so far are only the central estimates resulting from the application of the three main IAMs. The upper end of estimates is far higher, exceeding 1500 USD/t, according to a meta-analysis by Tol (2009). This high degree of uncertainty has led some economists to conclude that SCC values cannot usefully underpin climate policy (van de Bergh and Botzen 2015) – instead, the focus should be on setting climate targets that reduce the risk of catastrophic outcomes to a socially acceptable level (Weitzman 2007, Heal and Milner 2014). Measures should then be taken to achieve the emission reductions consistent with these targets at the lowest possible cost – which brings us to the SPC approach that will be discussed next.

2.2 The shadow price of carbon

The first step in estimating the SPC is setting a climate target. This is usually the goal of limiting the global average temperature increase to 1.5-2°C, as set out in the Paris Agreement, but can of course be any other (e.g. national) target. (By starting with a fixed target, the scientific uncertainty in the estimation of climate damages is side-stepped and ethical questions regarding inter- and intragenerational equity that are central to the SCC approach are implicitly answered.) The next step is to determine the amount of emission abatement necessary to achieve the target. This is done by establishing a business-as-usual pathway for emissions and comparing it to an emission pathway consistent with the climate target. (In the SPC approach, estimating the business-as-usual scenario is perhaps the greatest source of uncertainty [Sathaye & Shukla 2013]). The SPC is determined by the level of abatement that is necessary and the marginal cost of emission reduction measures (which increases along with the amount of abatement). The SPC is the carbon price that, if actually levied on all economic actors, would result in them collectively reaching the level of abatement necessary to achieve the climate target (with economic actors implementing all abatement measures whose unit cost is below the SPC). One characteristic that the SPC shares with the SCC is that it increases over time. In the case of the SPC, the increase can be attributed to the fact that the cheapest emission reduction measures are implemented first, but after exhausting these possibilities it is necessary to turn to increasingly expensive abatement options to maintain a reduction pathway consistent with meeting the target.

In practice, two main approaches exist for estimating the SPC. The bottom-up approach involves making a detailed analysis of the emission reduction technologies available in various sectors, determining their abatement potential and unit cost. Ordering these according to increasing unit costs gives the overall MAC (Marginal Abatement Cost) curve for GHG-reduction. The benefit of this approach is that it takes into account the specific characteristics of each sector and technology, while on the other hand, it does not reflect changes in the broader economic situation or developments in international energy markets, etc. Top-down models (such as input-output models or general equilibrium models), by contrast, calculate the cost of various decarbonization pathways from a macro-economic perspective, capturing interactions between various sectors of the economy, while their representation of intra-sectoral developments is limited (Sathaye & Shukla 2013).

Perhaps the most widely known attempt at calculating an SPC consistent with the 2°C climate scenario as presented by the IPCC is a study by the McKinsey company that adopts the bottom-up approach. After the analysis of a wide range of possible abatement options, they conclude that a carbon price of 60-100 EUR in 2030 would be sufficient to reduce emissions and stabilize GHG concentrations so that global warming would probably not exceed the 2°C threshold. (McKinsey 2009) A meta-analysis of 26 studies that provided SPC-estimates is presented by Kuik et al. (2008). Values range from 0-120 EUR/tonne with a median of 16.2 EUR for 2025, and increase to 1.4-450 EUR with a median of 34.6 EUR. However, the studies involved in the analysis differ in their climate targets, with most of them adopting a target higher than 2°C. In 2009, Kuik et al. published an updated version of the analysis that evaluated the 2°C-consistent SPC at 129 EUR in 2025 and 225 EUR in 2050 (in 2005 EUR). (Kuik et al. 2009)

In its most recent report, the IPCC (2018) also published SPC estimates for its 1.5 and 2°C climate scenarios, which are also the results of a meta-analysis involving multiple studies. The report puts the median SPC for a scenario in which there is a 66% likelihood that global warming will not exceed 2°C at 140 USD in 2030. For the most ambitious scenario, whereby a maximum of 1.5 C warming is achieved without any overshoot, the median SPC is nearly 1000 USD for 2030 (with all values increasing further into the next decades). The World Bank's High Level Commission on Carbon Prices concludes that carbon prices of minimum 40-80 USD/tonne in 2020 and 50-100 USD/tonne in 2050 would be necessary to ensure that warming does not exceed 2°C, but they note that these prices are only sufficient if part of a broader package of ambitious climate policy measures (Stern and Stiglitz, 2017).

3. Carbon prices applied in public decision-making

To date, several countries have established "official" carbon prices to be used in the evaluation of new policies or public investments. These are all based on one of the above approaches – but given the wide range of estimates we have seen above, national experts still have considerable room for maneuver when settling on specific values.

In the United States, the Interagency Working Group on the Social Cost of Greenhouse Gases was established in 2010 with the aim of determining carbon prices to be used by government agencies when conducting impact assessments. As indicated by its name, the working group used the SCC approach, combining estimates from the three main IAMs. They established four emission scenarios and ran the models 10,000 times, taking a random sample from the expected distribution of the climate sensitivity parameter, and calculated the simple average obtained from the different models, scenarios, and parameter values. According to the last published figures of the IWG, the central estimate for the year 2020 is 42 USD (applying a discount rate of 3%), but they also provided a lower estimate of 12 USD with a discount rate of 5%, and an upper estimate of 62 USD with a discount rate of 2.5%. In addition, the IWG also called attention to the necessity of taking into account the worst-case climate scenario, which is represented by the SCC of the highest estimates (95th percentile) – 123 USD at a 3% discount rate (IWG-SCGG 2016). (All prices above in 2007 USD.)

In 2017, however, the Trump administration disbanded the Interagency Working Group. Since that time, new official values have not been established, but the guidelines for impact assessments have been modified to state that such assessments should primarily focus on impacts occurring in the United States. In the case of climate change, this of course means that the majority of impacts are not taken into account and the damage estimates are considerably reduced. One study published by the US EPA in line with the new guidelines contained "interim" carbon prices as low as 1 USD for 2020 (at a 7% discount rate – the other published figure was 7 USD at a 3% discount rate) (at 2016 prices) (US-EPA 2019). Such low values of course mean that the range of climate mitigation investments considered worth implementing is substantially reduced.

In the United Kingdom, official carbon prices established by the Department of Energy and Climate Change (DEEC) were initially calculated using the SCC approach, but in 2009, the system was completely overhauled and is now based on the SPC (because of the perceived unreliability of the SCC). The current system uses different prices for sectors covered by the EU ETS (these are based on futures prices under the EU ETS) and the rest of the economy, where prices are estimated based on the UK's own climate targets and abatement cost estimates. The two values are set to converge (based on the latter approach) after 2030. The estimates are updated regularly, the most recent being 14 GBP for ETS and 69 GBP for non-ETS sectors, increasing to 81 GBP in 2030 (in 2018 GBP). However, the DEEC notes that in the future these values – and indeed the entire methodology – may be subject to change as a consequence of Brexit (DEEC, 2019).

Since 2019, France has also produced new, SPC-type official carbon prices in accordance with the country's recently adopted policies for achieving climate neutrality by 2050. (Previously, France also used SCC values, but these were established based on the literature and values used in other countries, not their own model calculations.) The current value is 87 EUR for 2020, increasing to 250 EUR by 2030 and further to 1203 EUR in 2060 (in 2018 Euros) (after which a further increase is not foreseen, assuming that carbon emissions will have been reduced to zero) (Quinet 2019).

In contrast to the UK and France, Germany moved in precisely the opposite direction when establishing their official carbon values. In 2012, the Federal Environment Agency (Umwetbundesamt) published carbon price recommendations based primarily on the SPC, set at 80 EUR/t "in the short term," increasing to 145 EUR "in the medium term" (in 2010 EUR) (UBA 2012). However, in its latest, revised recommendations, the UBA argues that the methodology of estimating the damages from climate change has improved sufficiently in recent years to base values on the SCC-approach, which it considers more theoretically sound. The calculations were done using the FUND model which, as we have seen above, provides the lowest SCC values under identical parameters; however, due to the UBA's use of a low discount rate and geographical equity weighting, the SCC thus obtained is quite high – 180 EUR in 2016, increasing to 205 in 2030 and 240 in 2050 (in 2016 EUR) (UBA 2019). (The discount rate used for these estimates is 2% – interestingly, the methodological background document [UBA 2018] argues, on ethical grounds, for an even lower, 1% discount rate, but the resulting SCC of EUR 640 for 2016 was probably considered too high to be applicable in practice. Another interesting feature of the German method is the approach to equity weighting – again, on an ethical basis, all climate damages are valued as if they would occur in Western Europe. This greatly increases the damage estimate, not just compared to a scenario with no equity weighing, but also compared to one where the basis for the weighting is the World average income.)

A direct comparison of the values cited above is difficult due to the differences in currencies and base years – in the table below, we provide a summary for the year 2020 (or closest year available) of the central estimates expressed in 2020 euros.

Table 1. Official carbon prices for 2020 in different countries (EUR/t, in 2020 euros)

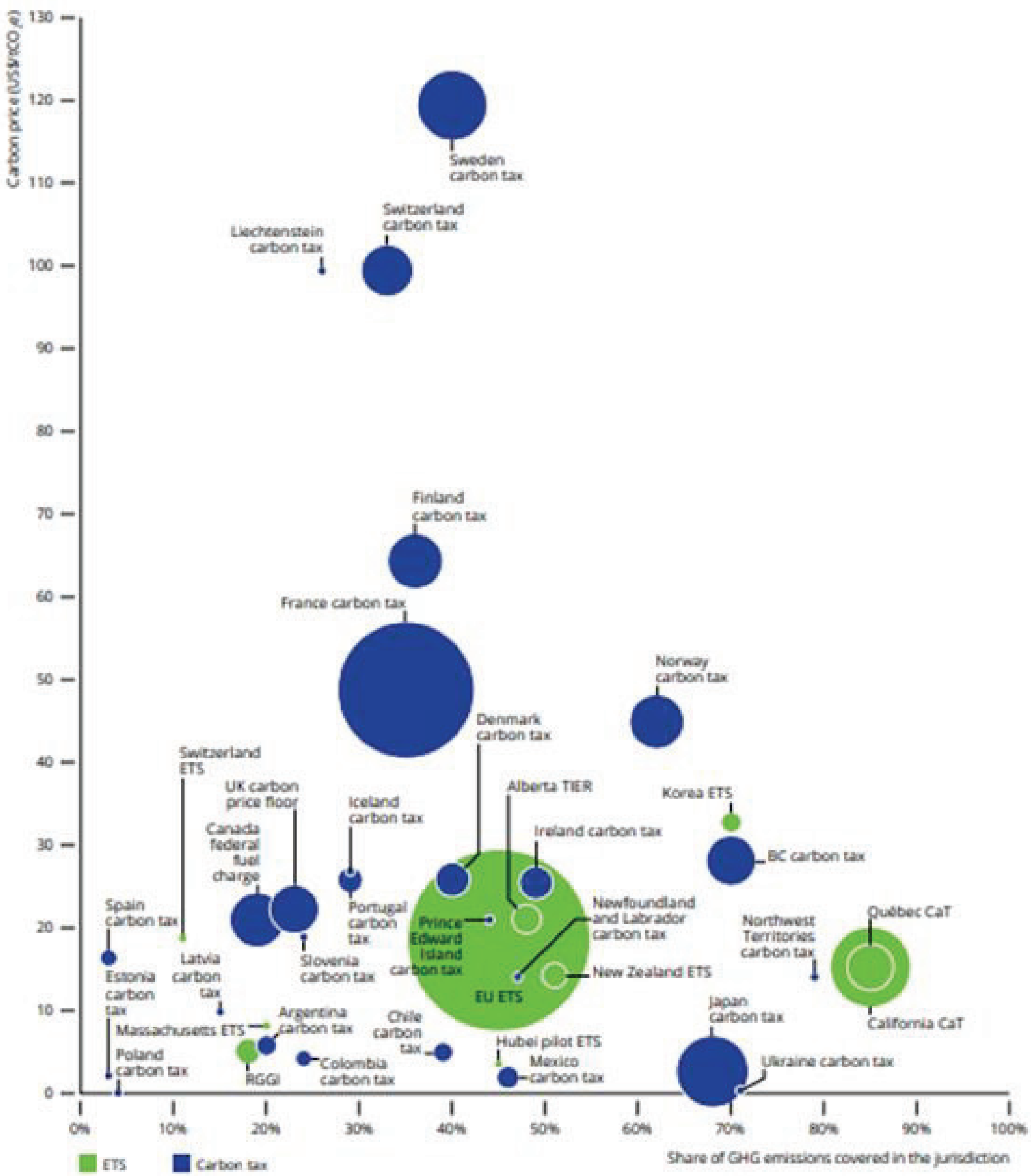
USA	UK	France	Germany
47 (old value)	16 (ETS sectors)	88	188 (value for 2016)
4 (new value)	79 (non-ETS sectors)		

4. Carbon prices levied on economic actors

Over the past years, carbon pricing schemes have been introduced in an increasing number of national and regional jurisdictions worldwide, and more are in the planning stages. These schemes can take two basic forms: taxes, or emissions trading systems. In the former case, prices are set by the authorities, while in the latter prices are more variable, being determined based on the market depending on the supply of credits (set by the authorities) and their demand (which ultimately depends on the baseline emissions of the actors involved and the cost of the abatement options available to them). Carbon pricing schemes are rarely universal, covering only a certain part of all carbon emissions in the given jurisdiction: carbon taxes are typically levied on transport fuels or all fossil sources of energy, while ETS systems usually cover large CO_2-emitting installations such as power plants and/or energy intensive industries.

The World Bank regularly publishes a report on carbon pricing schemes around the world – as of 2020, there are 30 carbon taxes and 31 ETSs implemented or scheduled for implementation (World Bank 2020). The main characteristics of some of these systems are summarized below Figure 2). The graph shows the price (as of 1 April 2020) and the percentage of emissions in the given jurisdiction covered by each scheme. The size of each circle is proportionate to the government revenue generated by the scheme.

Figure 2 Carbon pricing schemes around the World (source World Bank 2020, p.13)



It can be seen that the prices as well as the coverage of today's carbon pricing systems vary widely. The largest carbon pricing scheme currently in existence is the EU ETS – this is expected to change sometime in 2021, when, after a pilot phase involving several regional systems that are already operating, the Chinese national ETS is finally launched. Unlike the EU ETS, however, which covers all large emitters in energy intensive sectors and airlines, the Chinese system will initially only include the power sector (Reuters 2021). For most of its existence, the effectiveness of the EU ETS was hampered by very low prices resulting from an oversupply of permits, but the launch and subsequent strengthening of a market stability reserve mechanism appears to have solved this problem, with prices largely remaining in the 20-30 EUR range in 2019-2020 (EMBER 2021).

With a few exceptions, prices in most schemes are quite low. The highest carbon tax in existence is the Swedish carbon tax at 119 USD/t, followed by that of Switzerland and

Liechtenstein at 99 USD. The only other jurisdictions to have carbon taxes of over 30 USD are Finland, Norway, and France. Prices in ETS systems tend to be even lower, with the highest prices currently seen in the Korean ETS at 33 USD. Overall, about half of the emissions covered by the 61 schemes are associated with prices under 10 USD/tonne (World Bank 2020). It should be noted that the World Bank's report covers only explicit carbon pricing schemes – that is, schemes where the basis of the payment is solely CO_2 emissions. A much larger share of the World's fossil fuel consumption is subject to various energy taxes that also have the effect of increasing the cost of their use, but tax rates under such systems are not proportionate to the carbon content of the related fuels.

5. Discussion and conclusions

Putting a price on carbon is a difficult exercise that is fraught with scientific and ethical dilemmas, results in considerable uncertainty and a range of value estimates spanning four orders of magnitude – from under 10 USD/t to above 1000 USD/t. Nevertheless, looking at a wide range of studies, we can see a middle ground emerging that may be useful for guiding policymaking. From a cost-benefit analysis perspective, the carbon price (SCC) depends greatly on the assumptions that are made (notably the discount rate), but the mid-range of estimates corresponds fairly well to shadow price estimates compatible with a 2°C climate scenario (despite the fact that the two methods approach the problem from a completely different standpoint). Combining the two approaches, a carbon price of around 80-120 USD/t can be identified as a medium range for 2020 (always noting that the price should increase gradually over time until a state of carbon neutrality is reached).

Looking at the official carbon values for policy analysis (in countries where these exist), we can see that they are fairly ambitious and are largely in line with this medium range of theoretical recommendations (with the exception of the latest, extremely low American estimates that may well change again in the future). It is another question of course – and this would be a highly interesting topic for future study – to what extent these official values are actually utilized and influence public decision-making in these countries.

Regarding actual carbon prices, the picture is completely different – here, with a few exceptions, prices are much lower than the medium range of theoretical recommendations. Even if we adopt an SCC approach with a high discount rate, such as that proposed by Nordhaus, only 6 schemes out of 61 apply a carbon price that is as high as his recommendation of 37 USD for 2020. Only 5% of emissions under carbon tax or ETS schemes are currently are priced at a level the World Bank considers consistent with the 2°C climate target. (World Bank 2020) A further problem is that the coverage of these schemes does not extend to the entirety of emissions in the given jurisdiction – and many countries have no carbon pricing schemes. Overall, only around 22% of global carbon emissions are subject to explicit pricing schemes. Furthermore, according to the OECD, even if "implicit" carbon pricing schemes are taken into account, in most countries the effective carbon price still falls far short of what would be needed to meet the Paris climate targets (OECD 2018). All this means that – whatever one's position in the theoretical debate about carbon prices – actual prices are currently too low by any standards.

Of course, it would be wrong to assume that, useful as they might be, carbon pricing schemes will be the only tool of climate policy. A wide range of other measures – from renewable energy subsidies to energy efficiency standards and land use policies – can and do contribute to climate change mitigation, meaning that explicit carbon prices do not necessarily need to be of the magnitude identified in the theoretical calculations. Nevertheless, it is clear that the prices specified under most current carbon pricing schemes need to be substantially increased, and the scope of such systems extended if they are to play a meaningful role in the fight against global warming.

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References

Ackerman, F., & Munitz, C. (2016): A critique of climate damage modeling: Carbon fertilization, adaptation, and the limits of FUND. Energy Research & Social Science, 12, 62–67.

DEEC (UK Department of Energy and Climate Change) (2019): Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

EMBER (2021): Daily EU ETS carbon market price. https://ember-climate.org/data/carbon-price-viewer/

Fankhauser, S., Tol, R.S. & Pearce, D.W. The Aggregation of Climate Change Damages: a Welfare Theoretic Approach. Environmental and Resource Economics 10, 249–266 (1997). https://doi.org/10.1023/A:1026420425961

Hartje, V. Wüstemann, H. & Bonn, A (2015): Naturkapital Deutschland – TEEB DE: Naturkapital und Klimapolitik – Synergien und Konflikte. Technische Universität Berlin, Helmholtz-Zentrum für Umweltforschung – UFZ. Berlin, Leipzig

Heal, G., Millner, A. (2014): Uncertainty and decision-making in climate change economics. Review of Environmental Economics and Policy 8, 120–137.

Hope, C. (2011). The social cost of CO2 from the PAGE09 model. Economics discussion paper, (2011-39).

IPCC (Masson-Delmotte, V., Zhai, P., Pörtner, H. O., Roberts, D., Skea, J., Shukla, P. R., ... & Waterfield, T.) (2018). Global warming of 1.5 C. An IPCC Special Report on the impacts of global warming of, 1, 1-9.

IWG-SCGG (Interagency Working Group on Social Cost of Greenhouse Gases, United States Government) (2016): Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.
https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf

Kuik, O., Brander, L., & Tol, R. S. J. (2009): Marginal abatement costs of greenhouse gas emissions: A meta-analysis. Energy Policy, 37(4), 1395–1403.

Kuik, Onno; Brander, Luke; Tol, Richard S. J. (2008): Marginal abatement costs of carbon-dioxide emissions: A meta-analysis, ESRI Working Paper, No. 248, The Economic and Social Research Institute (ESRI), Dublin

McKinsey & Company (2009): Pathways to a low-carbon economy. Version 2 of the global greenhouse gas abatement cost curve

Neumayer, E. (1999). Global warming: discounting is not the issue, but substitutability is. Energy policy, 27(1), 33-43.

Nordhaus, W. D. (2007). A review of the Stern review on the economics of climate change. Journal of economic literature, 45(3), 686-702.

Nordhaus, W. D. (2017): Revisiting the social cost of carbon. Proceedings of the National Academy of Sciences, 114(7), 1518–1523.

OECD (2018), Effective Carbon Rates 2018: Pricing Carbon Emissions Through Taxes and Emissions Trading, OECD Publishing, Paris

Quinet, A. (2019). La valeur de l'action pour le climat. Une valeur tutélaire du carbone pour évaluer les investissements et les politiques publiques. France Stratégie. https://www.strategie.gouv.fr/sites/strategie.gouv.fr/files/atoms/files/fs-2019-rapport-la-valeur-de-laction-pour-le-climat_0.pdf

Reuters (2021): China's national emissions trading may launch in mid-2021 -Securities Times https://www.reuters.com/article/us-china-climatechange-ets/chinas-national-emissions-trading-may-launch-in-mid-2021-securities-times-idINKBN29G083?edition-redirect=in

Sathaye, J., & Shukla, P. R. (2013): Methods and Models for Costing Carbon Mitigation. Annual Review of Environment and Resources, 38(1), 137–168.

Stern, N. (2008). The economics of climate change. American Economic Review, 98(2), 1-37.

Stern, Nicholas and Stiglitz, Joseph E. (2017): Report of the high-level commission on carbon prices. World Bank, Washington D.C.

Tol, R.S.J. (2009): The economic effects of climate change. Journal of Economic Perspectives 23, 29–53.

UBA – UMWELTBUNDESAMT (2012): Best Practice Kostensätze für Luftschadstoffe, Verkehr, Strom- und Wärmeerzeugung, Anhang B der Methodenkonvention 2.0 zur Schätzung von Umweltkosten, Umweltbundesamt, Dessau-Rosslau.

UBA – UMWELTBUNDESAMT (2018): Methodenkonvention 3.0 zur Ermittlung von Umweltkosten - Methodische Grundlagen. Umweltbundesamt, Dessau-Rosslau.

UBA – UMWELTBUNDESAMT (2019): Methodenkonvention 3.0 zur Ermittlung von Umweltkosten - Kostensätze. Umweltbundesamt, Dessau-Rosslau.

US-EPA (2019): Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units. https://www.epa.gov/sites/production/files/2019-06/documents/utilities_ria_final_cpp_repeal_and_ace_2019-06.pdf

van den Bergh, J. C., & Botzen, W. J. W. (2015). Monetary valuation of the social cost of CO2 emissions: a critical survey. Ecological Economics, 114, 33-46.

Waldhoff, S., D. Anthoff, S. Rose and R. S. J. Tol (2014): The Marginal Damage Costs of Different Greenhouse Gases: An Application of FUND. Economics: The Open-Access, Open Assessment E-Journal 8(2014-31).

Weitzman, M. L. (2007). A review of the Stern Review on the economics of climate change. Journal of economic literature, 45(3), 703-724.

World Bank (2020). State and Trends of Carbon Pricing 2020. World Bank, Washington, DC.

The impact of ESG performance during times of crisis

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Abstract

In recent years, ESG (environmental, social and governance) investments have attracted the interest of mainstream investors. In the extreme years brought about by the pandemic, 2020 involved wild market trends. The first was a sharp decline in the market in March of last year, followed by a global economic recession and months of intense market volatility. Despite the rapid increase in responsible investment in recent years, the question of whether ESG can bring returns to shareholders and resist the risks of a crisis is still a controversial topic. The debate on whether ESG can fight the decline in stock prices during the crisis has been very hot in recent research. Based on this, this article will study the impact of ESG indicators in the global pandemic crisis and draw conclusions through empirical analysis to contribute to sustainable investment in reality.

This article proposes the hypothesize that ESG performance may serve as a valuable indicator to help companies get rid of negative risks during the crisis. Drawing on conclusions from the literature based on Albuquerque et al. (2020), Broadstock et al. (2020) and Demers et al. (2020) and using advanced econometric methods such as multiple regression and logit-based model to get the empirical results. In the multiple regression analysis, the correlation and causality among ESG indicators, accounting-based metrics and market-based metrics are discussed. The dependent variable in the logit model is a dichotomous discrete variable, which can be used to explain the "winner" and "loser" (whether EPS can rebound to pre-COVID level) during a crisis. The independent variables are ESG indicators, financial indicators, market risk measure, macro indicators or some other control variables. These fitted models can then be used to predict the probabilities of subsequent crises. Based on selected 969 sample data, the empirical results of binary models found that companies with high ESG risk score indicators have a 35 percentage lower chance of EPS recovery than those with low ESG risk scores in time of pandemic crisis. The conclusion of this article is that stocks with good ESG performance in their respective industries can indeed recover faster from the crisis and can withstand the current market turbulence caused by the COVID crisis. ESG indicators can be used as resilience indicators in times of crisis, that is, good ESG metrics can make stocks have the nature of a safe harbor during the COVID-19 pandemic.

***Keywords**:* ESG, Crisis Resilience, COVID-19, Corporate Social Responsibility

1. Introduction

In the extreme years brought about by the pandemic, 2020 involved wild market trends. The first was a sharp decline in the market in March of last year, followed by a global economic recession and months of intense market volatility, and finally ended with a rise in the market. The global stock market plummeted on March 23, 2020, and the MXEF index (MSCI emerging market index) dropped by 32.44% from the beginning of the epidemic (January 23) to March 23. The S&P index fell 32.11% over the same period. Since March 23, 2020, global stock markets have begun to rebound from the bottom. The S&P index has risen all the way, rebounding 76.4% from the trough. The MXEF index rebounded the most, at 88.78%.

The scale of ESG investment has maintained rapid growth over the years. ESG funds captured $51.1 billion of net new money from investors in 2020, a record and more than double the prior year. However, some critics of ESG investment often question whether this strategy can bring substantial returns. The debate on whether ESG can fight the decline in stock prices during the crisis has been very hot in recent research. Based on this, this article will study the impact of ESG indicators in the global pandemic crisis and draw conclusions through empirical analysis in order to contribute to sustainable investment in reality.

In the last year, a number of scholars have begun to study the relationship between ESG performance and firm financial performance and companies' resilience in the pandemic crisis. Pagano et al. (2020) measures the resilience of enterprises to the pandemic according to the method recently introduced by Dingel and Neiman (2020) in labor economics. This pandemic resilience refers to the price of technologies and organizational structures that are dependent on social isolation. After controlling for risk factors, they found that during the outbreak, companies with stronger resistance to social distancing were significantly better than those with lower resistance. A comprehensive study by Ramelli and Wagner (2020) showed that US companies with high international trade exposure and companies with high leverage and low cash holdings experienced the largest declines in the pre-eruption period (between January and February 2020). The leverage and cash holding effect will continue to exist in the following month. This shows that corporate leverage and international supply chain exposure and cash holdings have a significant impact on the company's pandemic resilience. Another study used a self-built crisis response index to reflect corporate resilience in crisis. The index is used as an independent variable to explain the crisis returns. By using natural language to process news from 3,023 companies in response to the coronavirus crisis, it was found that companies that responded with more positive sentiments would have fewer negative returns. (Cheema-Fox et al., 2020). Gerding et al. (2020) explored the factors that determine equity risk in the crisis from the macro level based on empirical research of 25,000 firms (more than 80 countries). In countries with lower fiscal capacity (defined as a higher debt/GDP ratio), the market decline is more severe. Capelle-Blancard & Desroziers (2020) use the increase in the number of COVID-19 cases and the increase in search intensity related to the COVID-19 pandemic on Google as independent variables of the regression benchmark, and evaluate the stock index returns in different time periods–outbreak, fever, and rebound. These results indicate that the stock market is less sensitive to the basic macroeconomic conditions of each country before the crisis than to the short-term response during the crisis. Some studies have linked the resilience of different stock prices to the exposure of the corresponding companies to the disease. Hassan et al. (2020) used the method of text mining to automatically classify the major issues related to the spread of infectious diseases raised by companies in quarterly earnings conference calls and constructed a text-based benefits and risk metrics. It was found that stock returns were significantly negatively correlated with disease exposure, and demand and supply-chain-related issues were the main driving forces. Albuquerque et al. (2020) examines how firms with highly rated environmental and social policies fare in the tumultuous marketplace. The article shows that the stock prices of high-ES companies in the crisis performed much better than the stock prices of other companies. In addition, high-ES stocks have less volatility in stock returns and higher trading volumes. Broadstock et al. (2020) explored the correlation between ESG performance and the short-term cumulative return of Chinese stocks before and after the COVID-19 crisis. The paper pointed out the ESG performance can mitigate financial risks during crisis, and the weakening of the role of ESG performance in the "normal" period proves its importance in a crisis. In addition, it also shows that investors may interpret ESG performance as a signal of future stock performance and/or risk mitigation during the crisis. In another strand of research Takahashi and Yamada (2020) offer mixed evidence on the relation between ESG and stock performance in Japan during COVID-19. While they find ESG ratings do not influence stock returns, they do find evidence of a non-linear relation between stock. Gamlath (2020) also makes a similar point and analyzes why the sustainability practices of ESG rating firms make ESG firms more resilient in times of crisis from the perspective of supply chain and investor loyalty. In addition, the barriers to sustainable investment are discussed. Rubbaniy (2021) found a strong and positive linkage relationship between GFI (daily global COVID-19 fear index) and ESG index, which confirmed the existence of the safe haven nature of ESG index during the COVID-19 pandemic. Demers et al. (2020) hold different opinions. With the company's industry and market risk measurement under control, they extensively analyzed the relationship between ESG scores and return performance during COVID-19. Regarding the role of ESG as a stock price resilience factor during the COVID crisis, they came to the opposite conclusion: ESG is not an important resilience factor during the crisis.

2. Research Methodology

2.1 Data and variable selection

Taking stocks in the MSCI emerging market index as the research object, collecting ESG-related and financial performance-related data of nearly a thousand companies for analysis.[9] In order to make the sample more standardized and the research results closer to the authenticity, this paper selects data based on the following principles, (1)Multiple imputation for sample companies with incomplete financial indicators or ESG data. Multiple imputation is based on the PMM method. (2) Exclude sample companies with abnormal data. After excluding the above samples, this article collected a total of 969 sample companies' relevant data. The sample data in the study comes from the sustainalytics database system of Morningstar and Bloomberg. After summarizing and sorting, the following variable definition table is obtained.

[9] Sample data collection as of March 22, 2020

Table 1. Variable definition summary

Variable type	Name	Description
ESG indicators	Combined controversy score	Composed of ten corporate controversy-related variables in the database; the calculation method is weighted from 1-5 to varying degrees according to each variable. For example, if the employee incidents score of a company is 2, then the corresponding added score is the square of 2, and so on.
	ESG score	Overall ESG score for each company
	ESG percentile-universe	ESG quantile, calculated from the overall ESG score
	ESG percentile-industry	ESG quantiles, but sorted by quantiles by different industries
	Overall management score	ESG risk management performance, indicating out of the total manageable risk exposure how much the company's management is able to manage properly.
Financial-related and other indicators	Financial leverage	Measures average assets to average equity
	Tobin Q	Ratio of the market value of a firm to the replacement cost of the firm's assets. Calculation method according to Bloomberg terminal
	Z score of PE_BT	Standardization of monthly PE data of the company's blended forward for the past three years, and latest value taken
	Latest PE_BT	Company's latest blended forward PE data
	Calmar ratio	Comparison of the average annual compound rate of return and the maximum drawdown risk. The higher the Calmar ratio, the better it performed.
	Profit recovery rate	EPS blended forward in 2021 divided by the indicator before the pandemic. Used to measure the EPS rebound rate.
	Momentum	Pace and the strength of a specific security's price movements. Taken from Bloomberg Terminal Database
Resilience indicators	Max drawdown	The decrease from the highest point to the bottom during the COVID-19 period (between January 1, 2020 and May 1, 2020)
	Recovery rate	The ratio of the company's stock price as of March 23,2021 to the pre-COVID-19 highest price level
	Volatilities 360	The 360-day price volatility equals the annualized standard deviation of the relative price change for the 360 most recent trading day's closing price
	Recovery_yesno	Whether the company's share price returned to the level it attained before COVID-19
	ESGrecovflag	When Profit recovery rate>0, this is 1, otherwise it is 0
Control variables	Market cap	The cCompany's stock market value, used to measure company size (million $U.S)
	GICS_sector	Global Industry Classification Standard. GICS is a four-tiered, hierarchical industry classification system. There are 11 sectors in GICS
	GICS_industry_group	There are 24 industries in the GICS classification

At present, the academic circles have not formed a unified view on the measurement methods of corporate resilience factors in crisis. Some use single indicators such as volatility to directly quantify, and some use their own indicators such as VOLARE (volatility and ROE) (Markman, GM, & Venzin, M. (2014)). Most of the papers on resilience indicators focus on the macro level, that is, in economic research, and there are few studies on the financial market type. By referring to related literature, this paper constructs four types of indicators to measure the comprehensive level of pandemic resilience, namely Max drawdown, Recovery rate, Volatilities 360,Recovery_yesno.

2.2. Research model

The research model of this paper mainly considers the correlation analysis of the impact of ESG and financial performance on the company's resilience in the crisis. The research hypothesis is verified through analysis methods such as correlation analysis, multiple regression test, and logistic regression to ensure the authenticity and objectivity of the research results. The statistical software used is R studio. In response to the above discussion, several regression models are proposed.

Multiple linear regression model

When Max drawdown as the dependent variable:

$$\text{Maxdrawdown} = \beta_0 + \beta_1 \text{ERS} + \beta_2 ERPU + \beta_3 ERPI + \beta_4 MS + \beta_5 FL + \beta_6 TQ + \beta_7 ZPB + \beta_8 LPB + \beta_9 SIZE + \beta_{10} \text{CCS} + \beta_{11} CR + \beta_{12} Mo + \beta_{13} PR$$

When recovery rate and volatility 360 as the dependent variables:

$$\text{Recovery rate} = \beta_0 + \beta_1 \text{ERS} + \beta_2 ERPU + \beta_3 ERPI + \beta_4 MS + \beta_5 FL + \beta_6 TQ + \beta_7 ZPB + \beta_8 LPB + \beta_9 SIZE + \beta_{10} \text{CCS} + \beta_{11} CR + \beta_{12} Mo + \beta_{13} PR$$

$$\text{Volatility360} = \beta_0 + \beta_1 \text{ERS} + \beta_2 ERPU + \beta_3 ERPI + \beta_4 MS + \beta_5 FL + \beta_6 TQ + \beta_7 ZPB + \beta_8 LPB + \beta_9 SIZE + \beta_{10} \text{CCS} + \beta_{11} CR + \beta_{12} Mo + \beta_{13} PR$$

Logit and probit and linear probability model（LPM）

$$y^P = \Lambda(\beta 0 + \beta 1 x1 + \beta 2 x2 + \dots) = \frac{\exp(\beta 0 + \beta 1 x1 + \beta 2 x2 + \dots)}{1 + \exp(\beta 0 + \beta 1 x1 + \beta 2 x2 + \dots)}$$

$$y^P = \Phi(\beta 0 + \beta 1 x1 + \beta 2 x2 + \dots) \quad \Phi(z) = \frac{\exp(z)}{1+\exp(z)} \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{t^2}{2}\right) dt$$

Logit and probit are nonlinear probability models. Logit: yP = Λ(β0 + β1x1, β2x2 + ...) where the link function Λ is called the logistic function. Probit: yP = Φ(β0 + β1x1, β2x2 + ...). According to the Profit recovery rate variable, redefine a new variable EPSrecovflag to measure whether the company's EPS forward (2020/2021) has returned to the level before the Covid-19 outbreak. 1 means it has returned to the level before the pandemic, and 0 means it has not returned to the level before the pandemic. EPSrecovflag is used as an explained variable, and the explanatory variables are ESG indicators, financial indicators, market risk indicators, etc. Use three models to predict EPSrecovflag and compare the models.

3. Empirical Results

3.1 Descriptive Statistics

Table 2. Descriptive statistics of main variables

Descriptive statistics							
Statistic	**N**	**Mean**	**St. Dev.**	**Min**	**Pctl(25)**	**Pctl(75)**	**Max**
Market_cap	969	17 603,06	44 421,32	706,32	4 086,63	15 488,36	818 563
Size	969	9,06	1,05	6,56	8,32	9,65	13,62
ESG_Risk_Score	969	29,48	10,02	8,45	22,39	34,98	67,81
ESG_RiskPercentile_Universe	969	0,51	0,27	0,01	0,29	0,74	1
ESG_RiskPercentile_Industry	969	0,46	0,26	0,01	0,24	0,65	1
Overall_Management_Score	969	33,93	12,66	7,12	24,07	41,88	76,66
Combined_controv_score	969	6,03	9,24	0	0	8	80
Fncl_LVRG	969	4,38	4,34	1,06	1,82	4,97	57,48
TobinQ	969	1,91	2,11	0,5	1	1,95	25,23

Zscore_PE_BT	969	0,37	1,48	-2,76	-0,78	1,44	4,54
Latest_PE_BF	969	50,76	206,64	1,59	10,17	32,17	3 861,05
Max_drawdown	969	-0,37	0,13	-0,93	-0,46	-0,26	-0,05
Vol_360	969	41,78	12,26	9,83	33,73	49,04	118,46
Calmar_ratio	969	0,78	1,94	-1	-0,33	1,12	17,74
Profit_recov	969	-1,57	60,37	-1 780,37	0,99	1,68	40,99
Momentum	969	13,05	4 071,95	-86 000,00	-1,2	1,5	49 500
Recovery_rate	969	0,11	0,44	-0,85	-0,16	0,27	2,46

The number of sample observations is 969. From the average point of view: the ESG risk score is 29.5, which is at the middle and lower level. The latest PE blended forward value is 50.8, which is more expensive. The largest retracement in the covid crisis is 37%, and the 360-day volatility is 41.8%. The stock price rebound level only reached 11.3% of the pre-crisis level, and the EPS recovery rate was negative.

According to whether the EPS level is restored, that is, EPSrecovflag variable, draw multiple sets of box plots for comparison. As shown in Figure 1, the groups with a P value of less than 0.05 include financials, materials, real estate, and industrial . When EPSrecovflag=1, the average value of max drawdown is significantly higher. Those companies that withdrew less in the face of the epidemic were the ones that recovered the fastest in terms of profits, which indicates that the market has fully considerd the company's industrial attributes and profit elasticity when pricing. Those stocks that were resilient were the first to emerge from the cloud of the pandemic, returning to pre-pandemic levels.

Figure 1. Multiple box plots based on whether the EPS level recovered

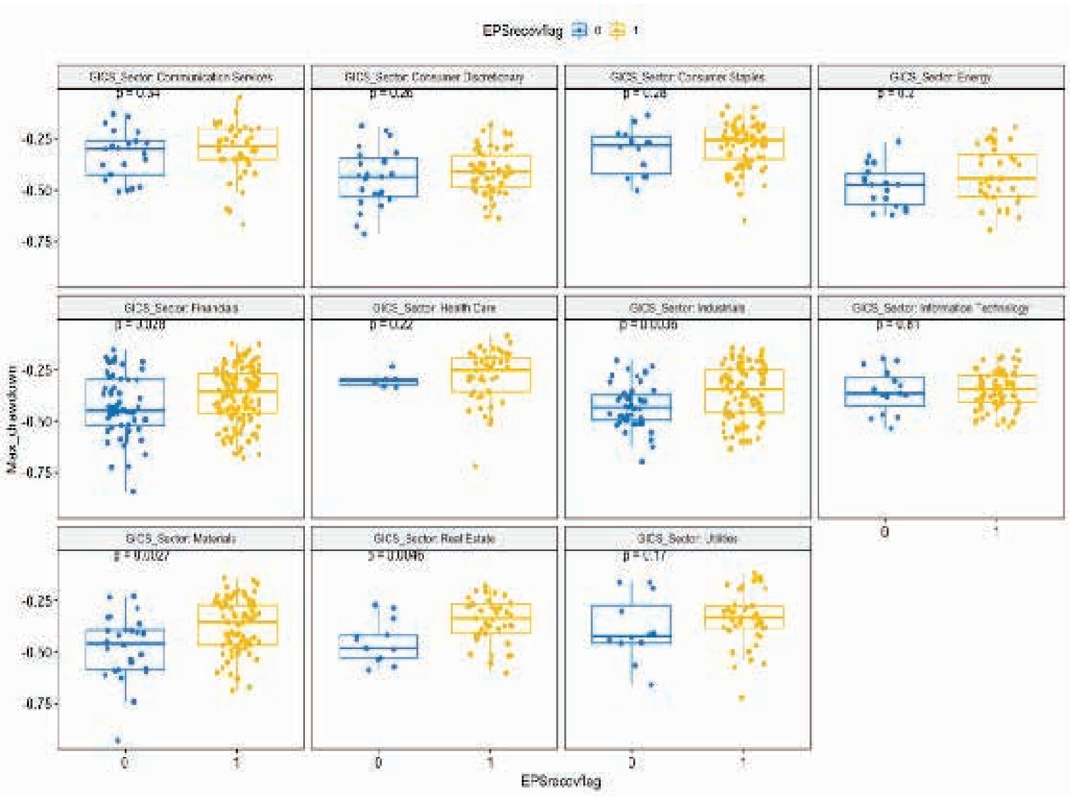

Figure 2. Multiple box plots based on whether the price level recovered

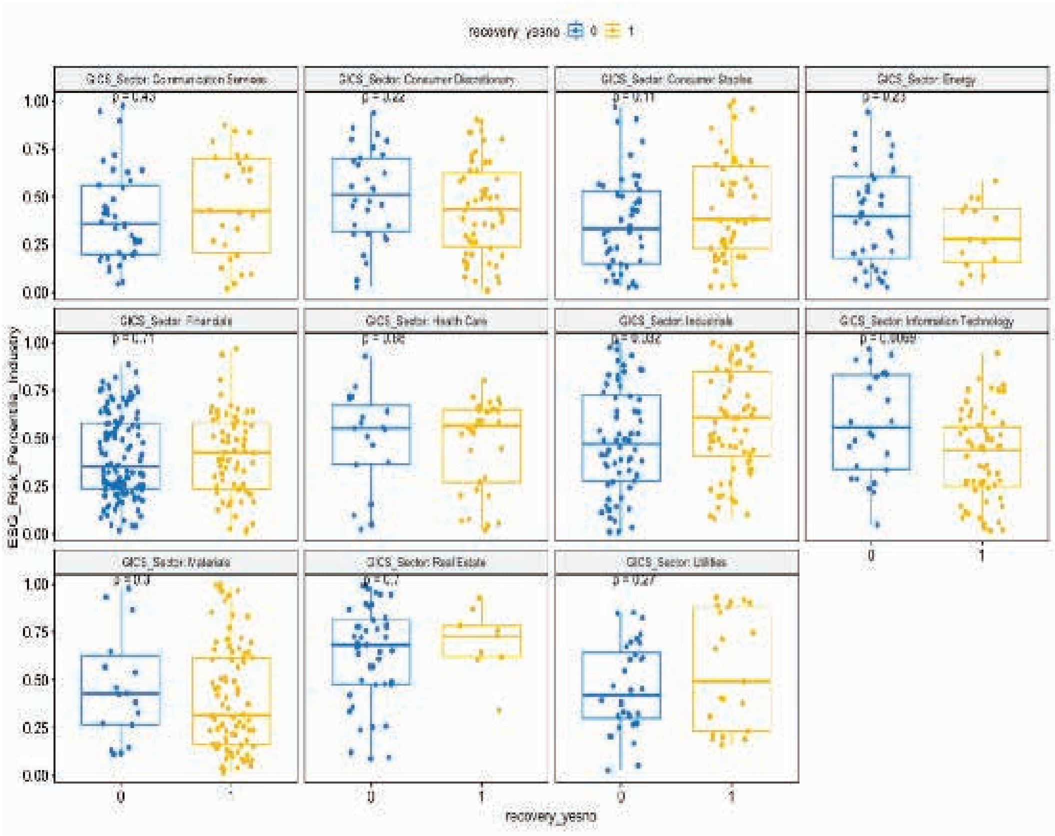

Figure 2 is about whether the company's stock price level has returned to the level before the pandemic, the only two groups with a P value less than 0.05 are industrials and information technology. The former has a P value of 0.032, and the latter has a P value of 0.0069, which is more significant. These two groups gave exactly the opposite results. In the industrials group, those companies whose stock prices recovered had a higher average ESG risk, while in the information technology industry, companies with a high level of industry-based ESG risk had poor stock price elasticity. The explanation for this may be that investors have different requirements for the two industries, or that the ESG factor of the information technology industry is more concerned by investors and reflected in the stock price. On the other hand, it can be said that in the industrials industry, everyone does not care much about the negative information (ESG risk) of the company. The reason for the stock price rebound may be mainly guided by other factors. Those companies with high ESG risks in the industrials industry may be the industry leaders and have a higher profitable market share. They cut down the cost of reducing ESG risks.

3.2 Multiple regression model

By observing the regression analysis results in the fourth column of Table 3, it is found that the ESG risk percentile industry are not significant after adding the overall management score variable. The regression coefficients of combined_controv and management_score are -0.002 and -0.003, respectively, and there is a significant negative correlation. At the same time, the company size SIZE, Tobin Q, and calmar ratio have a significant positive correlation, and the regression coefficients are 0.036, 0.005, and 0.009, respectively. From the perspective of regression performance, the explanation for this is the larger the company's controversy score, the greater the kinetic energy of the decline in the crisis (here, max drawdown is a negative number). management_score indicates, out of the total manageable risk exposure, how much is the company's management able to manage properly. One reason for the negative correlation here may be that despite the high management scores, the company's overall risk exposure is too large or unmanageable. Too much exposure leads to weak resilience in a crisis. In the crisis, the larger size of the company, TobinQ, the excess return per unit of retracement (calmer ratio), the more likely it is to bring a smaller retracement of the stock.

Table 3. Multiple Regression results

	Max_drawdown	**Max_drawdown**	**Max_drawdown**	**Max_drawdown**
(Intercept)	-0.394 ***	-0.252 ***	-0.621 ***	-0.618 ***
	(0.010)	(0.032)	(0.036)	(0.047)
combined_controv	-0.002 ***	-0.001 **		-0.002 ***
	(0.000)	(0.000)		(0.000)
ESG_Universe	0,016	-0,044		-0,088
	(0.020)	(0.060)		(0.054)
ESG_Industry	0.071 ***	-0,04		-0,032
	(0.020)	(0.026)		(0.024)
ESG_Risk_Score		0,001		0,003
		(0.002)		(0.001)
Management_Score		-0.003 ***		-0.003 ***
		(0.000)		(0.000)
Fncl_LVRG			-0,001	-0,001
			(0.001)	(0.001)
TobinQ			0.006 ***	0.005 *
			(0.002)	(0.002)
Zscore_PE_BT			-0.028 ***	-0.027 ***
			(0.003)	(0.003)
latest_PE_BF			0,000	0,000
			(0.000)	(0.000)
Size			0.027 ***	0.036 ***
			(0.004)	(0.004)
Profit_recov			0,000	0,000
			(0.000)	(0.000)
Momentum			0,000	0,000
			(0.000)	(0.000)
Calmar_ratio			0.011 ***	0.009 ***
			(0.002)	(0.002)
N	969	969	969	969
R2	0.047	0.087	0.194	0.277
F statistic	15.923	18.449	28.875	28.165
P value	0.000	0.000	0.000	0.000
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.				

From the regression analysis results in Table 4. One explanation for the positive correlation of Zscore_PE_BT is that companies whose valuations are higher than their historical average are more resilient. The regression in the third column is similar to the second column. It should be noted that Size has become a significant negative correlation, and the coefficient is larger, which is -2.934, indicating that the larger the company, the smaller the volatility. Secondly, the coefficients of Zscore_PE_BT and calmar ratio have been improved a lot, and the overall fit is higher.

Table 4. Multiple Regression results of different dependent variables

	Max_drawdown	**Max_drawdown**	**Max_drawdown**
(Intercept)	-0.618 ***	-0.062	63.939 ***
	(0.047)	(0.106)	(4.779)
combined_controv	-0.002 ***	0.004 ***	0.193 ***
	(0.000)	(0.001)	(0.047)
ESG_Universe	0.003	0.004	-0.081
	(0.001)	(0.003)	(0.152)
ESG_Industry	-0.088	-0.047	3.341
	(0.054)	(0.122)	(5.492)
ESG_Risk_Score	-0.032	-0.114 *	1.504
	(0.024)	(0.054)	(2.420)
Management_Score	-0.003 ***	0.000	0.071
	(0.000)	(0.001)	(0.047)
Fncl_LVRG	-0.001	-0.006 **	-0.183 *
	(0.001)	(0.002)	(0.090)
TobinQ	0.005 *	-0.017 ***	0.018
	(0.002)	(0.004)	(0.193)
Zscore_PE_BT	-0.027 ***	0.034 ***	1.437 ***
	(0.003)	(0.006)	(0.274)
latest_PE_BF	0.000	0.000	0.001
	(0.000)	(0.000)	(0.002)
Size	0.036 ***	0.002	-2.934 ***
	(0.004)	(0.009)	(0.421)
Profit_recov	0.000	0.000	-0.002
	(0.000)	(0.000)	(0.006)
Momentum	0.009 ***	0.176 ***	1.264 ***
	(0.002)	(0.005)	(0.221)
Calmar_ratio	0,000	0,000	0,000
	(0.000)	(0.000)	(0.000)
N	969	969	969
R2	0.277	0.653	0.110
F statistic	28.165	137.976	9.118
P value	0.000	0.000	0.000
*** p < 0.001; ** p < 0.01; * p < 0.05.			

Multiple regressions in most recent studies show the positive impact of ESG on stock price elasticity in crisis. Albuquerque et al. (2020) believe that the stock price of high-ES companies performs much better than the stock prices of other companies. Broadstock et al. (2020) shows that ESG performance can mitigate financial risks during crisis. Rubbaniy (2021) found a strong and positive linkage relationship between GFI (daily global COVID-19 fear index) and ESG index. Cheema-Fox et al. (2020) also found that companies that responded with more positive sentiments (measure ESG) would have fewer negative returns.

3.3 Logit and probit model

Establish three models with EPSrecovflag as the dependent variable respectively, where Logit_marg and Probit_marg refer to the marginal difference of these two models. The marginal difference is the average difference in the probability of y = 1 when all other explanatory variables are the same, which corresponds to a unit difference in the explanatory variable.

Table 5. LPM, logit and probit model estimates with the same right-hand-side variables

Dep.var:EPSrecovflag	LPM	Logit	Logit_marg	Probit	Probit_marg
(Intercept)	0.465 *	-0.387		-0.154	
	(0.200)	(1.198)		(0.695)	
Max_drawdown	0.345 **	1.616 *	0.268 *	1.033 *	0.294 *
	(0.122)	(0.708)	(0.120)	(0.415)	(0.117)
Combined_controv	-0.001	-0.007	-0.001	-0.004	-0.001
	(0.002)	(0.010)	(0.002)	(0.006)	(0.002)
ESG_Risk_Score	-0.005	-0.03	-0.005	-0.017	-0.005
	(0.006)	(0.032)	(0.005)	(0.019)	(0.005)
ESG_ Universe	0.607 **	3.466 **	0.575 **	2.032 **	0.578 **
	(0.206)	(1.180)	(0.201)	(0.695)	(0.195)
ESG_ industry	-0.365 ***	-1.988 ***	-0.330 **	-1.232 ***	-0.350 ***
	(0.100)	(0.597)	(0.103)	(0.348)	(0.097)
Management_Score	-0.002	-0.01	-0.002	-0.006	-0.002
	(0.002)	(0.011)	(0.002)	(0.006)	(0.002)
Fncl_LVRG	-0.001	-0.004	-0.001	-0.002	-0.001
	(0.004)	(0.022)	(0.004)	(0.013)	(0.004)
TobinQ	0.004	0.041	0.007	0.012	0.003
	(0.007)	(0.058)	(0.010)	(0.030)	(0.008)
Zscore_PE_BT	-0.045 ***	-0.242 ***	-0.040 ***	-0.141 ***	-0.040 ***
	(0.011)	(0.061)	(0.011)	(0.036)	(0.010)
Latest_PE_BF	-0.000 *	-0.001	0	0	0
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Size	0.045 **	0.241 *	0.040 *	0.144 *	0.041 *
	(0.016)	(0.100)	(0.017)	(0.057)	(0.016)
Calmar_ratio	0.022 **	0.254 **	0.042 **	0.127 **	0.036 **
	(0.008)	(0.079)	(0.014)	(0.041)	(0.012)
Momentum	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	969	969	969	969	969
Industry FE	YES	YES	YES	YES	YES
*** p < 0.001; ** p < 0.01; * p < 0.05.					

According to the model results in Table 5, First pay attention to the two indicators of ESG percentile. These results mean that, while controlling for other variables, 1) companies with high ESG risk percentile_universe indicator (Referring to those with high ESG risk in the overall stock pool) have a 60% higher chance of EPS recovery than those with low ESG risk percentile_universe. 2) Those companies with high ESG risk percentile_industry indicator (referring to those with high ESG risk in their respective industries) have a nearly 35% lower chance of EPS recovery than those with low ESG risk percentile_industry. This shows that on the basis of their respective industries, those companies with good ESG risk management can indeed lead the companies to recover faster after the crisis. Secondly, from the results of two indicators of Zscore_PE_BT and Calmar_ratio, 1) The EPS recovery chances of companies with high Zscore_PE_BT indicator are 4% lower than those of companies with low Zscore_PE_BT indicators. This reflects that the EPS recovery opportunities for companies that are more expensive than their past valuations are lower. This probably reflects part of the bubble, that is, the rebound of corporate earnings with high valuations may be less than expected. 2) Companies with a high Calmar_ratio metric have a 4% higher chance of EPS recovery than those with a low Calmar_ratio index. This implies that the better the Calmar ratio, the higher the profitability resilience.

4. Conclusions

This article selects companies in the MSCI emerging market index as the research object, adopts multiple linear regression and binary logistic regression analysis methods, and uses sustainable development theory, stakeholder theory and principal-agent theory as the theoretical basis. Based on the empirical results, the research conclusions are summarized as follows:

Despite the rapid increase in responsible investment in recent years, the question of whether ESG can bring returns to shareholders and resist the risks of a crisis is still a controversial topic. During the COVID-19 pandemic, global stocks fell sharply. This article proposes the hypothesis that ESG performance may serve as a valuable indicator to help companies get rid of negative risks during the crisis. The conclusion of this article is that stocks with good ESG performance in their respective industries can indeed recover faster from the crisis and can withstand the current market turbulence caused by the COVID crisis. Multiple regression analysis shows that companies with higher ESG risk percentile have higher max drawdowns during the COVID crisis and lower subsequent recovery rates, as well as higher stock price volatility.

The binary prediction model estimated in the COVID-19 crisis can be used to successfully predict the winners and losers during the subsequent humanitarian crisis that currently affects global capital markets. Based on selected 969 sample data, the empirical results found that companies with high ESG risk score indicators have a 35 percentage lower chance of EPS recovery than those with low ESG risk scores in time of pandemic crisis. On the basis of the respective industries, those companies with good ESG risk management can indeed lead the companies to recover faster after the crisis. This shows that stocks with high ESG performance have better resilience under the global pandemic.

Bibliography

Albuquerque, R. A., Koskinen, Y., Yang, S., & Zhang, C. (2020). *Love in the Time of COVID-19: The Resiliency of Environmental and Social Stocks* (SSRN Scholarly Paper ID 3594293). Social Science Research Network. https://papers.ssrn.com/abstract=3594293

Albuquerque, R., Koskinen, Y., Yang, S., & Zhang, C. (2020). Resiliency of Environmental and Social Stocks: An Analysis of the Exogenous COVID-19 Market Crash. *The Review of Corporate Finance Studies*, *9*(3), 593–621. https://doi.org/10.1093/rcfs/cfaa011

Broadstock, D. C., Chan, K., Cheng, L. T. W., & Wang, X. (2021). The role of ESG performance during times of financial crisis: Evidence from COVID-19 in China. *Finance Research Letters*, *38*, 101716. https://doi.org/10.1016/j.frl.2020.101716

Capelle-Blancard, G., & Desroziers, A. (2020). *The Stock Market Is not the Economy? Insights from the COVID-19 Crisis* (SSRN Scholarly Paper ID 3638208). Social Science Research Network. https://doi.org/10.2139/ssrn.3638208

Cheema-Fox, A., LaPerla, B. R., Serafeim, G., & Wang, H. (Stacie). (2020). *Corporate Resilience and Response During COVID-19* (SSRN Scholarly Paper ID 3578167). Social Science Research Network. https://doi.org/10.2139/ssrn.3578167

Danisman, G. O., Demir, E., & Zaremba, A. (2021). Financial Resilience to the Covid-19 Pandemic: The Role of Banking Market Structure. *Applied Economics*, *0*(0), 1–24. https://doi.org/10.1080/00036846.2021.1904118

Demers, E., Hendrikse, J., Joos, P., & Lev, B. (2020). *ESG Didn't Immunize Stocks During the COVID-19 Crisis, But Investments in Intangible Assets Did* (SSRN Scholarly Paper ID 3675920). Social Science Research Network. https://doi.org/10.2139/ssrn.3675920

Ferriani, F., & Natoli, F. (2020). ESG risks in times of Covid-19. *Applied Economics Letters*, *0*(0), 1–5. https://doi.org/10.1080/13504851.2020.1830932

Folger-Laronde, Z., Pashang, S., Feor, L., & ElAlfy, A. (2020). ESG ratings and financial performance of exchange-traded funds during the COVID-19 pandemic. *Journal of Sustainable Finance & Investment*, *0*(0), 1–7. https://doi.org/10.1080/20430795.2020.1782814

Lins, K. V., Servaes, H., & Tamayo, A. (2017). Social Capital, Trust, and Firm Performance: The Value of Corporate Social Responsibility during the Financial Crisis. *The Journal of Finance*, *72*(4), 1785–1824. https://doi.org/10.1111/jofi.12505

Pagano, M., Wagner, C., & Zechner, J. (2020). Disaster Resilience and Asset Prices. *ArXiv:2005.08929 [Econ, q-Fin]*. http://arxiv.org/abs/2005.08929

Rubbaniy, G., Khalid, A. A., Samitas, A., & Ali, S. (2021). *Are ESG Stocks Safe-Haven during COVID-19?* (SSRN Scholarly Paper ID 3779430). Social Science Research Network. https://doi.org/10.2139/ssrn.3779430

Sabatino, M. (2016). Economic crisis and resilience: Resilient capacity and competitiveness of the enterprises. *Journal of Business Research*, *69*(5), 1924–1927. https://doi.org/10.1016/j.jbusres.2015.10.081

Takahashi, H., & Yamada, K. (2021). When the Japanese stock market meets COVID-19: Impact of ownership, China and US exposure, and ESG channels. *International Review of Financial Analysis*, *74*, 101670. https://doi.org/10.1016/j.irfa.2021.101670

Empirical analysis of the weak and strong sustainability of economic growth: The wealth approach

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Abstract

This article is a contemplation on the sustainability of economic growth from the wealth accounting perspective. The wealth perspective of sustainability can provide the framework for the accountability and transparent settlement of accounts designed to provide input to assessments of the impact of various policy options on sustainability. In this framework, comprehensive wealth and genuine savings are two leading sustainability indicators, as underpinned by established theory. The accumulation of wealth, the source of wellbeing of future generations, and the savings of the current generation are two sides of the same coin. In this article, changes in comprehensive wealth are investigated in relation to the criteria of weak and strong sustainability. Using the World Bank's Total Wealth indicator, as an estimate we found that 13% of economies globally do not meet the criteria of weak sustainability, while more than 48% were found to be unsustainable according to strong sustainability criteria, including countries from all income classes. However, the World Bank database has been heavily criticized due to methodological problems that, with improved data in the future, might call for a reconsideration of our results.

Keywords: Comprehensive wealth, Wealth Accounting, Total Wealth, weak and strong sustainability,

JEL codes: Q01, Q56, O44, O47

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1. Introduction

Over the past decades, the development of sustainability indicators has accelerated, as seen in the burgeoning literature. Sustainability concerns all the social, economic, and environmental aspects of human life, and there is a growing need for evidence-based research to grasp sustainability in its entirety to aid in policymaking. This comprehensive framework can be supplied by employing the wealth perspective of sustainability and its indicators.

Ecological and economic indices are two major groups within the various systems of classification. Ecological indicators are rooted in some notion of carrying capacity, or some condition of resilience of the natural environment. They are designed to describe a selected attribute of the state of the environment, or the socio-environmental system, but are difficult to translate into economic terms, or policy actions. Economic indicators, on the other hand, are based on economic theory, which can be empirically tested, at least in principle, and could directly provide evidence-based input for policy design.

GDP, the most broadly used economic indicator since Keynesian times, does not transmit information about the sustainability of an economy. According to a World Bank publication, GDP, "used alone,… may provide misleading signals about the health of an economy…as it does not reflect depreciation and depletion of assets, whether investment and accumulation of wealth are keeping pace with population growth, or whether the mix of assets is consistent with a country's development goals" (Lange et al., 2018, p. 3). The problem of finding a universally applicable, GDP-complementary sustainability indicator has been on the agenda of economic research for several decades, and is called for even in UN Agenda 2030. The Sustainable Development Goal 17. Subgoal 19 directly calls for "developing measurements of progress on sustainable development that complement gross domestic product."

For judging the performance of an economy from a sustainability perspective, Partha Dasgupta in a seminal paper entitled "The Welfare Economic Theory of Green National Accounts" classifies indices into four categories, depending on the question they answer: (A) How is the economy doing now? (B) How has its performance been in recent years? (C) How is it likely to perform under alternative policies? and (D) What policies should be pursued there? Then Dasgupta explains that GDP is the indicator that can answer the questions (A) and (B), but it cannot be used to assess the future, or alternative development paths for an economy – i.e. questions (C) and (D), which relate to sustainability, future welfare, and wellbeing. Within this classification, Dasgupta suggests that inquiries about sustainable development are concerned with questions (B) and (C) (Dasgupta, 2009).

Dasgupta shows that the right welfare index for addressing C and D is a comprehensive measure of wealth, which he calls *comprehensive wealth* that moves in unison with the (long-term) wellbeing (of nations) (ibid. p. 4). In a recent seminal publication, "The Economics of Biodiversity: The Dasgupta Review," the author uses the expression *inclusive wealth*, a slightly different definition from that of comprehensive wealth. While this change (which concerns the theoretical foundations of wealth) is an important improvement, in this practice-oriented article the notion of comprehensive wealth is used.

Conceptually, comprehensive wealth is the sum of all capital elements – i.e., the source of income and wellbeing of future generations (Dasgupta, 2009), which includes reproducible capital assets (buildings, infrastructure, machines), human capital (demography, health, education, skills), natural capital (ecosystems, minerals, and fossil fuels), and various forms of social capital. Theoretically, the value of the capital elements is the multiple of some biophysical volume and a shadow price which expresses the social value of the capital element, which is distinguishable from market price, or transaction cost. Asset valuation, in particular across time, is a critical element of the wealth approach to sustainability, and is addressed intensely in the academic literature – for example, by Marjainé Szerényi (Kerekes et al., 2018; Marjainé Szerényi, 2018).

Dasgupta builds on earlier work by Pearce and others who have argued that wealth is the appropriate index for judging whether economic development is sustainable (Pearce and Atkinson, 1993). According to Pearce, the rule of *weak sustainability* requires that the overall capital base (comprehensive wealth) should not decline over time. It is distinguished from *strong sustainability*, which does not allow for depreciation in any 'critical' capital element – for example, the decrease in natural capital, is not allowed to be offset by the increase of other capital types (ibid.).

Hamilton and Hepburn (2014) discuss GDP and its use from a historical perspective and explain why wealth is the right indicator of sustainability as a complement to GDP, in particular if sufficient data is available for assessing intertemporal and intergenerational problems (ibid.). Arrow shows that intergenerational wellbeing would not decline…if (resulting from economic activity) comprehensive wealth does not decline (Arrow et al., 2010).

Hereinafter, for the empirical analysis of changes in comprehensive wealth, Total Wealth, an indicator in the World Bank database, is used as an approximation. In the World Bank database, five sets of Total Wealth data, between 1995 and 2014, are currently available for 141 countries. It is important to mention another "wealth indicator," Adjusted Net Savings (ANS), which in the World Development Indicators database of the World Bank is available for 217 countries – practically since the early 1990s. The two indicators are constructed based on two different approaches and rely on different sets of assumptions and have been used separately for assessing sustainability (Carey et al., 2018, p. 72). The linkages between the two indicators have also been researched both theoretically and in practice to underpin the World Bank's development policy, targeting mainly resource-rich, low- and middle-income developing economies (Arrow et al., 2010; Dasgupta, 2009; Hamilton and Withagen, 2007; Hartwick and Hamilton, 2014). This article contemplates sustainability by investigating changes in Total Wealth and its components over the 1995-2014 period.

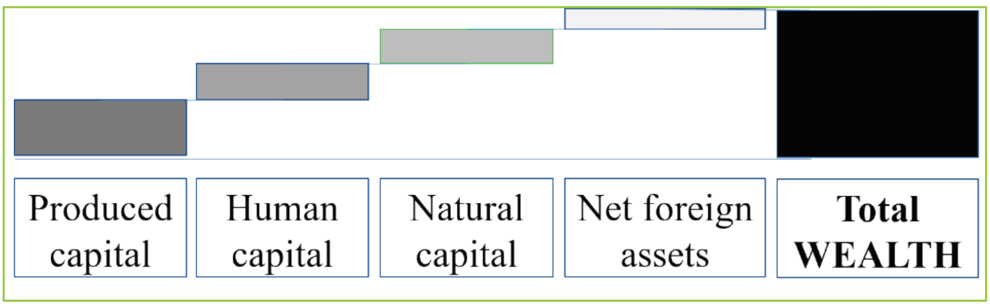
The paper is built as follows: The construction and the database of Total Wealth is presented in Section 2. Section 3. presents the analysis according to the criteria of weak and strong sustainability. A discussion of results follows in Section 4, then Section 5 concludes with a summary of the findings and suggestions for further research.

2. Data

The World Bank Open Data (WBOD) offers open access to Total Wealth data and its components in the Wealth Accounts database for 141 countries for the years 1995, 2000, 2005 and 2014. In the analytic research the database of 141 countries is considered a non-random sample of the population, which consists altogether of 214 UN member states.

The World Bank's Total Wealth indicator is defined as the sum of produced, human, and natural capital, plus net foreign assets. The composition and derivation of each of these elements are explained in the metadata section attached to the data series, as well as in the related literature (Hamilton et al., 2006; Lange et al., 2018).

Figure 3 Composition of Total Wealth



Source: author's construction

The components of Total Wealth are sourced from national statistics. As a general concept, values are measured at market exchange rates at constant US$ (2014) using a country-specific GDP deflator. Values for produced capital and net foreign assets are generally derived based on observed transactions and accounting values (Lange et al., 2018). The values of natural capital and human capital components are based on estimates. These estimates are based on the concept that the value of an asset should equal the discounted stream of expected net earnings (resource rents or wages) that it earns over its lifetime. Natural capital includes fossil fuel energy (oil, gas, hard and soft coal) and minerals (bauxite, copper, gold, iron ore, lead, nickel, phosphate, silver, tin, and zinc), agricultural land (cropland and pastureland), forests (timber and some non-timber forest products), and protected areas (ibid.). The valuation of both human and natural capital raises very important methodological questions, which are at the center of both academic discourse and practice (Marjainé Szerényi, 2018).

The wealth database built by the World Bank has been heavily criticized and suggestions have been made about the refinement of the methodologies used to calculate the estimates of various capital elements. One of the estimation problems is that Total Wealth is supposed to be comprised of as many types of assets as possible. Another problem is the methodology of defining the value of assets, which ideally results in estimates as close as possible to the theoretical shadow price, or social cost. To highlight how these problems are addressed in practice, reference is made to McGrath et al., who reported comprehensive estimates for genuine savings, a theoretical indicator, using an extended method that was compared with Adjusted Net Savings (ANS), another wealth indicator in the World Bank database (McGrath et al., 2019). Macroeconomic theory states that savings equal investments in capital assets (Arrow et al., 2010), therefore savings and changes in wealth are two sides of the same coin. In this way, as genuine savings equal the accumulation of comprehensive wealth, ANS is directly related to Total Wealth, and the methodological reasoning of McGrath et al. regarding estimating genuine savings applies to comprehensive wealth, too. McGrath et al. focused on the differences between the World Bank data and their own estimates for human capital and natural capital for the case of Ireland. Akin to the World Bank data, genuine savings estimates were derived from official Irish sources, but with extended accounting for pollutants, including transboundary impacts. To estimate human capital accumulation, in addition to the expenditure method by the World Bank, returns to education were assessed, etc. The authors conclude that different methodologies of data compilation can lead to considerable divergence from the World Bank data, and suggest that (1) governments, when assessing sustainability, should focus on wealth, rather than national income, being aware of the limitations of the World Bank data, and (2) the construction of the indicator should allow for country-specific characteristics to be taken into account.

The construction of Total Wealth is of crucial importance because it represents an improved estimate of comprehensive wealth. In this respect, the composition of natural capital is foreseen to be considerably improved by inputs from amended national statistics. In the System of National Accounts, SNA, the introduction of ecosystem accounting based on the System of Environmental Economic Accounting, SEEA, the UN standard, has been progressing, and its Ecosystem Accounting module (SEEA EEA) is foreseen to provide a new and improved methodological framework for assessing the volume and value of natural capital (Kovács, 2018). Several global projects are ongoing that are being managed by the UN Statistical Division, which aim at introducing SEEA EA into national statistics, and at the same time linking ecosystem accounts to the Wealth Accounts database of the World Bank (UNSD, n.d.). For our analysis, the currently available data in the World Bank data repository are used, which do not yet include these methodological improvements, although this is acknowledged as a major limitation of our research and the conclusions that may be drawn from it.

In the analysis designed to assess changes in comprehensive wealth, the growth rate in Total Wealth is used. The geometric growth rates of the per capita values of Total Wealth and its components over four periods[10] between 1995 and 2014 are calculated as follows:

$$r = \exp\left[\frac{\ln\left(\frac{pn}{po}\right)}{n}\right] - 1,$$

where r is the geometric growth rate, pn and po are the values at the beginning and the end of the periods, and n is the number of periods. The analysis is designed to capture long-term trends, therefore the advantage of applying a geometric growth rate is that only the values at the beginning and the end of the periods are considered – i.e., temporary, short-term outliers are ignored.

In the latter sections of the article a comparative analysis of wealth and GDP trends is presented, too. So that the two trends can be compared, a purpose-designed index is used to characterize GDP growth, ΔGDP, which is calculated using standard GDP data available in the World Bank database. ΔGDP – so as to be aligned with the available (five-yearly) wealth data – is defined as the average of the geometric growth rates of GDP during the four time periods between 1995 and 2014. With this methodology, GDP growth over the 1995-2014 period is collected in one number, which is compared with the geometric growth rate of per capita Total Wealth, the indicator designed to characterize the growth of wealth over the same period.

Descriptive statistics for the growth rates of per capita Total Wealth (YTWpC), Human Capital (YHCpC), Natural Capital (YNCpC), and Produced Capital (YPCpC), as well as ΔGDP are shown in Table 2.

Table 2 Statistics, Geometric Growth Rates of per capita Total Wealth and its components, ΔGDP 1995-2014

Variable	Obs	Mean	Std. Dev.	Min	Max
YTWpC	141	.1016112	.1056203	-.1312391	.7187951
YTWpCA	141	.1017996	.1077589	-.132184	.7179459
YHCpC	141	.1161414	.1240547	-.1963516	.5382232
YNCpC	141	.0708412	.1433378	-.2577408	.9640006
YPCpC	141	.0933372	.1496282	-.3314776	.8643824
ΔGDP	140	.023475	.0194589	-.0252538	.085928

Source: author's construction based on data from WBOD

Histograms with a normal distribution estimate are provided in Appendix 1.

[10] Three five-year periods and one four-year period between 1995 and 2014

3. Analysis

Hereinafter, the World Bank's Total Wealth data will be used to analyze national economies from the perspective of weak and strong sustainability. The definition by Pearce and Attkinson is the following: weak sustainability requires no decline in comprehensive wealth, while in case of strong sustainability no capital elements are allowed to decrease, even if the reduction is compensated for by the increase of another capital element (Pearce, 1993). Over time, as academic discourse evolved, this criteria has been relaxed and non-decline has been required for critical assets only (Dasgupta, 2021). Addressing the subject of critical assets, however, is beyond the scope of this article. Accordingly, to analyze weak sustainability, the growth rates of Total Wealth, and for strong sustainability, the growth rates of each component of Total Wealth will be used, respectively. The analysis of the composition of various elements of natural capital is beyond the scope of the investigation.

It is emphasized that comprehensive wealth is a theoretical indicator that is estimated using Total Wealth, an indicator in practice, in the World Bank database. The estimation depends on the type and amount of different capital elements that make up Total Wealth data, as well as the methodology used to value the different capital elements. Both issues have been at the center of academic discourse, which constantly pursues improvements in the quality of data available for estimation. In the analysis, limitations due to currently available data are acknowledged and accounted for.

3.1 Weak sustainability

The criteria of weak sustainability is that the sum of all elements of comprehensive wealth should not decline over the period of time that is under consideration. The statistics of non-sustainable economies according to this weak criteria are shown in Table 3. The World Bank database includes wealth data for 141 countries, of which 19 were found to have negative growth in Total Wealth over the examined period. This means that 13% of the sample does not meet the criteria of weak sustainability. Accordingly, the Total Wealth net of Net Foreign Assets in 18 countries (i.e. 13% of the sample) was found to be non-sustainable, which result is almost identical to that which uses Total Wealth data that includes Net Foreign Assets. The table shows that in 10-12% of high-income countries the socio-economic system is not sustainable according to the weak criteria. For low-income countries, the proportion is almost three times as high: 26-30%. For middle-income countries, the proportion, 8-11%, appears to be the lowest.

Table 3 Statistics, non-sustainable economies, weak criteria, 1995-2014

	Unit	Low-income	Low-middle income	Upper-middle income	High income	Total
YTWpC	#	7	3	4	5	19
YTWpC	%	26%	8%	11%	12%	13%
YTWpCA	#	8	3	3	4	18
YTWpCA	%	30%	8%	8%	10%	13%
Sample size	#	27	36	37	41	141

Source: the author, based on WBOD

The list of countries in Table 3 is shown in Appendix 2.

3.2 Strong sustainability

The criteria of strong sustainability is that none of the capital components of comprehensive wealth are allowed to decline. The analysis is limited to three main components of Total Wealth: Human Capital, Natural Capital, and Produced Capital. A further break-down of the asset components was not considered – for example, changes in critical assets within the Natural Capital component were not researched. The Net Foreign Assets component is not considered either, as it is directly linked to fiscal policy and therefore is not considered to transmit information about sustainability.

Regarding Human Capital, 23 of the 141 countries in the World Bank's Wealth Accounts database were found to have a negative growth rate, and are therefore non-sustainable. In the case of Natural Capital, 39 countries, and for Produced Capital 32 countries were found to be unsustainable. These findings are summarized in percentages in Table 4.

Table 4 Qualification, Strong sustainability criteria, types of capital

Qualification	Human Capital	Natural Capital	Produced Capital
Sustainable	77%	73%	77%
Unsustainable	23%	27%	23%

Source: author's construction

A further break-down according to income classes is provided Appendix 2. Table 5 shows the proportion of non-sustainable countries according to income groups with the UN classification. In the case of human capital and produced capital criteria, the share of non-sustainability in low-income countries is far higher than in higher income countries. However, interestingly, in the case of the natural capital criteria, the number of non-sustainable countries in the Upper-Middle Income and High Income group is double that of those in the Low Income group.

Table 5 Proportions of unsustainable countries, strong criteria

	LI	LMI	UMI	Hi
Total Wealth	26%	8%	11%	12%
Human Capital	37%	6%	8%	20%
Natural Capital	22%	17%	41%	29%
Produced Capital	41%	28%	11%	15%

Source: author's construction based on WBOD

Combining the results of the analysis, it is found that 68 countries (i.e. 48% of the 141) do not meet the strong criteria for one or more capital types. The breakdown per income class is shown in Table 6.

Table 6 Non-sustainable countries, strong criteria

	LI	LMI	UMI	HI	Total
No. countries	17	14	18	19	68
% of countries	63%	39%	49%	46%	48%
No. of countries in the income class	27	36	37	41	141

Source: author's construction based on WBOD

The figures indicate that the proportion of non-sustainable countries in the Low-Income group is about 50% greater than in the High-Income group.

3.3 Correlation, GDP – Wealth

Table 7 shows correlation coefficients between GDP growth and Total Wealth and its components.

Table 7 Correlation, GDP, Total Wealth and capital types

	ΔGDP	YTWpC	YHCpC	YNCpC	YPCpC
ΔGDP	1,0000				
YTWpC	0,6486	1,0000			
YHCpC	0,7168	0,6897	1,0000		
YNCpC	0,3075	0,7313	0,2892	1,0000	
YPCpC	0,5386	0,7494	0,3653	0,4512	1,0000

Source: author's construction based on WBOD

The coefficients indicate relatively strong correlation between GDP growth and changes in Wealth, although in the case of natural capital the correlation is weak compared to that with other capital elements. Also, the correlations of Natural Capital with other capital elements lag well behind the strength of correlation among other capital elements.

4. Discussion

The weak and strong sustainability of 141 economies in the World Bank database was investigated between 1995 and 2014. While the limitations caused by the construct and quality of available data are acknowledged, the results allow us to highlight certain trends. It has been shown that while the proportion of non-sustainable countries according to the weak criteria is relatively small (13%), under the strong criteria almost half of the countries (48%) were found to be unsustainable. Also, the proportion of non-sustainable countries in the Low-Income group was found to be far higher than those in higher income groups. As regards the correlation between GDP growth and changes in comprehensive wealth, strong correlations were found for all capital types, except for Natural Capital.

These results cover about half of the countries in the UN database and, obviously, the sample is not random. Wealth estimates are calculated for countries where more or less reliable data exist – i.e., where national statistical systems are sufficiently advanced. Therefore, it seems justified to assume that most countries that are not included in the sample belong to the group of low-income, less developed countries, and that estimates are rather optimistic – i.e., in reality, the proportion of non-sustainable countries is even larger, and the gap between high-income and low-income countries is also even wider. Three major advances are foreseen to improve the estimate results: (1) the construction of the different capital elements; i.e., more asset types are foreseen to be included in Total Wealth, in particular within the natural capital and human capital elements; (2) the methodologies used to value different assets could be substantially improved and the currently broadly applied market price method could be replaced by theoretically more substantiated methodologies; (3) the introduction of ecosystem accounts in national statistics would allow for a more comprehensive assessment of the state and value of natural capital, which would result in both substantial rebalancing between the different capital types within Total Wealth, as well as amendments of the trends found in our research.

Summary

In this article, an analysis of the weak and strong sustainability of 141 countries in the World Bank database was reported. While data limitations are acknowledged, the results allow us to draw several conclusions. It is shown that about 50% of the economies that were analyzed are non-sustainable according to the strong criteria of sustainability, and the share of non-sustainable countries in the low-income class is far larger than that in higher income groups. It is foreseen that major changes in data generation methodologies could create the conditions for more precise estimates that would clear the floor for further research.

References

Arrow, K.J., Dasgupta, P., Goulder, L.H., Mumford, K.J., Oleson, K., 2010. Sustainability and the Measurement of Wealth (Working Paper No. 16599), Working Paper Series. National Bureau of Economic Research. https://doi.org/10.3386/w16599

Carey, K., Sahnoun, H., Wodon, Q., 2018. Wealth Accounts, Adjusted Net Saving, and Diversified Development in Resource-Rich African Countries, in: The Changing Wealth of Nations, 2018, Bulding a Sustainable Future. World Bank, Washington DC., pp. 69–84.

Dasgupta, P., 2021. The Economics of Biodiversity: The Dasgupta Review. HM Treasury, London, UK.

Dasgupta, P., 2009. The welfare economic theory of green national accounts. Environ. Resour. Econ. 42, 3–38. https://doi.org/10.1007/s10640-008-9223-y

Hamilton, K., Hepburn, C., 2014. Wealth. Oxf. Rev. Econ. Policy 30, 1–20. https://doi.org/10.1093/oxrep/gru010

Hamilton, K., Ruta, G., Markandya, A., 2006. Where is the Wealth of Nations? Measuring Wealth for the 21st Century. The World Bank.

Hamilton, K., Withagen, C., 2007. Savings growth and the path of utility. Can. J. Econ. Can. Déconomique 40, 703–713. https://doi.org/10.1111/j.1365-2966.2007.00427.x

Hartwick, J., Hamilton, K., 2014. Wealth and sustainability. Oxf. Rev. Econ. Policy 30, 170–187. https://doi.org/10.1093/oxrep/gru006

Kerekes, S., Marjainé Szerényi, Z., Kocsis, T., 2018. Sustainability, Environmental Economics, Welfare. Corvinus University of Budapest.

Kovács, A.F., 2018. Environmental economic accounting to advance EU policies and private contribution to nature investments. Köz-Gazd. 2018, 178–190.

Lange, G.-M., Wodon, Q., Carey, K., 2018. The Changing Wealth of Nations, 2018, Building a Sustainable Future. World Bank, Washington DC.

Marjainé Szerényi, Z., 2018. The economics of natural resources, in: Sustainability, Environmental Economics, Welfare. Corvinus University of Budapest, Budapest, pp. 89–132.

McGrath, L., Hynes, S., McHale, J., 2019. Augmenting the World Bank's estimates: Ireland's genuine savings through boom and bust. Ecol. Econ. 165, 106364.

Pearce, D., 1993. Measuring sustainable development, 1st ed, The Sequel to Blueprint for a Green Economy. Earthscan Publications Limited, London.

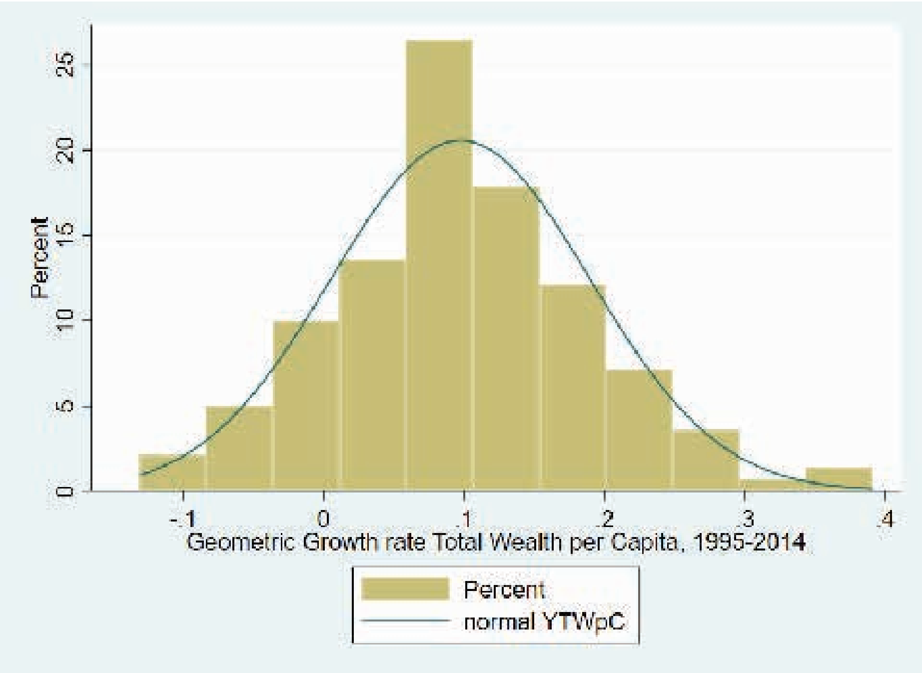
Pearce, D.W., Atkinson, G.D., 1993. Capital theory and the measurement of sustainable development: an indicator of "weak" sustainability. Ecol. Econ. 8, 103–108.

UNSD, n.d. System of Environmental Economic Accounting | [WWW Document]. SEEA. URL https://seea.un.org/ (accessed 4.17.19).

APPENDIX 1.

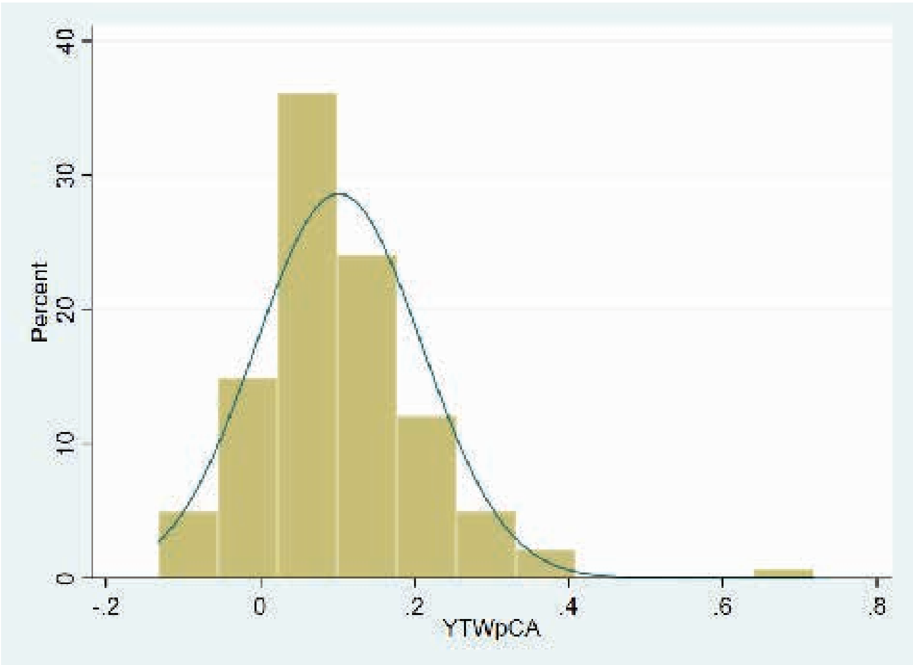
Density of Growth rates of Total Wealth and its components, 1995-2014

Figure 4 Total Wealth growth rates



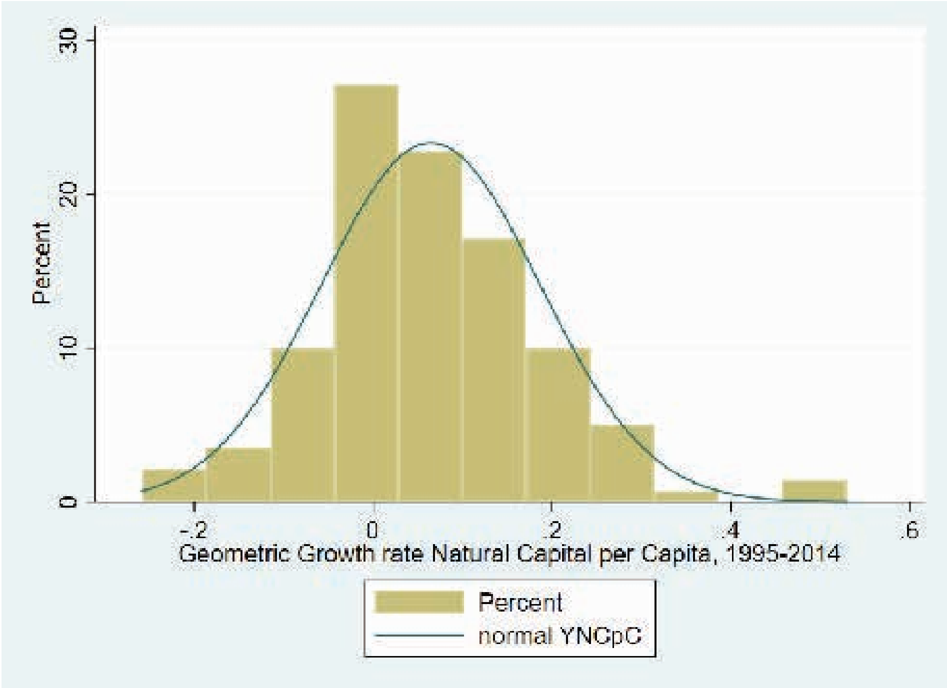
Source:author's construction based on WBOD, Wealth Accounts

Figure 5 Density of growth rate, Total Wealth net of Net Foreign Assets



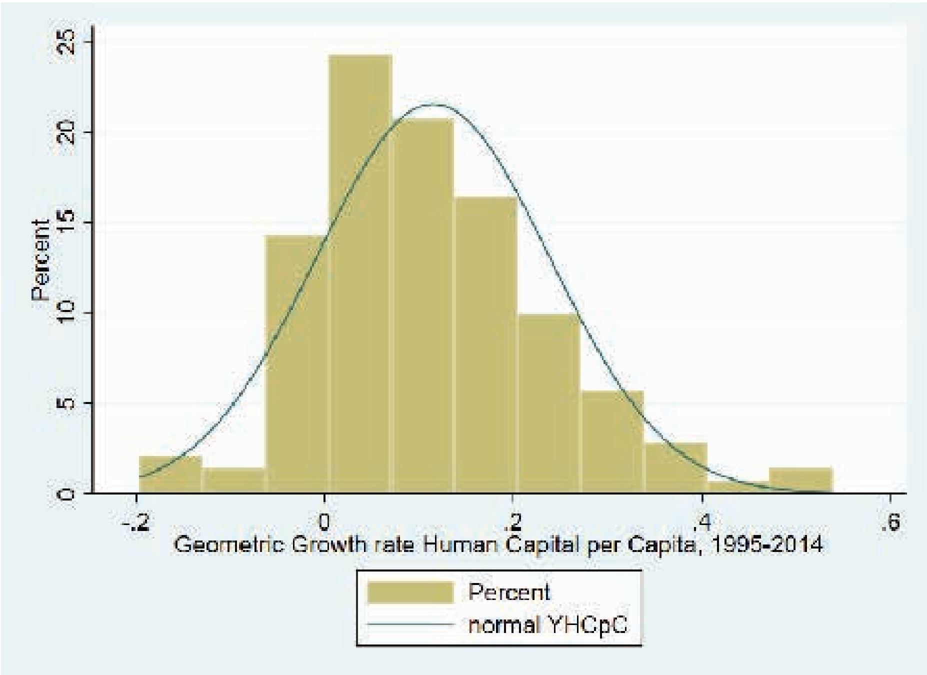
Source: author's construction based on WBOD, Wealth Accounts

Figure 6 Human Capital growth rates



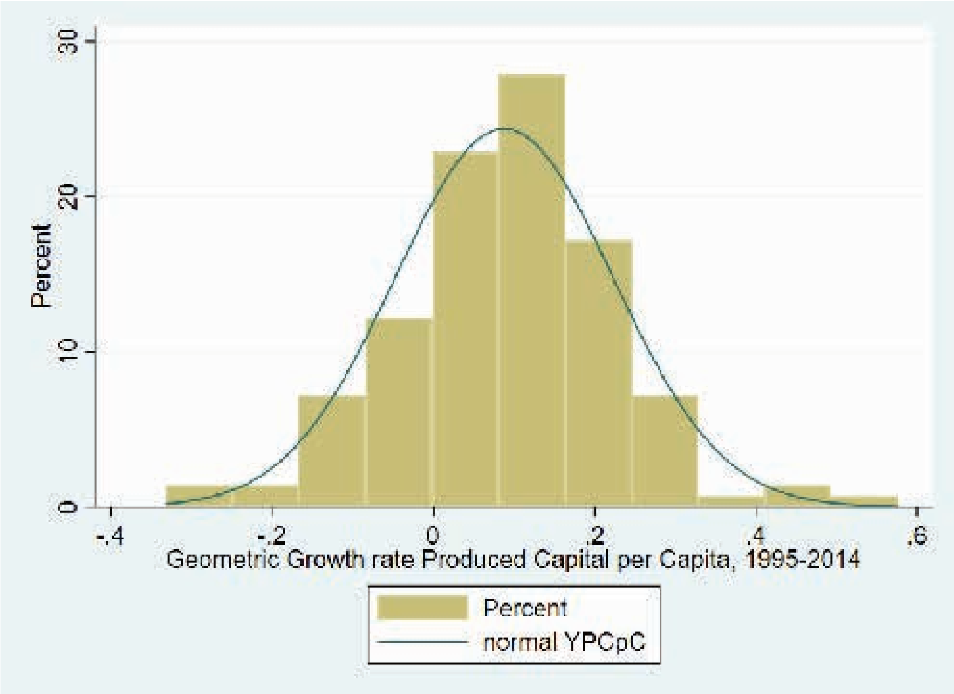
Source:author's construction based on WBOD, Wealth Accounts

Figure 7 Correlations, GDP growth, changes in Total Wealth and capital elements



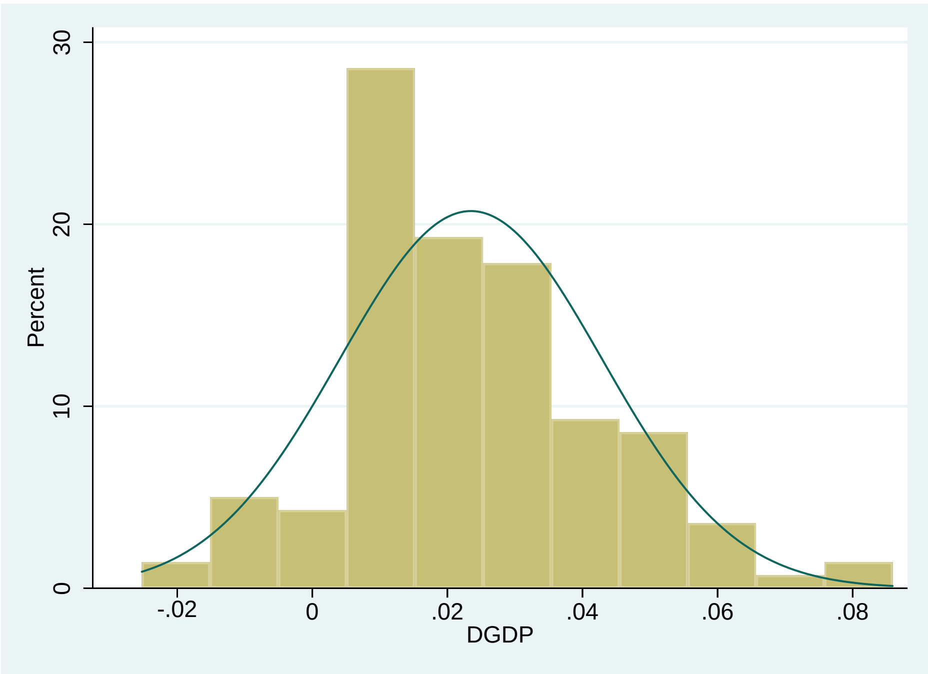
Source:author's construction based on WBOD, Wealth Accounts

Figure 8 Produced Capital growth rates



Source:author's construction based on WBOD, Wealth Accounts

Figure 9 DGDP (ΔGDP), histogram and estimate normal distribution, 1995-201



Source:author's construction based on WBOD, World Development Indicators

APPENDIX 2.

List of non-sustainable economies

The criteria for strong sustainability is that, in an economy, none of the capital components decrease over the investigated period. The three tables below show the list of countries with negative geometric growth rates of human, natural, and produced capital, respectively, over the four time periods between 1995 and 2014. The subsequent table shows the list of countries, with UN income classification, which do not meet the criteria of strong sustainability for any of the capital components.

Table 8 Non-sustainable countries, Weak sustainability, Total Wealth 1995-2014

CountryName	YTWpC, %
Bahrain	-3,8
Belize	-1,5
Burundi	-11,6
Comoros	-4,8
Congo, Dem. Rep.	-9,5
Cote d'Ivoire	-1,8
Gabon	-0,3
Greece	-3,6
Jamaica	-2,7
Kenya	-2,5
Lebanon	-7,8
Madagascar	-5,5
Nigeria	-6,1
Portugal	-0,1
Solomon Islands	-0,1
Spain	-0,4
Tanzania	-4,4
United Arab Emirates	-13,1
Zimbabwe	-6,6

Source: author's construction

Table 9 Non-sustainable countries, Weak sustainability, Total Wealth net of Net foreign Assets, 1995-2014

CountryName	YTWpCA
Bahrain	-3,9
Burundi	-11,6
Comoros	-5,8
Congo, Dem. Rep.	-10,5
Cote d'Ivoire	-4,6
Gabon	-2,3

Greece	-1,3
Jamaica	-1,5
Kenya	-3
Lebanon	-3,8
Liberia	-2,3
Madagascar	-5,6
Nigeria	-6,9
Oman	-0,6
Solomon Islands	-0,6
Tanzania	-4,7
United Arab Emirates	-13,2
Zimbabwe	-6,1

Table 10 Non-sustainable countries, Strong Sustainability, Human Capital

CountryName	YHCpC
United Arab Emirates	-11,4
Burundi	-3,1
Central African Republic	-14,8
Cote d'Ivoire	-1,6
Congo, Dem. Rep.	-2,7
Comoros	-0,5
Spain	-3,6
Gabon	-8,0
Guinea	-1,2
Gambia, The	-2,3
Greece	-6,0
Italy	-1,2
Japan	-2,3
Kuwait	-2,9
Madagascar	-3,6
Mexico	-1,9
Niger	-19,6
Oman	-1,2
Portugal	-2,4
Solomon Islands	-3,8
Tanzania	-1,1
Venezuela, RB	-0,5
Zimbabwe	-13,1

Table 11 Non-sustainable countries, Strong sustainability, Natural Capital

CountryName	YNCpC
United Arab Emirates	-3,9
Austria	-0,8
Burundi	-14,5
Belgium	-4,5
Belize	-2,5
Switzerland	-0,5
Cote d'Ivoire	-7,4
Congo, Dem. Rep.	-12,8
Colombia	-2,2
Costa Rica	-0,3
Greece	-5,1
Honduras	-8,2
Ireland	-10,0
Italy	-4,8
Jamaica	-19,9
Jordan	-15,3
Kenya	-7,6
Lebanon	-18,5
Liberia	-4,3
Sri Lanka	-6,0
Luxembourg	-25,8
Moldova	-13,3
Madagascar	-6,0
Maldives	-7,7
Mexico	-0,7
Malta	-4,7
Mauritius	-5,2
Malaysia	-0,7
Namibia	-2,7
Nigeria	-22,4
Netherlands	-1,6
Panama	-3,7
Portugal	-1,2
Romania	-2,1
Suriname	-0,2
Slovak Republic	-2,0
Swaziland	-1,4
Turkey	-4,7
Tanzania	-9,3

Table 12 Non-sustainable countries, Strong Susainability, Produced Capital

CountryName	YPCpC
United Arab Emirates	-25,7
Burundi	-33,1
Bahrain	-10,7
Cote d'Ivoire	-2,9
Cameroon	-1,4
Congo, Dem. Rep.	-12,1
Comoros	-15,4
Ethiopia	-1,1
Gabon	-1,4
Ghana	-7,1
Jamaica	-0,1
Kazakhstan	-0,1
Kenya	-10,7
Kuwait	-10,8
Lebanon	-7,1
Liberia	-23,0
Madagascar	-10,3
Mauritania	-2,0
Malawi	-7,9
Nigeria	-2,8
Oman	-11,1
Papua New Guinea	-0,8
Russian Federation	-10,2
Saudi Arabia	-7,4
Solomon Islands	-21,2
Sierra Leone	-6,4
Chad	-12,3
Togo	-7,1
Ukraine	-7,2
Yemen, Rep.	-6,3
Zambia	-14,4

Table 13 Unsustainable countries, Strong sustainability criteria

CountryName	Low-income	Low-middle income	Upper-middle income	High income
United Arab Emirates				HI
Austria				HI
Burundi	LI			
Belgium				HI
Bahrain				HI
Belize			UMI	
Central African Republic	LI			
Switzerland				HI
Cote d'Ivoire		LMI		
Cameroon		LMI		
Congo, Dem. Rep.	LI			
Colombia			UMI	
Comoros	LI			
Costa Rica			UMI	
Spain				HI
Ethiopia	LI			
Gabon			UMI	
Ghana		LMI		
Guinea	LI			
Gambia, The	LI			
Greece				HI
Honduras		LMI		
Ireland				HI
Italy				HI
Jamaica			UMI	
Jordan			UMI	
Japan				HI
Kazakhstan			UMI	
Kenya	LI			
Kuwait				HI
Lebanon			UMI	
Liberia	LI			
Sri Lanka		LMI		
Luxembourg				HI
Moldova		LMI		
Madagascar	LI			
Maldives			UMI	
Mexico			UMI	
Malta				HI
Mauritania		LMI		

Mauritius			UMI	
Malawi	LI			
Malaysia			UMI	
Namibia			UMI	
Niger	LI			
Nigeria		LMI		
Netherlands				HI
Oman				HI
Panama			UMI	
Papua New Guinea		LMI		
Portugal				HI
Romania			UMI	
Russian Federation				HI
Saudi Arabia				HI
Solomon Islands		LMI		
Sierra Leone	LI			
Suriname			UMI	
Slovak Republic				HI
Swaziland		LMI		
Chad	LI			
Togo	LI			
Turkey			UMI	
Tanzania	LI			
Ukraine		LMI		
Venezuela, RB			UMI	
Yemen, Rep.		LMI		
Zambia		LMI		
Zimbabwe	LI			

Source: author's construction based on WBOD, Wealth Accounts

Chapter II: Regions

Climate mainstreaming in the MFF 2021-2027: A simple slogan without political will?

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Abstract

The European Commission is looking at cost-efficient ways to finance the transition towards a new European economic model which is more climate-friendly and less energy consuming. The delivery of the EU's climate objectives, however, will require significant investment. The Multiannual Financial Framework (MFF) provides a framework for the above-mentioned efforts. It lays down the maximum annual amounts ('ceilings') which the EU may spend in different political areas ('headings') over a period of at least five years. It also allows the Union to implement common policies over a period of time that is long enough to make them effective. In line with the Paris Agreement and the commitment to the United Nations Sustainable Development Goals, the Commission proposes to set a more ambitious goal for climate mainstreaming across all EU programmes, thus across the whole MFF, with a target of 25% of EU expenditure contributing to climate objectives, while the European Parliament has called for an even more ambitious approach. The main purpose of this article is to present climate mainstreaming and climate-related measures under the future MFF. The author argues that it is a cause of concern that the amount of climate-related spending is still a political issue and that without the critiques from Parliament, the Commission would never have been as ambitious as it ultimately was.

Introduction

The Multiannual Financial Framework (MFF) is one of the most important elements in the European Union's decision-making. The importance of this seven-year budgetary framework is clearly reflected in the fact that it must be adopted unanimously, thus both net contributors and net beneficiary Member States must agree on it. Its size is only around 1% of the EU's GNI, which is frequently criticized by mostly net beneficiary countries, taking into consideration the high number of challenges the MFF must respond to – such as the enlargement of the EU, income and wealth inequality, the risk of poverty, migration, demographic changes, regional disparities, and unemployment (in particular, youth unemployment), etc. Climate change is one of these challenges, mostly raised by net contributor countries, especially northern Member States. Our research is primarily of a qualitative nature, based on macro-level document analysis. In this context, the study uses primary textual sources – in particular, proposals, resolutions, and press releases of the European Council, the European Commission, and the European Parliament.

Research objective

The article presents the emergence of the topic of the climate in the 2014-2020 as well as in the 2021-2027 MFFs based on legislation, communications, and press releases. The aim of the article is to give the reader a clear picture of the issues and solutions related to climate change conveyed by hundreds of pages of EU documents, with special emphasis on MFF 2021-2027. The article seeks to highlight that the issue of climate change in the EU is inextricably intertwined with the negotiations related to the MFF 2021-2027. Apart from its function as an overview, the article questions the readiness of the three main EU institutions (the Council, the Commission and the Parliament) to mainstream the climate objectives of the Paris Agreement in the MFF 2021-2027. The author argues that it is a cause of concern that the amount of climate-related spending is still a political issue, and that without the critiques of the Parliament, the Commission would have never been as ambitious as it ultimately was.

Why was the MFF 2014-2020 not ambitious enough?

The Multiannual Financial Framework sets the ceilings for EU spending for seven years, aggregated and broken down by area of activity and fund. This spending can be divided into broader "chapters" that correspond to each of the EU's priorities. In the MFF 2014-2020, there was a separate chapter related to sustainability (competitiveness and cohesion resources) and one on the conservation of natural resources (CAP, fisheries policy, and the environment). These two chapters represented about 85% of the expenditure associated with the common budget, while the remaining 15% was typically divided between the chapters of European citizenship, administrative costs and the EU as a global partner

(https://www.consilium.europa.eu/en/policies/the-eu-budget/long-term-eu-budget-2014-2020/).

There was thus a strong intention to elaborate an MFF that mainstreams the climate goals the EU has agreed on. Member States signed up to achieve two major climate targets: 1. a 40% reduction in greenhouse gas emissions at the EU level by 2030 compared to 1990, and 2. climate neutrality by 2050. According to Béla Galgóczi, senior researcher at the European Trade Union Institute (ETUI) in Brussels, from 2020 to 2050 three times more GHG emissions cuts are needed than those achieved in the 30 years to 2020 (Galgóczi, 2018. p. 2). Because of this, some increase in the 2030 target – if economically and politically feasible – would be helpful (Elkerbout et al., 2020. p. 2).

Keeping in mind all the financial needs related to these GHG emissions cuts, MFF 2014-2020 have been often criticized for being highly dominated by CAP-related (39% of total commitment appropriations) and cohesion-policy-related spending (34%) and for not contributing sufficiently to the overarching goal of sustainable growth and development (Schratzenstaller, 2017. p. 6).

As illustrated by Figure 1, the share of expenditure dedicated to infrastructure and competitiveness, including research (13%), also seemed to be moderate (ibid.). Moreover, both CAP and cohesion policy were not targeted enough and coupled too weakly with climate goals. They both focused insufficiently on climate and environmental goals, and in cohesion policy, infrastructure projects were often given priority. The share of “green” R&D (35% of R&D expenditure reserved for climate-related targets) and that of low-carbon infrastructure expenditure was also considered to be low, and there was a strong need to introduce new, sustainability-oriented “green” own resources and to implement a supranational, sustainability-oriented tax shift (ibid. p. 7). MFF 2021-2027 must thus be overhauled fundamentally to generate European “green” added value and a new approach based on the comprehensive concept of sustainability, including economic, social, and environmental sustainability. A great number of

Member States (mostly old Member States, such as the "Frugal Four") also urged a reduction in overall spending on CAP, reinforcement of the "greening" of the first pillar (capping; conditionalities) and a shift to the second pillar (rural development) (ibid.).

What was the European Parliament's initial position on MFF 2021-2027?

Back in 2018, the European Parliament issued its guidelines and opinion in relation to the negotiation of the new Multiannual Financial Framework. In its resolution of 14 March 2018, under the title Preparing the Parliament's position on the MFF post-2020, the European Parliament stood up for climate mainstreaming in the MFF 2021-2027. It declared the MFF 2014-2020 inadequate for tackling the challenge caused by climate change and defined preparing the ground for a stronger and more sustainable Europe as well as fighting climate change as the main priorities (European Parliament, 2018. points No. 3 and 4). According to the document, climate change is a complex issue which also includes natural disasters, environmental degradation, and biodiversity loss (ibid. point No. 5). The Parliament's intentions are best summarized in point No. 6., which points out that the EU must deliver on its commitment to be a frontrunner in implementing the UN Sustainable Development Goals (SDGs); […] underlines that the next *MFF must be aligned with the SDGs; welcomes the Commission's commitment to mainstreaming the SDGs into all EU policies and initiatives; expects the EU to fulfil its commitments to those goals; […] considers that, following the Paris Agreement, climate-related spending should be significantly increased compared to the current MFF and reach 30% as soon as possible and at the latest by 2027.*

The resolution incorporates reference to the climate in several headings in the proposed structure of the MFF post-2020 too, such as in its Heading 1 (A stronger and sustainable economy), Heading 2 (Stronger cohesion and solidarity in Europe), and Heading 3 (Stronger and sustainable agriculture and fisheries). Concerning Heading 1, point No. 76. makes reference to the EU's climate goals and the SDGs and point No. 82. *recalls the goals set by COP 21 with regard to transport in order to combat climate change*. Moreover, point No. 83. *considers that an updated and more effective CEF programme should prioritise greater links between comprehensive networks and modes of transport that contribute to reducing CO_2 emissions.*

Climate seems to be even more strongly emphasized in relation to energy policy: point No. 86. supports a strategic transition to a low-emission economy, the development and deployment of renewable sources, early adaptation to future environmental standards as well as addressing environmental impacts. Point No. 88. goes even further, and is fully dedicated to climate mainstreaming, as it stresses the importance of and the EU's leading role in preserving, protecting and improving the quality of the environment and tackling climate change, the degradation of ecosystems and biodiversity loss; considers that stable and appropriate funding is essential to achieving the EU's international commitments such as the Paris Agreement; recalls that the next MFF should help the Union to achieve those objectives and should contribute to the transition to a low-carbon economy by 2050; underlines that the EU should not finance projects and investments that are contrary to the achievement of these goals; calls for the thorough climate mainstreaming of future EU spending; calls, in this respect, for the programmes concerned, such as LIFE+, to be properly funded and for their financial resources to be doubled, and for the establishment of dedicated envelopes for biodiversity and the management of the Natura 2000 network.

On the other hand, Heading 2 mentions climate objectives much less frequently, since only points No. 89. and 90. refer to these goals. The same applies to Heading 3, Heading 4, and Heading 6. The climate does not appear in Heading 5 (Security, peace and stability for all). All in all, the European Parliament seemed to be very ambitious before starting the negotiations and, as demonstrated above, has tried to push the Commission towards climate mainstreaming many times.

What was the European Commission's initial proposal in May 2018?

Elaborating its proposals for MFF 2021-2027 in May 2018 was thus not an easy task for the European Commission. Reacting to the critics, the share for CAP and cohesion expenditure has been decreased to about 29% each. At the same time, the research framework programme has been slightly increased from 7.3% to 7.6% (European Commission, 2018). The Connecting Europe Facility (CEF) has been maintained at about 2%. Regarding the climate, as illustrated by Figure 2, the biggest step forward was that climate mainstreaming across all EU programmes increased from 20% to at least 25% of EU expenditure that contributes to achieving climate objectives (€ 320 billion, i.e. + € 114 billion compared to MFF 2014-2020) (ibid.).

Amongst other topics, addressing the climate has become a conditional item in regional development and cohesion. The low-carbon transition and energy efficiency have been given priority and support for fossil fuel projects has been almost comprehensively excluded. Thirty percent of the European Regional Development Fund and 37% of the Cohesion Fund have been climate earmarked, which, however, may not suffice to reach the overall 25% climate mainstreaming target (ibid.). As for CEF, even though fossil fuel infrastructure was not completely ruled out, 10% of the related funding was dedicated to cross-border renewable energy projects. The same problem with fossil fuel infrastructure appeared in InvestEU as well, where climate proofing has been introduced but was not applied comprehensively. A constant share of 35% of the climate mainstreaming allocation was spent on R&D (ibid.). Finally, the Commission proposed three new "green" own resources: 1. a share of 3% of the Common Consolidated Corporate Tax Base (CCCTB); 2. a tax rate of € 0.80 per kilo of non-recyclable plastic waste; and, 3. a share of 20% of revenues from the auctioning of emission trading certificates (ibid.).

What was the European Parliament's reaction to the Commission proposals in May 2018?

The resolution of 30 May 2018 on the 2021-2027 multiannual financial framework and own resources was basically the European Parliament's official response to the European Commission's proposals. The document requested a doubling of the Life+ programme and reaffirmed the EP's position that *the EU must deliver on its commitment to be a frontrunner in implementing the UN Sustainable Development Goals (SDGs)* and deplored *the lack of a clear and visible commitment to that end in the MFF proposals*. The resolution also asked for *the mainstreaming of the SDGs into all EU policies and initiatives of the next MFF* and underlined the Parliament's position that, *following the Paris Agreement, climate-related spending should be significantly increased in comparison with the current MFF and reach 30% as soon as possible and at the latest by 2027*. Nonetheless, the document was not fully negative about the Commission's proposals, as it supported them in relation to the reform of the EU own resources system, and noted with satisfaction that the new resources also correspond to *the protection of the environment and the fight against climate change* (European Parliament, 2018).

The European Green Deal: more than just big words?

The Commission published its Communication on the European Green Deal on 11 December 2019. Heads of State and Government discussed the document and endorsed the objective of a climate neutral EU by 2050 at the European Council summit, starting a day later. The European Green Deal is not a detailed legislative package, but rather a kind of brainstorming and agenda organized under thematic objectives, so it does not detail concrete implementation options. The document builds heavily on the existing EU environmental strategies, envisages their review, and, in the case of legislation, their amendment and tightening.

The document confirms the Commission's commitment to tackling climate and environmental-related challenges and emphasizes the EU's commitment to the United Nation's 2030 Agenda, the Sustainable Development Goals, as well as to climate neutrality by 2050 by decoupling economic growth from resource use. In order to support a just and inclusive transition, the Commission *aims to protect, conserve and enhance the EU's natural capital and protect the health and well-being of citizens from environment-related risks* (European Commission, 2019. p. 2). According to the Communication, Europe *has the collective ability to transform its economy and society to put it on a more sustainable path* (ibid.). In this sense, the document is an *initial roadmap of the key policies and measures needed to achieve the European Green Deal* (European Commission, 2019. p. 3). The biggest weakness of the document is that it does not assign similarly ambitious financing opportunities to these strong climate policy ambitions. In essence, it specifies the need to decouple economic growth opportunities from the "over-consumption" of resources in such a way that by 2050 the EU is climate neutral. Climate neutrality is achieved when the amount of carbon dioxide emitted by products, services, and organizations and the amount of greenhouse gases (GHGs) removed from the atmosphere are equal (Murray–Dey, 2009).

The EU budget will play a *key role* in this transformation and, according to the document, in the framework of the Sustainable Europe Investment Plan, the Commission will propose a Just Transition Mechanism (JTM), including a Just Transition Fund, to leave no one behind. The JTM will be additional to the EU budget, while the Commission Communication on the European Green Deal also sets out that both at the EU and national level, a socially just transition must be reflected in policies such as carbon pricing policies, measures for addressing energy poverty, and re-skilling.

According to the proposal, the Mechanism would consist of three pillars and is planned to channel at least € 100 billion into the process of transitioning to a sustainable economy. The first pillar is the Just Transition Fund itself, a financial fund that would provide € 7.5 billion at 2018 prices. The second and third pillars of the Just Transition Mechanism are strongly interlinked. The second pillar is the Just Transition Scheme that is to be set up within InvestEU, which is expected to mobilize around € 45 billion in private investment. This would actually be a credit line for supporting "green" private investment. At the same time, the third pillar, the European Investment Bank Facility, is a credit line specifically designed to support sustainable projects in the public sector and local government. The latter would be expected to invest € 25-30 billion in public money. Under the second and third pillars, infrastructure investments based on renewable energy and energy efficiency, energy and transport infrastructure development, and other decarbonisation projects will also be eligible (European Commission, 2020a).

For many Member States, however, the Just Transition Fund is not a suitable solution since the resources provided by the Fund cannot be used for making investments into the construction / decommissioning of nuclear power plants and the combustion, production, and processing of fossil fuels or investments related to the circular economy and research activities (European Commission, 2020b). Member States should draw up their own territorial transition plans with a view to national climate neutrality, indicating the areas of use of the resources provided by the Mechanism in line with the priorities of their operational programs for mobilizing cohesion funds (European Commission, 2020c). However, it is questionable, for instance, to what extent Poland, having many coal mines, or Hungary and the Czech Republic, currently building nuclear power plants, can make use of these resources.

According to the Communication on the European Green Deal, national budgets also play a key role in the transition. Screening and benchmarking green budgeting practices, green public investment, well designed tax reforms, and environmental and energy State aid guidelines are an essential part of this. The main objective here is to eliminate subsidies for fossil fuels, to shift the tax burden from labour to pollution, and to take into account social considerations.

Of course, EU policies such as Research & Development will be at the heart of the transition. New solutions for the climate that are relevant for implementing the Green Deal will be supported by the full range of instruments available under the Horizon Europe programme, and will receive 35% of its budget. According to the Communication, *conventional approaches* will not be enough and *data-driven innovation* is needed (ibid. p. 18).

Another core area of the Green Deal is education and training. Schools, universities, and other training institutions are the right places to disseminate knowledge for a successful transition. In line with the Communication, a *European competence framework* will be prepared in order to *develop and assess knowledge, skills and attitudes* about sustainable development and climate change. At the same time, the Commission is taking steps to make school buildings and operations more sustainable as well. Third, to understand and take advantage of the *benefits of ecological transition*, pro-active re-skilling and upskilling are needed (ibid. p. 19).

Finally, to ensure that all Green Deal initiatives achieve their objectives in the most effective and least burdensome way and to identify and remedy inconsistencies in current legislation, stakeholders are invited to use the available platforms to make legislation simpler and to identify problematic cases. The Commission has introduced a so-called green oath to 'do no harm' principle, which has to be uphold by each initiative (ibid. p. 19).

Were the results of the July 2020 Council Conclusions compatible with the Green Deal?

Charles Michel, President of the European Council, published the draft European Council conclusions on the MFF and the recovery package on 10 July 2020, which were discussed by the Heads of State and Government from 17 to 21 July and finally accepted on 21 July.

Member States agreed on mainstreaming climate action in all policies and programmes, as well as on an overall climate target of 30% to apply to the total expenditure (European Council, 2020). According to the Conclusions, *EU expenditure should be consistent with Paris Agreement objectives and the "do no harm" principle of the European Green Deal.* Moreover, the document also envisages the creation of an *effective methodology for monitoring climate-spending and its performance, including reporting and relevant measures in case of insufficient progress* to ensure that *the next MFF as a whole contributes to the implementation of the Paris Agreement* (ibid.). The Commission is obliged to annually report on climate expenditure. The previously discussed Just Transition Mechanism, including a Just Transition Fund, will be established to address *the social and economic consequences of the objective of reaching climate neutrality by 2050 and the Union's new 2030 climate target.*

As for the Connecting Europe Facility, the Conclusions emphasize the importance of trans-European networks for combatting climate change by taking into account decarbonisation commitments. A key role in relation to *reaching the ambitious target of at least 30% of EU expenditure contributing to climate objectives* by *mainstreaming of climate across the budget and enhanced integration of environmental objectives* on the other hand is clearly awarded to Heading 3 by providing about € 401 billion at current prices (see Natural Resources and Environment on Figure 3.). The CAP might be the most important policy of this heading, and the document sets out that 40% of CAP expenditure is *expected to be dedicated to climate action* (ibid.). Moreover, both pillars of the new CAP seem to contain a stronger focus on the environment. While in Pillar I (market measures and direct payments) it is planned that a new environmental architecture will be set up, Pillar II (Rural Development) *will deliver specific climate and environmental public goods.*

The previously discussed Just Transition Mechanism, including a Just Transition Fund, has also been integrated into the final deal *in order to address social and economic consequences of the objective of reaching EU climate neutrality by 2050*. Last but not least, to see the big picture, we must understand that climate is present in nearly all headings, even in chapters such as Neighbourhood Policy & External Action, which refers to the 2030 Agenda for Sustainable Development, and the Paris Climate Agreement.

Could the European Parliament's approval further strengthen climate mainstreaming?

On 14 December 2020, the European Parliament Committee on Budget adopted a draft recommendation on the draft Council regulation related to the MFF 2021-2027. Two days later, on 16 December, the European Parliament gave its consent to the regulation about the 2021-2027 MFF. After receiving the Parliament's consent, the MFF regulation was adopted unanimously by the Council. The regulation applies from 1 January 2021. (https://www.europarl.europa.eu/legislative-train/theme-new-boost-for-jobs-growth-and-investment/file-mff-2021-2027-mff).

In a paper under the title Parliament approves seven-year EU budget 2021-2027, the EP highlighted that in relation to biodiversity targets, there will be improved tracking to make sure that at least 30% of the total amount of the European Union budget and Next Generation EU expenditures will support climate protection objectives, and that 7.5% of annual spending will be dedicated to biodiversity objectives from 2024 and 10% from 2026 onwards.

The press release *Long-term EU budget and Own Resources: statements by Parliament's negotiators* clearly summarizes the ideas of the members of the EP's negotiating team about what has been achieved during the trilateral talks. MFF co-rapporteur Margarida Marques (S&D) highlighted, for instance, that the Parliament had *managed to improve the European Council July agreement by increasing the EU's capacity to achieve its political goals in climate*. José Manuel Fernandes (EPP), on the other hand, praised the new own resources and the fact that they will be aligned with EU's priorities such as the *fight against climate change* and *circular economy*. Finally, in the Greens/EFA Group, Rasmus Andresen mentioned the fact of the 30% climate expenditure as a *strong climate and biodiversity target,* emphasizing its *improved methodology* as well as the *do-no-harm principle*.

A European Parliament press release entitled *MEPs debate EU summit results on long term budget, rule of law, climate* gives further examples of MEP's views on climate mainstreaming. According to this document, Commission President Ursula von der Leyen praised *the 55% reduction target for greenhouse gas emissions*. MEP Ska Keller from the Greens/EFA Group, on the other hand, said that *"the 2030 climate actions target is still far short of what is needed according to the scientific consensus"*. Johan Van Overtveldt (ECR) was also negative about the final approval stating that *"the costs of dealing with climate change are not factored in enough"*. Manon Aubry (GUE/NGL) also criticized the final deal, deploring the fact that *the EU's declared ambitions on protecting the climate are not matched by its deeds* and that *the agreement ended up amounting to over € 200 billion less than the EP's original position, bringing fewer investments for environment*.

Conclusion

As we have seen, the Multiannual Financial Framework (MFF) is one of the most important elements of the European Union's decision-making, providing a framework for delivering the EU's climate objectives. Since the number of challenges is increasing, the MFF is under continuous pressure. Climate change remains one of the biggest challenges the MFF must face. The macro-level document analysis we have carried out on primary textual sources showed that all three main institutions were committed to the mainstreaming the Paris climate objectives into the MFF 2021-2027. However, the European Parliament took the initiative in many cases, as is clearly shown by its resolution of 14 March 2018 and of 30 May 2018. It cannot be said that the Commission lacked the same enthusiasm for fighting climate change, but the pushes from Parliament from time to time certainly contributed to a more ambitious outcome.

Bibliography

Amundi Research Center: EU agreement: a powerful answer that can lift further EU assets and ESG investing, 22 July 2020 https://research-center.amundi.com/page/Article/Amundi-Views/2020/07/EU-agreement-a-powerful-answer-that-can-lift-further-EU-assets-and-ESG-investing

Elkerbout, M. – Egenhofer, C. – Núñez Ferrer, J. – Cătuţi, M. – Kustova, I. – Rizos, V.: The European Green Deal after Corona: Implications for EU climate policy, *CEPS Policy Insights*, No. 2020-06 / March 2020

European Commission (2018): A Modern Budget for a Union that Protects, Empowers and Defends, The Multiannual Financial Framework for 2021-2027 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A321%3AFIN

European Commission (2019): The European Green Deal https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588580774040&uri=CELEX%3A52019DC0640

European Commission (2020a): The Just Transition Mechanism: Making Sure No One Is Left Behind. DOI: https://doi.org/10.2775/19010

European Commission (2020b): Financing the green transition: The European Green Deal Investment Plan and Just Transition Mechanism – Press Release https://ec.europa.eu/commission/presscorner/detail/en/ip_20_17

European Commission (2020c): Proposal for a regulation of the European Parliament and of the Council establishing the Just Transition Fund. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020PC0022

European Commission: https://ec.europa.eu/info/strategy/eu-budget/long-term-eu-budget/eu-budget-2014-2020/funding-programmes_en

European Council (2020): Special meeting of the European Council (17, 18, 19, 20 and 21 July 2020) – Conclusions https://www.consilium.europa.eu/media/45109/210720-euco-final-conclusions-en.pdf

European Council: Long-term EU budget 2014-2020 https://www.consilium.europa.eu/en/policies/the-eu-budget/long-term-eu-budget-2014-2020/

European Parliament (2018): The next MFF: Preparing the Parliament's position on the MFF post-2020 https://www.europarl.europa.eu/doceo/document/TA-8-2018-0075_EN.html

European Parliament (2018a): Long-term EU budget: MEPs lay down funding priorities for post-2020 budget – Press Release. https://www.europarl.europa.eu/news/en/press-room/20181106IPR18317/long-term-eu-budget-meps-lay-down-funding-priorities-for-post-2020-budget

European Parliament (2020): Parliament approves seven-year EU budget 2021-2027 https://www.europarl.europa.eu/news/en/press-room/20201211IPR93621/parliament-approves-seven-year-eu-budget-2021-2027

European Parliament (2020): Long-term EU budget and Own Resources: statements by Parliament's negotiators https://www.europarl.europa.eu/news/en/press-room/20201216IPR94102/long-term-eu-budget-and-own-resources-statements-by-parliament-s-negotiators

European Parliament (2020): MEPs debate EU summit results on long term budget, rule of law, climate https://www.europarl.europa.eu/news/en/press-room/20201213IPR93804/meps-debate-eu-summit-results-on-long-term-budget-rule-of-law-climate

European Parliament: Legislative Train Schedule: new boost for jobs, growth and investment https://www.europarl.europa.eu/legislative-train/theme-new-boost-for-jobs-growth-and-investment/file-mff-2021-2027-mff

Galgóczi, Béla: From Paris to Katowice: the EU needs to step up its game on climate change and set its own just transition framework, *European Economic, Employment and Social Policy*, No. 4/2018

Murray, Joy – Dey, Christopher (2009): The carbon neutral free for all. *International Journal of Greenhouse Gas Control*, Vol. 3, No. 2. 237–248. DOI: https://doi.org/10.1016/j.ijggc.2008.07.004

Schratzenstaller, Margit (2017): The next Multiannual Financial Framework (MFF), its Structure and the Own Resources, *FairTax Working Paper Series*, No. 14, November 2017

Weber, Martin (2020): Climate change action and the new MFF: earmarking 'climate' financing in times of the Covid-19 pandemic, 15 July 2020 https://medium.com/ecajournal/climate-change-action-and-the-new-mff-earmarking-climate-financing-in-times-of-the-covid-19-4df05a4a87be

Low-carbon sustainable energy trends towards 2030 in Arab countries

Prof. Dr Moustafa El-Abdallah Alkafry, Ph.d Economics

Abstract

The Arab world is known as the world's oil capital, home to over 60% of the world's proven oil reserves. Its vast oil wealth and export revenues have been a critical factor in financing the achievement of development goals for many years. (From 1970-2010, the countries of the Arab Gulf saw one of the planet's fastest rates of development according to the Human Development Index [HDI], with oil exports serving as the main driver). However, as countries set their sights on achieving the 2030 targets related to the Sustainable Development Goals (SDGs) and the Paris Agreement on climate change, the position of carbon in the region's development strategies is shifting. This is driven by three main factors:[11]

First – Gulf countries now have one of the world's fastest annual growth rates of domestic electricity consumption. With a large share of this power generated by oil-burning power plants, this acts as a drain on oil reserves, reducing export revenues and creating serious risks for the sustainability of the oil-export based model of development.

Second – the Gulf has some of the world's largest per capita carbon footprints, and is witnessing the rapid rise of temperatures in the region, faster than the global average. Indeed, some parts of the Gulf may become uninhabitable in the second part of the twenty-first century as a result.

Third – a global shift is underway towards using low-carbon solutions to combat climate change, with projections of global oil demand potentially peaking by 2030, creating fragility for countries overly reliant on oil exports. (When United Nations Secretary-General Ban Ki-moon announced that he would convene an unprecedented Climate Change Summit at UN Headquarters on 22 September 2009, he said that we had less than ten years to halt the rise in greenhouse gas emissions to avoid catastrophic consequences for people and the planet. The small Island Developing States that are facing the threat of rising sea levels called for a peak in emissions by the end of 2010, and the stabilization of greenhouse gas concentrations at 350 parts per million (ppm) CO_2 equivalent as fast as possible).[12]

This rapid transformation has of course raised tremendous concern in the oil-rich Arab countries, whose economies are mainly dependent on oil exports. The cost of climate change is too high to accept. Even the Arab countries themselves will suffer, especially in relation to agriculture and water resources. Sea level rise will also threaten many low-lying countries and

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[11] Kishan Khoday, Decarbonizing Development in the Middle East, Posted on December 3, 2018. https://www.arabstates.undp.org/content/rbas/en/home/ourperspective/ourperspectivearticles/2018/decarbonizing-development-in-the-middle-east.html

[12] Wael Hmaidan, Oil in a Low-carbon Economy, https://www.un.org/en/chronicle/article/oil-low-carbon-economy.

agricultural areas in the region, such as Bahrain, Qatar, the United Arab Emirates, and the Nile basin. Therefore, the overall transformation of our societies to a low-carbon economy needs to happen. The question for the region should be, "What is our role in creating a low-carbon economy?"

Keywords: Arab Countries; energy; fossil fuels; CO_2 emissions; Climate Change; Sustainable Development.

Introduction

The Arab region obtained its momentous place in the global energy system due to its hydrocarbon industry, which boomed during the 1960s. However, the abundance of low-cost energy resources has significantly driven growth in energy demand. Oil and natural gas supply the majority of the region's energy needs – a historical trend since the 1950s that has always been closely tied to the region's role as a global supplier of both oil and natural gas[13] – as the largest proven oil reserves in the Arab region, including oil deposits, are located in Saudi Arabia (18% of global reserves) followed by Iraq (10.6% of global reserves). This section presents an overview of the total available fossil fuel resources across the four countries and covers two fossil fuel resources: oil, and natural gas.

The Arab world consists of twenty-two countries: namely, Bahrain, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, the UAE, Egypt, Libya, Tunisia, Algeria, Morocco, Mauritania, Sudan, Somalia, Comoros, Djibouti, Palestine and Yemen. Out of the twelve countries, Saudi Arabia, Iraq, Kuwait, The UAE, Algeria, Libya, and Qatar are the largest oil exporters in the region.

The Arab world is facing unprecedented challenges – social, economic and environmental – driven by accelerating globalization and a fast rate of technological development. However, those forces are providing us with myriad new opportunities for human advancement. The future is uncertain and we cannot predict it, but we need to be open and ready for it.

The children entering education in 2020 will be young adults in 2032. Schools will need to prepare them for jobs that have not yet been created, for technologies that have not yet been invented, and for solving problems that have not yet been anticipated. It will be a shared responsibility to seize such opportunities and find solutions to them.

(The Arab region could therefore continue to play a key role in the energy sector in the future, and the strength of this role will be determined by the decisions it takes now. The first to invest in developing CSP technology will benefit from selling the technology or the energy generated by it in the future, similarly to the situation with wind energy technology in some European countries. Renewable energy represents a unique opportunity for the Arab region. If the newly industrialized oil-exporting Arab countries invest their healthy revenues from oil trade into solar technology, they will not only help save lives across the planet by reducing climate change but also ensure that their economies will benefit from exporting clean solar energy. Additionally, in time, this will help them diversify their economies and prolong the life of their oil, which will become even more valuable in the future. Some oil-exporting Arab countries are starting to see this opportunity).[14]

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[13] World Bank. World Development Indicators; World Bank: Washington, DC, USA, 2016.
[14] Wael Hmaidan, Oil in a Low-carbon Economy, https://www.un.org/en/chronicle/article/oil-low-carbon-economy.

1. Energy intensity in Arab countries:

Energy intensity in the majority of Arab countries is still well above the European average, indicating high energy requirements for economic development in the region. In general, energy intensity in the Arab region is driven by the region's economic growth (average 4.5% GDP growth/year based on 2010$), rapid industrialization, population growth (average growth 2.26%/year), and highly subsidized energy market. This high energy intensity has been translated into excessive CO_2 emissions, especially in the oil-rich countries that record the highest CO_2 emissions/capita in the world. Managing and reducing energy consumption is both a vital cost-saving requirement for Arab countries and will significantly help with scaling down the regional impact on climate change.

The Arab Countries are a region with hydrocarbon-rich economies that are heavily dependent on fossil fuels for energy supply and domestic consumption. Their role in the global energy market stems from the large fossil fuel reserves that represent over 70% of the world's proven crude oil, and a third of global natural gas reserves. [15]

When it comes to the subject of energy in Arab countries, we instinctively think of oil as the source of the stable economies of these countries. Nevertheless, this is about to change. With the lead up to the United Nations Climate Change Conference in Copenhagen, governments are realizing the imminent threat of climate change, and that there is no choice but to act fast. According to the 2009 World Economic and Social Survey: Promoting Development, Saving the Planet, Arab countries need to transform their economies.[16]

Oil and natural gas resources are considered the main source of income for the majority of oil Arab countries. The Arab Countries have about 70% of the global proven crude oil reserves, putting the region in an elite position in the global oil market. These large oil reserves are distributed differently across the four countries. The differences between the Arab countries in terms of their production and available reserves are summarized in Table 1, below.

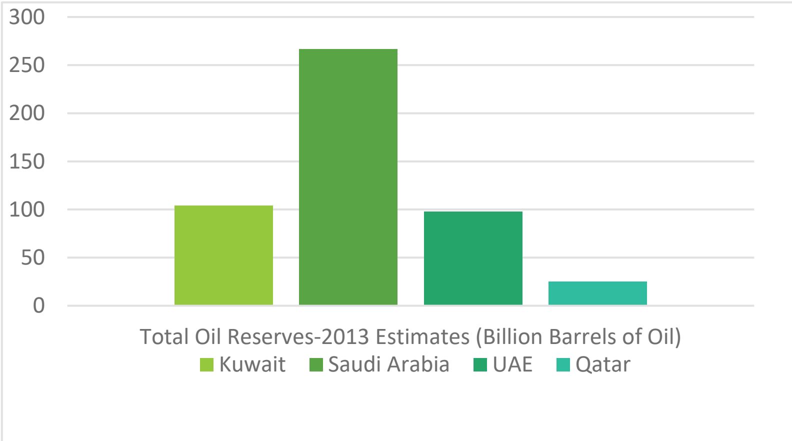
Table 1: Total Oil Reserves-2013 Estimates (Billion Barrels of Oil)

	Kuwait	*Saudi Arabia*	*UAE*	*Qatar*
Total Oil Reserves-2013 Estimates (Billion Barrels of Oil)	104	267	97.8	25.2

Source: Norhan Bayomi and John E. Fernandez, Towards Sustainable Energy Trends in the Middle East. https://www.researchgate.net/publication/332729344_Towards_Sustainable_Energy_Trends_in_the_Middle_East_A_Study_of_Four_Major_Emitters

[15] British Petroleum. BP Statistical Review of World Energy; British Petroleum: London, UK, 2015.
[16] http://www.un.org/esa/policy/wess/wess2009files/wess09/wess09pressreleases/pr_en.pdf.

Figure 10: Total Oil Reserves – 2013 Estimates (Billion Barrels of Oil)



However, the expected life span of the country's total reserves is estimated to be approximately 94 years.[17]

For Kuwait, oil is considered a vital component of its energy supply system. By the end of 2012, Kuwait's total proven crude oil reserves represented 8% of all global oil reserves. However, most oil fields in Kuwait are over 60 years old, which may limit the expansion of production capacity in the future.[18]

Table 2: Oil Reserves Estimates in Arab countries (Billion Barrels of Oil)

country	At the end of 1998 Thousand million barrels	At the end of 2008 Thousand million barrels	At the end of 2017 Thousand million barrels	At end 2018			
				Thousand million barrels	Thousand million tonnes	Share of total	R/P ratio
Iraq	112.5	115.0	147.2	147.2	19.9	8.5%	87.4
Kuwait	96.5	101.5	101.5	101.5	14.0	5.9%	91.2
Oman	5.4	5.6	5.4	5.4	0.7	0.3%	15.0
Qatar	13.5	26.8	25.2	25.2	2.6	1.5%	36.8
Saudi Arabia	261.5	264.1	296.0	297.7	40.9	17.2%	66.4
U A E	97.8	97.8	97.8	97.8	13.0	5.7%	68.0
Algeria	11.3	12.2	12.2	12.2	1.5	0.7%	22.1
Libya	29.5	44.3	48.4	48.4	6.3	2.8%	131.3
Syria	2.3	2.5	2.5	2.5	0.3	0.1%	284.8
Egypt	3.8	4.2	3.3	3.3	0.4	0.2%	13.6
Tunisia	0.3	0.6	0.4	0.4	0.1	-	23.2
Yemen	1.9	2.7	3.0	3.0	0.4	0.2%	121.4
Sudan	0.3	5.0	1.5	1.5	0.2	0.1%	41.1

https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-oil.pdf

[17] Nejat, P.; Morsoni, A.K.; Jomehzadeh, F.; Behzad, H.; Saeed Vesali, M.; Majid, M.Z.A. Iran's Achievements in Renewable Energy During Fourth Development Program in Comparison with Global Trend. Renew. Sustain. Energy Rev. 2013,22, 561–570.

[18] Ramadhan, M.; Hussain, A. Kuwait Energy Profile for Electrical Power Generation. Strateg. Plan Energy Environ. 2012,32, 18–25.

With oil reserves amounting to around 16% of the world's total, Saudi Arabia is by far the largest oil producer and exporter in the Middle East, which puts the country at the top of the list compared to the others. Its economy is largely based on oil, as oil revenues account for around 90% of total national income and about 50% of its GDP.[19]

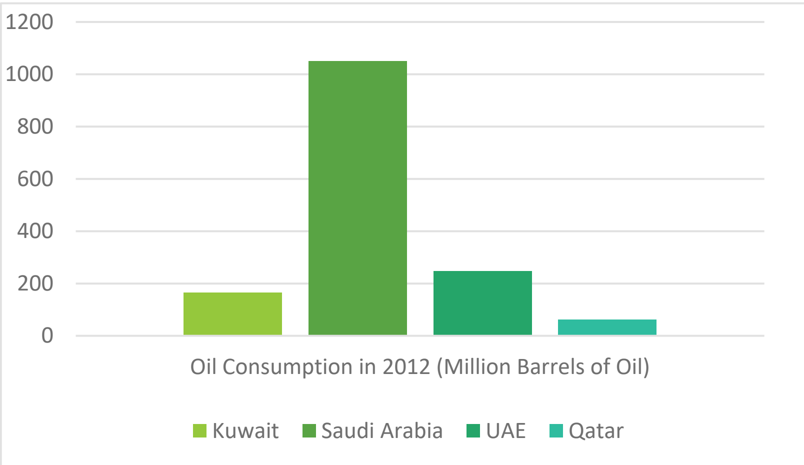
On the consumption side, the country is ranked as the world's sixth-largest oil consumer, with total energy consumption higher than the global average. The UAE is currently ranked as having the eighth largest oil reserve in the world, with about 5.8% of global oil reserves. While its total population is only 0.1% of the global population, the country accounts for around 0.8% of the world's total oil consumption.[20]

Table 3: Oil Consumption in 2012 (Million Barrels of Oil)

	Kuwait	Saudi Arabia	UAE	Qatar
Oil Consumption in 2012 (Million Barrels of Oil)	166	1051	248	62

Source: Norhan Bayomi and John E. Fernandez, Towards Sustainable Energy Trends in the Middle, https://www.researchgate.net/publication/332729344_Towards_Sustainable_Energy_Trends_in_the_Middle_East_A_Study_of_Four_Major_Emitters

Figure 11 :Oil Consumption in 2012 (Million Barrels of Oil)



Examining oil resources across the four countries, oil is a vital component in both energy supply and demand. Saudi Arabia has the region's largest oil production, reserves, production, and related CO_2 emissions. Although the UAE has a smaller reserve than Kuwait, its total oil production and consumption are much higher than those of Kuwait. Moreover, during the past thirty years, oil demand has been growing faster than production across the four countries.

[19] Mezghani, I.; Ben Haddad, H. Energy Consumption and Economic Growth: An Empirical Study of the Electricity Consumption in Saudi Arabia. Renew. Sustain. Energy Rev. 2016, 1–12.

[20] Sgouridis, S.; Abdullah, A.; Griffiths, S.; Saygin, D.; Wagner, N.; Gielen, D. E-Mapping the UAE's Energy Transition: An Economy-Wide Assessment Of Renewable Energy Options and Their Policy Implications. Renew. Sustain. Energy Rev. 2016,55, 1166–1180.

Table 4: Oil reserves, production, consumption, and related emissions across the four Arab Countries, Kuwait, Saudi Arabia, UAE, and Qatar.

Oil Profile	Kuwait	Saudi Arabia	UAE	Qatar
Total Oil Reserves-2013 Estimates (Billion Barrels of Oil)	104	267	97.8	25.2
Share of Global Oil Reserves (%)	8%	16%	5.8%	1.53%
Oil Production in 2012 (Million Barrels of Oil)	962	3588	1032	725
Oil Exports in 2012 (Million Barrels of Oil)	545	2281	796	183
Oil Consumption in 2012 (Million Barrels of Oil)	166	1051	248	62
CO2Emissions from oil consumption in 2012 (Million Metric Tons)				52

Source: Norhan Bayomi and John E. Fernandez, Towards Sustainable Energy Trends in the Middle, https://www.researchgate.net/publication/332729344_Towards_Sustainable_Energy_Trends_in_the_Middle_East_A_Study_of_Four_Major_Emitters

The oil production of Saudi Arabia and Kuwait have been growing at an average annual rate of 1.5%, while Iran's and the UAE's growth rate reached 2% annually (Figure 1a). On the other hand, UAE's oil demand has risen fastest, growing at an average annual of 7.20% since 1980 followed by that of Saudi Arabia, as illustrated in Figure 1. This growing demand for oil will be a challenge to the low-carbon transition in the next few years.[21]

Table 5: Oil Production in 2012 (Million Barrels of Oil)

	Kuwait	Saudi Arabia	UAE	Qatar
Oil Production in 2012 (Million Barrels of Oil)	962	3588	1032	725

Source: Norhan Bayomi and John E. Fernandez, Towards Sustainable Energy Trends in the Middle, https://www.researchgate.net/publication/332729344_Towards_Sustainable_Energy_Trends_in_the_Middle_East_A_Study_of_Four_Major_Emitters

[21]https://www.researchgate.net/publication/332729344_Towards_Sustainable_Energy_Trends_in_the_Middle_East_A_Study_of_Four_Major_Emitters

Figure 12: Oil Production in 2012 (Million Barrels of Oil)

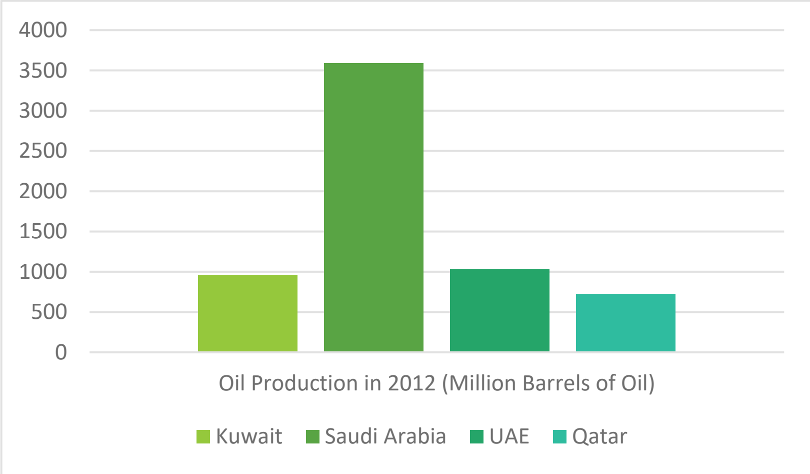


Table 6: STEEP comparison between Saudi Arabia, Kuwait, UAE and the world's average between 1990 & 2010.

	World	Saudi Arabia	Kuwait	UAE
S: Primary Energy Consumption per capita (QBtu/Capita)	1.53	6.1	9.5	15.8
T: % of Electricity Losses	9%	7%	11%	8%
E: Energy Intensity (Btu per Year (2005 U.S. Dollars)	8334	12047	9153	14.858
E: Emission Intensity (Metric tons of Carbon Dioxide per thousand USD)	80.8	138.5	113.3	
P: % of Renewable Electricity Generation	20%	0.0%	0.0%	0.0%

Source: Norhan Bayomi and John E. Fernandez, Towards Sustainable Energy Trends in the Middle, https://www.researchgate.net/publication/332729344_Towards_Sustainable_Energy_Trends_in_the_Middle_East_A_Study_of_Four_Major_Emitters

2. Annual growth rates of domestic electricity consumption in Arab countries:

The Arab countries now have one of the world's fastest annual growth rates of domestic electricity consumption. With a large share of power generated by oil-burning power plants, this acts as a drain on oil reserves, reducing export revenues and creating serious risks for the sustainability of the oil-export based model of development.

A second and related factor is that members of the Arab countries have some of the world's largest per capita carbon footprints. This occurs alongside the rapid rise in temperatures in the region, which is faster than the global average. Indeed, some parts of Arab countries may become uninhabitable in the second part of the twenty-first century as a result.

Last, and likewise related to climate change, a global shift is underway towards low-carbon solutions for combating climate change, with projections of global oil demand potentially peaking by 2030, creating fragility for countries overly reliant on oil exports.

3. Arab Future Energy Index (AFEX):

The Arab Future Energy Index (AFEX) is the first Arab index dedicated to tracking low carbon sustainable energy trends in the run-up to 2030 and has been issued on an annual basis since 2015 by UNDP and the Regional Center for Renewable Energy and Energy Efficiency, a specialized entity affiliated to the League of Arab States. Referred to by some as the region's "energy HDR," AFEX monitors and analyzes trends across the region in the run-up to 2030, and ranks countries annually using a set of 28 indicators in the areas of institutional capacity, policy frameworks, market structures, and innovative finance.

While the Arab countries have the world's highest levels of solar radiation, this has remained an untapped resource over the years, despite rising levels of energy insecurity and growing attention to climate change. But things are starting to change. As shown by AFEX, the past decade has seen a ten-fold increase in solar and wind power capacity in the Arab countries, and a doubling of capacities in the past two years alone. These are positive and unprecedented trends. However, further acceleration is needed if the region is to achieve its ambitious target of creating 190 gigawatts (GW) of renewable energy by 2030, from the 7 GW in place today.

(As countries in the Gulf chart their pathways to 2030, most seek a more diverse economy so that public revenues and development budgets are not as dependent on oil exports, while simultaneously putting in place new low-carbon solutions to address growing electricity needs. As the UNs largest provider of technical assistance for climate action, with over $3 billion of ongoing projects around the world today, the United Nations Development Programme (UNDP) has been expanding its support for partners in the Arab Gulf to generate a new low-carbon sustainable energy trajectory. Today, UNDP implements over $100 million of local projects in Gulf countries to advance a low-carbon, sustainable energy transition).[22]

The Arab region obtained its momentous place in the global energy system due to its hydrocarbon industry, which boomed during the 1960s. However, the abundance of low-cost energy resources has significantly driven growth in energy demand. Oil and natural gas supply the majority of the region's energy needs – a historical trend since the 1950s that has always been closely tied to the region's role as a global supplier of both oil and natural gas[23] – as the largest proven oil reserves in the Arab region, including oil deposits, are located in Saudi Arabia (18% of global reserves) followed by Iraq (10.6% of global reserves). This section presents an overview of the total available fossil fuel resources across the four countries and covers two fossil fuel resources: oil. and natural gas.

[22] Kishan Khody, Stephen Gitonga, Decarbonizing Development in the Middle East, December 3, 2018, https://www.arabstates.undp.org/content/rbas/en/home/ourperspective/ourperspectivearticles/2018/decarbonizing-development-in-the-middle-east.html

[23] World Bank. World Development Indicators; World Bank: Washington, DC, USA, 2016.

Table 7: Arab countries + Iran crude oil exports to major consumers 2012–2017 (1,000 b/d),

	2012	2013	2014	2015	2016	2017
Europe	3,148.3	2,985.3	2,626.1	2,773.7	3,245.6	3,682.1
North America	2,501.1	2,323.0	2,001.3	1,645.1	2,004.9	1,999.7
Asia & Pacific	12,676.7	12,103.7	11,534.8	11,931.9	13,232.7	12,909.1
Latin America	207.9	120.8	104.0	161.1	249.8	145.5
Africa	409.5	300.2	273.4	270.9	239.2	234.3
Middle East	290.1	282.2	277.8	293.2	274.2	204.0
Total	19,233.7	18,115.1	16,817.5	17,075.9	19,246.5	19,174.6

Note: Arab countries are considered the following:
Algeria, Iraq, Kuwait, Libya, Qatar, Saudi Arabia and UAE, + Iran.
Source: OME analysis based on OPEC (2018).

Table 8: Gas exporter regions (bcm) in 2016 2025 2040

Net exporting regions	2016	2025	2040
Arab countries+ Iran	150	183	248
Russia	188	265	314

Source: OME analysis based on IEA (2017b) New Policies Scenario.

4. Clean energy investment is on the rise in Arab countries:

The Arab countries are entering a critical phase on the road to 2030. If clean energy investments continue their upward momentum, the coming years could see the region transition to a low carbon sustainable energy future. UNDP stands ready to help its partners achieve this goal, with over $500 million of UNDP grant projects today across the region for helping countries take climate action, accelerate sustainable energy pathways, and promote more sustainable use of natural resources and the environment.

The Middle East is known as the world's oil capital, home to over 70% of the world's proven oil reserves. Its vast oil wealth and export revenues have been a critical factor in financing the achievement of development goals for many years. (From 1970-2010, the countries of the Arab Gulf saw one of the planet's fastest rates of progress according to the Human Development Index [HDI], with oil exports serving as the main driver behind this acceleration of results). However, as countries set their sights on achieving the 2030 targets related to the Sustainable Development Goals (SDGs) and the Paris Agreement on climate change, the position of carbon in the region's development strategies is shifting. This is driven by three main factors[24]

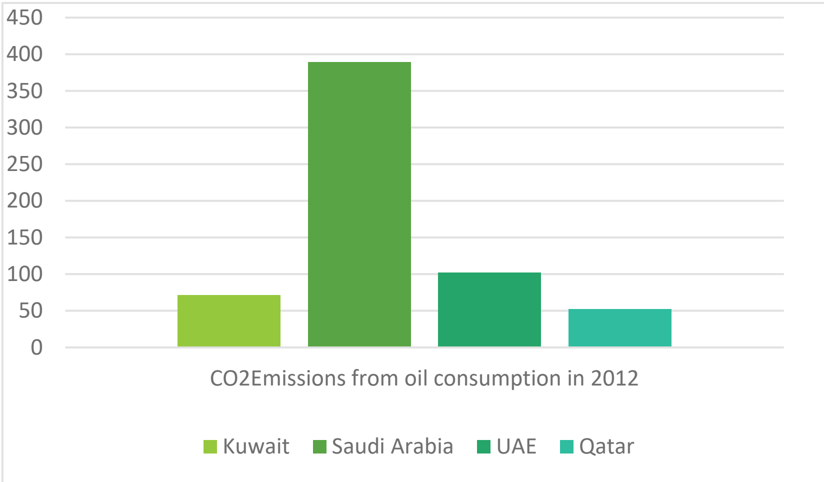
[24] Kishan Khody, Stephen Gitonga, Decarbonizing Development in the Middle East, December 3, 2018, https://www.arabstates.undp.org/content/rbas/en/home/ourperspective/ourperspectivearticles/2018/decarbonizing-development-in-the-middle-east.html

Table 9: CO2 Emissions from oil consumption in 2012 (Million Metric Tons)

	Kuwait	Saudi Arabia	UAE	Qatar
CO2 Emissions from oil consumption in 2012 (Million Metric Tons)	71	389	102	52

Source: Norhan Bayomi and John E. Fernandez, Towards Sustainable Energy Trends in the Middle, https://www.researchgate.net/publication/332729344_Towards_Sustainable_Energy_Trends_in_the_Middle_East_A_Study_of_Four_Major_Emitters

Figure 13: CO2 Emissions from oil consumption in 2012 (Million Metric Tons)



5. Alternative and renewable energy in the Arab countries:

In the field of alternative and renewable energy, the Arab countries have the potential to take greater advantage of their proven wind, solar and geothermal resource base in their power generation mixes. While there are several well-funded academic and research institutions in the region working on the development of technologies in these areas, there is a large scope for the acceleration of renewable energy penetration through the implementation of policy goals, formalized networks, and regional coordination. In addition to the potential for increased integration of established alternative energy technologies, the Arab countries have an opportunity to develop new renewable technology niches in applications suited to their climatic conditions, such as algal biofuels and dust-resistant solar photovoltaics.

This strategic approach to alternative energy development could provide an important source of diversification for the region's economies and a source of competitive advantage in a carbon-constrained global economy. In CCS, the Arab countries have both the means and the motivation to be a leader in the development of a technology that will play a major part in achieving global emissions-reduction targets. With huge projected increases in their power sector capacities – most of which, notwithstanding the progress made on alternative energy sources, are likely to be met with natural gas – the countries in the region have the opportunity to serve as a platform for global development of carbon capture technology.

With large amounts of available investment capital, economies optimized for energy-intensive industry, and a near-term economic incentive for the use of captured carbon, over the next twenty years the countries of the Arab countries are likely to experience some of the fastest economic and energy-consumption growth rates anywhere in the world. Already almost exclusively dependent on hydrocarbons for their energy supply, the Arab countries face increasing environmental and economic costs from continued heavy reliance on oil and gas in their power-generation and industrial sectors.

6. The interest of Arab countries in diversifying their economies:

Several of the Arab countries have asserted their interest in diversifying their economies away from a focus on the export of raw materials and energy-intensive industry to achieve sustainable long-term economic growth and security. The extent to which such diversification is likely to occur in the short-term should not be overestimated.

The principal source of foreign-exchange earnings for the Arab countries is through rent on oil and gas exports and the exploitation of comparative advantages in the low-cost energy-intensive industry. Any large-scale switch away from energy-intensive economic activity is likely to act, at least in the short-term, to the detriment of the Arab countries' competitiveness and terms of trade. However, there are opportunities for the Arab countries to achieve the parallel objectives of reducing carbon emissions, reducing domestic consumption of valuable oil and gas resources, and increasing economic diversity without major structural change to their economies and with significant potential net benefits in terms of both carbon reductions and economic performance.

These opportunities lie in the development and adoption of technologies and improved management systems in the areas of alternative energy, energy efficiency, and carbon capture and sequestration (CCS).

The macroeconomic consequences of these persistently low oil prices are far-reaching for the Arab region, both for oil-exporting and oil-importing countries. Variations in oil prices have an impact on oil and energy derived revenues and therefore on government budgets. Oil-related revenues accounted for over half of government income in Arab countries oil-exporting countries in 2015. [25]

Therefore, a sustained low oil price results in significant revenue losses for Arab oil-exporting countries. Indeed, low oil prices from 2013 to 2016 have considerably reduced government surpluses and widened deficits in the region, with fiscal balances in Arab oil-exporting states evolving from 128 billion US dollars surplus to a deficit of 264 billion US dollars. GCC countries alone saw their oil revenues decline by 157 billion US dollars in 2015. According to the IMF, the countries whose current accounts were most impacted in absolute terms in 2015 were Kuwait, Qatar, Iraq, Libya, Saudi Arabia, Oman and Bahrain, all of which experienced substantial oil revenue losses (20 per cent of GDP).

(From 2000 to 2013, MENA states' overall fiscal balances were positive at a surplus of 2.7 per cent of GDP. However, following the oil price drop in mid-2014, fiscal balances dropped to a level of –2.8 per cent of GDP in 2014, reaching a low of –9 per cent of GDP in 2016, and they are forecast to be around –4.1 per cent of GDP by the end of 2018).[26]

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[25] According to the World Bank's 2015 MENA Quarterly Economic Brief (Devarajan and Mottaghi 2015: 1).

[26] - https://www.iai.it/sites/default/files/menara_wp_21.pdf

7. Meet growing energy demand and reduce carbon emissions:

Instead, Arab countries' energy planners have an opportunity to focus on making a greater investment into the development of domestic and regional research networks, the creation of standards and goals, and increased collaboration with the private sector in relation to the transfer of best practice, and the commercialization of technologies likely to be a source of competitive advantage.

At the regional level, Arab countries will encounter many of the most pressing challenges facing the global economy in the twenty-first century: a self-interested need to reduce carbon emissions while meeting increased energy demand, and a desire to develop new technologies that will provide a source of long-term economic growth. Through the adoption of policies that encourage the role of alternative energy, energy efficiency, and carbon capture and sequestration, the Arab countries can meet their own environmental and economic objectives and remain at the centre of the energy economy for decades to come. The Arab countries have a unique opportunity to invest in "first-mover" research and development to accelerate the commercialization of CCS.

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References:

Kishan Khoday, Decarbonizing Development in the Middle East, Posted on December 3, 2018.

Wael Hmaidan, Oil in a Low-carbon Economy,

World Bank. World Development Indicators; World Bank: Washington, DC, USA, 2016.

British Petroleum. BP Statistical Review of World Energy; British Petroleum: London, UK, 2015.

Nejat, P.; Morsoni, A.K.; Jomehzadeh, F.; Behzad, H.; Saeed Vesali, M.; Majid, M.Z.A. Iran's Achievements in Renewable Energy During Fourth Development Program in Comparison with Global Trend. Renew. Sustain. Energy Rev. 2013,22, 561–570.

Ramadhan, M.; Hussain, A. Kuwait Energy Profile for Electrical Power Generation. Strategy. Plan Energy Environ. 2012,32, 18–25.

Mezghani, I.; Ben Haddad, H. Energy Consumption and Economic Growth: An Empirical Study of the Electricity Consumption in Saudi Arabia. Renew. Sustain. Energy Rev. 2016, 1–12.

Sgouridis, S.; Abdullah, A.; Griffiths, S.; Saygin, D.; Wagner, N.; Gielen, D. E-Mapping the UAE's Energy Transition: An Economy-Wide Assessment Of Renewable Energy Options and Their Policy Implications. Renew. Sustain. Energy Rev. 2016,55, 1166–1180.

According to the World Bank's 2015 MENA Quarterly Economic Brief (Devarajan and Mottaghi 2015: 1),

https://www.iai.it/sites/default/files/menara_wp_21.pdf

Transition to "Greener Growth" in Central Asia

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Abstract

Central Asia – being a vast land-locked region that is extremely rich in natural resources – has experienced dynamic growth over the past decades since its five countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan) gained their independence after the disintegration of the Soviet Union. The region – especially Kazakhstan, the largest country in Central Asia – was able to benefit from the transition to the market economy and take advantage of the then relatively high prices of hydrocarbons and metals on the world market. However, the Central Asian countries are facing multiple challenges due to climate change and its consequences that are associated with the volatility of commodity prices, coupled with the issues of connectivity, infrastructure, and underinvestment, and finally burdened by a lack of sufficient regional cooperation.

The paper aims to reveal the challenge of the transition to "greener growth" in Central Asia. The introduction presents the concept of green growth and provides its definition. The first section sheds light on the reasons why Central Asia needs greener growth. The second section presents the commitments of the five countries of the region to green growth both on the international and the national level. The third section examines if growth in Central Asia is heading in the direction of a low-carbon economy and sustainability. The conclusions summarize the findings and reveal future research opportunities. The paper concludes that Central Asia has taken the first important steps towards greener growth, but this is just the beginning of a long journey, especially for the fossil-fuel-rich countries thereof. However, there is no real long-term alternative even for the former to green their growth and ensure sustainable development. The sooner, the better.

Keywords: green growth, low carbon economy, development, transition, Central Asia

Introduction

The concept of green growth was born in Asia and the Pacific in the middle of the first decade of the new millennium. It attracted wide attention after the 2008 financial crisis as a possible way out and a new form of stimulus, and by now it has become the only justifiable and acceptable growth model that seeks to *harmonize economic growth with environmental sustainability*.

Green growth is defined in several ways that have been reviewed and their drivers and barriers synthetized in the literature in great detail (Capasso et al., 2019). This paper provides definitions from four major international institutions, which are those most widely referred to. One of them focuses on the balance between economic growth and the environment, while the others also incorporate social elements.

According to the Organization for Economic Co-operation and Development (OECD), green growth means *"fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies"* (OECD, 2019, p. 4). Green growth – the World Bank says – is *"growth that is efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of environmental management and natural capital in preventing physical disasters. And this growth needs to be inclusive"* (The World Bank, 2012, p. 20). The United Nation's Economic and Social Commission for Asia and the Pacific (UNESCAP) defines green growth as *"growth that emphasizes environmentally sustainable economic progress to foster low-carbon, socially inclusive development"* (UNESCAP, 2013, p. 7). As for the Global Green Growth Institute (GGGI), *"green growth is a multidimensional concept with the aim to deliver economic growth that is both environmentally sustainable and socially inclusive"* (GGGI, n.d.).

Although a holistic approach that sees the economy, environment, and society as an interdependent unity would give a fuller picture, this paper is concerned with the aspects of economic growth and the environment. Extending the analysis to social aspects is a future research option.

The purpose of this paper is to present Central Asia's move towards greener growth. Central Asia means the five countries of the region: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan.

Methods used for the research are literature review, document analyses based on original and secondary sources accessible through the web, and statistical analysis using the open-access data sources of major international organizations.

The paper is structured into three parts around three topics. The first part investigates why Central Asia needs greener growth. The second part sheds light on the efforts of the five countries of the region to create a greener future. The third part analyses how "green" the growth in the Central Asian countries has been since their independence until now. The paper ends with conclusions and reveals further potential avenues of research.

1. Why does Central Asia need Greener Growth?

Central Asia is a vast land-locked area, a transit route between East and West. It covers 4 million km^2 and has 70 million inhabitants of different nationalities in the five countries established after the collapse of the Soviet Union. The region is rich in natural resources such as hydrocarbons and minerals like uranium and gold. Water is a key resource due to the geographical location. Central Asia is being especially badly hit by global warming, which has greatly accelerated during the past couple of years. It has already had serious effects on nature, water resources, and arable land.

The economic growth model in Central Asia was traditionally energy and material intensive, low value-added, demand-reliant, and without major technological development. It has resulted in an increase in the greenhouse gas (GHG) emissions of the region that contribute to climate change (OECD, 2019).

Table 1 presents the GHG emissions of Central Asia from 1990 to 2016.

GHG emissions							
	million t CO2e		Change from 1990 to 2016 (%)	Share of total global emissions (%)		Share of the given country in CA (%)	
Country	**1990**	**2016**		**1990**	**2016**	**1990**	**2016**
Kazakhstan	308.63	299.92	-3	1.00	0.65	48.61	44.94
Kyrgyzstan	32.68	16.83	-49	0.11	0.04	5.15	2.52
Tajikistan	17.67	13.32	-25	0.06	0.03	2.78	2.00
Turkmenistan	80.17	126.17	57	0.26	0.27	12.63	18.91
Uzbekistan	195.77	211.09	8	0.64	0.46	30.83	31.63
Total CA	***634.92***	***667.33***	***5***	***2.06***	***1.45***	100.00	100.00
World	30770	46140	50	100	100		

Source: Our World in Data https://ourworldindata.org/grapher/total-ghg-emissions-excluding-lufc?tab=table&time=earliest..latest

The data above show that Central Asia is a relatively small GHG-emitting region on a global basis. Emissions from the five countries altogether amount to around 700 million tons per year, representing 1.5 percent of global emission. Half of the emissions of the region come from Kazakhstan, and one-third from Uzbekistan. Turkmenistan accounts for 20 percent of the latter, while Kyrgyzstan and Tajikistan for only 2.5 and 2.0 percent, respectively.

From 1990 to 2016 emissions from Central Asia increased by 5 percent. During the first half of the 1990s, emissions declined in line with the sharp drop in GDP. From the mid-1990s onwards, when the economic recovery of the region started with steady, dynamic GDP growth in all countries, emission patterns changed. They increased in parallel with GDP growth in Kazakhstan and Turkmenistan, remained nearly constant in Kyrgyzstan and Uzbekistan, and somewhat declined in Tajikistan. In 2020, emissions dropped due to the recession caused by COVID, but are likely to increase again when the recovery starts.

In Central Asia, 80 percent of emissions come from the energy sector. Agriculture is responsible for half of the rest, industry is the next largest source of emissions, followed by the waste sector.

Emissions per capita are highest in Kazakhstan at 21.8 thousand tons, followed by Turkmenistan at 17.5 thousand tons, both significantly exceeding the world average. Uzbekistan emits 5.9 thousand tons per capita, close to the world average. The emissions per capita of the mountainous Kyrgyzstan and Tajikistan are relatively small, amounting to 1.9 and 2.5 thousand tons respectively, which is far below the world average (OECD, 2019).

Regarding CO2 emissions in the region, Kazakhstan takes the lead. In 2018, Kazakhstan was twenty-first on the global list by quantity, and second according to per capita emissions (UCSUSA, 2020).

To manage environmental challenges related to emissions, and cope with the challenge of climate change, Central Asian countries need to "green" their growth to ensure long-term sustainability while catching up with the developed world.

2. Efforts for a Greener Future

All Central Asian countries are committed to greener growth both on the international and on the national level.

Regarding the main international "green" initiatives, countries of Central Asia have all signed the Kyoto Protocol, the Paris Declaration, the UN Sustainable Development Goals (SDGs), the OECD Green Growth Declaration, and have defined objectives for reducing GHG emissions in their Nationally Determined Contributions (NDC). From this perspective, there is no significant difference between the countries of Central Asia.

On the national level, each country of the region has in force a longer-term strategy with various green elements and a dedicated green growth strategy.

Table 2 lists the main strategic documents related to "greening" growth in the five countries of Central Asia.

Strategic Planning Documents in force related to Green Growth in Central Asia	
Country	**Strategic Document in force**
Kazakhstan	Kazakhstan-2050
	Concept on Transition towards Green Economy 2013-2020
	Strategic Plan for Development until 2025
Kyrgyzstan	National Development Strategy 2040
	Development Programme 2018-2022: "Unity, Trust, Creation"
	Green Economy Concept
Tajikistan	Sustainable Development Transition Concept (2007-2030)
	National Development Strategy for the period to 2030
	National strategy of adaptation to climate change for the period till 2030
Turkmenistan	National Socio-economic Development Programme for 2011-2030
	A shorter-term document for 2019-2025 as a supplement to the strategy
	National Climate Change Strategy
Uzbekistan	Action Strategy on Five Priority Directions for the Development 2017-2021
	Government Program for each year
	The Strategy for the Transition to a Green Economy

Source: OECD https://www.oecd-ilibrary.org/sites/d1aa6ae9-en/1/2/4/index.html?itemId=/content/publication/d1aa6ae9-en&_csp_=7ff3031e5342fd61a300145da6a7d7a7&itemIGO=oecd&itemContentType=book

Besides the common characteristics mentioned above, the "greening" efforts defined in strategic documents are quite different in the five countries.

In *Kazakhstan,* the main long-term development strategy "*Kazakhstan-2050*" (Kazakhstan2050 Strategy, n.d.) was adopted in 2012. It has ambitious objectives in relation to promoting greener development on various time horizons, such as being ranked among the first 30 most developed nations by 2050, creating a favourable investment climate for boosting economic development, increasing its share of alternative and renewable energy sources in total energy consumption, and solving problems associated with water supply and irrigation water. Based on this strategy, the "*Concept on Transition to Green Economy*" document (GoK, 2013) was adopted in 2013, which aims to raise the efficiency of the use of resources, to modernize and develop infrastructure, increase the well-being of the population and the quality of the environment, and increase water security. The elements of the Concept were later integrated into the "*Strategic Plan for Development until 2025*" (policy.thinkbluedata, n.d.), which was adopted in 2018 and defines objectives related to commitments under the Paris Declaration, decarbonization, the protection of water resources, green finance, investment and technology, the development of alternative energy sources, waste management, and the conservation of biodiversity. Due to the dramatically changing situation worldwide and in Kazakhstan caused by COVID, these ambitious objectives were reconsidered in 2020 and adjusted to the new realities (NewEurope, 2020).

In *Kyrgyzstan* the "*National Development Strategy 2040*" (GoK, 2018a), which was adopted in 2018 sets out the main development objectives. This document, together with the "*Development Programme of the Kyrgyz Republic for the period 2018-2022: 'Unity, Trust, Creation*'" (GoK, 2018b), include the formation of a sustainable environment for development; however, they latter documents are not closely linked and do not include budgets dedicated to reaching the objectives or creating accountable institutions for implementation. The "*Green Economy Concept: 'Kyrgyzstan – Country of Green Economy*'" document, which was also adopted in 2018, targets explicitly a transition to a "green economy". It is "aimed at improving the well-being of citizens and strengthening social justice while significantly reducing risks to the environment, preserving the country's natural ecosystems and increasing natural capital" (OSCE, 2019). These objectives do support greener growth but are very broad and hard to execute without a timeframe, budget, and the definition of implementing institutions.

Tajikistan has two main long-term development documents. The "*Sustainable Development Transition Concept 2007-2022*" (UNESCAP, n.d.) describes effective governance, energy and social security, and the promotion of environmentally sustainable production as the main objectives. The "*National Development Strategy for the period to 2030*" (GoT, 2016), adopted in 2016, targets industrial development through – amongst other means – promoting the rational use of land, water, and energy resources. Environmental aspects and concerns, however, are not effectively handled during implementation due to the related institutional structure and poor coordination. As Tajikistan is especially vulnerable to climate risks, a "*National strategy of adaptation to climate change for the period till 2030*" (CIS Legislation, n.d.) was also approved in 2019 and serves as a base for climate-related measures.

In *Turkmenistan,* the "*National Socio-economic Development Programme for 2011-2030*" – supplemented with *a shorter-term document for 2019-2025* (Big Asia, 2019) – provides a vision of the diversification of the economy away from reliance on natural gas. The "*National Climate*

Change Strategy" (UNDRR, n.d.), published in 2012, identifies and assesses climate change risks to development and describes a vision in which renewable energy plays a role in the country's energy supply, and high-tech sectors reduce dependence on fossil fuels. Though these documents envisage greener growth, the steps and the measurements for achieving the goals, and the designation of institutions accountable for the implementation, are missing.

In *Uzbekistan,* the "*Action Strategy on Five Priority Directions for the Development of the Republic of Uzbekistan 2017-2021*" (GoU, 2017) – in line with which the government publishes a "*Government Programme*" each year – sets goals for five priority areas: governance, rule of law, economic liberalisation and development, social reforms (including infrastructure development), and security. One of the goals in the field of economic liberalization and development is to ensure the efficient use of natural, mineral, raw and industrial resources, which signals the government's intention to "green" the economy. "*The Strategy for the Transition to a Green Economy*" (IEA, 2020), adopted in 2019, aims to ensure stable economic progress with minimal GHG emissions, increase the effectiveness of energy production and use by using modern technology, ensure the rational use of natural resources, and introduce environmentally friendly criteria as components of the process of evaluating investments.

The actionability of the national strategies, however, depends on the objectives, the budgets, and the institutions accountable for the implementation, and in these areas further improvements seem to be essential.

Table 3 details some major issues with the regulatory framework and implementation where further efforts are needed for improvement based on the OECD reviews (OECD 2019b).

Issues of Regulatory Framework & Implementation of Green Growth Strategies in Central Asia	
Regulatory Framework	**Implementation**
Long-term	**Institutions**
•Lack of longer-term economy-wide vision	•No environment ministry
•Lack of a long-term strategy	•Lack of authority of Committee on Environmental Protection
•Plans are insufficiently aligned with long-term vision related to diversifying the economy away from fossil fuels & extractive industry	•Lack of authority and resources of Temporary inter-sectoral State Commissions related to environmental issues and climate change
Hierarchy	**Priorities**
•Lack of defined hierarchy of documents	•Institutional setup risks that environmental issues will not be ranked highly on government agenda
•Different time-horizons, topics of documents	•Environmental concerns are not channeled into decision-making process
Actionability	•Poor integration of environmental concerns into sectoral documents
•Difficult to identify government's key objectives	**Capacity**
•Lack of concrete definition of intermediate steps	•Weak implementation capacity
•Does not specify goals & responsibilities	•Poor/suboptimal coordination between ministries/institutions
Assessment	•Unclear legislation about strategic planning
•Lack of legislation regarding environmental assessments	**Evaluation**
•Lack of Environmental Impact Assessments, or these are carried out without public participation & consultation	•Lack of evaluation of investment projects against environmental goals
	•No proper indices for benchmarking development

Source: OECD https://www.oecd-ilibrary.org/sites/d1aa6ae9-en/1/2/4/index.html?itemId=/content/publication/d1aa6ae9-en&_csp_=7ff3031e5342fd61a300145da6a7d7a7&item1GO=oecd&itemContentType=book

3. How Green is Growth in Central Asia?

To measure how green growth in Central Asia is, selected data from the OECD's Green Growth Indicators (GGI) and the Sustainable Development Index (SDI) will be used.

OECD's Green Growth Indicators (GGI) capture the main features of green growth in line with four focal areas, including (1) environmental and resource productivity, (2) the natural asset base, (3) environmental dimension of quality of life, and (4) economic opportunities and policy responses, and provide a set of defined indicators within different metrics (OECD, n.d.).

Table 4 presents some selected GGIs in the five countries of Central Asia in 1990 and 2017.

Selected OECD Green Growth Indicators for Central Asia (1990-2017)														
	Resource productivity				Natural asset base			Environmental dimension of quality of life				Economic opportunities	
Country	Production-based CO_2 productivity (USD/kg CO_2)		Production-based CO_2 intensity (t/capita)		Annual surface temerature, change since 1951-1980 (estimate)			Population exposed to pollution levels above WHO guidelines (%)		Population exposed to PM (microgr/m3)		Share of environmental patents (% of all patents)	No of environmental patents (thousand)
	1990	2017	1990	2017	1995	2017	2019	1990	2017	1990	2017	2014-2016 average	2014-2016 average
Kazakhstan	0.97	1.83	14	14	2.04	1.78	1.47	99	92	17	14	16.81	6.05
Kyrgyzstan	0.96	3.39	5	1	0.45	1.5	1.68	100	98	28	23	46.39	0.56
Tajikistan	1.98	5.00	2	1	0.24	1.32	1.38	100	100	56	47	0	0
Turkmenistan	0.63	1.25	12	12	1.44	1.76	1.89	100	100	27	23	66.67	0.67
Uzbekistan	0.64	2.71	6	3	1.38	1.78	1.93	100	100	38	31	10.49	0.83
OECD	*2.81*	*4.82*	*10*	*9*				*77.6*	*58.67*	*16*	*12*	*10.25*	*29400.66*

Source: ECD, https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH

The above statistics allow judgement of whether growth in the countries of Central Asia had become greener by the end of the 2020s compared to the dawn of their independence in 1990, using some selected indicators concerning the four focal areas of the GGI. Criteria for the selection of the indicators were the availability and comparability of data, and their relative importance for the analysis.

Resource productivity has improved but is still far behind that of the OECD average.

- GDP per unit of energy-related CO_2 emissions (*CO_2 productivity*) increased 2-4 times from 1990 to 2017 and reached nearly 60 percent of the OECD average by 2017 from below 40 percent in 1990.
- Energy-related CO_2 emissions per capita (*CO_2 intensity*) considerably fell in Kyrgyzstan, Tajikistan, and Uzbekistan between 1990 and 2017, and dropped from 20-60 percent to 10-30 percent of the OECD average. However, in the two energy-rich countries – Kazakhstan and Turkmenistan – emissions per capita remained constant during the same

period and exceeded the declining OECD average by 33-55 percent in 2017 against 20-40 percent in 1990.

Natural asset base hit by global warming.

- Between 1995 and 2019, the *estimated annual surface temperature change* since 1951-1980 increased in all countries of the region, except for in Kazakhstan, where it fluctuated.

Quality of life is badly affected by the heavy air pollution.

- In 1990, the total population of the region was exposed to *pollution levels* above WHO guidelines (more than 10 μg/m3). By 2017, the exposure of the population was still 92 percent in Kazakhstan, 98 percent in Kyrgyzstan, and 100 percent in Tajikistan, Turkmenistan, and Uzbekistan, while the OECD average was 77.6 percent.
- The *concentration level* to which a typical resident was exposed throughout a typical year declined in each country of the region from 17-56 to 14-47 μg/m3 between 1990 and 2017, while still much above the OECD average of 15.97 in 1990 and 12.50 in 2017.

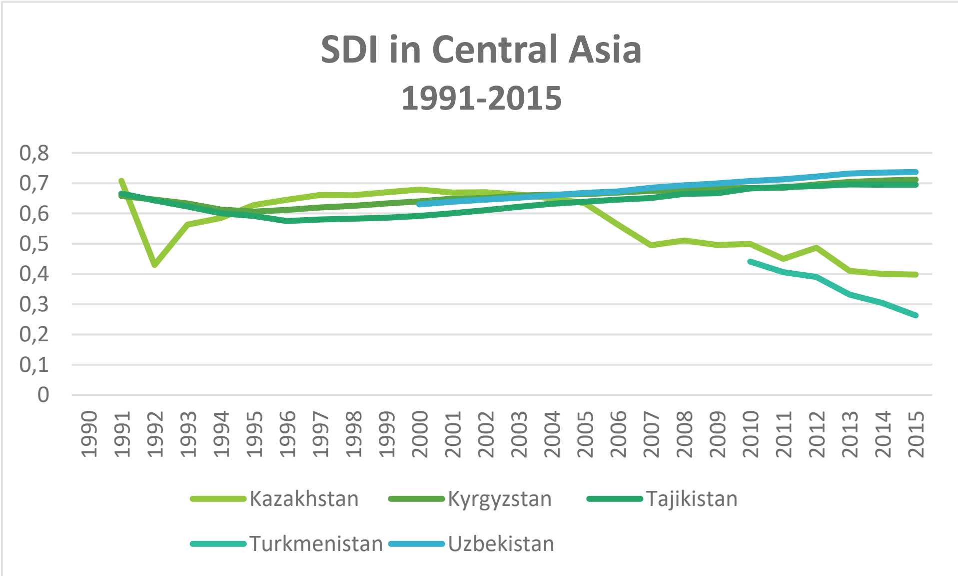
Economic opportunities are still not fully and unevenly utilized in terms of green technologies and innovation.

- *The development of environment-related technologies* in all technologies is still minimal, except for occasional innovation projects. The share of green innovations of Central Asia on a global basis is still close to zero. The number of environmental patents is also very low, but because the number of all patents is low to, the former share is relatively large. Calculated by the 2014-2016 averages, the region had 8.11 thousand environmental patents altogether – compared to 8.62 thousand owned by Egypt alone. Kazakhstan had three-quarters of these patents, while the other four countries shared the remainder. Although Turkmenistan and Kyrgyzstan have only around 600 environmental patents each, this represents one-third and one-half of all their patents, respectively, which ranks them as third and ninth on the global list of countries according to this indicator.
- In terms of policy responses, *environmental taxes* are collected in Kazakhstan only. They represent 1.61 percent of GDP (similar to the OECD average). These taxes, however, account for close to 10 percent of all tax revenues, which is double that of the OECD average.

The analysis carried out using OECD's GGI for Central Asia shows mixed results. On the one hand, development in the five countries in Central Asia has become greener compared to the early years of their independence. However, in the four areas of green growth, they are still below the OECD average, and in terms of some important indicators they have not caught up or have even moved further away from parity.

To test and validate the above results regarding green growth in Central Asia using other metrics, the *Sustainable Development Index (SDI)* created by anthropologist and author Dr Jason Hickel (Hickel, 2020) is used. This expresses the sustainability of the development of a country in an aggregate form. It modifies the widely used but recently often criticized Human Development Index (HDI) designed by Pakistani economist Mahbub ul Haq, which has been used by the United Nations Development Programme (UNDP) for its annual reports since 1990. While the HDI combines economic and social factors of development, but ignores the environmental harm they cause, the SDI adds ecological impact to them. It aggregates components of life expectancy, schooling, GNI per capita, CO_2 emissions, and material footprint per capita. The index ranges between 0 and 1, where "0" means not sustainable at all, and "1" means fully sustainable with regard to the combination of all three aspects of development.

Chart 1 Sustainable Development Index (SDI) for Central Asia (1991-2015).



Source: SDI https://www.sustainabledevelopmentindex.org/

Chart 1 suggests that in terms of sustainable development there are clearly *two groups of countries* in Central Asia. The first group consists of Uzbekistan, Kyrgyzstan, and Tajikistan, where SDI was relatively high and even slightly improved between 1990 and 2015. These countries were ranked thirty-second, forty-fourth, and fifty-third on the global list of 163 countries in 2015, suggesting that their development is sustainable in terms of economic, social, and ecological aspects. Kazakhstan and Turkmenistan belong to the second group. In Kazakhstan, SDI started to decline from 2005 and fell far below the 1991 level. In Turkmenistan SDI was the lowest and fell even more sharply between 2010 (when data were first reported) and 2015. On the global list, Kazakhstan is in 133rd and Turkmenistan in 150th place, indicating that their development is not sustainable.

Tables 5a and 5b present the SDI scores with their components in the five countries of Central Asia in 1991 and in 2015.

Sustainable Development Index (SDI) and its Components for Central Asia 1991							
5a							
Country	**SDI**	**Life expectancy (years)**	**Expected years of schooling**	**Mean years of schooling**	**Income (GNI per capita constant 2011 USD PPP)**	**CO_2 emissions per capita (tonnes)**	**Material footprint per capita (tonnes)**
Kazakhstan	0.708	66.3	12.3	8.3	12230	7.38	4.85
Kyrgyzstan	0.658	66.3	11.8	8.7	3096	1.53	9.22
Tajikistan	0.666	62.9	12	9.8	3662	0.66	1.45
Turkmenistan	*0.441*	62.8	*10.2*	*9.9*	7770	4.07	4.63
Uzbekistan	*0.63*	66.4	11.1	*9.1*	2972	7.38	3.21

Note: data for Turkmenistan in italics relate to 2010; data for Uzbekistan in italics relate to 2000

Source: SDI https://www.sustainabledevelopmentindex.org/

Sustainable Development Index (SDI) and its Components for Central Asia 2015								
5b								
Rank	**Country**	**SDI**	**Life expectancy (years)**	**Expected years of schooling**	**Mean years of schooling**	**Income (GNI per capita constant 2011 USD PPP)**	**CO_2 emissions per capita (tonnes)**	**Material footprint per capita (tonnes)**
133	Kazakhstan	0.398	69.7	15	11.7	23164	11.34	17.87
44	Kyrgyzstan	0.712	70.8	13.3	10.8	3086	1.71	8.49
53	Tajikistan	0.695	70.9	11.2	10.5	3074	0.87	3.52
150	Turkmenistan	0.263	67.7	10.8	9.8	14293	13.56	20.68
32	Uzbekistan	0.737	71.2	11.7	11.4	5811	3.05	5.86

Source: SDI https://www.sustainabledevelopmentindex.org/

Analysis of the components of the SDI and their combination in Tables 5a and 5b helps to explain the level of sustainability in the five countries in Central Asia and the reasons behind it.

- *Life expectancy* was between 62.8 and 66.4 years in Central Asia in 1991. It had increased in all countries to between 67.7 and 71.2 years by 2015.
- *Expected years at school* ranged between 10.2 and 12.3 years in 1991 and increased in all countries to between 10.8 and 15 years by 2015.
- There were greater differences among the countries in terms of *GNI per capita*. This amounted to between USD 2972 and 12230 (at constant 2011 PPP) in 1991 and increased to between USD 3074 and 23164 by 2015. Income per capita is highest in Kazakhstan, followed by Turkmenistan and Uzbekistan. While Uzbekistan doubled per capita income from 1991 to 2015, Kazakhstan and Turkmenistan nearly doubled it, then in Kyrgyzstan and Tajikistan income per capita dropped during the same period.

- *CO_2 emissions per capita* were between 0.66 and 7.38 tonnes in 1991, which grew to between 0.87 and 13.56 tonnes by 2015. Uzbekistan is the only country that succeeded in reducing emissions per capita to less than half by 2015. However, emissions per capita in Turkmenistan increased threefold and in Kazakhstan increased by one-and-a-half times.
- *Material footprint per capita* ranged between 1.45 and 9.22 tonnes in 1991, while it increased to 3.52 and 20.68 tonnes by 2015. It increased in all countries except for Kyrgyzstan and by 2015 it was nearly five times more than in 1991 in Turkmenistan and nearly four times more in Kazakhstan.

These data show that while the economic and social components of the SDI improved in Central Asia from 1991 to 2015 – although not to the same extent in the five countries –, the ecological impact greatly worsened during this period across the entire region. The improvement in life expectancy, schooling, and income per capita was accompanied by an increase in CO_2 emissions per capita – except for in Uzbekistan –, and a strongly growing material footprint per capita – with no exceptions – in Central Asia. The sustainability of development is associated with the greatest risk in the two energy-rich countries – Kazakhstan and Turkmenistan – where economic and social development has occurred to the detriment of the environment.

A comparison of the results of the OECD's GGI and the SDI proves that growth in Central Asia became greener by the middle of the 2010s than at the beginning of the independence of the five countries of the region in the early 1990s, but it is still not low-carbon and environment-friendly, especially in the fossil-fuel-rich countries.

4. Summary and Conclusions

The challenge of climate change and the unsustainability of the growth model followed by the countries of Central Asia calls for a transition to green growth in the region. Green growth would ensure a balance between economic growth and the preservation of natural assets. The five countries of the region are all committed to this concept. They have joined up to the main international initiatives and elaborated national development and green growth strategies for the transition. However, they must make further efforts to manage regulatory and implementation issues to make their strategies actionable. By the late 2010s, growth in Central Asia became greener than it was in the 1990s, when the countries of Central Asia gained their independence but yet not really green. The availability of natural resources in the region seems to be a barrier to "greening", especially in the fossil-fuel rich countries. It is evident, however, that there is no alternative to green growth in the long term. The pathways for achieving this may differ from country to country – but the overall goal cannot.

To further explore issues related transition to green growth in Central Asia, two different paths can be followed. First, the current focus on the balance between growth and environment should be maintained, and how the green growth transition may be financed should be addressed. Second, the focus may be enlarged by incorporating social aspects and analysing inclusion and social justice in the five countries as well. The decision to do this will depend on time and research capacity.

5. Bibliography

Big Asia (2019) *Türkmenisztán 2025-ig tartó fejlesztési programja jóváhagyva.* https://bigasia.ru/content/news/businness/utverzhdena-programma-razvitiya-turkmenistana-do-2025-goda/?utm_source=yxnews&utm_medium=desktop (accessed on 17.09.2020)

Capasso, M., Hansen, T., Jonas Heiberg, J., Klitkou, A., Steen, M. (2019) *Technological Forecasting and Social Change*. Volume 146, September 2019, pp. 390-402, https://doi.org/10.1016/j.techfore.2019.06.013, https://www.sciencedirect.com/science/article/pii/S0040162518311028 (accessed on 25.09.2020)

CIS Legislation (n.d.) *Order of the Government of the Republic of Tajikistan of October 2, 2019 No. 482, About the National strategy of adaptation to climate change of the Republic of Tajikistan for the period till 2030*. https://cis-legislation.com/document.fwx?rgn=119703 (accessed on 13.11.2020)

GGGI (n.d.) *Global Programs, Tools and Indicators* https://gggi.org/global-program/tools-and-indicators (accessed on 10.09.2020)

GoK (2013) *Concept for transition of the Republic of Kazakhstan to Green Economy*. p. 51, https://policy.asiapacificenergy.org/sites/default/files/Concept%20on%20Transition%20towards%20Green%20Economy%20until%202050%20%28EN%29.pdf (accessed on 15.09.2020)

GoKR (2018a) *National Development Strategy of the Kyrgyz Republic for 2018-2040*. p. 131, https://policy.thinkbluedata.com/sites/default/files/National%20Development%20Strategy%20of%20the%20Kyrgyz%20Republic%20for%202018-2040%20%28EN%29.pdf (accessed on 16.09.2020)

GoKR (2018b) *Development Programme of the Kyrgyz Republic for the period 2018-2022: 'Unity, Trust, Creation*. p. 58, https://www.un-page.org/files/public/the_development_program_of_the_kyrgyz_republic_for_the_period_2018-2022.pdf (accessed on 16.09.2020)

GoT (2016) *National Development Strategy of the Republic of Tajikistan for the period up to 2030*. p. 93, http://medt.tj/en/strategy-and-programes/nds2030. (accessed on 13.09.2020)

GoU (2017) *The state program for implementation of the national action strategy on five priority development areas 2017-2021*. https://strategy.uz/files/news/45467/eng.pdf (accessed on 14.11.2020)

Hickel, J. (2020) *The Sustainable Development Index: Measuring the Ecological Efficiency of Human Development in the Anthropocene*. Ecological Economics vol 167 106331 [PDF]. Data management, data visualization and program coding is by Huzaifa Zoomkawala, p. 10, https://static1.squarespace.com/static/5c77afeb7fdcb89805fab2a0/t/5de248f378ecef6237c3f5e7/1575110909448/Hickel+-+The+Sustainable+Development+Index.pdf (accessed on 05.07.2020)

IEA (2020) *Strategy for the Transition to a Green Economy for the 2019-2030 Period - Resolution of the President of the Republic of Uzbekistan No. PP-4477*. https://www.iea.org/policies/11979-strategy-for-the-transition-to-a-green-economy-for-the-2019-2030-period-resolution-of-the-president-of-the-republic-of-uzbekistan-no-pp-4477 (accessed on 14.11.2020)

Kazakhstan2050 Strategy (n.d.) *A New Course for the Republic*. https://kazakhstan2050.com/ (accessed on 15.09.2020)

NewEurope (2020) *Kazakhstan to review 2025 economic development plan due to crisis*. https://www.neweurope.eu/article/kazakhstan-to-review-2025-economic-development-plan-due-to-crisis/ (accessed on 15.09.2020)

OECD (2019) *Work on Green Growth 2019-20* p. 68, https://issuu.com/oecd.publishing/docs/gg_brochure_2019_web (accessed on 01.12.2020)

OECD (2015) *Towards Green Growth? Tracking Progress.* OECD Green Growth Studies, https://issuu.com/oecd.publishing/docs/brochure_-_final__en_issuu (accessed on 20.08.2020)

OECD (2011) *Towards Green Growth A summary for policy makers.* https://www.oecd.org/greengrowth/48012345.pdf (accessed on 20.08.2020)

OECD (2019b) *Sustainable Infrastructure for Low-Carbon Development in Central Asia and The Caucasus, Hotspot Analysis and Needs Assessment*. https://www.oecd-ilibrary.org/sites/d1aa6ae9-en/1/2/4/index.html?itemId=/content/publication/d1aa6ae9-en&_csp_=7ff3031e5342fd61a300145da6a7d7a7&itemIGO=oecd&itemContentType=book (accessed on 15.09.2020)

OECD (n.d.) *Green Growth Indicators*. https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH (accessed on 10.10.2020)

OSCE (2019) *Prospects to stimulate green economy through private sector discussed in Kyrgyzstan*. https://www.osce.org/programme-office-in-bishkek/439268 (accessed: 16.09.2020)

Our World in Data (n.d.-a) *Global CO2 emissions* https://ourworldindata.org/co2-emissions (accessed on 20.10.2020)

Our World in Data (n.d.-b) *Total GHG emissions* https://ourworldindata.org/grapher/total-ghg-emissions-excluding-lufc?tab=table&time=earliest..latest (accessed on 20.10.2020)

policy.thinkbluedata (n.d.) *Kazakhstan: Strategic Development Plan of the Republic of Kazakhstan until 2025*. https://policy.thinkbluedata.com/node/4025 (accessed on 15.09.2020)

Sustainable Development Index (SDI) (n.d.) *SDI*. https://www.sustainabledevelopmentindex.org/ (accessed on 03.09.2020)

UNDRR (n.d.) *Turkmenistan: National climate change strategy* https://www.preventionweb.net/english/professional/policies/v.php?id=58413 (accessed on 17.09.2020)

UNESCAP (2013) *Green growth indicators: A practical approach for Asia and the Pacific.* Greening of Economic Growth Series 4, ST/ESCAP/2674, p. 25, https://www.unescap.org/sites/default/files/publications/GGI_2014.pdf (accessed on 01.12.2020)

UNESCAP (n.d.) Asia Pacific Energy Portal: *Tajikistan: Concept of Transition of the Republic of Tajikistan to Sustainable Development*. p. 117, https://policy.asiapacificenergy.org/node/3890, (accessed on 13.09.2020)

UCSUSA (2020) *Each Country's Share of CO2 Emissions*. https://www.ucsusa.org/resources/each-countrys-share-co2-emissions (accessed on 30.09.2020)

World Bank (2012) *Inclusive Green Growth - The Pathway to Sustainable Development*. ISBN (electronic): 978-0-8213-9552-3, DOI: 10.1596/978-0-8213-9551-6, p. 192, https://openknowledge.worldbank.org/bitstream/handle/10986/6058/9780821395516.pdf?sequence=1 (accessed on 01.12.2020)

World Bank (n.d.) *Total greenhouse gas emissions (kt of CO2 equivalent)* https://data.worldbank.org/indicator/EN.ATM.GHGT.KT.CE (accessed on 12.09.2020)

6. Annexes

See attached

Modelling the economic impact of climate transition and physical risks for Central Eastern European countries

This paper outlines the key methodological concepts of quantifying climate risks. Assessing the impact of different levels of climate action and global warming trajectories is key for financial institutions to develop climate-risk-aware portfolios. As impacts heavily depend on geographical location and economic structure, there is a clear need for detailed country and sector-specific modelling. Such detail is needed to capture the risks Central Eastern European economies face in relation to the physical impacts of climate change, as well as those of a transition to a less fossil-fuel intensive economy. In this paper, we introduce the key climate risk types, the E3ME macro-econometric model, which is used to capture the impact of transition policies, and our framework for translating gradual global warming into economic impacts.

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JEL keywords: Q54 Climate; Natural Disasters and Their Management; Global Warming, E12Keynes; Keynesian; Post-Keynesian; Modern Monetary Theory, E17 Forecasting and Simulation: Models and Applications, Q56 Environment and Development; Environment and Trade; Sustainability; Environmental Accounts and Accounting; Environmental Equity; Population Growth, G18 General Financial Markets Government Policy and Regulation

1. Introduction

There is a growing consensus and emerging requirements from central banks and supervisory agencies to assess the impact of climate risks. These systemic risks include transition risks stemming from climate policies that are implemented, and the physical risks of climate change itself.

Assessment reports by the Intergovernmental Panel on Climate Change (IPCC) document unprecedented warming since the 1950s that is strongly linked to anthropogenic emissions of greenhouse gases (e.g. IPCC (2014), IPCC (2018)). As the global temperature is rising compared to its pre-industrial level, climate-related physical risks increasingly impact economic productivity and human living conditions. To mitigate those risks and keep global warming at a manageable level, substantial policy changes are needed to cut back on emissions. Strong transition policies also affect economic productivity. Different countries may face markedly different physical risks based on their geographical location and substantially different transition risks depending on their economic structure and reliance on fossil fuels.

Organisations and financial institutions specifically are facing increasing pressure to consider climate change and the risks related to it in their investment decisions. Pension funds, sovereign wealth funds, and various other institutional investors need to secure income streams that reflect the risk profiles of these investments in the coming years and decades. These risks profiles are expected to be altered by both climate change and climate action. For instance, investments in fossil fuels have had high returns historically, which drew capital to the related sectors and infrastructure. In the coming years, these high-emission sectors are expected to be impacted by significant realignment towards a low carbon economy. Each region and country will be affected differently by the restructuring of the industry during a low-carbon transition. Producers and importers of fossil fuel resources will face radically different risks under the changing circumstances.

As both climate change and climate action pose risks to the financial system, more and more institutions are advocating for climate-related risk assessments. Reliable information is needed for financial markets to price climate-related risks and opportunities correctly. This is key to maintaining the stability of the financial system, for making informed, efficient capital-allocation decisions, and for adjusting to potential risks. The Task Force on Climate-related Financial Disclosures (TCFD) recommends that private companies disclose their climate-related financial risks to lenders, insurers, and other stakeholders (Task Force on Climate-related Financial Disclosures, 2017). Government leaders, supervisors and regulators are also announcing policies to endorse and support climate risk disclosures to ensure the resilience of the economy. The Network for Greening the Financial System (NGFS) consists of Central Banks and Supervisors and related guidelines (see Network for Greening the Financial System (2020)) to improve the climate risk management of financial institutions.

NGFS recommends scenario analysis as a tool for climate-stress testing. Developing alternative futures with different levels of climate action and climate change permits the assessment of the risks associated with each pathway. Developing standard scenarios is aimed at reducing the uncertainty inherent in such analysis. This report presents Cambridge Econometrics' approach to modelling both transition and physical risks. The research is unique in that in tackles a small economy in Central Europe, which is not usually the focus of global analysis – a country with strong trade links to the EU, and low-hanging fruits in terms of decarbonisation.

Section 2 introduces the science behind climate change and policy developments. Section 3 presents climate stress-testing and compares our approach to that of the NGFS. Section 4 presents our methodology for quantifying transition risks in detail: namely, our approach, the E3ME model, and the logic behind it, as well as linkages. Section 5 describes our approach to quantifying physical risk. Section 6 concludes.

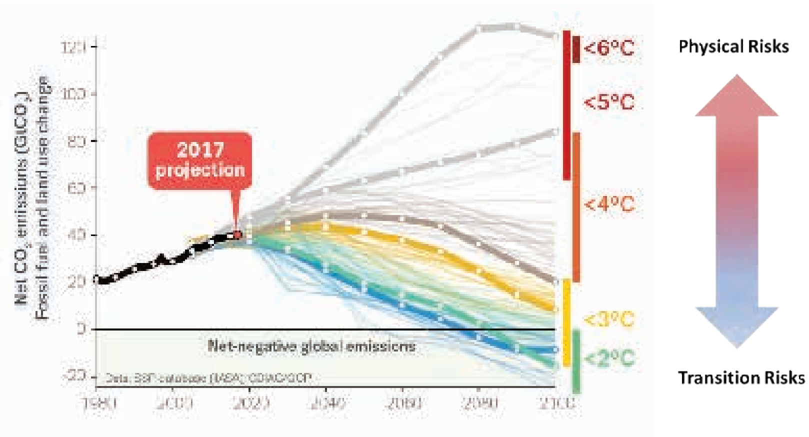
2. Global Warming Pathways

Assessment reports by the Intergovernmental Panel on Climate Change (IPCC) provide an integrated view of the current state and prospects related to climate change. Their recent reports show a continuous and unprecedented warming since the 1950s that is strongly linked to anthropogenic emissions of greenhouse gases (IPCC, 2014) (IPCC, 2018).

The cumulative amount of greenhouse gases in the atmosphere and continuing emissions will further warm the planet. Increases in global average temperatures and the incidence of extreme weather events are likely to cause 'severe, pervasive and irreversible impacts for people and ecosystems' (IPCC, 2014). To mitigate climate change, to prevent and to 'lock-in' the physical risk impacts of associated with it, substantial and sustained policy actions are needed.

Hiba! A hivatkozási forrás nem található. from the Global Carbon Budget 2017 (Le Quéré, C. & al., 2017) illustrates the average amount of global warming by 2100 compared to the pre-industrial level for given carbon-dioxide emission pathways. The emission pathways depend on economic activity and which policies are introduced to mitigate emissions. With the current commitment to climate action and economic trends, warming is expected to be kept just below 4°C by 2100. However, it is possible that current pollution trends will be exacerbated, or that the climate system of the Earth will react more sensitively to emissions and reach tipping points which will accelerate warming. In such cases, global average warming may reach 5 or even 6°C. For global warming to be kept well below 2°C, and preferably at 1.5°C, substantial and urgent climate action is needed. This requires a high level of economic and social transformation, which was committed to in the Paris Agreement in 2015 (UNFCCC, 2015) by several countries, including all Central Eastern European countries. Despite the commitments, the actual level of climate action and emission trends makes it likely that warming will already reach 1.5°C between 2030 and 2052 (IPCC, 2018), thus temperature will rise even higher by 2100.

Figure 2-1 Potential global warming pathways from the Global Carbon Budget 2017



Source: Global Carbon Budget 2017, Le Quéré, C. & al. (2017) and authors' elaboration

Small changes in the global average temperature mean very severe changes to our living environment. Warming will be uneven globally, being higher on land than sea, and rising to two to three times the average as we move toward Arctic regions. There it will melt permafrost and sea ice, which will impact seaside regions across the globe (IPCC, 2018). The higher the average temperature gets, the more the intensity and severity of extreme weather events will increase. The latter impacts will include heavy precipitation with tropical cyclones bringing floods, severe droughts in other regions causing wildfires, extreme hot days, and cold nights in other areas (IPCC, 2018). Even 2°C of warming is projected to lead to a severe increase in climate-related risks to economic growth, human health, food, and water security (IPCC, 2018). These risks grow steeply as we reach higher temperature pathways, approaching an increasingly uninhabitable

Earth by the end of the century with the highest temperature pathways. The locally specific nature of those risks calls for modelling that focuses on specific regions and countries separately.

3. Climate-risk stress-testing for financial institutions

Several organisations have recommended the use of stress-testing to estimate climate-related risks. In 2016, the European Systemic Risk Board recommended including a disruptive energy transition scenario into stress-testing. In 2017, the Taskforce on Climate related Financial Disclosures (TCFD) recommended long-term, forward-looking scenario analysis to better understand the likely impacts of climate change and related policy on investment portfolios. In 2019, the Network for Greening the Financial System (NGFS) published recommendations for financial institutions to improve their risk management guidelines (Network for Greening the Financial System, 2020). One such recommendation is integrating climate-related risks into financial stability monitoring. NGFS recommends taking into account, for all risk types associated with different global warming pathways.

- ***Physical risks,*** which refer to the impacts of climate change on physical capital and economic performance. In most analyses a distinction is made between gradual and extreme weather-related risks. Gradual physical risks involve slow-onset impacts, such as increasing temperature, which gradually decreases agricultural yields and economic productivity. Extreme weather events refer to the increase in severity and frequency of meteorological, hydrological, and climatological events that cause physical damage and involve high costs. The impacts of both types of physical risks are highly uneven at a global scale and increase with the average temperature.
- ***Transition risks,*** which capture the impacts of all decarbonisation policies aimed at mitigating climate change. Keeping global average warming well below 2°C requires a high level of economic and social transformation. The severity of transition risks associated with decarbonisation policies depends on the economic structure and resource intensity of production. A global phase out of fossil-fuel-reliant technologies from all segments of the economy could severely hurt some countries. Other regions may benefit from the restructuring, becoming suppliers of sustainable technologies.

As shown in **Hiba! A hivatkozási forrás nem található.**, physical risk impacts substantially increase the higher the warming becomes, while transition risks grow with the strength of mitigation policies. For fully quantifying local physical risks and economy-specific transition risks, a highly disaggregated form of global modelling is needed.

Developing climate scenarios and building a climate-risk stress-testing framework is the recommended tool of risk assessment. In the next sections, we describe the steps of undertaking such an analysis with the E3ME model of Cambridge Econometrics, which is in line with the recommendations of NGFS. However, there are some differences between the modelling of NGFS and our approach.

- Our approach uses a top-down, forward-looking scenario-based modelling approach, similarly to the NGFS, but uses a different type of macroeconomic model. E3ME is a macro-econometric model (see Section 4.1) based on historical relationships and econometrics. Our approach allows for spare capacities and technological transitions.
- Second, both approaches use scenario analysis to assess the impacts of green policies and climate change under different states of the world. There are three main pathways built on IPCC scenarios covered in NGFS, and in our approach as well: the SSP2, RCP 2.6 and RCP 6.0 (IPCC, 2014).

- Assumptions are quite similar for both methodologies. Both approaches calculate gradual physical damages based on the findings of literature (Table 5-1), which links the average temperature change and decrease in economic productivity. There is a difference in that our approach goes beyond global-level results and provides extra components for analysing the climate risks – e.g., sectoral- and regional-level breakdowns of results are available as well.

It is widely recognised that these guidelines will be turned into regulation soon. Therefore, it is key for supervisors and financial institutions to start developing their own climate-risk stress-testing methodologies to prepare for forthcoming regulations and potential climate risks.

4. Modelling transition risks: The E3ME Macro-econometric model

For capturing the full impact of global climate action at a large-scale, a model is needed which is able to link economy, energy and environment, in a so-called E3 system. The model also needs to have a global coverage and sufficient sectoral- and fuel-use-related detail to capture the scope of policies. There are a few such models which are commonly used for policy analysis. In this report, we present the E3ME model developed by Cambridge Econometrics, which can be used to capture transition risk impacts in climate risk modelling (Cambridge Econometrics, 2019).

4.1 General description E3ME model

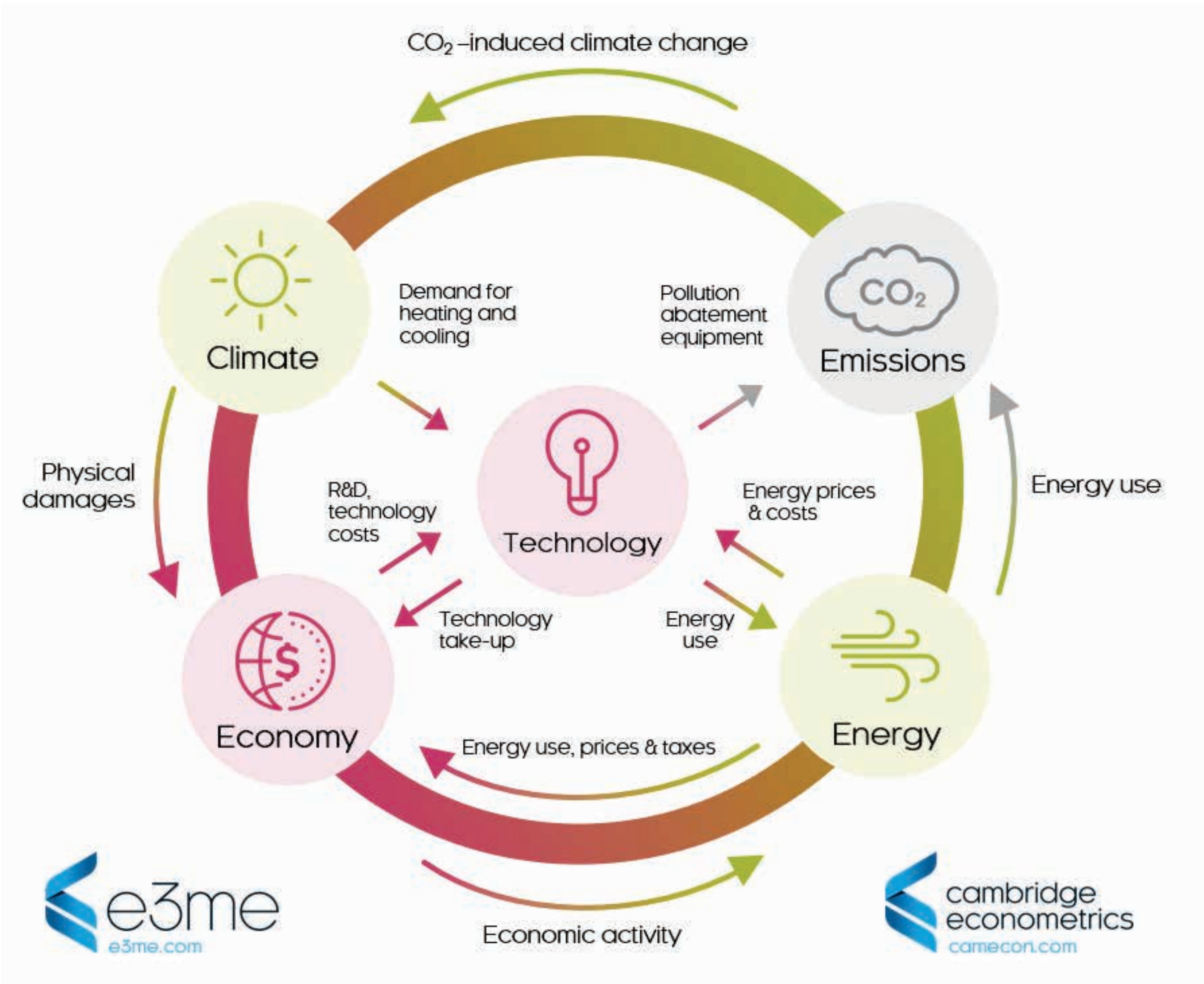
E3ME is a macroeconometric model of the world's economic and energy systems and the environment. It was originally developed through the European Commission's research framework programs and is now widely used in Europe and beyond for policy assessment, for forecasting, and for research purposes. Key features of E3ME include:

- the close integration of the economy, energy systems, and the environment, with two-way linkages between each component
- the detailed sectoral disaggregation in the model's classifications, allowing for the analysis of similarly detailed scenarios
- its global coverage, while still allowing for analysis at the national level for large economies
- the econometric approach, which provides a strong empirical basis for the model and means it is not reliant on some of the restrictive assumptions common to Computable General Equilibrium (CGE) models (e.g.: equilibrium on the labour market)
- the econometric specification of the model, making it suitable for short- and medium-term assessment, as well as longer-term trends

The structure of E3ME is based on the system of national accounts, with further linkages to energy demand and environmental emissions. The labour market is also covered in detail, including both voluntary and involuntary unemployment. In total, there are 33 sets of econometrically estimated equations, also including the components of GDP (consumption, investment, and international trade), prices, energy demand and material demand. Each equation set is disaggregated by country and by sector.

Figure 4-1 represents how E3ME operates as a translation tool for investigating linkages across the four key dimensions of the model (climate, emissions, economic performance, and the energy sector) under various climate scenarios. The economy module provides measures of economic activity and general price levels to the energy module; the energy module provides measures of emissions of the main air pollutants to the environment module, which in turn can predict damage to health and buildings. The energy module provides detailed price levels for energy carriers that are distinguished in the economy module, and the overall price of energy, as well as energy use in the economy. Emissions are determined by economic activity and the energy modules, in relation to the technologies used for production. Emissions affect the pace of global warming and the level of climate risks, which impact the economy through productivity impacts and physical damage. Innovation is modelled in separate submodules that affect all pillars of the model. Section 9 with the annexes presents how specific climate action measures are modelled in E3ME.

Figure 4-1 The broad structure of the E3ME model



Source: Cambridge Econometrics (2019)

Exogenous factors from outside of the modelling framework are shown on the outside edge of the chart as inputs into each pillar of the model. The set of assumptions describing these exogenous factors are the set of policy assumptions per climate pathway that help model the transition and gradual physical risks in E3ME. For each region's economy, the exogenous factors are economic policies (including tax rates, growth in government expenditure, interest rates and exchange rates). For the energy system, the external factors are energy policies (including regulation of the energy industries). The linkages between the components of the model are shown explicitly by the arrows that indicate which values are transmitted between components.

E3ME's historical database goes back to 1970 and the model projects forward annually to 2050. The main data sources are Eurostat, the OECD (both the National Accounts section and STAN), the World Bank, UN statistics, IMF, and ILO, supplemented by data from national sources. Energy and emissions data are sourced from the IEA and EDGAR.[27]

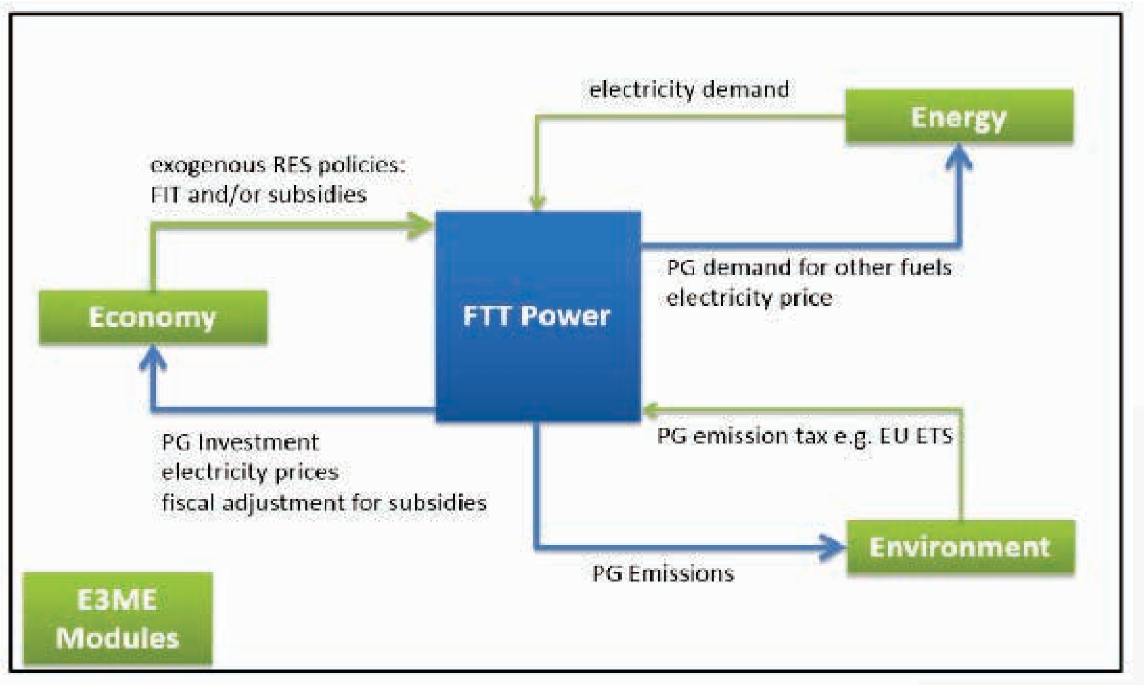
FTT: the technology innovation modules in E3ME

The econometric relationships and accounting identities in the model determine total demand for manufactured products, services, and energy carriers. While long time series may capture well the behaviour of economic indicators, they cannot be used to model the innovation and the spread of new technologies. Future Technology Transformation (FTT) modules represent bottom-up simulations of technology diffusion in E3ME for several sectors, building on the same principles. Technology diffusion determines changes in the environmental intensity of economic processes, including changes in amounts of energy required for transport, electricity generation and household heating. Greenhouse gas emissions are produced by the combustion of fuels and by other industrial processes, which interfere with the climate system.

FTT:Power is the energy system sub-model of the E3ME, developed by Mercure et al. (2012), which represents the power sector using an advanced framework for the dynamic selection and diffusion of innovations. It uses a decision-making core for investors wanting to build new electrical capacity but who face several technologically feasible options associated with different costs. The resulting diffusion of competing technologies based on investor choices is constrained by globally available renewable and non-renewable resources. The decision-making takes place according to pairwise levelized cost (LCOE) comparisons, conceptually equivalent to a binary logit model, parameterised by measured technology cost distributions. Costs include reductions originating from learning curves, as well as the increasing marginal costs of renewable natural resources (for renewable technologies) using cost-supply curves. The diffusion of technology follows a set of coupled non-linear differential equations, sometimes called 'Lotka-Volterra' or 'replicator dynamics', which represent the better ability of larger or well-established industries to capture the market, and the life expectancy of technologies. For a given energy demand calculated based on the needs of the economy, FTT calculates how that energy demand is met depending on the available technologies and their costs in a bottom-up modelling framework. FTT:Power determines a technology mix by region given a detailed electricity policy scenario: carbon prices, investment subsidies, feed-in tariffs and forced phase-out regulations by technology. Changes in the power technology mix result in changes in production costs, reflected in the price of electricity and emissions.

[27] The full model manual and a list of peer-reviewed publications in which it has been applied are available from www.e3me.com.

Figure 4-2 FTT: Power in the E3ME model



Source: Cambridge Econometrics (2019)

FTT:Transport models the passenger car transport sector, which accounts for by far the largest share of transport emissions and is described in detail in Mercure, Lam, Billington, & Pollitt (2018). FTT:Transport assesses the types of vehicles that are purchased in three size bands (small, medium, and large) and several technology classes (including basic and advanced forms of ICE, hybrid, and electric cars). The policy options cover ways of differentiating costs between different vehicles (either in terms of capital costs through variable taxation or fuel/running costs) or regulations on the sale and operation of certain types of vehicles (e.g., phasing out inefficient old cars, biofuel mandates).

FTT:Heat models the technology changes in the residential heating sector (for a detailed description see Knobloch (2019)). Rather than assuming that energy efficiency happens (e.g., due to public mandate), it provides a range of policy options for heating appliances (e.g., boilers, heat pumps) including subsidies, specific taxes, or phasing out old products. It thus assesses the take-up rates of the different technologies around the world.

The FTT module family is continuously expanding, with FTT:Steel being the most recent addition, and FTT:Agri, which captures full land-use dynamics is currently under development.

4.2 Standard scenarios and their assumptions in E3ME

There is a wide range of potential policy and technology combinations for achieving the emissions reduction consistent with each climate pathway. It is important to note that scenarios are not standalone forecasts for the economic outcomes of these potential future scenarios, but always provide results under selected, specific scenario assumptions that are consistent with each climate pathway. E3ME's standard scenario offering for climate risk includes two scenarios:

- ***Failed transition scenario*** – capturing a business-as-usual case in which climate action is limited and warming reaches 3.5-4°C by 2100. This assumes a continuation of current policies, which are essentially consistent with the IEA's World Energy Outlook Current Policies scenario (IEA, 2019). Under this scenario, physical risks related to climate change are severe.

- ***Paris transition scenario*** – capturing ambitious decarbonisation which keeps warming below 2°C. In this scenario, organisations act quickly to implement the recommendations of the Paris Agreement (UNFCCC, 2015). With rapid and aggressive decarbonisation, global CO_2 emissions start to fall almost immediately. Financing for meeting ambitious low-carbon investment goals is made available in all world regions. In this scenario, physical risks are locked-in and their impact is weaker. Transition risks accompanying policy changes strongly affect the economy.

Figure 4-2 provides a broad overview of the key characteristics of the two scenarios.

Figure 4-2 E3ME's standard climate risk scenarios

	Paris Transition	Failed Transition
Temperature	Below 2°C	Below 4°C
Key risks	Transition risks & locked-in physical impacts	Dramatic physical impacts
Key policies	• Global ETS for most sectors & increasing carbon price • Large subsidies and feed-in tariffs for renewables • Strong EV and biofuel blending mandates • High investment in energy efficiency in all sectors • Investment in CCS	• EU ETS with same carbon price • Modest biofuel blending mandates • Some support for renewables and energy efficiency

Key impacts	• Investment stimulus:
	  • positive for some sectors
	• Stranded fossil-fuel assets:
	  • negative for resource intense sectors
		• Physical damages:
		  • negative and different magnitude for each sector

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Source: Cambridge Econometrics (2020)

Emission and warming pathways under the standard scenarios

In the standard scenarios, the emission trajectories of the modelled global warming pathways correspond roughly to RCP2.6 and RCP6.0 from the IPCC (IPCC, 2014). Relatively high climate sensitivity is applied (TCRE[28] of 2.5°C/Tt C), which leads to a temperature well below 2°C by 2100 for the Paris Transition and just below 4°C for the Failed Transition Scenario.

[28] The transient climate response to cumulative carbon emissions (TCRE) is the ratio of the globally averaged surface temperature change per unit of carbon dioxide (CO2) emitted. This is also called 'climate sensitivity'. TCRE implicitly captures a unique relationship between CO_2 emissions, non-CO_2 emissions, and total warming, although there is large uncertainty about the extent to which this relationship will continue in the future.

Table 4-1 Emission and warming pathways under the standard scenarios

Source	Model/approach	Scenario	Global GDP impact in 2100
Burke, Hsiang, & Miguel (2015)	Econometric study (national-level data)	5-6˚C	-23%
Burke, Davis, & Diffenbaugh (2018)	Econometric study (national-level data)	1.5˚C	-11%
		2˚C	-16%
		3˚C	-25%
OECD (2015)	IAM (DICE)	1.5˚C	-2%
		4.5˚C	-10%
Nordhaus & Moffat (2017)	IAM (DICE)	6˚C	-8,16%
Hsiang, et al. (2017)	Spatial Empirical Adaptive Global-to-Local Assessment System (SEAGLAS)	1.5˚C	-1. to -1.7%
		4.5˚C	-6.4 to -15.7%
		8˚C	-1.5 to -5.6%
Kahn, et al. (2019)	Econometric analysis	1.5˚C	-1%
		4˚C	-7%
Zenghelis, D. (2006)	IAM (PAGE)	5-6˚C	-5% to -20%

Source: Cambridge Econometrics (2020)

5. Modelling physical risks

5.1 Gradual physical risks

Understanding the macroeconomic consequences of climate change is an issue that is pervaded by huge levels of uncertainty. As an unprecedented challenge, this uncertainty exists both in relation to the link between emissions and temperature change, and in assessing the wider economic effects of temperature change itself.

The application of Integrated Assessment Models (IAMs) and econometric analysis have previously been used to estimate the impact of climate change on future economic growth. The literature reflects a wide range of estimated GDP impacts associated with future temperature and climatic change (as shown in Table 5-1). Many of these approaches have been criticised for underestimating the likely scale of future climate damage, since the estimates are often based on the impact of temperature on GDP at much lower levels of temperature change, as has been historically observed.

Table 5-1. Comparison of global GDP impact across different studies and models

Standard scenarios:	Cumulative emissions (2019-2100 in Gt CO2)	Cumulative emissions (2019-2100 in Tt C)	TCRE (°C/Tt C)	Reference: Pre-industrial time	Warming 2050 (°C)	Warming 2100 (°C)
Failed Transition	4163	1,1	2,5	1850-1900	1,9	3,8
Paris Transition	682	0,2	2,5	1850-1900	1,4	1,5

Source: Cambridge Econometrics (2020)

In our modelling approach, systemic gradual physical risks are represented as aggregate productivity (GDP) impacts due to increasing temperatures (controlling for the effects of precipitation). Such impacts thus represent temperature impact on agricultural, industrial, and worker productivity. The approach draws from the work of Burke and Tanutama (2019), which builds on earlier work by Burke, Hsiang, & Miguel (2015) and Burke, Davis, & Diffenbaugh (2018).

Burke and Tanutama (2019) econometrically estimate the relationship between temperature and GDP growth rates at a sub-regional level. In their paper, a district-level panel dataset was used on climate and GDP across 37 countries and multiple decades, which confirmed that economic production is also concave in temperature exposure on a district level, with a negative slope throughout nearly all the observed temperature distribution and an increasingly steep one at warmer temperatures.

The regional change in temperature is used with the marginal effect of a +1°C increase in temperature on GDP growth rates, as estimated by Burke and Tanutama (2019) to estimate an adjusted GDP growth rate for each year in each region. The temperature-adjusted GDP growth rate is used to calculate a climate-adjusted GDP for each year in each region.

Using this damage function, combined with regional-specific temperature impacts, we find much higher impacts on GDP related to temperature change compared to other literature sources, ranging from the estimated -18% impact on GDP by 2100 in the Paris scenario to -60% GDP impact by 2100 in the Failed Transition scenario by 2100.

In terms of the impact of temperature change on GDP growth, the approach also takes account of regional differences. For example, under this approach, countries with current average annual daytime temperatures below 5°C initially (such as Iceland) experience positive GDP growth impacts from warming, while countries with initially high average temperatures experience large negative impacts on GDP growth (e.g., India and Saudi Arabia). The following are some of the strengths and limitations of this approach:

- The approach has been updated to use the most recent literature on estimating the economic impacts of climate change – Burke and Tanutama (2019).
- The approach explicitly accounts for the differences in warming that occur in different regions and for regional differences in terms of the impact of temperature change on GDP growth.
- The impacts are consistently implemented across the different pathways and does not require any down-scaling or up-scaling of results based on published impacts for any one temperature pathway.
- The econometric approach captures some of the effects of extreme weather events, but only to the extent that warming has increased the incidence and severity of extreme weather events over the historical period. It is highly likely that this relationship is non-linear, with extreme weather events (such as wildfires, flooding, and tropical storms) increasing in frequency and severity as temperatures increase. As such, this method is likely to underestimate the full impacts of future temperature change on future GDP growth.
- The approach cannot capture potentially devastating climate tipping points, or the potential knock-on effects of complex political and social processes hastened by the stresses of climate change (i.e., mass migration, war, or political and social instability).

5.2 Extreme weather risks

In the E3ME model, findings from Burke and Tanutama (2019) are incorporated to estimate the economic impacts of climate change, but not the effects of extreme weather events. Extreme weather events are not evenly distributed across time, unlike the economic impacts of decreased productivity due to gradual temperature change. Incorporating the effects of extreme weather events such as flooding, tropical cyclones, or forest fires, would require making assumptions about what time period these events occurred over, which would then impact results in subsequent periods. This is too large an assumption to make without additional research about the distribution of these events and additional data on the economic impacts of extreme weather. Instead, we use implied productivity losses from mean temperature change over time.

It is possible to incorporate the layer of extreme weather events to the transition and gradual physical risk shocks of E3ME. Ortec Finance uses PALGamma, a proprietary catastrophe model (see Ortec Finance (2019)). The PALGamma model uses a statistical algorithm to identify at-risk locations and total number of loss events per year. This is combined with climate attribution factors, urbanization data, and hazard risk scores per type of loss event (meteorological, hydrological, and climatological). With this model it is possible to determine the frequency and intensity of extreme weather events at a city level. The disaster predictions based on these risk profiles are then translated to climate-related disaster costs into impact on economic growth using country-level Economic Amplification Ratios (EAR) (Hallegatte, Hourcade, & Dumas, 2007). Once the extreme weather event risks are quantified as economic shocks, their impacts on financial indicators can be modelled.

6. Conclusions

The approach described in this paper is apt for determining both the physical impacts of climate change, and the locked-in physical impacts of our past polluting activity, even if we now embark on a decarbonisation pathway, as well as future physical impacts should we decide not to take a more ambitious approach to reducing our emissions. Cambridge Econometrics' scenario approach is suitable for analysing what would happen if global policymakers do indeed adopt more aggressive targets and more ambitious policies to get us on a cleaner pathway; in this case, we can quantify what the so-called transition risks are that are entailed in a transition scenario.

Developing climate scenarios and building a climate-risk stress-testing framework is the approach recommended by the Network for Greening the Financial System (NGFS). This paper has described the steps involved in undertaking such an analysis with Cambridge Econometrics' E3ME model – in line with the recommendations of NGFS. We have undertaken this analysis globally, but also with a special focus on the Hungarian economy.

For capturing the full impact of global climate action, a macro model is needed with global coverage and sufficient sectoral and fuel use detail to capture the impact of policies. The E3ME model is designed for analysing how macro-economic variables evolve under different climate scenarios and decarbonisation policies. Modelling results can help with understanding portfolio exposure to climate risks and fostering informed decision making by the financial sector.

With the E3ME model we can create analytical descriptions of how different sectors and regions are expected to be affected by the low-carbon transition. This paper has described our standard scenarios: a failed transition scenario assuming the continuation of current policies (those already implemented or announced) and a decarbonisation scenario, whereby the global temperature increase does not reach 2°C by 2100.

Our methodology for quantifying climate-risks is a continuously improving approach, with several planned developments in the pipeline. Physical risks are often categorised into gradual (slow-onset) impacts and extreme weather events. Gradual impacts are currently modelled, while climate-related extreme weather events are addressed using a separate methodology and input data. For the upcoming model update we are working on integrating a better representation of land use into the model. By explicitly capturing different forms of land use based on differing food and biofuel demand, it is possible to capture land-use related emissions more completely. We are also updating our treatment to incorporate gradual climate impacts in response to updates in the literature and new, cutting-edge econometric techniques.

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8. Bibliography

Burke, M., & Tanutama, V. (2019). *Climatic Constraints on Aggregate Economic Output.* Stanford Working Paper No. 1044. Retrieved from https://kingcenter.stanford.edu/sites/default/files/publications/wp1044.pdf

Burke, M., Davis, W. M., & Diffenbaugh, N. S. (2018). Large potential reduction in economic damages under UN mitigation targets. *Nature, 557*(7706), 549.

Burke, M., Hsiang, S. M., & Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature, 527*(7577), 235.

Cambridge Econometrics. (2019). *E3ME Technical Manual v6.1.* Retrieved from https://www.e3me.com/wp-content/uploads/2019/09/E3ME-Technical-Manual-v6.1-onlineSML.pdf

Cambridge Econometrics. (2020). *Climate-related scenario analysis for the Hungarian Central Bank (forthcoming).* Working Paper.

Hallegatte, S., Hourcade, J. C., & Dumas, P. (2007). Why economic dynamics matter in assessing climate change damages: illustration on extreme events. *Ecological Economics, 62*(2), 330-340. Retrieved from https://hal.archives-ouvertes.fr/hal-00164626/document

Hsiang, S., Kopp, R., Jina, A., Delgado, M., Mohank, S., Rasmussen, J., . . . Houser, T. (2017). Estimating economic damage from climate change in the United States. *Science, 356*(6345), 1362-1369. Retrieved from https://science.sciencemag.org/content/356/6345/1362

IEA. (2019). *World Energy Outlook 2019.* Retrieved from https://doi.org/10.1787/caf32f3b-en

IPCC, I. P. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* (R. P. Core Writing Team, Ed.) Geneva, Switzerland: IPCC. Retrieved from https://www.ipcc.ch/report/ar5/syr/

IPCC, I. P. (2018). *Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to.* Retrieved from https://www.ipcc.ch/sr15/

Kahn, M. E., Mohaddes, K., Ng, C., Ryan, N., Pesaran, M. H., Raissi, M., & Yang, J. C. (2019). *Long-term macroeconomic effects of climate change: A cross-country analysis.*

Retrieved from https://www.imf.org/en/Publications/WP/Issues/2019/10/11/Long-Term-Macroeconomic-Effects-of-Climate-Change-A-Cross-Country-Analysis-48691

Knobloch, F., Pollitt, H., Chewpreecha, U., Daioglou, V., & Mercure, J.-F. (2019). Simulating the deep decarbonisation of residential heating for limiting global warming to 1.5 °C. *Energy Efficiency*, 521–550. doi: https://doi.org/10.1007/s12053-018-9710-0

Le Quéré, C., & al., e. (2017). *Global Carbon Budget 2017.* Retrieved from https://www.globalcarbonproject.org/global/images/carbonbudget/Infographic_Emissions2017.png

Mercure, J.-F. (2012). FTT:Power: A global model of the power sector with induced technological change and natural resource depletion. *Energy Policy, 48*, 799-811. doi: https://doi.org/10.1016/j.enpol.2012.06.025

Mercure, J.-F., Lam, A., Billington, S., & Pollitt. (2018). Integrated assessment modelling as a positive science: private passenger road transport policies to meet a climate target well below 2 ∘C. *Climatic Change*, 109–129. Retrieved from https://link.springer.com/article/10.1007/s10584-018-2262-7

Network for Greening the Financial System. (2020). *Guide for Supervisors Integrating climate-related and environmental risks into prudential supervision.* Retrieved from https://www.ngfs.net/sites/default/files/medias/documents/ngfs_guide_for_supervisors.pdf

Nordhaus, W. D., & Moffat, A. (2017). *A survey of global impacts of climate change: Replication, survey methods, and a statistical analysis.* National Bureau of Economic Research. Retrieved from https://econpapers.repec.org/paper/nbrnberwo/23646.htm

OECD. (2015). *The Economic Consequences of Climate Change, OECD Publishing.* Retrieved from https://www.oecd-ilibrary.org/environment/the-economic-consequences-of-climate-change_9789264235410-en#:~:text=The%20sectoral%20and%20regional%20analysis,strong%20in%20Africa%20and%20Asia.

Ortec Finance. (2019). Full recording and presentation of the Ortec Finance webinar on Predict Ability Ltd (PAL) - 19 March 2020. Retrieved from https://www.ortecfinance.com/en/insights/presentation/full-recording-and-presentation-of-the-ortec-finance-webinar-on-predict-ability-ltd

Task Force on Climate-related Financial Disclosures. (2017). *Recommendations of the Task Force on Climate-related Financial Disclosures.* Retrieved from https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf

UNFCCC, U. N. (2015). *What is the Paris Agreement?* Retrieved from https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement

Zenghelis, D. (2006). *The Economics of Climate Change: The Stern Review.* HM Treasury, London. Retrieved from https://www.lse.ac.uk/granthaminstitute/publication/the-economics-of-climate-change-the-stern-review/

9. Annex: Representation of transition policies

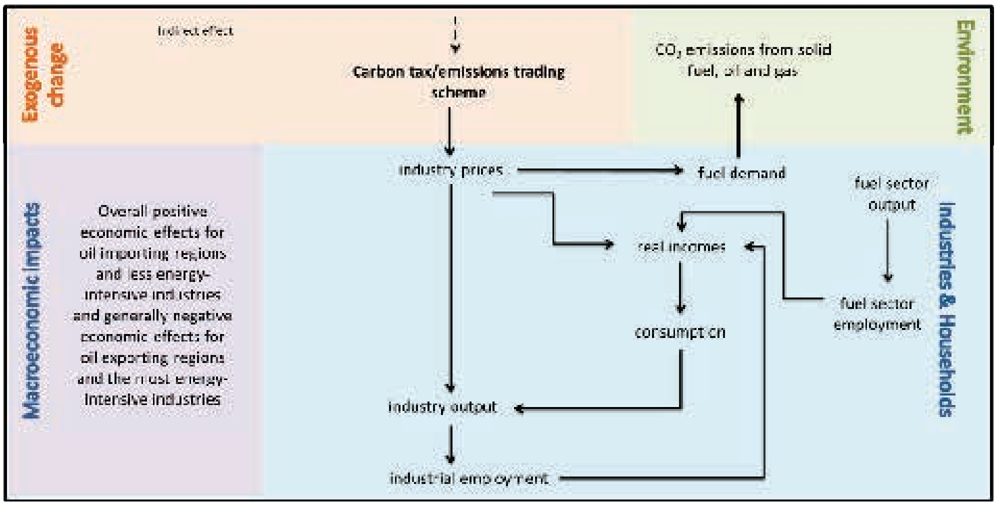
There are wide range of possible policy and technology combinations to achieve the emissions reduction consistent with each climate pathway. This annex shows how three core types of climate policy and their effects feed through the economy in E3ME.

9.1 Carbon tax in E3ME

The ETS scheme and energy taxes are similar policy mechanisms because they increase the price of fossil-fuel, or energy-intensive inputs to production. Industry can pass the costs on to consumers, but this reduces real incomes and reduces aggregate consumption. In cases where industry adjusts other inputs to production to keep prices faced by consumers constant, less output may be produced requiring fewer employees. Reductions in employment also has negative effects on real incomes and feeds into further reductions in aggregate demand.

In response to the price increase, industry might reduce demand for fossil fuels, which leads to reductions in emissions. In regions where fossil fuels are a large part of industrial production, a reduction in demand for these products could lead to decreases in output and employment in fossil fuel producing sectors. This would have additional negative effects on real incomes, consumption, and total output. Figure 9-1 summarises the main economic impacts when an energy tax or ETS scheme is introduced and how these effects feed through the economy.

Figure 9-1 Overview of economic linkages for a carbon tax policy in E3ME

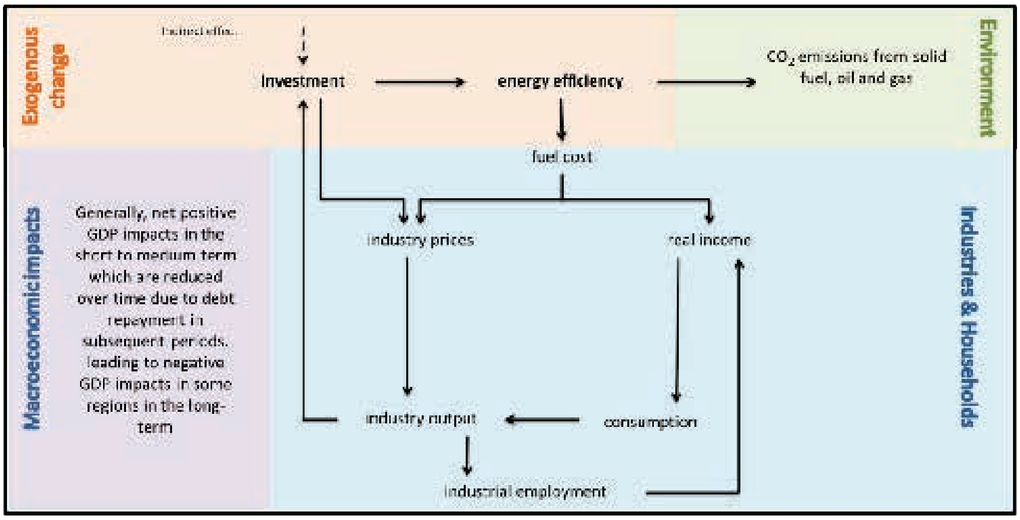


Source: Cambridge Econometrics (2019)

9.2 Energy efficiency improvement policies in E3ME

Energy efficiency investments reduce fuel costs for households, which has positive impacts on real incomes and consumption. At the same time, investment in energy efficiency reduces industry costs. With massive investments in energy efficiency measures, there is an increase in industry output to meet this demand along with increases in employment. This has further positive impacts on income and consumption. Energy efficiency improvements have generally positive GDP impacts while reducing total fuel demand and total emissions. Energy efficiency gains in different sectors are modelled through reduction in fuel demand. The higher energy efficiency is achieved through energy efficiency investments. Figure 9-2 summarises the main economic impacts when energy efficiency policies are introduced and how these effects feed through the economy.

Figure 9-2 Overview of economic linkages for energy efficiency improvements policy



Source: Cambridge Econometrics (2019)

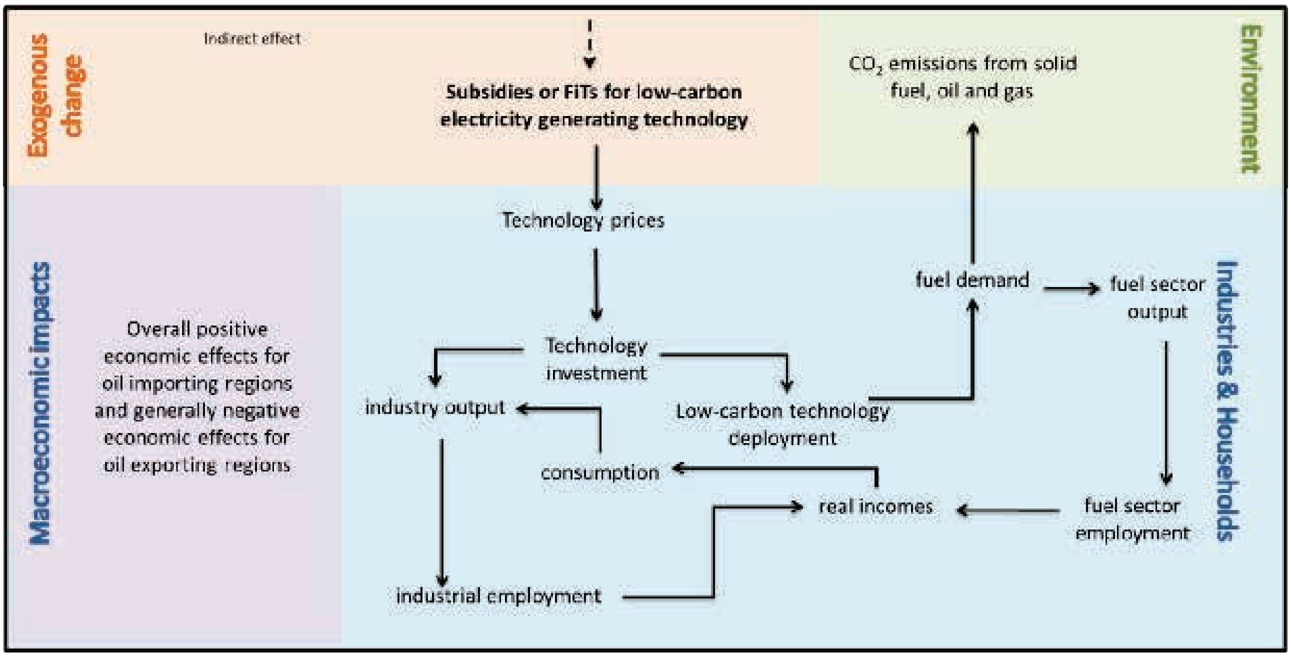
9.3 Subsidies of Feed-in-Tariffs for low-carbon energy technology

Feed-in-Tariffs and technology investment subsidies both act to lower the cost of investment in low-carbon electricity generation technologies. With greater investment and deployment of these technologies, there is a reduction in fuel demand and total emissions.

Given increased investment in these technologies and the electricity sector more generally, there is an increase in output and employment. This has a positive impact on real incomes, which drives increases in consumption. As consumers have more income to spend on goods and services this creates additional demand, additional output is produced to meet this demand, which engenders additional employment and so on.

At the same time, with reduced demand for fossil fuel inputs for electricity generation, there is a decrease in output and employment in fossil fuel related sectors. This has negative macroeconomic impacts in regions that are fossil fuel exporters and experience the double effects of reduced output and employment in these sectors and reductions in government spending due to reduced fossil fuel extraction royalties paid to government. Figure 9-3 summarises the main economic impacts when feed-in tariffs are introduced and how these effects feed through the economy.

Figure 9-3 Overview of economic linkages for a Feed-in-Tariff or technology subsidy policy



Source: Cambridge Econometrics (2019