VILNIAUS UNIVERSITETO
VERSLO MOKYKLA

SUSTAINABLE CORPORATE FINANCE AND INVESTMENT PROGRAM

Ignas Dovidonis

THE FINAL MASTER'S THESIS

ŽALIASIS FINANSAVIMAS: VAIDMUO UŽTIKRINANT TVARŲ EKONOMIKOS AUGIMĄ EUROPOJE	**GREEN FINANCING: THE ROLE IN ENSURING SUSTAINABLE ECONOMIC GROWTH IN EUROPE**

Student _____
(signature)

Supervisor _____
(signature)

Greta Keliuotytė-Staniulėnienė, Doc., Dr.
Name, surname, academic title, scientific degree of the supervisor

Vilnius, 2024

SUMMARY IN ENGLISH

VILNIUS UNIVERSITY BUSINESS SCHOOL

SUSTAINABLE CORPORATE FINANCE AND INVESTMENT STUDY PROGRAMME

IGNAS DOVIDONIS

GREEN FINANCING: THE ROLE IN ENSURING SUSTAINABLE ECONOMIC GROWTH IN EUROPE

Supervisor - Greta Keliuotytė-Staniulėnienė, Doc., Dr.

Master's thesis was prepared in Vilnius, in 2024

Scope of Master's thesis – 86 pages.

Number of tables used in the FMT – 16 pcs (tables) and 14 pcs (charts).

Number of figures used in the FMT – 4 pcs.

Number of bibliography and references – 58 pcs.

The FMT described in brief:

Sustainability in nowadays world is a trending topic that attracts a lot of attention from various sources. Private sectors are sending capital to the money-making business without the decency to validate if the overall activity is unharmful to the environment by only aiming to increase profits hence the economy but the economy can be increased also by making sustainable investments. Acknowledging that, the sustainable financing absorbs more and more participants, therefore, increasing attention to this process is presenting the relevance of the topic and necessity to understand green investments impact to the overall economy growth.

Problem, objective and tasks of the FMT:

Problem. The problem derives whether the green financing and its instruments such as green bonds can be the perfect mediator between the economy growth and sustainability by channeling the funds towards the green investment projects and provide satisfactory results to the European economy which would ultimately attract more attention and investors.

Objective. The goal of this research is to determine the impact on the sustainable economic growth from the green financing sector and establish its role and significance by incorporating the green bonds and Dow Jones Sustainability Index along with greenhouse gas emissions.

Tasks. The tasks were **1)** Conduct the literature and information analysis to understand the importance of the green financing and its current research level in terms of participation in the economy growth of Europe; **2)** Analyze the most used determinants that are used to reflect the economic growth in the literature research by other authors; **3)** Research and analyze the most used analysis methods to understand the relationship and effect between green financing and economic factors and to select the most appropriate model for this paper; **4)** Formulate the methodology of this research by establishing the variables and suitable analysis models that would support raised hypotheses; **5)** Establish the green financing and economic growth regression models that would determine the significancy and impact level alongside test the stability and reliability of the created models.

Research methods used in FMT:

Literature and Statistical data analysis in literature part and multi-linear regression model by Ordinary Least Squares (OLS) powered with Impulse Response Function (IRF).

Research and results obtained:

The research results showed that in regression model by applied lag structure the green bonds are affecting gross capital formation and final consumption expenditure negatively, whereas the gross domestic product is affected positively. By analyzing the impulse response functions (IRF) it showed that green bonds negative effects are temporary and delayed. DJ Sustainability Index gave the opposite effect and contributed positively on gross capital formation and final consumption expenditure, by reviewing the IRF charts it contributed positively the GDP later on further periods showing significant delay in economy growth. Overall, the contribution of sustainability variables is minimal.

Conclusions of the FMT:

The research showed that there is a participation in the sustainable economy growth from the green financing part, however the share of the overall growth is not very significant therefore by creating a gap for recommendations. The output of the research identifies that it necessitates more of the participation from the various stakeholders – public and private partnerships should get a signal to establish more attractive ways for natural, legal persons and underserved segments to contribute their capital towards sustainable projects and therefore increasing the economic growth in a greener and healthier way.

SUMMARY IN LITHUANIAN

VILNIAUS UNIVERSITETO VERSLO MOKYKLA

TVARŪS VERSLO FINANSAI IR INVESTICIJOS STUDIJŲ PROGRAMA

IGNAS DOVIDONIS

ŽALIASIS FINANSAVIMAS: VAIDMUO UŽTIKRINANT TVARŲ EKONOMIKOS AUGIMĄ EUROPOJE

Darbo vadovė - Greta Keliuotytė-Staniulėnienė, Doc., Dr.

Darbas parengtas – 2024m. Vilniuje

Darbo apimtis – 86 puslapiai.

Lentelių skaičius darbe – 16 vnt. lentelių ir 14 vnt. diagramų.

Paveikslų skaičius darbe – 4 vnt.

Literatūros ir šaltinių skaičius – 58 vnt.

Trumpas darbo apibūdinimas:

Tvarumas šių dienų tematikoje yra be jokios diskusijos vienas iš labiausiai aptarinėjamų temų, kuris pritraukia nemažai dėmesio iš skirtingų rinkos segmentų. Privatus sektorius tokie kaip finansinės korporacijos arba finansinių technologijų kompanijos dažniausiai skiria savo kapitalą ir investicijas į projektus, kurie generuoja didžiausias pajamas, pelną, tačiau visiškai nesidairydami pašonėje ir reflektuojant ar atliekant savo veiklą nėra daroma žala gamtai, tvarumui. Pripažįstant, kad tvarus finansavimas įtraukia vis daugiau dalyvių, didėjantis dėmesys šiam procesui rodo temos aktualumą ir būtinybę suprasti žaliųjų investicijų poveikį bendram ekonomikos augimui.

Darbo problema, tikslas ir uždaviniai:

Problema. Problema kyla dėl to, ar žaliasis finansavimas ir jo priemonės, pavyzdžiui, žaliosios obligacijos, gali būti puikus tarpininkas tarp ekonomikos augimo ir tvarumo, nukreipiant lėšas į žaliuosius investicinius projektus ir užtikrinant patenkinamus rezultatus Europos ekonomikai, kurie galiausiai pritrauktų daugiau dėmesio ir investuotojų.

Tikslas. Pagrindinis šio darbo tikslas buvo nustatyti poveikio buvimą tvariam ekonomikos augimui, kuris kyla nuo žaliojo finansavimo įtraukiant žaliąsias obligacijas ir Dow Jones tvarumo indeksą kartu identifikuojant šio poveikio stiprumą ir svarbą.

Uždaviniai. 1) Atlikti literatūros ir informacijos analizę, siekiant išsiaiškinti žaliojo finansavimo svarbą ir dabartinį jo tyrimų lygį, kalbant apie dalyvavimą Europos ekonomikos augime; **2)** Išanalizuoti dažniausiai naudojamus veiksnius, kurie naudojami ekonomikos augimui atspindėti kitų autorių literatūros tyrimuose; **3)** Ištirti ir išanalizuoti dažniausiai naudojamus analizės metodus, siekiant suprasti žaliojo finansavimo ir ekonominių veiksnių ryšį ir poveikį bei parinkti tinkamiausią modelį šiam darbui; **4)** Suformuluoti šio tyrimo metodiką, nustatant kintamuosius ir tinkamus analizės modelius, kurie pagrįstų iškeltas hipotezes; **5)** Sudaryti žaliojo finansavimo ir ekonomikos augimo regresijos modelius, kuriais būtų nustatomas reikšmingumo ir poveikio lygis, kartu patikrinant sukurtų modelių stabilumą ir patikimumą.

Darbe taikyti tyrimo metodai:

Tyrimas buvo atliekamas naudojant patikimą informaciją iš mokslinių šaltinių ir jų analizės literatūrinėje dalyje bei empirinėje dalyje - regresinės analizės metodą, bei atliekant gautų modelių diagnostiką dėl jų patikimumo kartu analizuojant ir impulsinio atsako funkcijas bei jas interpretuojant.

Atlikti tyrimai ir gauti rezultatai:

Tyrimo rezultatai parodė, kad pagal regresijos modelį, kuriam buvo pritaikyta atsilikimo struktūra, žaliosios obligacijos daro neigiamą poveikį bendrojo kapitalo formavimui ir galutinio vartojimo išlaidoms, o bendrajam vidaus produktui - teigiamą. Analizuojant impulsinių atsakų funkcijas paaiškėjo, kad žaliųjų obligacijų neigiamas poveikis yra laikinas ir uždelstas. *Dow Jones* tvarumo indeksas turėjo priešingą poveikį ir teigiamai veikė bendrojo kapitalo formavimą ir galutinio vartojimo išlaidas, o peržiūrėjus impulsinio atsako diagramas matyti, kad jis teigiamai veikė BVP vėlesniais laikotarpiais, o tai rodo, kad ekonomikos augimas gerokai vėluoja. Apskritai tvarumo kintamųjų įtaka yra minimali, bet teigiama.

Darbo išvados:

Išvados nurodo, kad žaliasis finansavimas bendrai veikia ekonomikos augimą teigiamai, tačiau poveikis neužima bendrai didelės makroekonominės dalies. Išvados nurodo, kad turi būti taikomas didesnis dėmesys iš viešojo ir privataus sektorių kartu bendradarbiaujant ir kurti alternatyvius investavimo produktus įvairiems investuotojų segmentams, kurie turi kapitalo investuoti, tačiau šiuo metu esami rinkoje produktai yra nepasiekiami arba neįperkami. Tobulinant šią sferą iš naujų produktų kūrimo gali būti pasiektas efektyvus ir tvarus ekonomikos augimas.

TABLE OF CONTENTS

INTRODUCTION

The relevance of the topic. Green financing in nowadays landscape is quite a popular and well-known term, however, there might be a misunderstanding with its meaning and purpose as genuinely the word green is usually resonating an ecology and recycling as the first impression. In adding the word financing the combination of it becomes actually close to reality talking about the recycling and ecology – it is the same just the funds for the devoted process are being channeled to such activity. The term green financing is a very popular financial trend and process. The reason standing behind its loudness is the global warming consequences of increasing temperature in our Earth – that was noted and mutually agreed in Paris 2015 where countries approved seventeen ultimate goals to prevent further warming and achieve sustainability by the year 2030 (*Sustainable Development Goals | United Nations Development Programme*, n.d.).

Economy is all about the capital and funds channeling to various industries and micro-economies in order to create additional value and to maintain the current one. It is important because the economy creates the products, we use every day and paying for that. However, the products can be interestingly different despite their similarity and the best example of that is the vehicles that are mainly petrol driven and worldwide we have just a small share of the market with electronic module cars – the product ultimate goal is the same, however the nature of it is different. The root cause of the overall problem is exactly the nature of the economy and business overall – is the desire to gain profits and turnovers by producing the goods or services, however, the businessmen and governments understood that there is a second side of the coin and that products can be created using renewable energy or recycled resources which would lead to a circular economy.

The movement or investment of the funds to the sustainable projects such as renewable energy, electric vehicles, recycling sites or companies and furthermore is called the green financing. The nature of it is simple the same funds generated through investment instruments or other means are channeled to the sustainable, governing and socially responsible projects. The trend of this type of financing is getting at a higher pace due to more and more people understanding the fact about the global warming and greenhouse gas consequences that are already

irreparable. In order to achieve the financing for such projects and innovations the instrument such as green bond was created which is purely with the same purpose – a loan, however the beneficiary of the proceeds is committed to use the funds only for the sustainable and already approved projects. Nevertheless, it is also crucial that green financing process allows to move the investment capital or start-up companies towards the sustainability and therefore to achieve the SDGs. The fundamentals of any project and any business venture starts with financing therefore it requires capital which can be borrowed, in case the project is considered sustainably-driven the bonds or the loans that were used can be called green bonds. "The first issue of green bonds, carried out by the European Investment Bank under the name of Climate awareness bonds and worth EUR 600 million, took place on 5 July 2007." (Frydrych, 2021) this shows us that more than 16 years ago the acknowledgment of the green financing begun in the Europe region. As already known the bond market is considerably old in the economy as a mean for investing and it is considered a very secure investment. Governments, private companies are issuing the bonds when there is a necessity for the funds to finance the projects or innovations, usually the bonds are the instrument with the lowest return rate compared to stocks or cryptocurrency, exchange traded funds and more, however in terms of financial risk the bonds are deemed to be low-risk instruments. Therefore, the bond market is considerably vast and major in terms of economy financing. The eager to know emerges – what are the capabilities of green bonds to have a share in the overall market and what are the return rates in the European region. In the mentioned region the green bonds popularity is increasing as the European Commission approved the NextGenerationEU (*NextGenerationEU*, n.d.-a) project with which the green bonds are issued on the supranational level and also in the 2014 introduced the green bond principles (*Green Bond Principles, 2014 Voluntary Process Guidelines for Issuing Green Bonds*, 2014). All these actions shows that green financing is being taken seriously and that there is a proper goal to achieve which would serve both – the environment and the economy.

Level of research of the topic. The green financing impact on the economy growth research is increasing by newest studies written in 2023 such as (Atayah et al., n.d.; Awais et al., 2023; Mirza et al., 2023; Siddik et al., 2023; Zhang, 2023), however the studies are aiming towards pollution causality and financial technology and its power to aim the economy towards the more sustainable way. In the best effort of research there are not so much researches on the green

financing and in particular the green bonds and sustainability indices such as Dow Jones Sustainability Index also in addition, most of the researches are locally orientated meaning assessment was done on a specific country. This gives the level of the research that on the European level using the green bonds and sustainability indices this topic is not considerably well analyzed.

Novelty of the topic. In general, the sustainability topic is already known and analyzed, however as per literature research more of the analyzes were done on the regional level (Cheng et al., 2021; Lee & Lee, 2022; Nassiry, 2018) on top of that usually only the greenhouse gas emissions are being taken as the variable for the sustainability whereas talking about the economy there are more way to identify the sustainability. As per this research the novelty is provided by the introducing the Dow Jones Sustainability Index that was not used before in the literature analysis that was done by putting the best effort.

Formulation of the problem. Can the green financing and its instruments such as green bonds be the perfect mediator between the economy growth and sustainability by channeling the funds towards the green investment projects and provide satisfactory results to the European economy which would ultimately attract more attention and investors.

Objective. To test the green bonds and sustainability indices affection to the European economy growth by creating statistical models which would allow to accurately understand the size of the impact its relation and also attraction of such green investments.

Tasks of the subject:

1. Conduct the literature and information analysis to understand the importance of the green financing and its current research level in terms of participation in the economy growth of Europe.
2. Analyze the most used determinants that are used to reflect the economic growth in the literature research by other authors.
3. Research and analyze the most used analysis methods to understand the relationship and effect between green financing and economic factors and to select the most appropriate model for this paper.

4. Formulate the methodology of this research by establishing the variables and suitable analysis models that would support raised hypotheses
5. Establish the green financing and economic growth regression models that would determine the significancy and impact level alongside test the stability and reliability of the created models.

Subject matter. European region economy indicators that provide growth observations along with financial markets such as indices that tracks the sustainability goals along with green financing tools which aims capital transition to the green-related projects.

Chosen research methods:

1. For the literature research part, the period of analysis is various, from the old sources that describes the economy definition and main determinants that are one-time developed and reliable to the newest researches that analyzes the sustainability element in the economic growth:
    a. Statistical data analysis and interpretation – as the economy is the statistical and numbered science that various charts and graphs are published by European Commission and other reliable sources about different economy parts and industries.
    b. Official sources, scientific studies and researches analysis and interpretation from the *Web of Science*[1] - the literature analysis is fundamental for the understanding the current level of the research in the topic therefore creating its significance and outlining emerging problems. It also provides the analysis methods used by the other authors, therefore, benefiting this paper by allowing to understand already used methods and apply them.
2. For the empirical part of the research the time span of 2014 to 2022 will be used to gather the last 10 years of data that includes recent events such as COVID-19 pandemic

[1] https://clarivate.com/products/scientific-and-academic-research/research-discovery-and-workflow-solutions/webofscience-platform/

and can provide actually the transparency in the analysis and how green financing supporting the economic growth during various periods:

a. Multiple linear regression modelling using Ordinary Least Squares method – since in the research is about the role and significance of the green financing the regression model shows the statistical significance and relevance to the model using the OLS method.
b. Impulse response function (IRF) analysis – as the economy is cycling process and shifting the reactions can be delayed or put of further, in accordance to this, the impulse response function allows to see the shock waves of one variable to another therefore by allowing to interpret the results more accurately in the timespan understanding.

Difficulties and limitations. Since the novelty of this subject especially on the green finance side is particularly new, there is in the best of search effort limited long-term statistical data in quarterly frequency that would provide more observations and more accurate calculations. Economy indicators such as gross domestic product are usually calculated and reported on the quarterly basis therefore limiting the desire to have more frequent periods.

The research will adopt a multi-disciplinary approach, drawing upon theories and concepts from sustainable finance, financial technology, innovation studies, and policy analysis. Through a comprehensive literature review and empirical analysis, this study aims to provide insights into the transformative potential of green financing and its ability to address the financing needs of sustainable projects and businesses in Europe. By identifying the key challenges, opportunities, and success factors, this research seeks to inform policymakers, financial institutions, and stakeholders about the implications of green fintech for sustainable economic growth.

Rest of the master thesis is formulated as following: Section 1 – Theoretical work section provides the literature analysis in regards of green financing and fintech definition, consensus on the fintech concept and linkage between sustainable economic growth. In this section the scientific articles and credible researches along with trustworthy information found in the databases are reviewed, where the aim is to review the past analysis on the related topics, gather the research

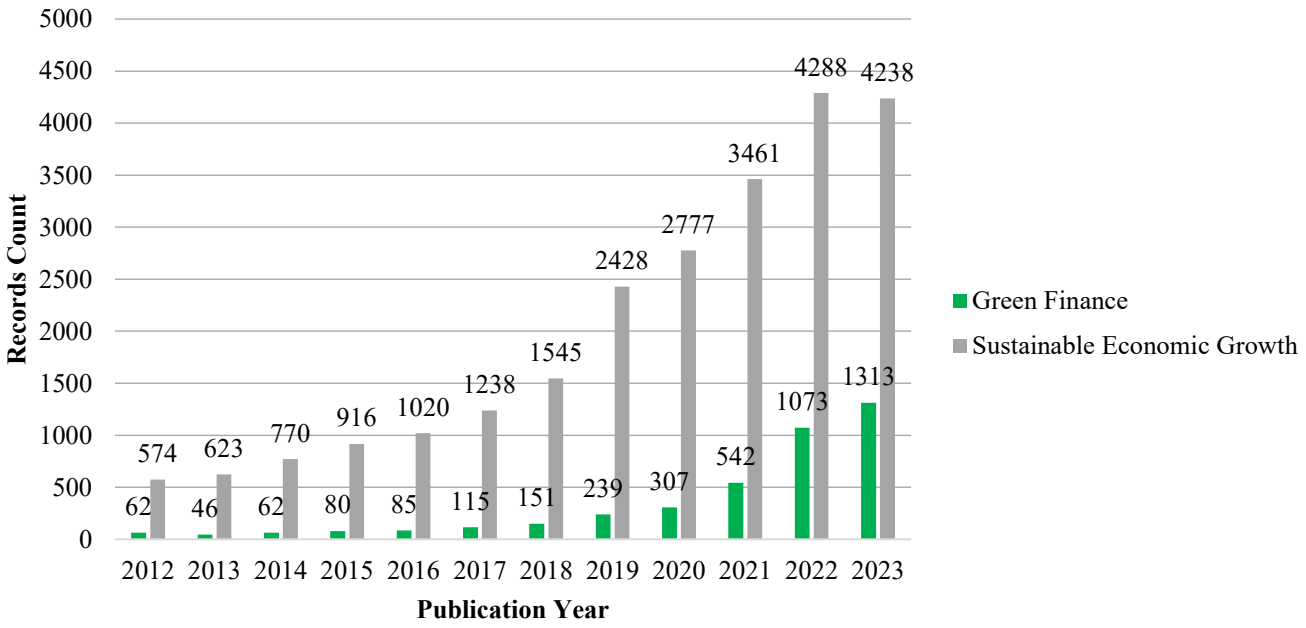
methods that were used and raise the hypothesis to support the already predefined goal. Furthermore, Section 2 – Methodological section gives a detailed overview of the selected models and research logic that will be used in the research section to determine the nexus between sustainability and factors that defines economic growth. Moving further, Section 3 – Research section gives accurate calculations and models applications by the predetermined methodology in order to assess the correlation and other fundamental analysis and results interpretation that derived from the calculus with justifiable solutions that is addressing the expected goal. Finally, Conclusions and recommendations gives all the stakeholders which are: policymakers, financial institutions, private investors, customers of financial services the insights of this trending and emerging topic.

1. ANALYSIS OF THEORETICAL ASPECTS OF GREEN FINANCE AND SUSTAINABLE ECONOMY

The importance of this subject and the level of the already completed research gives the understanding that this topic is clearly emerging and important as more and more researches are delving into the green financing topic. The statistical literature analysis ranging from 2012 to 2023 showed that scientific researches of the green financing topic are visually several times lower analyzed than the sustainable economic growth topic. This chart (*Chart 1*) indicates two-fold assumptions - the relevance of the topic and also the rising attention and importance.

Chart 1

Published scientific researches of "Green Financing" and "Sustainable Economic Growth" topics during 2012-2023 in the Web of Science.



Source: Compiled by the author, using Web of Science database.

From the analysis it is observable that green financing is less analyzed than the sustainable economic growth, in addition, the both topics together are interrelated with each other. This

outlines the problem that there is a necessity to better understand the relation between both areas and join them into one research that would allow to understand the actual importance and relevance including the chemistry and impulses.

Green finance has emerged as a critical field in sustainable development, aiming to integrate environmental considerations into financial decision-making processes. The analysis of theoretical aspects of green finance plays a crucial role in understanding its foundations and implications. One key aspect is the identification and evaluation of environmental risks and opportunities within financial systems. This involves assessing the impact of climate change, resource depletion, and pollution on financial assets, as well as identifying investments that support the transition to a more sustainable and low-carbon economy. Furthermore, understanding the theoretical underpinnings of green finance involves examining concepts such as sustainable investment criteria, environmental valuation methods, and the role of financial institutions in promoting environmentally responsible practices. Through comprehensive analysis, researchers can provide insights into the conceptual frameworks and mechanisms that guide the integration of environmental considerations into financial decision-making, thereby contributing to the development and implementation of effective green finance strategies.

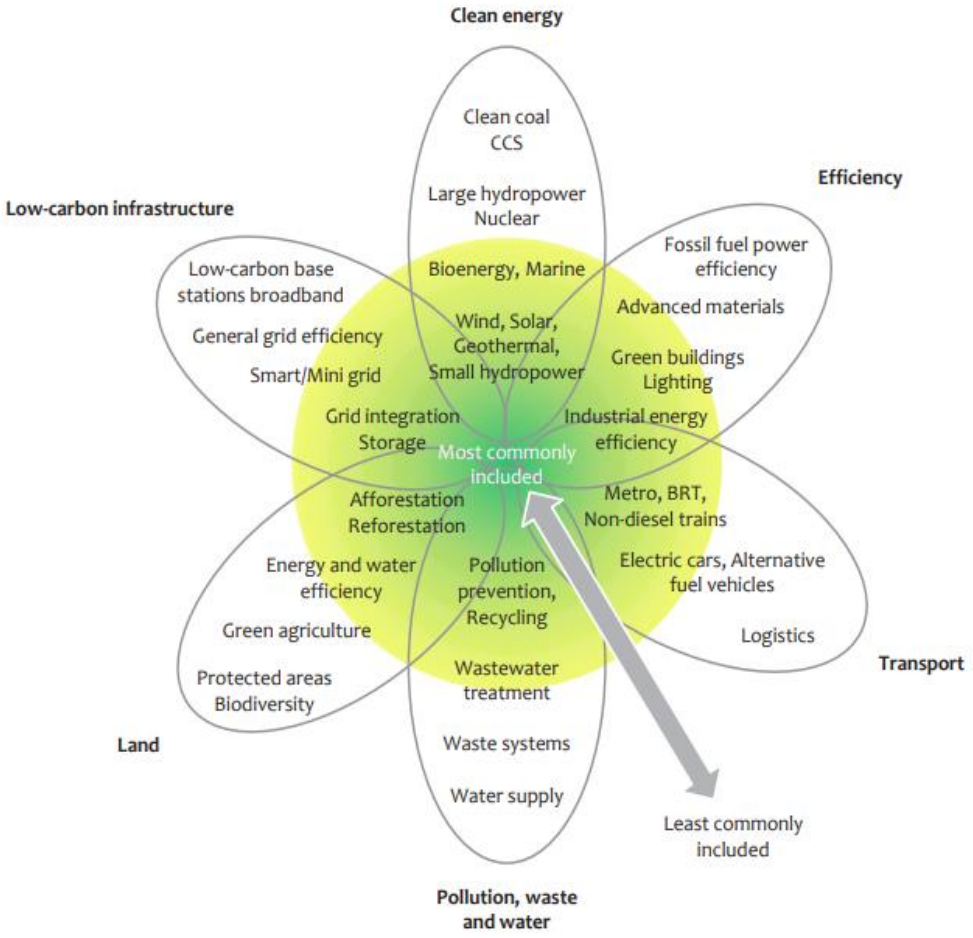
1.1. Green finance definition and instruments

When assessing the definition in the scientific researches it was identified that green finance refers to financial arrangements specifically designed for environmentally sustainable projects or those that incorporate elements aimed at addressing climate change. It encompasses a range of financial instruments, investments, and initiatives that support and promote environmental sustainability. These financial arrangements prioritize projects that have a positive impact on the environment, such as renewable energy initiatives, energy-efficient infrastructure, sustainable agriculture, and clean technology developments. The overarching goal of green finance is to channel capital towards activities that contribute to mitigating climate change, reducing carbon emissions, and fostering a more sustainable and environmentally friendly future (Nenavath, 2022). The main goal for the financial institutions in general is to generate the revenue and profit therefore financial services such as investments are driving its capital to the money-making markets

therefore aiming for the high-rate of return (Yoshino et al., 2019) and as tends to be in regards with sustainable and non-sustainable sides, financial institutions tend to choose more non-sustainable direction such as fossil fuel projects than green investment projects (Taghizadeh-Hesary & Yoshino, 2019). As per the (Stojanović et al., 2018) definition taken from the United Nations of the green financing components (Environment Inquiry, 2017) it is observed that there are various types of the areas and factors that while the lack of a universally accepted definition presents challenges in methodology, the analysis of current definitions reveals a general agreement among them, alongside certain points of difference, as depicted below (*Figure 1*).

Figure 1

Components of the green financing definitions



Source: United Nations Environment Program (UN Environment), 2017

Delving in the green financing part it is already established that the main goal of the green investments is to align the investors' goals with the more sustainable projects by providing the profitable returns. Green financing, encompassing instruments like green bonds and loans, represents a pivotal shift in funding practices towards environmental sustainability. It enables the channeling of capital into projects that yield environmental benefits, such as renewable energy, pollution control, and sustainable resource management. Green bonds, a prominent tool in green financing, offer investors fixed-income investments while ensuring funds are exclusively used for eco-friendly projects. With a growing focus on Sustainable Development Goals, the link between green economics and finance is becoming increasingly important worldwide (Afzal et al., 2022). The main idea is that countries can achieve economic and financial growth without harming the environment. This approach aims to blend sustainable practices into economic strategies, ensuring financial progress goes hand in hand with environmental care.

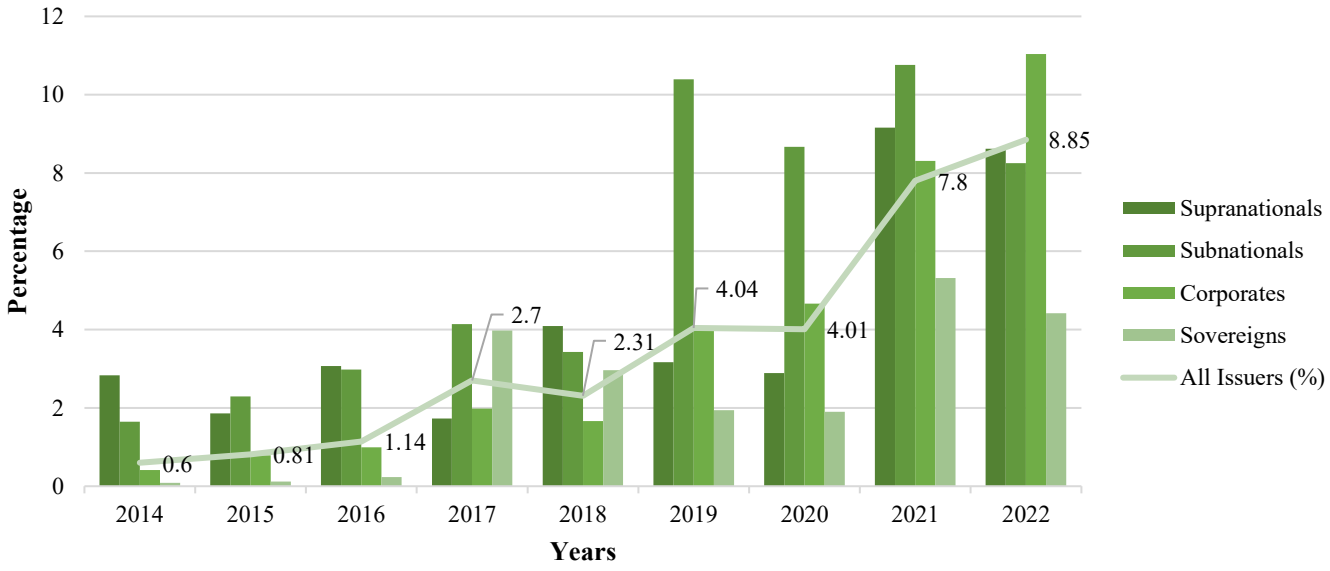
Another important area of analysis in the field of green finance pertains to the measurement and evaluation of the impact of green investments and initiatives. This involves developing methodologies to assess the environmental, social, and economic outcomes of sustainable financial activities. Researchers explore various indicators and metrics that can be used to quantify the environmental benefits and sustainability performance of green projects and portfolios. Additionally, the analysis of theoretical aspects of green finance delves into the challenges and opportunities associated with the integration of environmental considerations into financial markets, such as the development of green financial instruments, the establishment of regulatory frameworks, and the mobilization of private capital towards sustainable investments. Understanding these theoretical aspects enables policymakers, financial practitioners, and researchers to design effective strategies, policies, and incentives that promote the adoption of green finance and facilitate the transition to a more sustainable and resilient global economy.

Traditionally, standard bonds are instruments for raising capital by incurring debt from individual or collective investors. Here, the issuer markets its bond, investors purchase it, and later, they recoup their investment plus interest. But times are changing, and investors are now looking beyond mere profit. They seek investments that have a positive societal impact. This is where green bonds come into play – "A green bond is a type of fixed-income instrument that is

specifically earmarked to raise money for climate and environmental projects. These bonds are typically asset-linked and backed by the issuing entity's balance sheet, so they usually carry the same credit rating as their issuers' other debt obligations" (Green Bond: Types, How to Buy, and FAQs, n.d.). These bonds are not just a financial tool – they are a choice for eco-conscious investing, gaining significant traction in recent years due to their dual promise of returns and societal benefits (Laborda & Sánchez-Guerra, 2021). The attention that green bonds are receiving is vividly visible (*Chart 2*) as the percentage of this green financing instrument is rising through the years in the European region as the share of the market increased more than 14 times in the past 8 years as illustrated below[2]. The increasing numbers of the graph shows us that investors and stakeholders are devoted to sustainability and that it is emergingly becoming more attractive in the bonds market.

Chart 2

Green bond issuance as a percentage of total bond issuance by all issuers and each type of bond issuer in the EU, 2014-2022



Source: European Environmental Agency

[2] https://www.eea.europa.eu/data-and-maps/daviz/percentage-of-green-bond-issuances-1#tab-chart_5

Retrospectively, tackling the shift towards a low-carbon economy might be most effectively managed using debt instruments and a select number of equities, known for their financial resilience (Zhao et al., 2022). This approach involves crafting a market portfolio focused on environmental sustainability and creating financial incentives that are aimed at encouraging active involvement from both the private and public sectors in directing resources towards sustainable initiatives. A critical aspect of this strategy is a detailed analysis of the associated risks and the potential for hedging within these financial instruments, ensuring they are viable within a constrained yet sustainable financial framework. Further in this research the green financing definition will be used as the green bond instrument used for raising borrowing the funds necessary for the projects aimed towards the sustainability.

1.2. Green financing channels and research methods

In the green financing environment, there are a lot of instruments and channels that are used to achieve such type of capital shifting. One of the derivatives that were established in the background of adopted SDG goals by the European Commission is called green fintech which refers to the application of financial technology or fintech specifically in the context of environmental sustainability and addressing climate-related challenges. To address the original definition of fintech consensus of the it is abstract and to determine the singular and united form of description is quite challenging, therefore in some researches it was found out that fintech is distinguished from its own originated combination of “financial technology”. The reason of this is that the same working of “financial technology” is abstract and not concrete, therefore the beginning of identifying the fintech definition must start with proper analysis and observation on what the financial technology actually is. In terms of that, it can be described as the process that allows to provide a certain financial services or product to the market (Knewtson & Rosenbaum, 2020). Therefore, fintech might be associated with the original term but the preview of the concept is different and it should be understood as sophisticated technology that surpasses the existing technological landscape within the market which is able to provide financial services or products. Also, fintech can be distributed through vast majority of the sectors since it is adopted as the “sophisticated technology” which means it can bring beneficial impact to not only banking sector but also to and not limited: credit, settlement services, investment or insurance products (Thakor,

2020). As our economic understanding of the financial sector is embedded with these financial sectors and we observe that fintech can be also applied to them it already shows a great participation and key role playing in the economy. In addition, the fintech covers payments, peer-to-peer lending and more sectors: investing, cryptocurrency the investing in this technology is rising however, as per fundamentals the financial sector is highly regulated in regards of supervision, capital adequacy, anti-money laundering and terrorist financing, proliferation of illegal activities, products and more this sector is still being developed and regulatory obstacles are still present (*Financial Technology (Fintech): Its Uses and Impact on Our Lives*, n.d.).

Returning to the green fintech part in the green financing family tree it focuses on leveraging technology to promote environmentally friendly and sustainable practices in the financial industry. The green fintech definition is quite similar to the solely fintech description, the main change here is that by applying the same process and sophisticated technology those derived solutions must be environmentally responsible and also be aimed into the renewable energy, green finance, sustainable projects. In regards with the definition of the green finance or green fintech again, there is a gap between united description as indicated (Lee & Lee, 2022). A more recent perspective posits that green finance serves as a financial mechanism to encourage investments that are environmentally friendly and support the development of an ecologically conscious society. This approach encompasses various financial instruments such as green-oriented credit, securities, insurance, and investment products. Additionally, it includes the concept of carbon finance, which focuses on financing projects and initiatives aimed at reducing carbon emissions and mitigating climate change. The objective of this perspective is to mobilize financial resources towards sustainable and environmentally beneficial activities, fostering a greener economy and promoting a sustainable future (Hu et al., 2021).

The correlation between fintech and green fintech is also associated with the possibilities of introducing this process into the vast majorities of the industries and also there are numerous stakeholders including individual and business consumers, producers, investors, and financial lenders. The expression and adoption of green finance can vary among these participants, driven by various factors such as financial incentives, environmental stewardship, or a combination of both. Each participant's engagement in green finance contributes to the collective effort of

fostering sustainable practices and preserving the planet (Y. Wang & Zhi, 2016). As identified by the authors Yao Wang, Qiang Zhi the green finance is the opposing side of standard financial services since its focus and devotion is aimed towards sustainability only. In terms of the challenges that green finance is facing is also an important thing to address. The development of green energy projects faces significant challenges, including the absence of long-term financing options, relatively low rates of return, the presence of diverse risks, and limited capacity among market players. These obstacles pose hurdles to the growth and implementation of sustainable energy initiatives. Addressing these challenges is crucial for creating a conducive environment that supports the advancement of green energy projects and the transition towards a more sustainable energy landscape (Taghizadeh-Hesary & Yoshino, 2020).

There were some researches done in terms of finding or identifying the link green economy and fintech by time-varying causality technique that actually resulted in robust relationship between green financing and financial technology (Metawa et al., 2022). Furthermore, in more studies semi-parametric difference-in-differences (SDID) model was applied to green finance analysis with climate change tackling and provided astonishing results that indicated the impact of green fintech to reduction of sulfur dioxide emissions (Nenavath, 2022). To correctly approach this research regarding the analysis methods used in the determination of the impacts or relations with the variables that represents fintech, green financing, sustainability and economic growth, the literature was deeply analyzed and most accurate authors and their researches were compiled into a table (*Table 1*). It is observable that most of the time the regression modelling is the top pick for the researchers in their studies as they provide insight on the relations and importance.

Table 1

Literature analysis of used analysis methods regarding sustainability and economy

Author	Object	Method	Variable
(Merello et al., 2022)	Sustainability profile of FinTech companies	Regression model using GMM estimation of system of equations fllowed by the Ramsey RESET test	Market capitalisation & Book Value per Share
(Awais et al., 2023)	Fintech contribution to green economic growth	Regression model using Ordinary Least Squares (OLS)	Green Gowth Index
(Tao et al., 2022a)	Fintech development support to economy transition to low-carbon economy	Regression model 2SLS and GMM estimations with Breusch-Pagan-Godfrey (BPG) testing	Greenhouse gas emissions (GHG)
(Zhang, 2023)	Connection between green finance, financial technology (FinTech), and high-quality economic development	Panel regression analysis and using a two-step generalized method of moments (GMM)	FinTech, and its corollaries - technology input, capital, and labor input.
(Lee & Lee, 2022)	Influence of green finance on green total factor productivity	Super efficiency SBM model	Green total factor productivity (GTFP)
(Zioło et al., 2022)	Sustainable finance impact presence on building a sustainable economy	Log-linear model	Sustainable economy functionality

Source: Compiled by the author

To round up, by analyzing the literature on the green fintech it is generally observed that solely aim is to sustainability and SDGs implementation, among other many beneficial impacts it also covers the ESG (Environmental Social Governance) responsibility therefore covering numerous of financial activities and other industries. The definition of the green fintech can be described as application of financial technology specifically in the context of environmental sustainability and addressing climate-related challenges. It involves leveraging innovative technological solutions to promote environmentally friendly and sustainable practices within the financial industry.

1.3. Sustainable economic growth determinants

By identifying what is the sustainable economy firstly it was divided into smaller parts and the definition of economy in general was assessed. An economy is an intricate network of interconnected activities involving production, consumption, and exchange. It plays a vital role in determining the allocation of resources among participants. Through the interplay of production, consumption, and distribution of goods and services, the economy serves to meet the diverse needs of individuals and entities operating within it (*Economy: What It Is, Types of Economies, Economic Indicators*, n.d.). More condensed definition is determined as the system of trade and industry through which a nation generates, utilizes, and manages its wealth (*ECONOMY | English Meaning - Cambridge Dictionary*, n.d.). By analyzing these descriptions, the keywords must be highlighted such as “network”, “interconnected”, “system” which shows that it covers numerous factors and criteria and also relates quite significantly with other processes such as consumption, sales of goods or wealth. Since it is described as the network and system identities there is a need to evaluate what actual criteria and axis are used to determine and calculate the economic trends whether it is rising or increasing.

Gross Domestic Product (GDP) is a commonly employed measure that represents the total value added by all producers residing within an economy. It serves as an indicator of economic growth, which is determined by changes in GDP at constant prices. Another widely used metric for evaluating a nation's prosperity and ability to support its population is Gross National Income (GNI) per capita. This figure is derived by aggregating the combined value added from both domestic and foreign sources, claimed by residents, and dividing it by the total population (*WDI - Economy*, n.d.). Unemployment rate, imports, exports, inflation rate, purchasing power parities, interest rates, production sales – the small part of the indicators identified by the Organization for Economic Cooperation and Development (OECD) where they provide dozens of indicators called Main Economic Indicators (*OECD Main Economic Indicators (MEI) - OECD*, n.d.). Therefore, we understand that economy defined by the keywords “system” or “network” is accurate since by having hundreds of indicators it is leading to the core of the economy itself as a “relationship” between those indicators which general overview and totality of them forms this definition. By analyzing the past researches on the similar topics in terms of sustainable economic growth it was determined that the further indicators to identify the economy and its increasing or decreasing

direction were: population growth on annual basis, unemployment rate calculated by the percentage of the total labor force, tourism as of number of arrivals (Awais et al., 2023). In addition, it was also observed gross domestic product, gross capital formation and exports that were assessed in the study of linkage between economic growth and fintech development (Tao et al., 2022a).

Addressing the sustainability in economy it is crucial to define what is necessary to have, what can be fundamental tools and what approach should be when applying the "sustainability" clause. To achieve sustainable economic and industrial growth, it is essential to have access to secure and sustainable energy resources. The transition towards a sustainable economy, centered on the use of biological raw materials, necessitates innovative approaches in research and development, production methods, and economic models. This shift calls for novel strategies and practices to ensure the long-term viability and sustainability of economic activities (Naik et al., 2010). The underlying philosophy of a sustainable economy lies in recognizing natural resources, rather than man-made, as a shared heritage of humanity. This perception entails the importance of fair distribution and equitable utilization of resources, promoting intragenerational justice (Lorek & Spangenberg, 2014). It also emphasizes the responsibility of leaving a just bequest for future generations, ensuring that they too can access and benefit from these resources. Economic sustainability pertains to the adoption of practices that foster sustainable long-term economic growth while safeguarding the well-being of the community in terms of social, environmental, and cultural aspects. It involves finding a balance where economic development aligns with the preservation of social cohesion, environmental integrity, and cultural heritage (*Economic Sustainability - Office of Sustainability*, n.d.). By prioritizing these interconnected elements, economic sustainability aims to ensure the continued prosperity and resilience of both the economy and the community it serves.

Another logical deriving opinion is that sustainable economy means the circulation of the materials that can be reused to produce the same goods when using the raw materials only once. Therefore, the circular economy model was developed in opposing view to the linear economy model. The concept of the circular economy revolves around a production and consumption model that promotes sharing, leasing, reusing, repairing, refurbishing, and recycling of materials and

products for as long as feasible. This approach aims to extend the life cycle of products while minimizing waste generation. When a product reaches its end-of-life stage, emphasis is placed on retaining its materials within the economy through effective recycling practices. By continually harnessing the productive utilization of these materials, the circular economy generates additional value over time (*Circular Economy: Definition, Importance and Benefits | News | European Parliament*, n.d.). In terms of reusing the same product as a resource it was very accurately identified by the United Nations Conference on Trade and Development (UNCTAD) "*the goods of today are the resources of tomorrow at yesterday's resource prices*" (*Circular Economy | UNCTAD*, n.d.). Also, they are actively involved in promoting the principles of the circular economy through various initiatives. These efforts encompass fostering dialogues and initiatives aimed at extracting value from waste streams, stimulating discussions on collaborative economy sectors, exploring innovative business models, and promoting consumer awareness along with behavioral changes. Through partnerships with other international organizations, UNCTAD's engagement in the circular economy extends to national and multilateral levels, serving the international community by prioritizing this crucial agenda.

As an mirroring view the linear economy model concept is pretty simple (*What Is the Linear Economy?*, n.d.) often known as the take-make-waste economy, operates on a system where resources are extracted for the production of goods that eventually become waste and are discarded. In this linear model, products and materials are typically underutilized, following a unidirectional flow from raw materials to waste. This inherently polluting system poses a threat to natural ecosystems and is a significant contributor to global issues such as climate change and the loss of biodiversity. A continuous direction of this linear model by logical means should empty the resources and ability to produce anything as correctly identified this harmful economy model led us to the growing scarcity of resources coupled with the rapid proliferation of electrical and electronic equipment. The recent studies showed that this subject is fundamental in order to perceive the sustainability and biodiversity (Leitão et al., 2023). Financial institutions and other companies should bear great responsibility and adequacy to this topic (*Linear and Circular Economies: What Are They and What's the Difference?*, n.d.) in light of the finite nature of our planet's resources, it is essential for individuals, governments, and companies to collaborate in order to adopt more responsible resource utilization practices. This is where the circular economy

comes into play, presenting a novel model that offers an alternative to the conventional linear economy.

Nevertheless, the transition to the circular economy model for industries and companies is not a straightforward task. It often entails more than just altering the product chain - in certain cases, it necessitates a complete reorganization of the company itself. The complexities arise from the need to shift mindsets, reconfigure production processes, establish new supply chains, and foster collaborations throughout the value chain. Moreover, embracing the circular economy may demand substantial investments in research and development, technology upgrades, and the cultivation of new skill sets among employees. Such comprehensive transformations underline the multifaceted nature of adopting the circular economy model and highlight the significant efforts required to achieve its implementation across industries and companies. In recent years, there has been an increasing interest in the circular economy due to its potential for positive transformation in environmental, social, and economic aspects. However, the adoption of circular economy business models (CEBMs) poses significant challenges for organizations, requiring substantial changes that can be particularly demanding. The transition from a linear to a circular economic model, as envisioned by the circular economy, entails a transformative and radical process. It necessitates systemic shifts at all levels during each phase of production, with businesses and consumers playing crucial roles as facilitators of this transition (Arranz & Arroyabe, 2023). There is a belief that the conceptualization of the circular economy as a sustainable production-consumption system has not received adequate attention and exploration (Suárez-Eiroa et al., 2021). While the principles of the circular economy offer immense potential for resource efficiency and waste reduction, there is a need for greater emphasis on the integration of resilience thinking within the circular economy paradigm. The inclusion of resilience thinking would enhance the CE (circular economy) framework by considering the capacity of systems to adapt, withstand disruptions, and recover from shocks. This integration would contribute to building robust and adaptable circular systems that can effectively address challenges posed by environmental, social, and economic dynamics.

When identifying the economic criteria and main indicators on the literature research it was observed that some of the indicators are also determined to track the sustainability. To expand the

background, when the SDGs were adopted, there were also indicators added to each of the goals that would help to trace the progress. The Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs) formulated the global indicator framework for Sustainable Development Goals (SDGs). This framework was collectively established and approved during the 48th session of the United Nations Statistical Commission in March 2017 (*SDG Indicators — SDG Indicators*, n.d.). In addition, this framework concludes out of 231 indicators that are collectively supervising and addressing the SDGs. On the 8th Sustainable Development Goal which is "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" directly intervenes with the current subject and the indicators to measure the traceability of this goal are: Gross Domestic Product per capita, average hourly earnings, tourism directed to GDP and more (*Global Indicator Framework for the Sustainable Development Goals and Targets of the 2030 Agenda for Sustainable Development Goals and Targets (from the 2030 Agenda for Sustainable Development) Indicators*, n.d.). Sustainability indicators are valuable instruments for policymaking and public communication. They serve as effective means to convey information regarding the performance of countries and corporations across various domains, including the environment, economy, society, and technological advancements. These indicators and indexes play a crucial role in simplifying, quantifying, analyzing, and communicating complex and intricate information by visualizing phenomena and highlighting trends (Singh et al., 2009). By doing so, they facilitate a better understanding of sustainability-related aspects and support informed decision-making processes. When considering the aspect of sustainability and examining its indexes or indicators, we realize that there is a wide array of options available for conducting an analysis that encompasses various possible variables. It is noteworthy that economic indicators and sustainable economy indicators often overlap and intersect, as the Sustainable Development Goals (SDGs) explicitly address issues that can be measured and evaluated using standard economic factors. These factors include, but are not limited to, metrics such as Gross Domestic Product (GDP), unemployment rates, tourism statistics, Consumer Price Index (CPI), and interest rates. The integration of these indicators within the framework of the SDGs demonstrates the interconnection between economic considerations and sustainable development, underscoring the significance of aligning economic policies and practices with environmental and social goals.

In analyzing the concept of the economy and sustainable economy, it becomes evident that the economy itself is defined by a complex network of indicators that enable the measurement of a country, jurisdiction, or area's economic level. On the other hand, the sustainable economy goes beyond mere economic considerations and strives for a delicate 'balance' between economic activities and environmental responsibility. This involves transitioning towards greener practices that prioritize reusability, recycling, and the implementation of circular economy principles. This shift towards sustainability can be seen as the distinguishing 'label' for both the economy and the community, signifying a collective commitment to fostering environmentally conscious practices while maintaining economic viability.

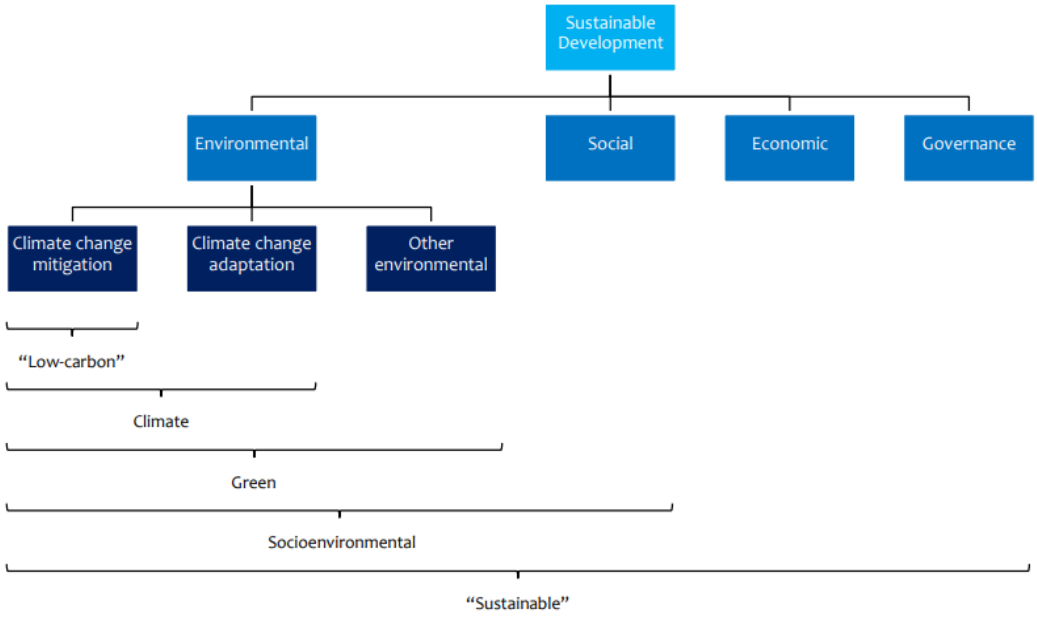
1.4. The nexus of green finance and sustainable economic development

To further analyze the sustainability involvement in the economy the term 'sustainable finance' is acknowledged as the most comprehensive, covering social, environmental, and economic factors. Meanwhile, 'green finance' pertains to financial tools specifically allocated for projects and initiatives that support environmental sustainability, along with environmental products and strategies. This aims to facilitate a transition to a green economy, focusing on low-carbon, sustainable, and inclusive development (*Explore Green & Sustainable Finance | Green Finance Platform*, n.d.). To simplify the definitions and understanding the scheme below (*Figure 2*) explains the area of each definition in sustainability. The connection between green fintech, commonly referred to as green finance, and the sustainable economy is quite clear when analyzed. It has become apparent that the metrics used to evaluate progress toward the United Nations' Sustainable Development Goals (SDGs) are largely aligned with those used in green financing. Green fintech plays an essential role in shaping the sustainable economy by directing capital, investments, and purposes toward environmentally sustainable projects through channels like green bonds and loans. This helps promote sustainability by funding initiatives that reduce environmental harm, improve social welfare, and build economic resilience. Governments worldwide recognize the importance of addressing pressing issues like climate change, inequality, and social exclusion, which has led to the adoption of the SDGs as a top priority. It is crucial to recognize that achieving the Sustainable Development Goals (SDGs) requires access to adequate

financial resources. Governments should prioritize securing the necessary funding for implementing these objectives through various means.

Figure 2

Sustainable development definition scheme



Source: United Nations Environment, 2016

By proactively allocating resources toward SDG-oriented initiatives, governments can facilitate sustainable development, combat climate change, advance inclusiveness, and reduce disparities. Providing sufficient financial support serves as a critical factor in advancing the SDGs, paving the way toward a more environmentally conscious and socially just future (Ziolo et al., 2021). For instance, the European Union has launched the NextGenerationEU project, aimed at attracting funds and capital for green projects following the COVID-19 pandemic's impact on EU member states' recovery efforts. The ultimate goal of this process is to become stronger and sustainable than before therefore by allocating necessary funding in terms of digitalization, clean water, and technology (*NextGenerationEU*, n.d.-a). Moreover, by keeping the subject on sustainable economic investments and green financing the European Union on 2021 October 21st have issued their first NextGenerationEU green bonds to be used exclusively for green and sustainable investments across the region. The value of the issue was 12 billion euros however the

issuance of this security was so underestimated because eventually the book order exceeded €135 billion, indicating that the bond was oversubscribed more than 11 times. This represents the largest order book for a green bond in the history of global capital markets and the largest issuance of a green bond at that time (*NextGenerationEU*, n.d.-b). By taking these investments into accounts we understand that this is part of the total investment portfolio as this is supranational investment however by holding onto the green bonds and green loans topic there are a lot more entities that are already have incorporated this kind of capital investment strategy. Corporations is also acting in the green market however in terms of issuing values corporate level is far away from the governmental level but this is a necessary piece to grasp as corporations are usually profit-orientated. This gives the challenge that coupon rates of standard bonds may be higher than green bond and on top of that the proceeds of the green and sustainable bonds can be used only for sustainable projects as it must be described in the security prospectus. To navigate back to the European Union 2021 October 21st issued green bonds the coupon rate was 0.4% at the time when preparing this master thesis there were several more issuances, however, now the coupon rate was significantly higher, therefore potentially attracting new investors with more desirable returns. The below table (*Table 2*) provides us with all NextGenerationEU (*ticker NGEU*) issued bond rounds (*Transactions Data*, n.d.):

Table 2

European Union syndicated transactions

ISIN	Instrument	Transaction date	Maturity	Volume (MM EUR)	Coupon	Yield
EU000A3K4C42	NGEU green bonds	2021-10-12	04/02/2037	**12,000**	0.400%	0.450%
EU000A3K4DG1	NGEU green bonds	2022-04-05	04/02/2043	**6,000**	1.250%	1.370%
EU000A3K4DM9	NGEU green bonds	2022-06-21	04/02/2048	**5,000**	2.625%	2.713%
EU000A3K4DW8	NGEU green bonds	2022-11-15	04/02/2033	**6,000**	2.750%	2.820%

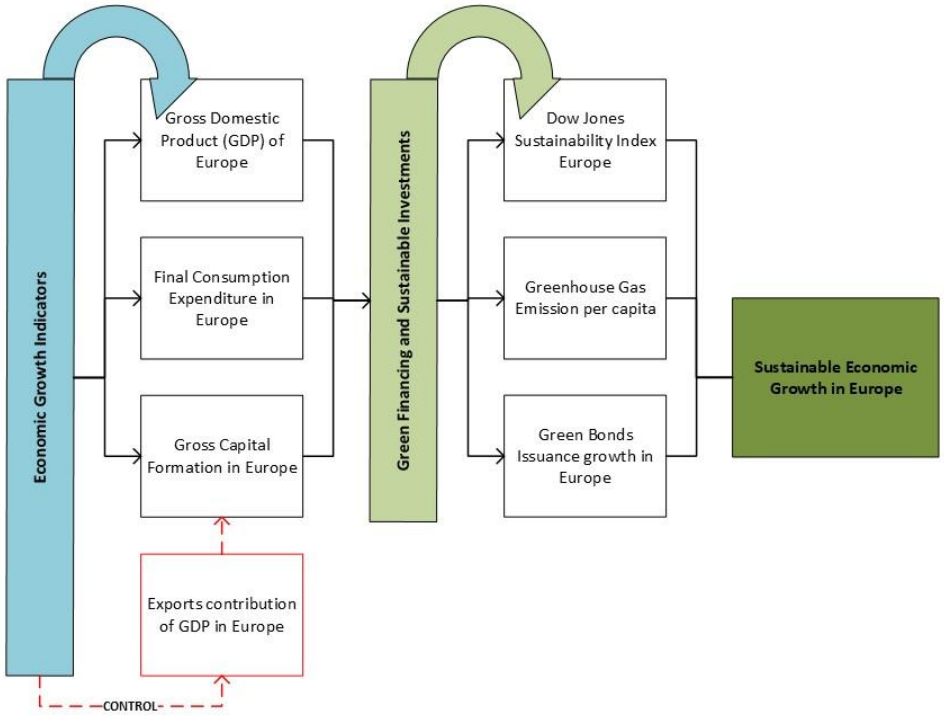
Source: European Commission

The interrelationship between green financing and sustainable development or economy can be identified as a dynamic nexus that operates in both directions. Extensive studies have been conducted to examine and analyze the reciprocal impact between sustainable development and green finance. These studies shed light on how sustainable development initiatives, encompassing environmental, social, and economic dimensions, can influence and shape the landscape of green financing. By exploring the intricate connections and feedback loops, researchers have gained valuable insights into the synergies and mutual benefits that arise when sustainable development principles are integrated into the realm of green finance. The findings from these studies contribute to a growing body of knowledge, fostering a deeper understanding of how green financing and sustainable development can collaboratively drive positive environmental and socio-economic outcomes. (Xiao et al., 2019). In accordance to the analyzed literature and compiling the problem that is arising, the conceptual model was created (*Figure 3*) to visualize potential synergy and positive impact of green financing to the sustainable economic growth.

Furthermore, it is worth noting that Environmental, Social, and Governance (ESG) factors play a vital role in underpinning sustainable development. Sinha et al. (2021) emphasizes the intrinsic connection between ESG considerations and sustainable development objectives. These factors are prominently incorporated within the green bonds market, actively contributing to its conservation and promotion. Green bonds, with their specific focus on financing environmentally sustainable projects, align closely with the principles of ESG (Sinha et al., 2021). By integrating ESG criteria into the evaluation and selection process of green bonds, issuers and investors can ensure that the funded projects uphold high environmental standards, address social concerns, and adhere to strong governance practices. The integration of ESG factors within the green bonds market serves as a mechanism to drive sustainable development efforts, enabling the allocation of capital towards projects that deliver positive environmental and social outcomes while maintaining robust governance frameworks.

Figure 3

Conceptual model



Source: Established by the author

To summarize, the literature research part of this subject that aims to observe a role and impact from the green financing to sustainable economic growth it was established that the relevance of this topic is increasing meaning that stakeholders and people are taking this matter seriously. Obtaining a more holistic approach on this subject the green financing it considered a process through which the funds are being channeled towards the sustainably driven projects that defines various problems and aspects as per provided *Figure 1* that depicts it. In the green financing channeling mostly, it is used via the technology therefore the definition of green fintech was established which connects the intersection of the sustainability and green principles with the investors and the capital. This part is considered to be crucial factor when determining the economy, as the investments results in the growth of the company, industry or country then it resonates into the economy, so the linkage between these variables are fundamental. In order to fulfil the research in a success manner the appropriate analysis method must be used to most accurately determine actual role of the green financing. After the analysis of the other case studies

and research papers it was compiled in the *Table 1* that most of the authors are using regression modelling when analyzing the economy and sustainability relationship, several of the studies used the more advanced analysis methods that were out of the competency and knowledge range. Out of the literature it was understood that sustainability and green investments has an impact on the economy without a doubt, however, since the economy itself is a complex conglomerate of various variables the studies are using different variables. Nevertheless, there are some most popular and top used variables such as gross domestic product or exports in terms of economy and green bonds issuance standing in the green financing side.

2. METHODOLOGY OF ASSESSING THE IMPACT OF GREEN FINANCE TO SUSTAINABLE ECONOMY

The literature research encompassed a comprehensive exploration of diverse interrelated topics, aimed at acquiring a nuanced understanding of the intricacies surrounding definitions, measurement, and evaluation within the field. Research methods exhibited considerable variation, highlighting the diverse approaches employed in the field. Notably, regression analysis and conducted surveys emerged as prominent methods (*Table 1*), along with the subsequent application of analysis models. In the process of assessing the referenced literature, a significant number of studies were identified that extensively utilized regression analysis and indexes, particularly within the context of the economy and financing domain. This case of studies employing regression analysis can be justified by its robust analytical capabilities, allowing for the examination of relationships, trends, and predictive factors within complex economic systems.

2.1. Establishment of objective and process of analysis

As the necessity to identify the impact between then green financing and economic growth in Europe we have to classify what variables will be used in the research part that would describe at its best mentioned factors. For the economic growth main indicators in economical perspectives are: Gross Domestic Product (GDP) it can be used as growth index, final consumption expenditure used as well, Consumer Price Index (CPI) and Imports in Europe. As per analyzed literature GDP and in some cases, Exports were used most of the time.

Objective of the research. The objective of this research is to analyze the impact of sustainable finance, as represented by green bonds, and environmental factors, reflected in greenhouse gas emissions, on economic performance indicators such as GDP growth rate, final expenditure and capital formation of the European region. Employing econometric models like Ordinary Least Squares (OLS) and Impulse Response Function (IRF), this study aims to reveal the dynamics of these relationships and offer insights into how sustainability efforts interact with economic activity.

Time period. The analysis period for the subject is from 2014 to 2022 (9 years) on quarterly basis in order to assess the statistical information with extremums and its values in cases

of COVID-19 and current ongoing war aggression and invasion in Ukraine. This will provide expected volatility in the analysis that will be interesting and useful to interpret and analyze. In addition to the time frame selected for this research the starting year of 2014 was selected since the Green Bonds Principles were introduced as per (Hyun et al., 2021) methodology.

Studied variables:

There will be different dependent and independent variables that will be used for this analysis. As our ultimate goal is to understand the green financing effect to the economy the independent variables such as Dow Jones Sustainability Index (DJSI), Green House Gas Emission per capita (GHG) and Green Bonds Issuance (GB) will represent the green financing segment. growth the variables were differentiated by the origin. The full raw spreadsheet of variables time series data is provided in the annexes of this research (*Annex No. 1*).

- Economic variables (EV)
- Green financing variables (GFV)

Table 3

Descriptions, symbols, measurement and sources of the independent, dependent and control variables

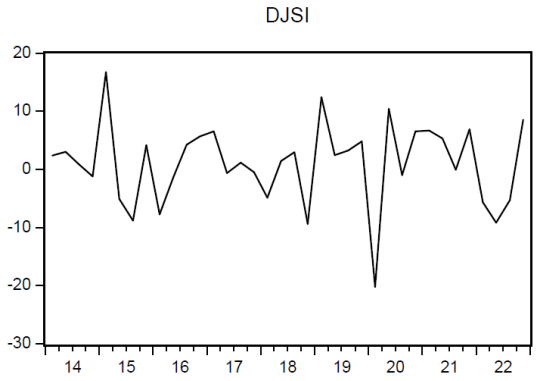
Type	Name of variable	Symbol	Measurement	Source
Dependent (EV)	Gross capital formation (as a % form GDP)	Y1	percentage (%)	Bloomberg Terminal
Dependent (EV)	Gross Domestic Product Growth	Y2	percentage (%)	Bloomberg Terminal
Dependent (EV)	Final consumption expenditure (as a % of GDP)	Y3	percentage (%)	Bloomberg Terminal
Independent (GFV)	DJ Sustainability Index	DJSI	percentage (%)	Bloomberg Terminal
Independent (GFV)	Greenhouse Gas Emission (per capita)	GHG	percentage (%)	Eurostat
Independent (GFV)	Green Bonds Issuance	GB	percentage (%)	Bloomberg Terminal
Control (EV)	Exports of goods and services (as a % of GDP)	EXPO	percentage (%)	Bloomberg Terminal

Source: Established by the author

Dow Jones Sustainability Index. The Dow Jones Sustainability Index (DJSI) is a globally recognized benchmark that assesses the sustainability performance of companies. It evaluates various environmental, social, and governance (ESG) factors to determine the inclusion of companies in the index. The DJSI serves as a valuable tool for investors and stakeholders to identify and compare the sustainability performance of companies, fostering transparency, accountability, and responsible investment practices. In the research the Dow Jones Sustainability Index will be used in percentage expression of the index value change, for the best effort of the literature research such variable was not taken into the consideration when assessing the impact of sustainable economy growth, therefore we expect that this variable would positively contribute to the estimated models. The raw data chart of the variable is provided below (*Chart 3*).

Chart 3

Dow Jones Sustainability Index variable time series graph



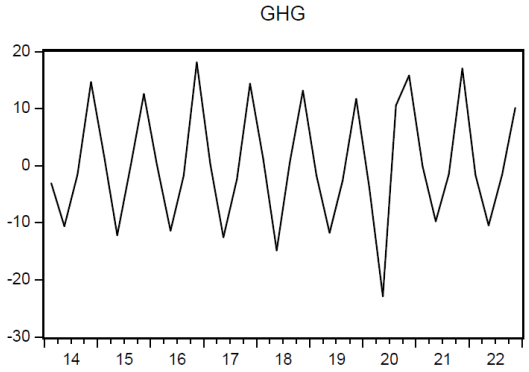
Source: Compiled by the author

Greenhouse Gas Emission. Greenhouse gas emissions (GHG) refer to the release of gases into the atmosphere that contribute to the greenhouse effect and global warming. These gases, such as carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), trap heat from the sun and prevent it from escaping back into space, leading to an increase in the Earth's temperature. GHG emissions are primarily generated through human activities, including the burning of fossil fuels, deforestation, and industrial processes. The accumulation of GHGs in the atmosphere is a significant driver of climate change, with adverse effects on ecosystems, weather patterns, and human health. This variable is broadly used by other researchers in their analysis such as (L. Wang

et al., 2020) or (Shahbaz et al., 2018a) who have used metric tons per capita, therefore, as a follow-up - the same measurement will be used with additional improvement – the variable will be estimated as percentage change of previous quarter of the greenhouse gas emission on tons per capita in the Europe. The raw data chart of the variable is provided below (*Chart 4*).

Chart 4

Greenhouse gas emission variable time series graph

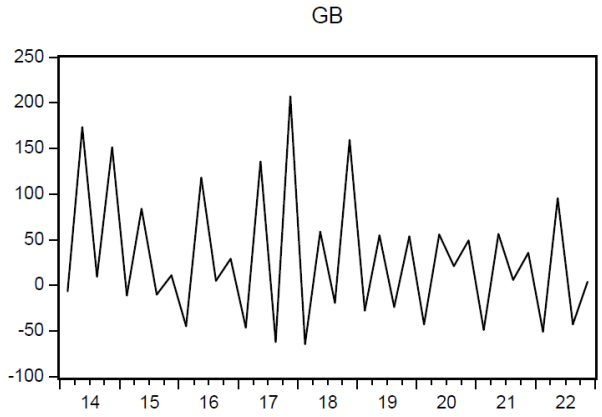


Source: Compiled by the author

Green Bonds (GB). Variable that represents the biggest share of the green financing in the European area both at municipal or governmental and corporate level as well as supranational level. The green bonds criteria were carefully collected from the Bloomberg Terminal from all of the securities with Green Instrument Indicator from Bloomberg Terminal with the field DT607 which indicates if the net proceeds of the fixed income instrument will be applied toward green projects or activities that promote climate change mitigation or adaptation, or other environmental sustainability purposes. Originally the value of this variable was taken as the total amount of bonds issued per period (quarter) the numbers were collected in millions, in accordance to achieve more statistically clearer results, the time series data was adjusted to the percentage change of previous period. In total during the period from 2014Q1 to 2022Q4 there were 26 038 bonds issued which country of incorporation is Europe with the green instrument indicator as per literature analysis of (Hyun et al., 2021) it differs in the amounts as the author used different labeling. In this research we are confident to use another Bloomberg terminal indicator that shows proceeds of the bonds are used for green projects. The raw data chart of the variable is provided below (*Chart 5*).

Chart 5

Green bonds variable time series graph

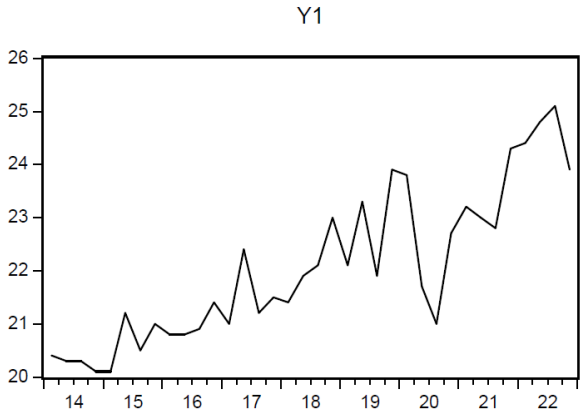


Source: Compiled by the author

Gross capital formation (GCF). This variable represents the investment part of the European region as a whole that was made into the capital goods that serves future production and tangible assets such as transportation infrastructure, machinery buildings or equipment, moreover, the variable also used in the other authors research (Tao et al., 2022a). Gross capital formation was selected as it contributes significantly to the overall economic growth and enhances the productive capabilities that are fundamental for the long-term economic growth. The raw data chart of the variable is provided below (*Chart 6*).

Chart 6

Gross capital formation variable time series graph

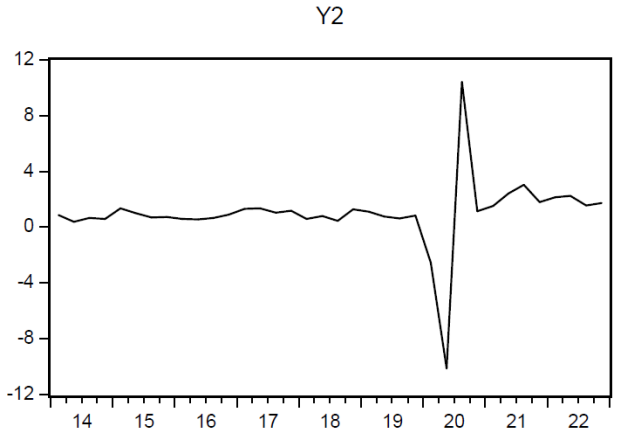


Source: Compiled by the author

Gross Domestic Product Growth (GDP). the percentage increase in the total value of goods and services produced within a country over a specific period of time. It is a key indicator of economic growth and is often used to assess the overall health and performance of an economy. Positive GDP growth signifies expanding economic activity, increased productivity, and higher standards of living. A higher GDP growth rate is generally associated with improved employment prospects, higher wages, and increased consumer spending. Policymakers and economists closely monitor GDP growth to inform policy decisions and assess the effectiveness of economic strategies. In the period from 2014Q1 to 2022Q4 the graph of the gross domestic product had a systematic break between 2019Q4 and 2021Q2 due to the COVID-19 pandemic that significantly affected the variable. As time series modelling regression is being used it can provide difficulties in determining the clean relationship between sustainable financing and the GDP. The variable is expressed as the percentage growth from the past period. This variable is also heavily supported by the (Ang, 2007) (Tao et al., 2022a) or (Shahbaz et al., 2018b) as its importance to measure the performance of the economy. The raw data chart of the variable is provided below (*Chart 7*).

Chart 7

Gross domestic product variable time series graph



Source: Compiled by the author

Final Consumption Expenditure (FCE). It is also one of the main contributors to the overall gross domestic product of the Europe, in the national accounts the final consumption expenditure accounts for the total spendings by households, non-profit organizations and

governments. This variable was chosen because it clearly depicts economy health meaning what is the current state in regards from the other metrics that support the economy and it also describes the consumers' confidence level that allows us to understand if the FCE is going up, meaning its share in overall GDP of the Europe rises as well, automatically boosting the GPD itself. The data was carefully collected from the Bloomberg Terminal of quarterly data in the European National Accounts statistics where the percentages of the % of this metric was provided. The raw data chart of the variable is provided below (*Chart 8*).

Chart 8

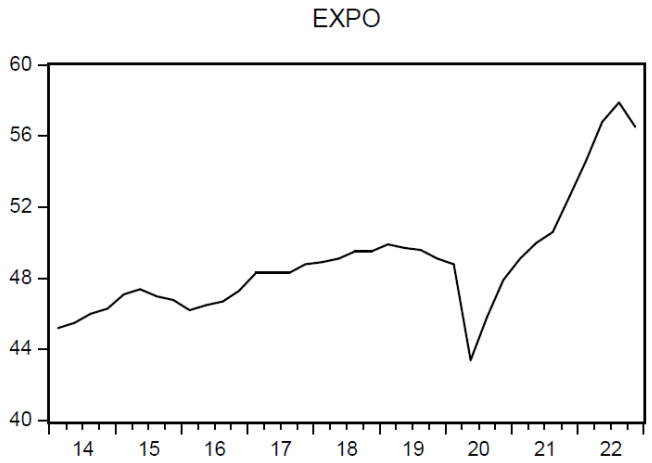
Final Consumption Expenditure variable time series graph

Source: Compiled by the author

Exports from Europe (EXPO). The trades of merchandise from Europe to the Non-European, the export is fundamental part for the economic growth because it serves as the economic indicator in macro understandings. The more value in exports means the more proceeds the exporter, in this case, The Europe receives which adds-up to the Gross Domestic Product as well. This metric was selected as a control variable in the regression model in order to improve model accuracy since the control variable is related to the independent variable, by doing this, the error term and bias is reduced. The exports from the Europe is expressed as percentage of the gross domestic product. The raw data chart of the variable is provided below (*Chart 9*).

Chart 9

Exports variable time series graph



Source: Compiled by the author

2.2. Regression analysis methodological approach and effectiveness

As per literature analysis where research methods of similar methods it was found out that regression models are the most effective and convenient way to establish relationships and measure relevance and impacts (*Table 1*). The main research part that will emerge from the methodology will rely on the regression analysis that was previously analyzed during the literature and case studies overview and research. Therefore, it is crucial to establish the full process of the selected regression analysis models and various tests. Linear regression allows us to understand the relationship between the dependent and independent variables and how powerful the effect is. As we are using more than one independent variable the model becomes multiple linear regression and it is provided below:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + .. + \beta_z X_z + \beta_{control} X_{control} + \varepsilon \quad (1)$$

Where:

Y – is the dependent variable; $X_{1,2,3,z}$ – are the independent variables; β_0 – is the intercept of the dependent variable or the value of Y when the $X_{1,2,3,z} = 0$; $\beta_{1,2,3,z}$ – are the slopes of the

$X_{1,2,3,z}$ accordingly that would indicate the change of the Y when the independent variable changes in one unit; $\beta_{control}$ – is the slope of the control variable; $X_{control}$ – is the control variable; ε - represents the error term, accounting for the difference between the observed and predicted values.

Given the previously described variables table and the multiple regression linear model in total of three regression models are comprised:

$$Y1 = \beta_0 + \beta_1 GB + \beta_2 GHG + \beta_3 DJSI + \beta_4 EXPO + \varepsilon \quad (2)$$

$$Y2 = \beta_0 + \beta_1 GB + \beta_2 GHG + \beta_3 DJSI + \beta_4 EXPO + \varepsilon \quad (3)$$

$$Y3 = \beta_0 + \beta_1 GB + \beta_2 GHG + \beta_3 DJSI + \beta_4 EXPO + \varepsilon \quad (4)$$

Where $Y1$ - represents the gross capital formation (GCF), $Y2$ - represents the gross domestic product (GDP) and $Y3$ - represents the final consumption expenditure (FCE). Further as of independent variables GB – green bonds issuance growth, GHG – greenhouse gas emission tones per capita growth, $DJSI$ – Dow Jones Sustainability Index growth, $EXPO$ – exports as a percentage of the gross domestic product.

2.3. The research method of relationship between variables and process.

1. Literature analysis is a crucial and fundamental part of research as it allows to introduce with the subject and the topic and to get knowledge on already completed studies, tests. In addition, it is necessary to understand the definitions and how they are interpreted by the researchers, to understand what is the approach and algorithm used in the analysis.
2. The process of attaining the objective is firstly by collecting correct variables time series data from trusted sources. In this case the sources were two – Eurostat (ticker – ESTAT) and Bloomberg Terminal (ticker – BT).
3. When data is collected in the xlsx format it is necessary to review if no mistakes in terms of number recognition is observed and prepare the files to be uploaded to the statistical analysis system. For this thesis the system EViews will be used which requires the data to be strictly correct.

4. Regression analysis is a statistical method used to examine the relationship between a dependent variable and one or more independent variables. In the context of the economy, regression analysis can be applied to explore how changes in independent variables. To create an accurate model the time series data must be stationary. For the stationarity checks the Augmented Dickey Fuller test (ADF) will be used to determine that, the goal is to receive the statistical significance or the p-value output of each variable that would be less than 0.05. In case at the level the p-value will be higher than 5% then differentiating will be used at 1st difference the natural logarithm LN will be used and if required at 2nd difference the subtraction of logarithmic values will be implemented.
5. Linear regression equation will be estimated using dependent variable and several independent variables, in addition a control variable also be used in the equation. To check the robustness of the model the tests below will be assessed:
    a. Serial correlation - Breusch-Godfrey Serial Correlation LM test - will help to detect the presence of autocorrelation in the residuals of the regression model. Autocorrelation can lead to inefficient estimates and can cause the standard errors of the coefficients to be biased, leading to unreliable hypothesis tests. To better improve the test robustness several attempts will be included using 2;3;4; lags respectively because the data is quarterly, and testing up to a year worth of lags is reasonable to capture any seasonal patterns that might not be accounted for by other variables in the model.
    b. Model specification – Ramsey RESET test – it helps to understand whether non-linear combinations of the fitted values help explain the dependent variable, which would indicate that the model might be incorrectly specified. Additionally, to make the testing more significant number of fitted terms that refers to the number of additional terms derived from the model's fitted values that are included in the test regression, will be squared (FITTED^2).
    c. Residual diagnostics - Breusch-Pagan and White test for heteroskedasticity - this test in the literature research was selected by the (Tao et al., 2022b) therefore used in this research as well. It helps to assess whether the variance of the errors from the regression is dependent on the values of the independent

variables, which is a violation of the homoskedasticity assumption of ordinary least squares (OLS). If heteroskedasticity is present, it can make the standard errors of the coefficient estimates biased, affecting the test statistics and confidence intervals. The objective of the test is that null hypothesis of homoskedasticity would not be rejected, meaning having a p-value (statistical significance value) above the 0.05 area. To strengthen this part of the testing additional White test will be conducted to compare the results, the main objective of this testing is that both test results would not reject homoscedasticity hypothesis and would complement each other.

6. When the regression models will be computed in order to visually understand the impacts the Impulse Response Function (IRF) will be used to analyze and determine the affection that variable has on each other during the period, since in the economy understanding at some situations the effect of one variable to another can be delayed due to economic cycles and complex processes.

From the comprehensive literature review examining the interplay between green financing, sustainability, and economic growth, and in alignment with the research objective, the following hypotheses are deriving:

H1. The gross capital formation (Y1) is affected positively by the green financing variables, therefore supporting sustainable economic growth. The similar approach was used by the (Tao et al., 2022a) in identifying the relationship between the financial technology and low-carbon economy the results showed that it contributes heavily to the sustainability.

H2. The gross domestic product (Y2) is affected positively by the green financing variables, therefore supporting sustainable economic growth. As per (Shahbaz et al., 2018b) the gross domestic product and environmental degradation is fundamental question. That results in short-term increase of economic growth and later on decreases. Greenhouse gas as one of the variables are included along with green financing ones to achieve the same causality.

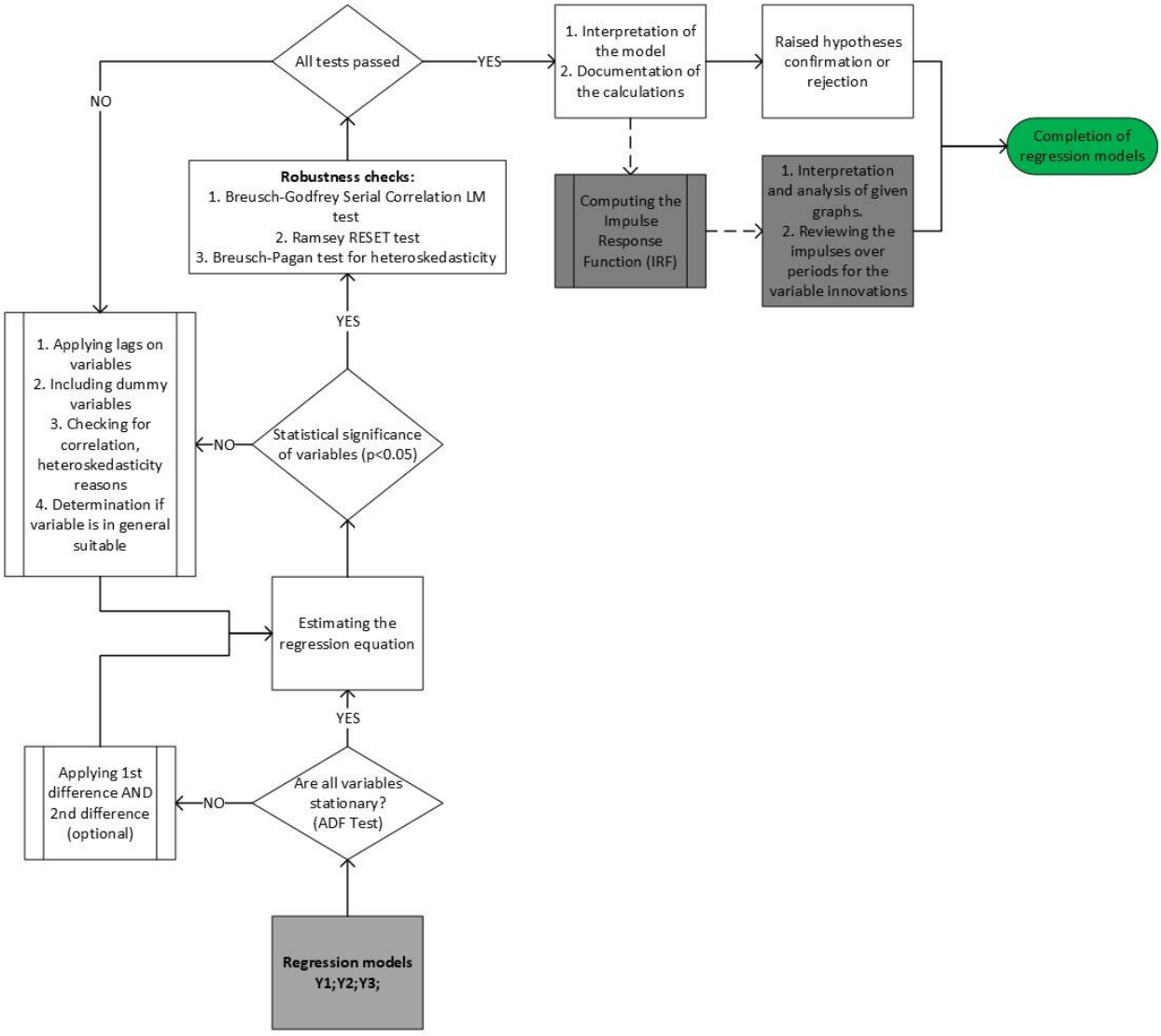
H3. The final consumption expenditure (Y3) is affected positively by the green financing variables, therefore supporting sustainable economic growth. By the (Hronová et al., 2022) it is established that final consumption expenditure heavily depends on economic policies so do green

bonds from this research therefore it is expected that green financing economy policies should also have impact and dependency.

By following these hypotheses, the visual plan map was created (*Figure 4*) to accurately depict the research approach and applied tests.

Figure 4

Flowchart of estimated research assessment process



Source: Compiled by the author

To summarize the methodological part of this research regarding the determination of the impact and relationship between economic growth indicators and green financing tools – green bonds and Dow Jones Sustainability Index along with overview of greenhouse gas emissions, very often used method – regression modelling was selected. As from the literature analysis the regression is the most efficient way to identify the relationships and measure the impact. Since the economy is a complex conglomerate of various metrics it was decided that one regression model is not enough to accurately address the research problem, therefore in total of three dependent variables were selected – gross domestic product (GDP), final consumption expenditure (FCE) and gross capital formation (GCF). To complement and make the model more robust the control variable was implemented – exports of the European region as a percentage of the GDP by the estimation since the export is one of the key components of the gross domestic product the significance of this variable should always be positive. In the methodological part the hypotheses were raised each of it aiming for the positive relationship and significance regarding each dependent variable. As the regression model can provide us with the insights of the significance and effect, the impulse response function (IRF) will also be conducted to receive impulse graphs that will be analyzed and interpreted as it helps to see the impulse response in the longer period of time, therefore increasing the accuracy of addressing the solution from the right angle and providing correct recommendations for improvements.

3. RESULTS OF ASSESSING THE IMPACT OF GREEN FINANCE TO SUSTAINABLE ECONOMY

The empirical part of this research aims to provide calculations that derives from the methodological part which establishes the analysis method which will be the multi regression linear model since more than one dependent variable is used. Out of this the three linear regression models were estimated and equations created. On the research part the main goal is to assess these calculations by testing the stationarity at first and check for the initial correlation between variables, furthermore, creating the actual regression models and modify if necessary, using lags or dummy variables as per accepted research flowchart (*Figure 4*).

3.1.Development of variables and stationary time series

By the developed methodological part and the flowchart of the estimated research assessment process (*Figure 4*) the modelling will be done with the time series. In order for the model to be accurate the time series must be stationary, meaning that variance, mean and autocorrelation do not change over the time. In situations where the time series are stationary, they can show us trends, seasonality. Since the economy itself has the economic cycles therefore the seasonality is expected and in some cases trend as well. Before starting reviewing covariance analysis and stationarity testing the time series were opened through the descriptive statistics of the independent variables (*Table 4*). The descriptive statistics shows us that green bonds and greenhouse gas emissions are showing a positive skewness meaning that the tail is indicating to the right, whereas Dow Jones Sustainability Index and exports are negative meaning that the tail is going left. As a highlight the exports skewness is significantly high indicating a substantial left side. In addition, it is observed that green bonds mean is 31.07 indicating that averagely per period the increase in value is more than one third which represents a quite significant increase. To put attention onto the control variable that represents also the economy growth it is exports that its mean is significantly small as the economy is not circulating in sharp increases or decreases the exports current mean is quite steady. However, in terms of sharp breaks in the time series the COVID-19 made a significant impact to economy therefore even in such complex criterions the systematic break is observable.

Table 4

Descriptive statistics of independent variables

	GB	GHG	DJSI	EXPO
Mean	31.07053	0.178225	0.961463	0.006376
Median	11.30952	-1.522310	1.471555	0.006501
Maximum	207.2848	18.09890	16.75771	0.053825
Minimum	-64.22414	-22.91181	-20.21032	-0.117271
Std. Dev.	72.66242	10.37116	7.187232	0.027450
Skewness	0.733171	0.036934	-0.511720	-2.397768
Kurtosis	2.670488	2.299200	3.864972	13.10064
Jarque-Bera	3.293992	0.724174	2.618593	182.3210
Probability	0.192628	0.696222	0.270010	0.000000
Sum	1087.469	6.237884	33.65119	0.223144
Sum Sq. Dev.	179514.1	3657.076	1756.314	0.025619
Observations	35	35	35	35

Source: Compiled by the author

Prior to conducting Augmented Dickey-Fuller (ADF) test on stationarity, the variables were checked and reviewed for potential multicollinearity which can lead to reduced precision, model misspecification and interpretation difficulties. In the process of correlation if the value is close to -1 or 1 therefore the correlation is considered as high and value closer to 0 indicated low correlation. The correlation analysis was compiled with selected statistics: correlation, t-Statistic and probability. In the correlation matrix (*Table 5*) it was observed that none of the variables have correlation that we could consider strong which would then indicate to not include one or another variable in the regression model. Before compiling and determining these variables there was an exchange traded fund – IUSK_GR which is iShares MSCI Europe SRI UCITS ETF had a very strong correlation with the Dow Jones Sustainability Index since both of the variables are tracking companies that are related to ESG frameworks and reduced fossil fuel indexes. Therefore, the ETF was removed from the studied variables even in the methodological part due to very strong correlation. Among the table provided above the strongest correlation is observed between exports and greenhouse gas emission which is 0.384542 with t-Statistic of 2.393029 and probability of

0.022600 however the correlation is not that significant that we should consider removing or adjusting the variables.

Table 5

Correlation matrix of independent variables

Correlation **t-Statistic** **Probability**	**GB**	**GHG**	**DJSI**	**EXPO**
GB	1.000000			

GHG	0.007324	1.000000		
	0.042071	----		
	0.966700	----		
DJSI	-0.050592	0.094462	1.000000	
	-0.291004	0.545083	----	
	0.772900	0.589400	----	
EXPO	-0.045264	0.384542	-0.108269	1.000000
	-0.260291	2.393029	-0.625637	----
	0.796300	0.022600	0.535900	----

Source: Established by the author

In the context of stationarity as per methodological part the Augmented Dickey-Fuller test is applied for each variable both independent and dependent in order to have stationary times series data. To achieve time series stationarity, it is necessary to reject the null hypothesis of the ADF test which is that variable has the unit root. The general equation of the ADF testing is provided below (*Equation No. 5*)

$$\Delta yt = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \delta_2 \Delta y_{t-2} + \ldots + \delta_p \Delta y_{t-p} + \epsilon t \qquad (5)$$

Where: Δ - is the difference operator, y_t - is the value of the time series at time t, α – is a constant, βt - represents a deterministic time trend, γ - is the coefficient on y_{t-1}, the lagged value of the series, $\delta_1, \delta_2, \dots, \delta_p$ - coefficients of lagged difference terms, ϵt – is the error term, p - is the number of lagged differences used in the regression.

Table 6

Augmented Dickey-Fuller test results of all variables (unit root testing on level basis)

Variable	t-Statistic	Probability
Y1	-1.841433	0.355100
Y2	-7.224243	0.000000
Y3	-2.174285	0.218900
GB	-12.381390	0.000000
GHG	-3.056615	0.041000
DJSI	-7.204743	0.000000
EXPO	-0.289214	0.916600

Source: Compiled by the author

From the Augmented Dickey-Fuller test on a level basis it is observed that several variables are having higher p-value than 0,05 meaning that the time series are not stationary – gross capital formation (Y1), final consumption expenditure (Y3) and exports (EXPO) are not stationary to be exact. By following the methodology estimated flowchart of the analysis, in case of ailed ADF testing it is necessary to do a 1st level differentiation and apply the test again. After the first application of difference where natural logarithm was used (*Equation No. 6*) all not stationary time series showed that null hypothesis was rejected and p-value was below 0,05.

$$\ln\left(\frac{X}{X_{-1}}\right) \qquad (6)$$

Where X – present value of the variable and X_{-1} – previous period pats value of the variable.

In the retrospective of this part of the research, the variables were carefully reviewed and in order to build a robust regression models the stationarity check was applied – Augmented

Dickey-Fuller testing to test if the time series has the unit root. Several variables were not stationary (Y1, Y3 and EXPO) therefore 1st difference was applied. After this process all variables a were stationary, however, since the 1st differentiation was applied, those variables created a new time series whereas 2014Q1 is N/A as by the equation (5) it is not possible to calculate it. Therefore, in general the regression model time period shrunk starting from 2021Q2 to 2022Q4 which applies to all the variables even those which were not differentiated.

3.2. Establishment of linear regression models

When creating the regression model the concept of the established flowchart in the methodology was used and using the already created equation template (*Equation No. 2*). Firstly, the variables were written directly without any specific modifications, meaning that time series are form 2014Q2 to 2022Q4 since the 1st differentiation was used. The initial regression model of gross capital formation (Y1) gave the result as indicated below in the regression model table (*Table 7*) of the independent variables. From the received output it is observed that the regression model is showing multiple discrepancies. The objective of the model is to achieve statistical significance meaning that p-value cannot be higher than 0.05, therefore, only green bonds are showing the statistical significance – exports as well, however it is a control variable that is very closely related to the independent variable therefore its significance is not surprising.

Putting more attention to the green bonds' issuance the coefficient β_1 of it is also relatively small indicating significantly small positive impact to the dependent variable. The R-squared indicates that the model or the independent variables explains only 32,17% of the whole model therefore it is not entirely accurate by also taking into the account the statistical significance of the variables. Therefore, trying to achieve the goal and to apply these variables to the gross capital formation it is necessary to apply modifications to the model. By the methodology flowchart (*Figure 4*) several modifications are considered – either lags or dummy variables. Dummy variables are being applied if some extreme values are observed in the residuals graph, whereas lags are being applied to one or more variables itself.

Table 7

Gross capital formation growth rate (Y1) not modified regression model

Dependent Variable: Y1 **Method: Least Squares** **Sample: 2014Q2 2022Q4**		
Variable	**Coefficient**	**Prob.**
C	-0.004832	0.4778
GB	0.000188	0.0296
GHG	0.000455	0.4767
DJSI	-0.000254	0.7661
EXPO	0.574968	0.0226
R-squared	0.321769	
Durbin-Watson stat	2.656044	

Source: Established by the author

The motivation behind putting lags on the variables is the economic assumptions that not automatically if one metric changes it makes impact instantly to another, since in the model we have corporate and governmental bonds which is complex investment instrument it might take time for that to reflect on economic cycle or other metrics. By trying different combinations with the lags for the first regression model (*Table 7*) it was successfully enhanced and developed into more accurate one as provided in the table below (*Table 8*). At final, it required to include lags on almost all variables besides greenhouse gas emissions and also, in order, to remove one extreme value the dummy variable was included in the equation. The final gross capital formation regression model (*Table 8*) shows that the variables are statistically significant and the R-squared almost two times up to 61,73% where we can consider the model acceptable, the Durbin-Watson criteria is also closer to the value of 2 which means that no autocorrelation is detected. To interpret the received regression model, it is observed that from the original model the green bonds are showing negative impact if the issuance is increasing 3 quarters prior meaning that potentially the green financing through the green bonds is making short-term negative effect to the gross capital formation.

Table 8

Gross capital formation growth rate (Y1) final regression model

Dependent Variable: Y1 **Method: Least Squares** **Sample: 2015Q1 2022Q4**		
Variable	**Coefficient**	**Prob.**
C	0.010122	0.0921
GB(-3)	-0.000240	0.0022
GHG	0.001148	0.0320
DJSI(-1)	0.002234	0.0037
EXPO(-1)	0.549615	0.0055
D1	0.081539	0.0112
R-squared	0.617351	
Durbin-Watson stat	2.264087	

Source: Established by the author

Since the description of the dependent variable indicates that it is investment for the tangible assets and represents investment part for long-terms therefore the included lag-length of 3 does have negative effect. On the other hand, it is observed that Dow Jones Sustainability Index (DJSI) with one lag which means one quarter prior value is providing a positive effect in the gross capital formation, showing positivity that can be explained when the companies who are tracked using the index are also heavily invested or rely on the assets such as machinery buildings or equipment that are being used for the production which raises the economic level as well. The effect is that if the DJSI growth rate would increase by 100 bps the overall gross capital formation would increase 22,34 bps and also given the probability value which is 0.0037 which is statistically significant it is stated that by given evidence the DJSI which represents the share of the green financing impact is positive and meaningful over the independent variable. Analyzing the greenhouse gas emission growth rate and it effect we see that by 100 bps increasement of the emission growth rate the gross capital formation would increase total of 11,48 bps which indicates that pollution, in this case, greenhouse gas emission growth is enhancing the economic growth factor. As the model shows us that emitting more greenhouse gas would increase the economic

growth for this metric it is worth to mention that in the real-world economic context and the sustainable approach the calculations should be taken with caution meaning that in the long term such decision might have negative results. When forming a policy or a strategy for an economic growth this model should be taken as an example that it is better to decouple the pollution from economic growth and focus more on sustainability axis and promoting green financing as it is showing positive impact as well. As a result, the final regression model equation (*Equation No. 7*) for the gross capital formation is provided below:

$$Y1 = 0{,}010122 - 0{,}00024 * GB_{t-3} + 0{,}001148 * GHG_t + 0{,}002234 * DJSI_{t-1} + 0{,}549615 * EXPO_{t-1} + 0{,}081539 * D1 + \varepsilon \quad (7)$$

Moving to another dependent variable which is gross domestic product growth (Y2) the same approach of compiling firstly the not-modified model was established showing us the results as provided in the table (*Table 9*). The model shows that it is statistically insignificant given then probability values that are over 0.05 threshold except the exports that is the control variable in this regression model. The R-squared is quite high which is 67,82% explanatory rate of the model, however, given probability ratios the model was considered inaccurate therefore requesting to some modifications that would be lags and dummy variables to increase the significancy of the model. After the several specifications added to the regression the final model was established (*Table 10*) where statistical significance was achieved. As in the previous gross capital formation regression model the lags and the dummy variables were applied to this model as well. What it is observed that green bonds variable is with the same lag length with the value of 3 that gives us the statistical significance where it can be stated that green financing through the bonds have pre-positive effect on the gross capital formation and gross domestic product growth rates which means that if the green bonds would be issued it would affect the economic growth positively in approximately three quarters – to be exact in terms of 100 bps increasement 3 quarters prior of the green bonds issuance growth rate the current GDP growth rate would increase 64,75 bps. In a callback to the previous regression model *(Table 8*) the green bonds actually showed a negative effect. The gross domestic product is by far considered one of the most important metrics as researched in literature analysis and methodology therefore the calculation importance showing that green bonds are supporting economic growth is crucial research point here.

Table 9

Gross domestic product growth rate (Y2) not modified regression model

Dependent Variable: Y2 **Method: Least Squares** **Sample: 2014Q2 2022Q4**		
Variable	**Coefficient**	**Prob.**
C	0.494577	0.1191
GB	7.68E-05	0.9839
GHG	0.022631	0.4406
DJSI	0.002609	0.9469
EXPO	75.76166	0.0000
R-squared	0.678288	
Durbin-Watson stat	2.384612	

Source: Established by the author

On the contrary, it is observed that greenhouse gas emission and Dow Jones Sustainability Index increasement one quarter and two quarters respectively prior are negatively affecting the GDP growth rate which indicates that at the past values it is decreasing the GDP growth rate. For comparison in the original regression model (*Table 9*) it is observed that all variables are providing positive result to the independent variable, therefore with the given evidence it can be stated that probably at the given lag times the effect can be negative but taking the real-world context and previous gross capital formation regression model the causation can be different. Moreover, the intercept C coefficient of this model is also considerably high meaning that if no variables are increasing including the dummy variable value is 0 then, the GDP growth rate increases by 6734 bps which is 67,34% evidencing us that GDP without analyzed variables has a very strong upside growth curve. Finally, reviewing the R-squared statistics it shows significant increase prior to the original model, indicating the model fitting of 88,22% which in economic complex metrics is clearly acceptable. For the Durbin-Watson statistics the value is ultimately close to 2 therefore it is stated that no autocorrelation is detected within the regression model.

Table 10

Gross domestic product growth rate (Y2) final regression model

Dependent Variable: Y2 **Method: Least Squares** **Sample: 2015Q1 2022Q4**		
Variable	**Coefficient**	**Prob.**
C	0.673460	0.0039
GB(-3)	0.006475	0.0395
GHG(-1)	-0.090219	0.0001
DJSI(-2)	-0.125960	0.0001
EXPO	77.49644	0.0000
D1	-4.130407	0.0037
D2	-2.419891	0.0414
R-squared	0.882295	
Durbin-Watson stat	2.090924	

Source: Established by the author

The final equation of the regression model where gross domestic product of Europe growth rate is analyzed reflects below (*Equation No. 8*).

$$Y2 = 0{,}673460 + 0{,}006475 * GB_{t-3} - 0{,}090219 * GHG_{t-1} - 0{,}125960 * DJSI_{t-2} + 77{,}49644 * EXPO_t - 4{,}130407 * D1 - 2{,}419891 * D2 + \varepsilon \quad (8)$$

Approaching the last dependent variable of the regression model which is final consumption expenditure growth rate from the original regression model it is observed that actually all independent variables are providing negative effect to the economic growth (*Table 11*) from the consumption expenditure point of view, however, the statistical significance is missing in the model, specifically talking about greenhouse gas emission, Dow Jones Sustainability Index, therefore, repeatedly it requires to apply modifications (lags and dummy variables). The R-squared is indicating poor fitting percentage only of 37,3% meaning that independent variables are able to explain only such percentage of the regression model which is unsatisfactory. Durbin-Watson

statistics evidences that the value is a little bit further than usual from value of 2 therefore indicating potential minor autocorrelation that could be existing within the model.

Table 11

Final consumption expenditure growth rate (Y3) not modified regression model

Dependent Variable: Y3 **Method: Least Squares** **Sample: 2014Q2 2022Q4**		
Variable	**Coefficient**	**Prob.**
C	0.000284	0.7760
GB	-0.000007	0.5767
GHG	-0.000127	0.1824
DJSI	-0.000144	0.2549
EXPO	-0.105325	0.0054
R-squared	0.373084	
Durbin-Watson stat	1.580061	

Source: Established by the author

In the modification process of the final consumption expenditure more saturation of lags was used, for the green bonds growth rate the lag length of 5 was used indicating one year and a quarter value to support current dependent variable value. Greenhouse gas emission growth rate was lagged by three quarters and Dow Jones Sustainability Index was lagged for a one year or total of 4 lags. To remove several extreme values two dummy variables were included in the model. The general observation of the regression model (*Table 12*) gives twofold assumptions and results. Putting more attention to the green bonds during the calculation it was failed to achieve the statistical significance it was tried over various lags from 1 to 5. However, it was not intended to go more than 5 lags as it was desired to keep at least 30 observations after all adjustments. The 5-lag length gave the best significance that was possible for this variable, on the same side we have the greenhouse gas emissions that is also not statistically significant to the model, however it is closer that green bonds as p-value is 0,1164 where it is close to 10% significance. To put attention where we have the accuracy it is the DJSI lagged by 4 quarters gave us almost the 1% statistical

significance with positive effect onto the final consumption expenditure growth rate of 2.52 bps in case the DJSI increase by 100 bps.

Table 12

Final consumption expenditure growth rate (Y3) final regression model

Dependent Variable: Y3 **Method: Least Squares** **Sample: 2015Q3 2022Q4**		
Variable	**Coefficient**	**Prob.**
C	0.000244	0.7556
GB(-5)	-0.000011	0.2622
GHG(-3)	0.000109	0.1164
DJSI(-4)	0.000252	0.0151
EXPO	-0.091995	0.0008
D1	-0.017505	0.0002
D2	0.009789	0.0196
R-squared	0.740372	
Durbin-Watson stat	1.990614	

Source: Established by the author

Taking into calculation the R-squared and Durbin-Watson statistics it can be stated that the model itself is more explanatory and no autocorrelation is detected. In interpretation terms of the model the green financing using the bonds did not show statistically significant effect that might be explained through that consumer spending patterns may take longer to manifest from the green bonds influence or potentially be indirect at all. To continue examining the DJSI role in this model besides its positive effect the explanation could be that companies included in the DJSI are performing better – those which are considered sustainable. As a result, sustainable companies contribute positively to the economy which resonates of increasing consumer confidence and spending.

In the retrospective of the first part of the regressions construction three models were established accompanying with the same independent variables and one control variable. All of the models at first were inaccurate and showed low significance levels or model fitting percentages. Modification and adjustments were necessary to increase the accuracy of the models and also to achieve the statistical significance of the variables so that it would be able to correctly interpret the outputs. The gross capital formation and gross domestic product growth rates showed positive increase from the green financing either from the green bonds issuance growth rate of Dow Jones Sustainability Index indicating that these variables are contributing to these metrics that support economic growth in a sustainable way. It is noted that the GDP in fundamental way represents the biggest picture of the economy therefore most of the effort and odds were given to this metric that resulted in quite significant increase from the green bonds financing overall in 64,75 bps uptrend. Moreover, the DJSI is also crucial point here as it encompasses the European companies that are considered sustainable and the companies' growth also resulting in economy growth of the European region. On the other hand, final consumption expenditure provided not clearly expected results with green bonds not being statistically significant and contributing negatively to this criterion. As a general output green bonds and DJSI companies provides different effect onto the European economy and after included lags it is determined that it requires several periods (from one quarter to over a year) to resonate onto the dependent variables, at certain points the output can be negative due to economy fluctuations and cycles. The regression model is a part of the whole research, furthermore, it requires robustness checks to ensure that models are not mis specified and robust during the periods.

3.3. Robustness checks of the regression models

In order to make sure that the models are stable during the time periods and are not mis specified the tests on them must be performed as per methodology points that would accompany these tests:

- Serial correlation - Breusch-Godfrey Serial Correlation LM test;
- Model specification – Ramsey RESET test;

- Residual diagnostics - Breusch-Pagan-Godfrey along with White test for heteroskedasticity.

The first test on the serial correlation depends on the included lags in the test, to be completely sure and content about the models it is decided to use three variances of the test firstly including 2 lags and then 3 and 4 accordingly to check if residuals are not exhibiting serial correlation. Since the input of the 2;3;4; lags are providing same template results it was decided to provide only results of the 4 lags included, however not missing out 2 and 3 lags it was also accomplished and the extensive results for each regression model is provided in the annex of this research. After the applied Breusch-Godfrey Serial Correlation LM test all of the three regression models passed all three stages of lagging.

By the table (*Table 13*) below it is a joint output of the 4 lags which is considered the highest at this research results indicating that all three models have p-value levels higher than 0.05 therefore not rejecting the null hypothesis of the absence of serial correlation with the indicated lag length. This result holds for up to 4 lags, which provides significant robust check against autocorrelation for quarterly data, covering a full year. The findings from this analysis indicate that the model is free from issues related to serial correlation. This is significant because it means that the standard errors in the regression coefficients are likely to be accurate and not distorted due to autocorrelation. Furthermore, the decision to use four lags in the model was informed by economic considerations. Typically, economic reactions lag behind their initiating actions, necessitating a delayed response in the model. This approach adds to the robustness of the model, confirming that it is not affected by serial correlation. By conducting this test and carefully selecting the number of lags, we have provided strong evidence that our models are reliable and free from serial correlation concerns.

Table 13

Breusch-Godfrey Serial Correlation LM Test results (up to 4 lags) on all regression models

Breusch-Godfrey Serial Correlation LM Test Null hypothesis: No serial correlation at up to 4 lags				
Regression model				
Y1	F-statistic	0.454812	Prob. F(4,22)	0.7679
	Obs*R-squared	2.444072	Prob. Chi-Square(4)	0.6547
	RESID(-1) Prob.	0.4260		
	RESID(-2) Prob.	0.3336		
	RESID(-3) Prob.	0.7775		
	RESID(-4) Prob.	0.8223		
Y2	F-statistic	1.206035	Prob. F(4,21)	0.3377
	Obs*R-squared	5.977834	Prob. Chi-Square(4)	0.2008
	RESID(-1) Prob.	0.4587		
	RESID(-2) Prob.	0.0790		
	RESID(-3) Prob.	0.2824		
	RESID(-4) Prob.	0.2029		
Y3	F-statistic	0.719579	Prob. F(4,19)	0.5891
	Obs*R-squared	3.946805	Prob. Chi-Square(4)	0.4133
	RESID(-1) Prob.	0.8729		
	RESID(-2) Prob.	0.2894		
	RESID(-3) Prob.	0.2473		
	RESID(-4) Prob.	0.6390		

Source: Established by the author

Moving further with the regression models robustness checks by the methodology that is compiled stability diagnostics with the Ramsey RESET test in order to determine if there are no missing variables that would increase the accuracy of the model and also if the regression models are not mis specified. The passing of the test is crucial in order to further move on with the analysis of the regression models and interpretation as if instability of the model presents therefore it can be established that the selected variables are not completely explaining the dependent variable itself correctly and accurately.

Table 14

Ramsey RESET Test for model specification (squared) on all regression models

Ramsey RESET Test			
Omitted Variables: Squares of fitted values			
Specification: Y1 C GB(-3) GHG DJSI(-1) EXPO(-1) D1			
Probability	0.6256	t-statistic	0.494076
FITTED^2	0.6256	F-statistic	0.244111

Ramsey RESET Test			
Omitted Variables: Squares of fitted values			
Specification: Y2 C GB(-3) GHG(-1) DJSI(-2) EXPO D1 D2			
Probability	0.8566	t-statistic	0.182614
FITTED^2	0.8566	F-statistic	0.033348

Ramsey RESET Test			
Omitted Variables: Squares of fitted values			
Specification: Y3 C GB(-5) GHG(-3) DJSI(-4) EXPO D1 D2			
Probability	0.2101	t-statistic	1.291159
FITTED^2	0.2101	F-statistic	1.667093

Source: Established by the author

The Ramsey RESET test (*Table 14*) showed that all three regression models are not showing mis specification, however by pointing out to the last regression model which is final consumption expenditure growth rate the probability is 0.2101 which is significantly lower than other regression models that might indicate the model is well-specified but there is a higher chance of mis interpretation of it. Recalling back to the construction of the final consumption expenditure it was also observed that several of the independent variables were not even statistically significant. To align both of the comparisons there might be the assumption that overall taking into consideration both the Ramsey RESET test and the regression model equation output the there is

very high chance that selected variables are either indirectly supporting the dependent variable or the model potentially be mis specified. Nevertheless, analyzing from the statistical point of view the numbers are not indicating model mis specification therefore the test is considered passed, however, looking at the real economy context that can be a signal to the strategies that green financing might not directly support the growth of the overall consumption expenditure in the European region and that there are other potentially more significant factors which were not located or analyzed in this research that could have more impact for this model.

As for the final robustness check it is the testing for the heteroskedasticity in the regression models, which would indicate that error terms is not constant across the observations. To do this test by the methodology confirmed types the Breusch-Pagan-Godfrey test will be done along with White test to ensure the output results. The null hypothesis of the test is that within the model we have homoskedasticity, therefore, in order to ass the test it is expected that probability values will be higher than 0.05 therefore we would not reject the null hypothesis. The first regression model which is determined in the previous equation of gross capital formation (*Equation No. 7*) was tested against both types the Breusch-Pagan-Godfrey and White tests in the results (*Table No. 15*) it is strongly evidenced that both the Breusch-Pagan-Godfrey and White tests indicate that there is no statistical evidence of heteroskedasticity in the model. This means that the assumption of constant variance in the error terms – is not violated. The absence of heteroskedasticity in the results reinforces the reliability of the standard errors in the regression coefficients, thereby ensuring the validity of the statistical tests conducted. This conclusion is drawn from the heteroskedasticity testing, which was performed using aggregated data. The detailed outcomes of these tests are included in the annex for comprehensive review (*Annex 2 – Annex 7*). In the main section of the research, the focus was on presenting only the most essential findings. This approach was chosen to facilitate a clearer and more visually comprehensible interpretation of the results. By limiting the presentation to key calculations, the research aims to provide a succinct yet thorough understanding of the data, ensuring that the findings are both accessible and informative.

Table 15

Heteroskedasticity test with Breusch-Pagan-Godfrey and White test for the gross capital formation regression model

Heteroskedasticity Test: Breusch-Pagan-Godfrey **Null hypothesis: Homoskedasticity**			
F-statistic	0.164620	Prob. F(5,26)	0.9733
Obs*R-squared	0.981960	Prob. Chi-Square(5)	0.9640
Scaled explained SS	0.433663	Prob. Chi-Square(5)	0.9944

Heteroskedasticity Test: White **Null hypothesis: Homoskedasticity**			
F-statistic	0.309846	Prob. F(5,26)	0.9858
Obs*R-squared	7.203039	Prob. Chi-Square(5)	0.9518
Scaled explained SS	3.181078	Prob. Chi-Square(5)	0.9994

Source: Established by the author

To continue with the rest of the regression models which is gross domestic product (Y2) and final consumption expenditure (Y3) growth rates regression models testing for the heteroskedasticity it was compiled in unified table in order to preserve the ability for the comparison from the data table. For both regression models it can be clearly evidenced and stated that using both the Breusch-Pagan-Godfrey and White tests (*Table 16*), continue to suggest that there is no violation of the homoskedasticity assumption in both models. The p-values are well above the conventional threshold of 0.05, indicating no evidence of heteroskedasticity. This implies that the error variances in both regression models are constant, affirming the reliability of the regression coefficients and their standard errors. Ultimately, it can be stated that all of the three models were tested for the heteroskedasticity using two types of test approaches and in the final output none of the models with the given probability values managed to reject the null hypothesis, resulting that in all of the regression models the variance of the error terms is constant across observations.

Table 16

Heteroskedasticity test with Breusch-Pagan-Godfrey and White test for gross domestic product (Y2) and final consumption expenditure (Y3) regression models

Heteroskedasticity Test: Breusch-Pagan-Godfrey **Null hypothesis: Homoskedasticity** **Regression model: Y2**					**Heteroskedasticity Test: Breusch-Pagan-Godfrey** **Null hypothesis: Homoskedasticity** **Regression model: Y3**			
F-statistic	1.022816	Prob. F(5,26)	0.4336		F-statistic	0.772917	Prob. F(5,26)	0.5992
Obs*R-squared	6.307007	Prob. Chi-Square(5)	0.3897		Obs*R-squared	5.033924	Prob. Chi-Square(5)	0.5395
Scaled explained SS	3.306132	Prob. Chi-Square(5)	0.7696		Scaled explained SS	1.688068	Prob. Chi-Square(5)	0.9460
Heteroskedasticity Test: White **Null hypothesis: Homoskedasticity** **Regression model: Y2**					**Heteroskedasticity Test: White** **Null hypothesis: Homoskedasticity** **Regression model: Y3**			
F-statistic	0.772663	Prob. F(5,26)	0.6932		F-statistic	0.839319	Prob. F(5,26)	0.6350
Obs*R-squared	14.457810	Prob. Chi-Square(5)	0.5646		Obs*R-squared	15.243540	Prob. Chi-Square(5)	0.5069
Scaled explained SS	7.578781	Prob. Chi-Square(5)	0.9604		Scaled explained SS	5.111745	Prob. Chi-Square(5)	0.9952

Source: Established by the author

3.4. Impulse response function establishment and analysis

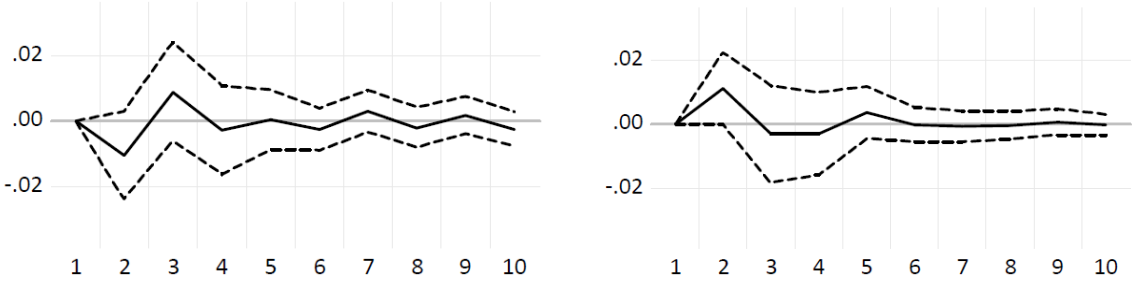
The impulse response function (IRF) as per methodology has beneficial overview of the variables and their impulses over the innovations on another variable. More importantly, it is focused on how the dependent variable is responding to the green financing variables and greenhouse gas emission growth rate. The regression models and lags included in that provides us with the insights that allows to understand the statistical significance and heaviness of the effect where IRF allows to see in the timeline if the impulse is significant and during the period in total of 10 quarters that represents two and a half years of responses it can allow to better interpret the long-term affection. It is already confirmed that economy has cycles and by the regression models'

estimations the responses can take some time to evolve usually it requires almost a year from this research. In addition, at first the impact might be negative or positive and during the time it can fluctuate in various directions indicating negative or positive output. In this part of the research the most significant impulses that would define the role in the sustainable economic growth will be described, whereas the full IRF analysis can be found in the research paper annexes (*Annex 8 – Annex 10)*.

For the gross capital formation (Y1) and its responses below (*Chart 10*) to the green bonds issuance growth rate innovation (left) and to Dow Jones Sustainability Index innovation (right) it is observed that at first two periods for the green bonds the effect aims towards the negative trend and by the third quarter repositions to the positive side. In general observation there is a slight impulse from the dependent variable at first year (1-4 periods) whereas later on the impulse fades out and mainly stays around value of 0. On the DJSI impulse response graph (*Chart 10, right*) a quite weaker impulse is detected, however it is worth noticing that the impulse is mainly positive indicating uptrend effect to the gross capital formation whenever the DJSI innovates. Looking to the longer periods the impulse almost fades out and again as the green bonds chart fluctuates around value of 0. Observing both of the impulses it is noted that it is present, however, not so strong resulting in minor role of the dependent variable (Y1) responses and significance.

Chart 10

Impulse response function of gross capital formation to green bonds innovation (left) and to DJSI innovation (right)

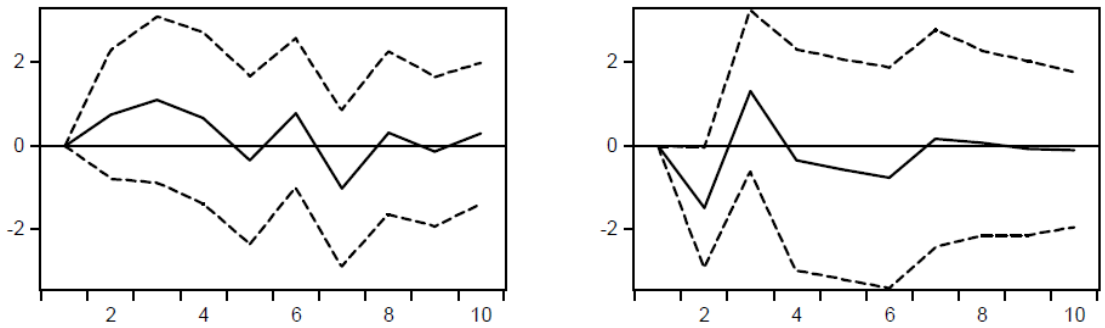


Source: Established by the author

Continuing with the impulse response functions for another dependent variable which is gross domestic product growth rate (*Chart 11*) depicts the Y2 response to the greenhouse gas emission growth rate (left) and to the green bonds issuance growth rate (right) innovations. For the greenhouse gas emission increasement the long-term impulse is observed ranging over 10 periods, however the fluctuations are crossing the 0 line quite frequently indicating waving pattern of GDP. To focus more on the beginning of the periods the impulse is showing the negative parabolic pattern slowly going down in the 5th period. Moving forwards to the green bonds issuance the more sharpen impulse is observed and first four quarters, the impulse of GDP starts with the negative effect of the green bonds' innovation and later on spiking to the positive trend and side. This can generally be expressed as the government or supranational issued bonds firstly lays off as the liability and the borrower which is the bonds issuer is increasing the debt level, however after several periods when the investment and the proceeds are incoming. In addition, market participants may initially react to green bonds issuance by adjusting their expectations about future economic performance, potentially factoring in short-term costs over long-term benefits.

Chart 11

Impulse response function of gross domestic product to the greenhouse gas emission (left) and to the green bonds issuance (right) innovation

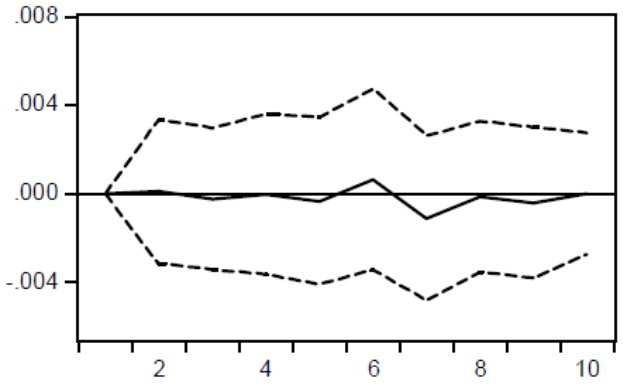


Source: Established by the author

As for the last the final consumption expenditure from the regression model estimation it was determined that green bonds unfortunately is not statistically significant, this can be proven also by the impulse response function on this variable (*Chart 12*) where it is clearly visible that innovation of the green bonds growth rate is resonating to almost none impulse rection from the final consumption expenditure variable. Also in addition, the chart axis values are lower in the decimal points. It is observed that impulse values are strongly close to 0 therefore resulting in no resonation at all.

Chart 12

Impulse response function of final capital expenditure to the green bonds issuance growth rate innovation



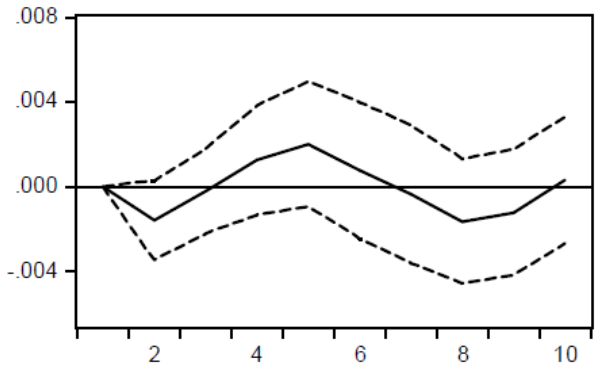
Source: Established by the author

Continuing analyzing the Y3 variable – final consumption expenditure the variable that was significant in the regression model was the Dow Jones Sustainability Index growth rate. In the IRF chart (*Chart 13*) it is observed that besides the statistical significance the values of the axis or in other words the fluctuation boundaries are relatively small ranging from -0.001 to 0.025. Generally, the chart is showing the impulses of the independent variable which is firstly decreasing in the first two periods and then slowly uprising between third and fifth periods. Furthermore, analyzing from another perspective it was observed that greenhouse gas emission responses from the final consumption expenditure is quite substantial (*Chart 14*) representing that the greenhouse gas emission increases at the start quite strongly if the dependent variable (Y3) innovates. This finding supports differently the GDP impulse response function chart where

the greenhouse gas emissions are actually decreasing quite heavily in terms of the GDP innovation, however in the longer term it starts again to go upwards. This concludes that resonation of the impulses for the econometric factors differs as each metric is being affected at the different times therefore providing more valuable interpretations and insights.

Chart 13

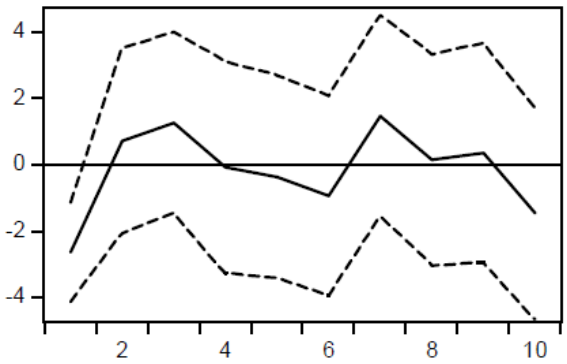
Impulse response function of final capital expenditure to the DJSI growth rate innovation



Source: Established by the author

Chart 14

Impulse response function of the greenhouse gas emission growth rate to the final capital expenditure.



Source: Established by the author

As the final overview of the research part the data was carefully collected and put into equal time series, after that it was tested for the stationarity and differences we applied where necessary. The estimated regression models showed differences, mainly it is possible to group that gross capital formation and gross domestic product is reacting to the green financing and its significance, with the additional support from the impulse response functions it visible that impacts are present and fluctuating. The biggest contribution from the green financing is to the gross domestic product where 64,75 bps of overall increase would be possible if the green bonds issuance would increase by 1%. Taking into the approximate calculation in the overall descriptive statistics (*Table 4*) the mean of the green bonds is around 30% therefore assuming that green bonds issuance would grow at least 20% in the 2023 it would result in the 1295 bps or 12.95% increase in the gross domestic product growth rate which is quite significant addition as it is coming from the green financing side. With the literature observations and analysis, it is considered that sustainability and green financing is an emerging field of financing and common understanding therefore the scenario where the green bonds issuance would increase is considered as positive scenario with a high chance of success. In terms of the impulses response functions the output is minimal and expected to be higher meaning providing higher shock waves than represented, however as already mentioned the sustainability and green financing is considerable new initiative taking into account the Green Bond Principles introduced in the 2014 and in general the bonds markets are long-term investment instruments ranging from 5 to 30 or more years of maturity therefore the response of such green financing instruments would require a deeper investigation on the future basis and its dependency and role in the sustainable economic growth. Overviewing the raised hypotheses in the methodological part it can be stated that all of the hypotheses were accepted (H1, H2 and H3) and in all cases the sustainability clause in terms of green financing or companies that are considered sustainable are contributing to the overall European economy growth. It was established via the regression modelling and observed that for the H1 which was gross capital formation green bonds showed negative impact through 3 quarters delay, however, the IRF showed that there is a positive uptrend in the earlier beginning of the time. For the H2 which was gross domestic product it was observed that green bonds are making positive impact also supported by the IRF analysis, the shock wave is quite sharp showing the sensitivity of the variable change. In terms of the final consumption expenditure, it was quite alike as with the gross capital formation, the green bonds showed negative effect in the 5 quarters delay, however the

effect was significantly small. Overlooking all regression models and impulses the result is not quite yet significant meaning that it is not comprising a bigger part of the overall economy growth share here, however, the trend is anyway uprising and showing promises that green financing can be the right way of channeling the funds and capital towards the economic growth and its sustainability.

CONCLUSIONS AND RECOMMENDATIONS TO STAKEHOLDERS AND POLICY MAKERS

The economy of the Europe is strong and evidently rich, the increasing gross domestic product and other economic indicators representing the growth is present. To align the economic growth with the sustainability and also to maintain the upside growth is challenging but attainable and achievable. In this research the main objectives were to understand and analyze the main drivers of the economy growth and green financing.

The conclusions from the literature part:

1. It was learned from the literature that economic growth is a complex web of metrics that combined together represents the region economic health and growth, however, the main indicators of such were the gross domestic product and in the national accounts used criterions as gross capital formation also used by the (Tao et al., 2022a) and the final consumption expenditure among that there are plenty more factors that could be also used to trace the economy growth. For the controlling part exports as a crucial land fundamental metric was used to control the upcoming regression models and understand the significancy.
2. For the green financing part from the literature overview and analysis the green loans and bonds is the current trend of financing the sustainable projects and developments, it results in the proceeds received from such bonds and loans to be used only for the sustainable activity that supports either the Sustainable Development Goals or is labeled as green financing indictor. Moving to the heaviness of the problem the literature showed us that this topic is crucial as the worldwide global temperature is uprising and the 2015 Paris Agreement that countries devoted themselves to shift towards a green financing due to natural disasters effects that are being caused by the global warming and greenhouse gas emissions.

In the research part the regression models were estimated and all of them required adjustments and inclusion of lags and dummy variables to make them accurate.

The conclusions form the research part:

1. The regression models showed us that green financing actually is providing positive effect on the gross domestic product from the green bonds perspective and using the impulse response function it is visible that green bonds issuance is receiving a resonated response from the GDP of the Europe therefore for this metric which is also considered one of the main components of the overall economy the green financing is significant and positive.
2. Dow Jones Sustainability Index provides positive effects on the gross capital formation and final consumption expenditure therefore signaling that companies which, are included in the DJSI list which are also, then considered as sustainable, are providing positive effect to the economic criterions when the index is uprising therefore meaning that private companies are growing and expanding with a sustainable mindset and development.
3. The resonation of the impulse response functions shows that greenhouse gas emissions are giving the short-term positive effect to the gross domestic product and in the long-term it is slowly decreasing resulting in immediate effect of action that gases emitted to create new products or services increases the economy growth only short-term. It is established that it is not efficient way to create goods or services using pollution-related instruments and sources.
4. As an opposing view the Dow Jones Sustainability Index is resonating positively to the gross domestic product in the long-term and negatively in the short-term, as an explanation for that it is delay of the impact of returns, declared profits of the companies and completed contracts. It is established that it is more efficient in the long-term to create products and services using a sustainable approach and investments.
5. IRF charts provides us with the in-depth analysis that the impulses are present however not such significant as it might be expected to be and therefore making a small part of the overall economy growth. It is an ultimate goal to raise the green financing part and role in the overall economy growth by channeling the funds through various instruments such as green bonds and investments into the companies that are behind sustainability indices.

In the research part and literature overview the main issue that is found out that currently only governments and corporates are doing such investing with a very small piece of private people. In the general belief the people usually are the key to every solution meaning that to solve the global warming and channeling the funds to sustainable projects ultimately raising the economy growth you also need to open the access to small private investors to contribute to such movement. At first it might result in poor results and small investing however, there is another key point by raising the awareness and understanding for the audience about the green financing. As the recommendations follows the research is finalizing with these findings and potential developments:

1. From the research it was identified that the participation of the green financing in the economic factors is playing a small role and as a recommendation of this research outflows that there might be not a lot of incentives for the investors to participate in such projects, therefore it is necessary for the policymakers to adjust the cooperation between the private and the public sectors. By creating incentives such as lower taxes for the companies who are investing at least 50% of their allocated funds for investments in the sustainable projects would be a proper motivation.
2. As the literature research showed and also supported by the empirical part the instruments that can be used to facilitate the green investments are mostly through the bond market which is unattainable for some segment of the private persons or companies despite the desire of investing. A recommendation would be to create a crowdfunding platform that would raise the funds through the green loans and which would be accessible to majority of investors (naturals included) so that more of the audience could participate, it is believed that people already have the knowledge, however, there is a lack of technology created for such process.
3. The policymakers must also pay attention that low-interests is a attractive way to find new project owners therefore the European Central Bank (ECB) can improve by not only giving the lower-interests but also by making the commercial banks to mandatory have the green loans product on their list and a proper communication to the bank's customers about the sustainability and its benefits, this could increase the loans issued for the sustainable needs such as high-efficiency housing purchases, purchases for electronic vehicles by giving a more flexible conditions on repayments.

4. There is a need for enhanced collaboration and partnerships among various stakeholders, including financial institutions, technology firms, governments, and civil society organizations. Such collaborations can facilitate knowledge sharing, capacity building, and the development of standardized frameworks for measuring and reporting the environmental and social impact of green fintech initiatives.

All in all, the sustainability is definitely not a negative-effect process to the economic growth, therefore as its perks are acknowledged and understood, the aim towards increasing the amounts of investment through such means can greatly benefit the European economy and support it by the agreed terms in the Paris Agreement and Next Generation EU framework. The key components to the goal achievement are to allow everyone even with minimal capital to have at least an ability to invest the funds to the sustainable projects through various means that could be crowdfunding platforms or any other financial technology created instruments. As the bonds are quite long-term and not always affordable instruments it is a great urgency to think of a new way of financing the sustainability as by the calculated results it shows partial role in the economy growth which can be increased significantly if the right tools and instruments would be used.

BIBLIOGRAPHY AND A LIST OF REFERENCES

1. Ang, J. B. (2007). CO2 emissions, energy consumption, and output in France. *Energy Policy*, *35*(10), 4772–4778. https://doi.org/10.1016/J.ENPOL.2007.03.032
2. Arranz, C. F. A., & Arroyabe, M. F. (2023). Institutional theory and circular economy business models: The case of the European Union and the role of consumption policies. *Journal of Environmental Management*, *340*, 117906. https://doi.org/10.1016/J.JENVMAN.2023.117906
3. Atayah, O. F., Najaf, K., Hakim Ali, M., Puteri, I., & Marashdeh, H. (n.d.). *Sustainability, market performance and FinTech firms*. https://doi.org/10.1108/MEDAR-08-2021-1405
4. Awais, M., Afzal, A., Firdousi, S., & Hasnaoui, A. (2023). Is fintech the new path to sustainable resource utilisation and economic development? *Resources Policy*, *81*. https://doi.org/10.1016/j.resourpol.2023.103309
5. Cheng, G., Zhao, C., Iqbal, N., Gülmez, Ö., Işik, H., & Kirikkaleli, D. (2021). Does energy productivity and public-private investment in energy achieve carbon neutrality target of China? *Journal of Environmental Management*, *298*. https://doi.org/10.1016/J.JENVMAN.2021.113464
6. *Circular Economy | UNCTAD*. (n.d.). Retrieved June 7, 2023, from https://unctad.org/topic/trade-and-environment/circular-economy
7. *Circular economy: definition, importance and benefits | News | European Parliament*. (n.d.). Retrieved June 7, 2023, from https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits
8. *Economic Sustainability - Office of Sustainability*. (n.d.). Retrieved June 6, 2023, from https://sustainability.umw.edu/areas-of-sustainability/economic-sustainability/
9. *ECONOMY | English meaning - Cambridge Dictionary*. (n.d.). Retrieved June 6, 2023, from https://dictionary.cambridge.org/dictionary/english/economy
10. *Economy: What It Is, Types of Economies, Economic Indicators*. (n.d.). Retrieved June 6, 2023, from https://www.investopedia.com/terms/e/economy.asp

11. Environment Inquiry, U. (2017). *Green Finance Opportunities in ASEAN*. http://web.unep.org/inquiry
12. *Explore Green & Sustainable Finance | Green Finance Platform*. (n.d.). Retrieved December 30, 2023, from https://www.greenfinanceplatform.org/page/explore-green-finance
13. *Financial Technology (Fintech): Its Uses and Impact on Our Lives*. (n.d.). Retrieved June 6, 2023, from https://www.investopedia.com/terms/f/fintech.asp
14. Frydrych, S. (2021). Green bonds as an instrument for financing in Europe. *Ekonomia i Prawo. Economics and Law*, *20*(2), 239–255. https://doi.org/10.12775/EiP.2021.014
15. *Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development Goals and targets (from the 2030 Agenda for Sustainable Development) Indicators*. (n.d.).
16. *Green Bond Principles, 2014 Voluntary Process Guidelines for Issuing Green Bonds*. (2014).
17. Hronová, S., Marek, L., & Hindls, R. (2022). The Impact of Consumption Smoothing on the Development of the Czech Economy in the Most Recent 30 Years. *Statistika*, *102*(1), 5–19. https://doi.org/10.54694/STAT.2021.40
18. Hu, G., Wang, X., & Wang, Y. (2021). Can the green credit policy stimulate green innovation in heavily polluting enterprises? Evidence from a quasi-natural experiment in China. *Energy Economics*, *98*, 105134. https://doi.org/10.1016/J.ENECO.2021.105134
19. Hyun, S., Park, D., & Tian, S. (2021). Pricing of Green Labeling: A Comparison of Labeled and Unlabeled Green Bonds. *Finance Research Letters*, *41*, 101816. https://doi.org/10.1016/J.FRL.2020.101816
20. Knewtson, H. S., & Rosenbaum, Z. A. (2020). Toward understanding FinTech and its industry. *Managerial Finance*, *46*(8), 1043–1060. https://doi.org/10.1108/MF-01-2020-0024
21. Lee, C. C., & Lee, C. C. (2022). How does green finance affect green total factor productivity? Evidence from China. *Energy Economics*, *107*. https://doi.org/10.1016/j.eneco.2022.105863

22. Leitão, F. O., de Sousa Martins, T., Guarnieri, P., & Ouro-Salim, O. (2023). Transition from linear to circular economy of electrical and electronic equipment: A review. *Business Strategy & Development*. https://doi.org/10.1002/BSD2.249
23. *Linear and circular economies: What are they and what's the difference?* (n.d.). Retrieved June 7, 2023, from https://www.santander.com/en/stories/linear-and-circular-economies-what-are-they-and-whats-the-difference
24. Lorek, S., & Spangenberg, J. H. (2014). Sustainable consumption within a sustainable economy – beyond green growth and green economies. *Journal of Cleaner Production*, *63*, 33–44. https://doi.org/10.1016/J.JCLEPRO.2013.08.045
25. Merello, P., Barberá, A., & la Poza, E. De. (2022). Is the sustainability profile of FinTech companies a key driver of their value? *Technological Forecasting and Social Change*, *174*. https://doi.org/10.1016/j.techfore.2021.121290
26. Metawa, N., Dogan, E., & Taskin, D. (2022). Analyzing the nexus of green economy, clean and financial technology. *Economic Analysis and Policy*, *76*, 385–396. https://doi.org/10.1016/J.EAP.2022.08.023
27. Mirza, N., Umar, M., Afzal, A., & Firdousi, S. F. (2023). The role of fintech in promoting green finance, and profitability: Evidence from the banking sector in the euro zone. *Economic Analysis and Policy*, *78*, 33–40. https://doi.org/10.1016/J.EAP.2023.02.001
28. Naik, S. N., Goud, V. V., Rout, P. K., & Dalai, A. K. (2010). Production of first and second generation biofuels: A comprehensive review. *Renewable and Sustainable Energy Reviews*, *14*(2), 578–597. https://doi.org/10.1016/J.RSER.2009.10.003
29. Nassiry, D. (2018). *ADBI Working Paper Series THE ROLE OF FINTECH IN UNLOCKING GREEN FINANCE: POLICY INSIGHTS FOR DEVELOPING COUNTRIES Asian Development Bank Institute*. https://www.adb.org/publications/role-fintech-unlocking-green-finance
30. Nenavath, S. (2022). Impact of fintech and green finance on environmental quality protection in India: By applying the semi-parametric difference-in-differences (SDID). *Renewable Energy*, *193*, 913–919. https://doi.org/10.1016/J.RENENE.2022.05.020

31. *NextGenerationEU*. (n.d.-a). Retrieved December 2, 2023, from https://next-generation-eu.europa.eu/index_en#make-it-green
32. *NextGenerationEU*. (n.d.-b). Retrieved December 2, 2023, from https://ec.europa.eu/commission/presscorner/detail/en/IP_21_5207
33. *OECD Main Economic Indicators (MEI) - OECD*. (n.d.). Retrieved June 6, 2023, from https://www.oecd.org/sdd/oecdmaineconomicindicatorsmei.htm
34. *SDG Indicators — SDG Indicators*. (n.d.). Retrieved June 6, 2023, from https://unstats.un.org/sdgs/indicators/indicators-list/
35. Shahbaz, M., Nasir, M. A., & Roubaud, D. (2018a). Environmental degradation in France: The effects of FDI, financial development, and energy innovations. *Energy Economics*, *74*, 843–857. https://doi.org/10.1016/J.ENECO.2018.07.020
36. Shahbaz, M., Nasir, M. A., & Roubaud, D. (2018b). Environmental degradation in France: The effects of FDI, financial development, and energy innovations. *Energy Economics*, *74*, 843–857. https://doi.org/10.1016/J.ENECO.2018.07.020
37. Siddik, A. B., Yong, L., & Rahman, M. N. (2023). The role of Fintech in circular economy practices to improve sustainability performance: a two-staged SEM-ANN approach. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-023-25576-7
38. Singh, R. K., Murty, H. R., Gupta, S. K., & Dikshit, A. K. (2009). An overview of sustainability assessment methodologies. In *Ecological Indicators* (Vol. 9, Issue 2, pp. 189–212). https://doi.org/10.1016/j.ecolind.2008.05.011
39. Sinha, A., Mishra, S., Sharif, A., & Yarovaya, L. (2021). Does green financing help to improve environmental & social responsibility? Designing SDG framework through advanced quantile modelling. *Journal of Environmental Management*, *292*, 112751. https://doi.org/10.1016/j.jenvman.2021.112751
40. Stojanović, D., Za Menadžment -Zajec• ar, F., Ilic, B., & Stojanovic, D. (2018). *GREEN FINANCING IN THE FUNCTION OF RISK MANAGEMENT ENVIRONMENT AND SUSTAINABLE ECONOMIC GROWTH*. https://www.researchgate.net/publication/325781000
41. Suárez-Eiroa, B., Fernández, E., & Méndez, G. (2021). Integration of the circular economy paradigm under the just and safe operating space narrative: Twelve

operational principles based on circularity, sustainability and resilience. *Journal of Cleaner Production*, *322*, 129071. https://doi.org/10.1016/J.JCLEPRO.2021.129071

42. *Sustainable Development Goals | United Nations Development Programme*. (n.d.). Retrieved May 28, 2023, from https://www.undp.org/sustainable-development-goals
43. Taghizadeh-Hesary, F., & Yoshino, N. (2019). The way to induce private participation in green finance and investment. *Finance Research Letters*, *31*, 98–103. https://doi.org/10.1016/J.FRL.2019.04.016
44. Taghizadeh-Hesary, F., & Yoshino, N. (2020). Sustainable Solutions for Green Financing and Investment in Renewable Energy Projects. *Energies 2020, Vol. 13, Page 788*, *13*(4), 788. https://doi.org/10.3390/EN13040788
45. Tao, R., Su, C. W., Naqvi, B., & Rizvi, S. K. A. (2022a). Can Fintech development pave the way for a transition towards low-carbon economy: A global perspective. *Technological Forecasting and Social Change*, *174*. https://doi.org/10.1016/j.techfore.2021.121278
46. Tao, R., Su, C. W., Naqvi, B., & Rizvi, S. K. A. (2022b). Can Fintech development pave the way for a transition towards low-carbon economy: A global perspective. *Technological Forecasting and Social Change*, *174*. https://doi.org/10.1016/j.techfore.2021.121278
47. Thakor, A. V. (2020). Fintech and banking: What do we know? *Journal of Financial Intermediation*, *41*, 100833. https://doi.org/10.1016/J.JFI.2019.100833
48. *Transactions data*. (n.d.). Retrieved December 2, 2023, from https://commission.europa.eu/strategy-and-policy/eu-budget/eu-borrower-investor-relations/transactions-data_en
49. Wang, L., Chang, H. L., Rizvi, S. K. A., & Sari, A. (2020). Are eco-innovation and export diversification mutually exclusive to control carbon emissions in G-7 countries? *Journal of Environmental Management*, *270*, 110829. https://doi.org/10.1016/J.JENVMAN.2020.110829
50. Wang, Y., & Zhi, Q. (2016). The Role of Green Finance in Environmental Protection: Two Aspects of Market Mechanism and Policies. *Energy Procedia*, *104*, 311–316. https://doi.org/10.1016/J.EGYPRO.2016.12.053

51. *WDI - Economy*. (n.d.). Retrieved June 6, 2023, from https://datatopics.worldbank.org/world-development-indicators/themes/economy.html
52. *What is the linear economy?* (n.d.). Retrieved June 7, 2023, from https://ellenmacarthurfoundation.org/what-is-the-linear-economy
53. Xiao, H., Tang, H., & Zhou, J. (2019). On the lceft multi-player collaborative innovation evolutionary game with the support of green finance. *Ekoloji*, *28*(107), 1349–1364.
54. Yoshino, N., Taghizadeh-Hesary, F., & Nakahigashi, M. (2019). Modelling the social funding and spill-over tax for addressing the green energy financing gap. *Economic Modelling*, *77*, 34–41. https://doi.org/10.1016/J.ECONMOD.2018.11.018
55. Zhang, Y. Q. (2023). Impact of green finance and environmental protection on green economic recovery in South Asian economies: mediating role of FinTech. *Economic Change and Restructuring*. https://doi.org/10.1007/s10644-023-09500-0
56. Zhao, L., Chau, K. Y., Tran, T. K., Sadiq, M., Xuyen, N. T. M., & Phan, T. T. H. (2022). Enhancing green economic recovery through green bonds financing and energy efficiency investments. *Economic Analysis and Policy*, *76*, 488–501. https://doi.org/10.1016/j.eap.2022.08.019
57. Ziolo, M., Bak, I., & Cheba, K. (2021). The role of sustainable finance in achieving sustainable development goals: Does it work? *Technological and Economic Development of Economy*, *27*(1), 45–70. https://doi.org/10.3846/tede.2020.13863
58. Zioło, M., Bąk, I., Filipiak, B. Z., & Spoz, A. (2022). IN SEARCH OF A FINANCIAL MODEL FOR A SUSTAINABLE ECONOMY. *Technological and Economic Development of Economy*, *28*(4), 920–947. https://doi.org/10.3846/tede.2022.16632

ANNEXES

Annex No. 1

Time series data of all variables used in the research

Date	Y1	Y2	Y3	DJSI	GHG	GB	EXPO
2014-03-31	20.4	0.861052	76	2.391324	-3.07377	-6.25	45.2
2014-06-30	20.3	0.371883	76	3.050602	-10.6554	173.3333333	45.5
2014-09-30	20.3	0.647344	75.9	0.904779	-1.60909	9.756097561	46
2014-12-31	20.1	0.602039	75.8	-1.19265	14.62241	151.1111111	46.3
2015-03-31	20.1	1.341659	75.1	16.75771	1.636593	-10.61946903	47.1
2015-06-30	21.2	0.989665	75.1	-5.07848	-12.2213	84.15841584	47.4
2015-09-30	20.5	0.699642	74.9	-8.81628	0.047037	-9.677419355	47
2015-12-31	21	0.716399	74.8	4.210985	12.55289	11.30952381	46.8
2016-03-31	20.8	0.579178	74.7	-7.70518	0.041771	-44.38502674	46.2
2016-06-30	20.8	0.542766	74.8	-1.35968	-11.3987	118.2692308	46.5
2016-09-30	20.9	0.65833	74.7	4.236354	-1.83789	5.286343612	46.7
2016-12-31	21.4	0.899927	74.7	5.67751	18.0989	29.28870293	47.3
2017-03-31	21	1.302823	74.6	6.582131	0.284553	-45.95469256	48.3
2017-06-30	22.4	1.357488	74.2	-0.61052	-12.5659	135.9281437	48.3
2017-09-30	21.2	1.039181	74.1	1.181288	-2.41076	-61.6751269	48.3
2017-12-31	21.5	1.161247	73.9	-0.5137	14.3943	207.2847682	48.8
2018-03-31	21.4	0.572978	74.2	-4.83492	1.245847	-64.22413793	48.9
2018-06-30	21.9	0.800035	74	1.471555	-14.8482	59.03614458	49.1
2018-09-30	22.1	0.462543	74.1	2.94904	0.578035	-18.93939394	49.5
2018-12-31	23	1.258422	73.8	-9.3964	13.1705	159.3457944	49.5
2019-03-31	22.1	1.1086	73.6	12.45549	-1.73508	-27.56756757	49.9
2019-06-30	23.3	0.764899	73.5	2.479339	-11.8002	54.97512438	49.7
2019-09-30	21.9	0.60534	73.7	3.233343	-2.58789	-23.27447833	49.6
2019-12-31	23.9	0.81228	73.6	4.833175	11.72932	53.76569038	49.1
2020-03-31	23.8	-2.53086	73.7	-20.2103	-3.85823	-42.44897959	48.8
2020-06-30	21.7	-10.1338	74.9	10.4303	-22.9118	56.02836879	43.4
2020-09-30	21	10.39677	74.5	-0.98008	10.53269	21.36363636	45.8
2020-12-31	22.7	1.12003	73	6.569285	15.77218	49.3133583	47.9
2021-03-31	23.2	1.512455	72.1	6.726088	-0.14191	-48.41137124	49.1

2021-06-30	23	2.417894	72.7	5.32669	-9.75841	56.23987034	50
2021-09-30	22.8	3.042387	73.2	-0.04664	-1.52231	6.12033195	50.6
2021-12-31	24.3	1.799973	73.2	6.886208	17.00426	35.87487781	52.6
2022-03-31	24.4	2.120554	73.1	-5.67544	-1.68565	-50.28776978	54.6
2022-06-30	24.8	2.226222	73.2	-9.17747	-10.4727	95.51374819	56.8
2022-09-30	25.1	1.532378	73.9	-5.29994	-1.60455	-42.48704663	57.9
2022-12-31	23.9	1.729738	74	8.587023	10.15255	4.118404118	56.5

Annex No. 2

Heteroskedasticity Test: Breusch-Pagan-Godfrey for Y1

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	0.164620	Prob. F(5,26)	0.9733
Obs*R-squared	0.981960	Prob. Chi-Square(5)	0.9640
Scaled explained SS	0.433663	Prob. Chi-Square(5)	0.9944

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/20/23 Time: 01:23
Sample: 2015Q1 2022Q4
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000654	0.000166	3.926391	0.0006
GB(-3)	1.12E-07	2.03E-06	0.054982	0.9566
GHG	-5.90E-06	1.46E-05	-0.404834	0.6889
DJSI(-1)	1.36E-06	2.01E-05	0.067421	0.9468
EXPO(-1)	-0.000223	0.005217	-0.042658	0.9663
D1	-0.000577	0.000858	-0.671735	0.5077

R-squared	0.030686	Mean dependent var	0.000638
Adjusted R-squared	-0.155720	S.D. dependent var	0.000749
S.E. of regression	0.000806	Akaike info criterion	-11.24249
Sum squared resid	1.69E-05	Schwarz criterion	-10.96767
Log likelihood	185.8799	Hannan-Quinn criter.	-11.15139
F-statistic	0.164620	Durbin-Watson stat	1.739152
Prob(F-statistic)	0.973326		

Annex No. 3

Heteroskedasticity Test: White for Y1

Heteroskedasticity Test: White
Null hypothesis: Homoskedasticity

F-statistic	0.309846	Prob. F(15,16)	0.9858
Obs*R-squared	7.203039	Prob. Chi-Square(15)	0.9518
Scaled explained SS	3.181078	Prob. Chi-Square(15)	0.9994

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/20/23 Time: 01:21
Sample: 2015Q1 2022Q4
Included observations: 32
Collinear test regressors dropped from specification

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000725	0.000462	1.569064	0.1362
GB(-3)^2	1.01E-08	5.04E-08	0.200630	0.8435
GB(-3)*GHG	1.23E-07	1.02E-06	0.120213	0.9058
GB(-3)*DJSI(-1)	4.10E-08	7.22E-07	0.056807	0.9554
GB(-3)*EXPO(-1)	-0.000177	0.000465	-0.381241	0.7080
GB(-3)*D1	5.79E-06	2.49E-05	0.232307	0.8192
GB(-3)	-8.36E-08	9.35E-06	-0.008940	0.9930
GHG^2	5.58E-07	4.38E-06	0.127302	0.9003
GHG*DJSI(-1)	2.51E-06	3.76E-06	0.667280	0.5141
GHG*EXPO(-1)	-0.001120	0.001555	-0.720363	0.4817
GHG	1.21E-06	4.67E-05	0.026014	0.9796
DJSI(-1)^2	-2.68E-06	3.85E-06	-0.694691	0.4972
DJSI(-1)*EXPO(-1)	0.001479	0.002259	0.654805	0.5219
DJSI(-1)	1.08E-05	4.31E-05	0.249339	0.8063
EXPO(-1)^2	-0.111908	0.229926	-0.486713	0.6331
EXPO(-1)	0.001255	0.019017	0.066019	0.9482

R-squared	0.225095	Mean dependent var	0.000638
Adjusted R-squared	-0.501378	S.D. dependent var	0.000749
S.E. of regression	0.000918	Akaike info criterion	-10.84134
Sum squared resid	1.35E-05	Schwarz criterion	-10.10847
Log likelihood	189.4614	Hannan-Quinn criter.	-10.59841
F-statistic	0.309846	Durbin-Watson stat	2.026021
Prob(F-statistic)	0.985769		

Annex No. 4

Heteroskedasticity Test: Breusch-Pagan-Godfrey for Y2

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	1.022816	Prob. F(6,25)	0.4336
Obs*R-squared	6.307007	Prob. Chi-Square(6)	0.3897
Scaled explained SS	3.306132	Prob. Chi-Square(6)	0.7696

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/20/23 Time: 12:06
Sample: 2015Q1 2022Q4
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.998785	0.233937	4.269461	0.0002
GB(-3)	-0.000933	0.003237	-0.288146	0.7756
GHG(-1)	-0.034393	0.020585	-1.670764	0.1072
DJSI(-2)	-0.031778	0.030120	-1.055024	0.3015
EXPO	1.827748	7.372724	0.247907	0.8062
D1	-1.484604	1.375963	-1.078956	0.2909
D2	-1.347777	1.240933	-1.086099	0.2878

R-squared	0.197094	Mean dependent var	0.855516
Adjusted R-squared	0.004397	S.D. dependent var	1.139189
S.E. of regression	1.136682	Akaike info criterion	3.284744
Sum squared resid	32.30114	Schwarz criterion	3.605373
Log likelihood	-45.55590	Hannan-Quinn criter.	3.391023
F-statistic	1.022816	Durbin-Watson stat	2.017807
Prob(F-statistic)	0.433564		

Annex No. 5

Heteroskedasticity Test: White for Y2

Heteroskedasticity Test: White
Null hypothesis: Homoskedasticity

F-statistic	0.772663	Prob. F(16,15)	0.6932
Obs*R-squared	14.45781	Prob. Chi-Square(16)	0.5646
Scaled explained SS	7.578781	Prob. Chi-Square(16)	0.9604

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/20/23 Time: 12:07
Sample: 2015Q1 2022Q4
Included observations: 32
Collinear test regressors dropped from specification

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.517398	0.466687	3.251427	0.0054
GB(-3)^2	-2.06E-05	6.19E-05	-0.332828	0.7439
GB(-3)*GHG(-1)	-0.000640	0.000826	-0.774889	0.4504
GB(-3)*DJSI(-2)	-0.000578	0.001115	-0.518291	0.6118
GB(-3)*EXPO	-0.244699	0.452445	-0.540838	0.5966
GB(-3)*D1	-0.032865	0.024684	-1.331400	0.2029
GB(-3)*D2	0.000714	0.047664	0.014980	0.9882
GB(-3)	0.014088	0.011526	1.222267	0.2405
GHG(-1)^2	0.000132	0.005729	0.023116	0.9819
GHG(-1)*DJSI(-2)	0.009631	0.005297	1.818130	0.0891
GHG(-1)*EXPO	0.375510	2.489104	0.150861	0.8821
GHG(-1)	-0.057397	0.060388	-0.950465	0.3569
DJSI(-2)^2	-0.009977	0.007512	-1.328057	0.2040
DJSI(-2)*EXPO	0.851343	3.393028	0.250909	0.8053
DJSI(-2)	0.002246	0.066395	0.033825	0.9735
EXPO^2	-88.33733	232.0838	-0.380627	0.7088
EXPO	-15.20183	19.44045	-0.781969	0.4464

R-squared	0.451807	Mean dependent var	0.855516
Adjusted R-squared	-0.132933	S.D. dependent var	1.139189
S.E. of regression	1.212545	Akaike info criterion	3.528134
Sum squared resid	22.05398	Schwarz criterion	4.306806
Log likelihood	-39.45015	Hannan-Quinn criter.	3.786242
F-statistic	0.772663	Durbin-Watson stat	2.258116
Prob(F-statistic)	0.693165		

Annex No. 6

Heteroskedasticity Test: Breusch-Pagan-Godfrey for Y3

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	0.772917	Prob. F(6,23)	0.5992
Obs*R-squared	5.033924	Prob. Chi-Square(6)	0.5395
Scaled explained SS	1.688068	Prob. Chi-Square(6)	0.9460

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/22/23 Time: 01:12
Sample: 2015Q3 2022Q4
Included observations: 30

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.21E-05	2.41E-06	5.000032	0.0000
GB(-5)	-3.22E-08	2.87E-08	-1.121694	0.2736
GHG(-3)	1.77E-07	2.08E-07	0.850304	0.4039
DJSI(-4)	1.54E-07	2.99E-07	0.514178	0.6120
EXPO	-5.56E-05	7.40E-05	-0.750607	0.4605
D1	-1.04E-05	1.22E-05	-0.849929	0.4041
D2	-1.22E-05	1.21E-05	-1.004079	0.3258

R-squared	0.167797	Mean dependent var	1.02E-05
Adjusted R-squared	-0.049299	S.D. dependent var	1.11E-05
S.E. of regression	1.13E-05	Akaike info criterion	-19.73443
Sum squared resid	2.96E-09	Schwarz criterion	-19.40749
Log likelihood	303.0165	Hannan-Quinn criter.	-19.62984
F-statistic	0.772917	Durbin-Watson stat	1.559902
Prob(F-statistic)	0.599150		

Annex No. 7

Heteroskedasticity Test: White for Y3

Heteroskedasticity Test: White
Null hypothesis: Homoskedasticity

F-statistic	0.839319	Prob. F(16,13)	0.6350
Obs*R-squared	15.24354	Prob. Chi-Square(16)	0.5069
Scaled explained SS	5.111745	Prob. Chi-Square(16)	0.9952

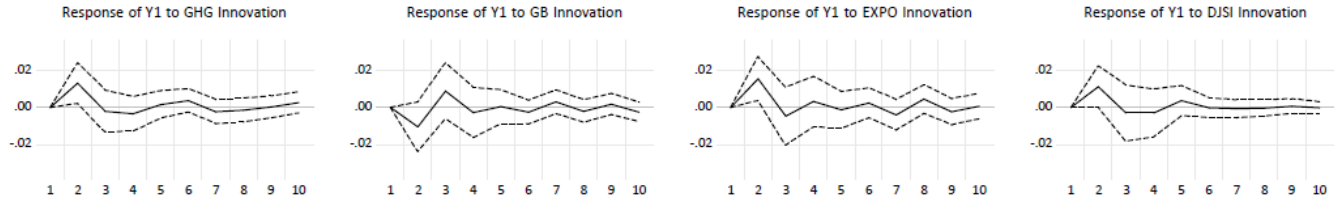
Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/22/23 Time: 01:13
Sample: 2015Q3 2022Q4
Included observations: 30
Collinear test regressors dropped from specification

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.21E-06	4.79E-06	1.296303	0.2174
GB(-5)^2	4.12E-10	5.74E-10	0.718105	0.4854
GB(-5)*GHG(-3)	-4.44E-09	5.28E-09	-0.841151	0.4155
GB(-5)*DJSI(-4)	6.86E-10	6.84E-09	0.100385	0.9216
GB(-5)*EXPO	-2.01E-06	3.89E-06	-0.516389	0.6143
GB(-5)*D1	4.79E-07	6.38E-07	0.751039	0.4660
GB(-5)*D2	-5.51E-07	2.62E-07	-2.104507	0.0554
GB(-5)	-1.99E-07	1.00E-07	-1.979580	0.0693
GHG(-3)^2	1.14E-07	4.76E-08	2.394412	0.0324
GHG(-3)*DJSI(-4)	-4.44E-08	4.62E-08	-0.959483	0.3548
GHG(-3)*EXPO	6.18E-06	2.28E-05	0.271716	0.7901
GHG(-3)	3.27E-07	7.07E-07	0.462489	0.6514
DJSI(-4)^2	-6.19E-08	5.74E-08	-1.077707	0.3008
DJSI(-4)*EXPO	-1.37E-05	3.65E-05	-0.374977	0.7137
DJSI(-4)	1.47E-07	6.14E-07	0.238921	0.8149
EXPO^2	0.000713	0.001932	0.369295	0.7179
EXPO	1.21E-05	0.000191	0.063155	0.9506

R-squared	0.508118	Mean dependent var	1.02E-05
Adjusted R-squared	-0.097275	S.D. dependent var	1.11E-05
S.E. of regression	1.16E-05	Akaike info criterion	-19.59360
Sum squared resid	1.75E-09	Schwarz criterion	-18.79959
Log likelihood	310.9040	Hannan-Quinn criter.	-19.33959
F-statistic	0.839319	Durbin-Watson stat	1.577295
Prob(F-statistic)	0.635020		

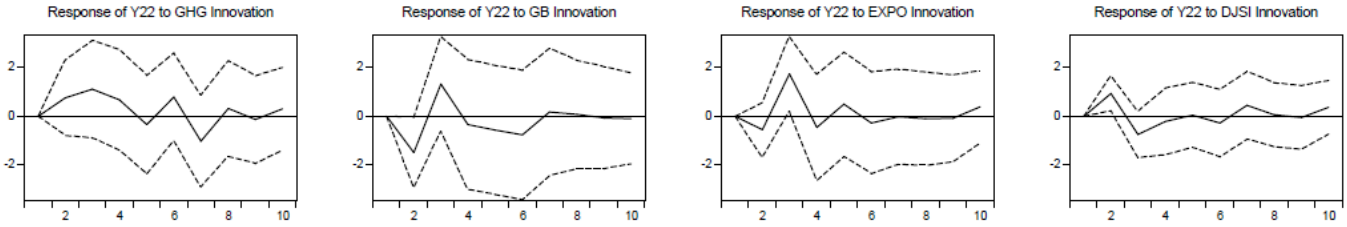
Annex No. 8

Impulse response function Y1 responses



Annex No. 9

Impulse response function Y2 responses



Annex No. 10

Impulse response function Y3 responses