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ŽALIOSIOS FINANSINĖS TECHNOLOGIJOS: VAIDMUO FINANSUOJANT TVARŲ EKONOMIKOS AUGIMĄ	GREEN FINTECH: THE ROLE IN FINANCING SUSTAINABLE ECONOMIC GROWTH

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INTRODUCTION

Relevance of the Topic. In the world of Green FinTech, sustainable finance is merged with financial technology to replace the traditional banking system with innovative solutions, including resource allocation, carbon credit transparency, and technology transparency. While usual financing follows bank-based procedures with heavily centralized institutions in place, Green FinTech instead democratizes raising capital for green projects by improving the allocation of resources, carbon credit transparency, and financial accountability. The connection between sustainable development and technological innovation sets new bridges to speed up and foster economic progress by making sustainability-oriented financing efficient, transparent, and accessible. The growing concern over global climate change and environmental degradation has urged transition into sustainable economies to become of paramount priority. To that end, instruments such as green bonds, green loans, carbon emissions tracking, blockchain, artificial intelligence (AI), digital wallets, and payment platforms have been gaining global traction. This set of tools is currently incapable of keeping up when it comes to funding green initiatives and reshaping the green financing landscape.

The impact of Green FinTech is increased by technology, which uses blockchain to guarantee both transparency and efficiency in the trading of carbon credits as well as the placement of green bonds, thus reducing greenwashing and building investor trust. Besides that, artificial intelligence supports decision making and optimizes energy usage for eco-friendly investments, thus fostering creative ideas in the areas of renewable energy and sustainability reporting. The amalgamation of technological innovations with green financial instruments, along with digital financial inclusion, ensures that Green FinTech delivers accountability, efficiency, and larger participation in sustainable financing, essentially harmonizing environmental goals with economic objectives. In its goal of establishing a low carbon and resilient global economy, Green FinTech holds the transformative potential for sustainable development.

Level of Research of the Topic. Research conducted to date on Green FinTech has disclosed its potential to enhance financial inclusion and sustainable economic growth, expedite the processes of green bond issuance, and promote innovative investment strategies that are environmentally conscious. Among the authors supporting the statement are Addy et al. (2024), Awais et al. (2023), Mirza et al. (2023), Nassiry (2019), Siddik et al. (2023), and Zhang (2023), pointing out that Green FinTech has already started to transform the entire environmental disclosures, finance, and the whole market for green finance by means of technologies like blockchain and AI. These, in turn,

have helped to optimize ESG investment decisions, curb greenwashing, and establish trust among stakeholders. Nonetheless, evidence shows that there is increased literature on regulatory frameworks and environmental reporting mechanisms, yet the knowledge gaps are inescapable. For example, some of the lesser explored topics in the literature include technological barriers to Green FinTech scalability in developing regions, such as inadequate digital infrastructure, limited access to AI and blockchain, and energy intensive operations (Dar et al., 2024; Vergara & Agudo, 2021). Furthermore, cybersecurity vulnerabilities such as weak encryption and threats of data breaches and insecure blockchain configurations are hardly ever addressed in the academic literature (Tamasiga et al., 2022; Addy et al., 2024). Additionally, what hardly gets discussed in the literature is the splintered global regulatory environment, wherein inconsistencies in ESG definitions, green taxonomies, and reporting standards deter cross border cooperation and innovation (Gabor & Brooks, 2017; Schletz et al., 2020). Along the same lines, the role of Green FinTech in carbon markets, supply chains, and financial inclusion is still a relatively less studied and less observed area, especially considering the issues of digital literacy and accessibility faced by marginalized populations (Li et al., 2023; Xue & Zhang, 2022; Anshari et al., 2019).

Novelty of the Thesis. This thesis contribution extends to the new redefining dimension of Green FinTech in sustainable growth, theoretically and practically. This study offers a new perspective by suggesting potential frameworks for integrating digital tools, green financial instruments and digital financial inclusions thus providing applicable insights for policymakers and other stakeholders.

Problem of the Thesis. Green FinTech is being more and more publicized as an essential method for providing money for the environment and sustainable economic growth. However, the reality of the situation is that Green FinTech's effectiveness in securing sustainable macroeconomic outcomes through financial green instruments, technology innovation, and inclusion of the digital finance sector remains ambiguous. The current studies give inconsistent and usually inconclusive empirical evidence thereby making it difficult to determine the true impact of Green FinTech on GDP growth and sustainability.

The aim of the thesis. The aim of this thesis is to empirically assess the role of Green FinTech in financing sustainable economic growth by examining how technological innovation (artificial intelligence), green financial instruments (green bonds), and digital financial inclusion (digital payments) influence sustainable macroeconomic outcomes, measured through GDP growth and unemployment.

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The objectives of this Thesis

1. To review the existing literature on Green FinTech and Green finance, identify research gaps and key determinants

2. To identify and justify an appropriate methodological approach for analyzing the determinants of sustainable economic growth within the context of Green FinTech.

3. To develop a conceptual framework for integrating Green FinTech into strategies aimed at fostering financing sustainable economic growth.

4. To present and interpret the statistical results of the multiple linear regression model factors that influence sustainable economic growth.

The methods deployed by this thesis. The period of analysis includes secondary sources that define the economy and identify its determinants, focusing on those that are well developed and considered reliable at the time of publication. Additionally, this research incorporates studies where sustainability is positioned as a key component of economic growth.

For a thorough understanding of the current situation regarding this topic, governmental publications, peer-reviewed scientific literature, and academic research studies are considered. Besides, these sources point out the relevant analytical methodologies applied by researchers in the past, which not only influence the approach taken in this study but also help to comprehend the established practices in the area. Making empirical results in time for the period 2014 through to 2024 to collect last decade data could bring in transparency in the analysis of green financing supporting growth in countries and during different periods

SWOT: This research investigates the role and limitations of Green FinTech in green financing, and as a result, SWOT analysis serves as a qualitative tool to determine the internal and external factors influencing its growth. Through examining its strengths, weaknesses, opportunities, and threats, SWOT facilitates orderly comprehension of the main factors that affect technology, regulations, the economy, and environment.

Multiple linear regression modelling: As this research is all about the role and significance of the green financing, the regression model would show the statistical significance and relevance to the model.

The use of artificial intelligence. In this research, AI tools were used only for supportive purposes. AI was used to help clarify and understand complex theoretical concepts, and Grammarly and ChatGPT was used to improve grammar and academic wording. These tools did not generate results, conduct analysis, or influence the research findings. All interpretations, methodological choices, and conclusions were made independently.

Difficulties and Limitations. Green finance, and the rest of this subject, is predominantly new in the world. There is a limited number of long-term statistical data in the quarterly frequency that can provide more observations and accurate calculations. This research will utilize a more multidisciplinary approach where theories and concepts from sustainable finance, technological innovations, green financial instruments and digital financial inclusions will be applied. By establishing the main challenges, opportunities and success factors, this research endeavors to advise policymakers, financial institutions, and stakeholders about the effects of green FinTech for financing sustainable economic growth. should explain the sequence of the sections of the thesis and the main issues discussed in them, indicating which section deals with which objective

Structure of the Thesis

The thesis is divided into three primary parts. In the first part, the theoretical basis is provided, and the literature on Green FinTech, green finance, and sustainable economic growth is analyzed, and important research gaps are revealed. The second part describes the research method that includes data sources, variable selection, SWOT analysis, and multiple linear regression modeling. The last part shows the empirical results and their discussion, after which conclusions and policy implications are given concerning the role of Green FinTech in making money for sustainable economic growth.

1. ANALYSIS OF THEORETICAL ASPECT OF GREEN FINTECH AND SUSTAINABLE ECONOMIC GROWTH

Theoretical foundations of Green FinTech and sustainable economic growth are the main focus of this chapter which also discusses important concepts, definitions, and their interrelationships. The chapter looks into the importance of green finance, technological innovation, and digital financial inclusion in supporting the sustainability goals, while at the same time examining the economic, environmental, and social aspects of sustainable development. Furthermore, the chapter provides a review of the relevant academic literature, in order to pinpoint the research gaps and establish a theoretical framework for the empirical research that is to be conducted in the following chapters.

In the context of increasing global environmental concerns and the pursuit of sustainability, the intersection of finance, technology, and ecological responsibility has become a pivotal area of academic and practical interest.

The importance of this thesis and the level of the existing research gives the understanding that this topic is developing and emerging and the importance as more studies explore the topic of green fintech, green financing and sustainable economic growth. A statistical literature review showed that scientific researches of the green Fintech and green finance topics are visually several times lower that the topic of sustainable economic growth. The figure 1 shows the relevance of the topic and the growing interest into the subject.

Figure 1: *Authors Working from Web of Sciences*

Sustainable economic growth attracts more attention as compared to green finance and green Fintech. It is a pretty clear statement on an issue that needs to be understood better; to merge these different fields into one comprehensive study to better understand the chemistry and impulses as well as their true significance and relevance.

1.1 Definition of Green Finance and Green Fintech and its relationship

Green finance, which is often referred to as sustainable finance, refers to the entire suite of financial transactions and tools focused on preserving the environment and ensuring the planet's ecological health in the long run. According to Lindenberg (2014) and Cen and He (2018), green finance is further explained as a financial activity merging environment protection with financial innovation to support environmental beneficial programs. This perspective is backed by Salazar (1998) who, in his definition of green finance, calls it a channel that leads monitory resources to the areas of economic activities that have good environmental impact in the long run. Coopers (2013) and Lindenberg (2014) add to this by stating that green finance is a concept dealing with financial services that encompass environmental factors in their decisions related to loans and handling risks, particularly in the sphere of providing support to low carbon technologies and companies.

In practical terms, green finance channels funds into sustainable investments such as renewable energy, energy efficiency, and other environmentally friendly projects (Puschmann, Hoffmann and Khmarskyi, 2020). It includes mechanisms that reduce ecological footprints while advancing sustainable development goals (Kwong, Kwok and Wong, 2023). Cen and He (2018) identify three primary justifications for the importance of green finance: it enhances sustainable development principles, promotes financial innovation while mitigating regulatory risks, and emphasizes a broader socio environmental economic approach post the 2008 financial crisis. Green finance, in the view of Nenavath (2022), is directed toward climate change mitigation and environment friendly development, whereas, for Yoshino et al. (2019), there has been insufficient consideration for it in mainstream financial allocations. Research has also dwelt on measuring the social, economic, and environmental impacts of green investments to further argue its strategic relevance in sustainability planning.

On a theoretical level, green finance has been split into the challenges and opportunities involved in this synthesis of environmental objectives with private capital mobilization and green product development. These developments bear on the design of practicable policies and regulatory frameworks that encourage a wider implementation of sustainable financial practices.

Another dimension is inclusivity, in which all relevant stakeholders from governments to corporations, financial institutions to individuals-collaborate to improve the environment through innovation (Fareniuk, 2024). Capital can be provided through financial instruments such as green bonds and green loans for grass-root projects (Gurunlu, 2023), whereas market instruments, such as carbon credits, are theoretically touted as scalable solutions for emission reduction (Zhou et al., 2022).

Green FinTech stands at the crossroads of environmental finance and financial technology, using digital innovation to promote greater efficiency, securities, and infiltration of sustainable financial operations. Varga (2018) states that Green FinTech ventures are those that, while not always fully regulated, technology is utilized to redesign financial services in manners supportive of environmental interests. According to the Financial Stability Board (Dovidonis, 2024), Green FinTech represents a wave of tech enabled innovation encompassing new models, processes, and products that addresses climate and environmental challenges directly within the financial sector. Jalal, Al Mubarak, and Durani (2023) describe Green FinTech as advanced financial models built on digital platforms, enabling more sustainable and transformative financial operations.

These innovations utilize cutting edge technologies such as the Internet, Mobile Internet, Big Data, Artificial Intelligence (AI), Distributed Systems, and Security Technologies to implement sustainability aligned financial services. Specific applications include carbon credit trading platforms, green peer to peer lending, crowdfunding for renewables, ESG analytics powered by big data, green robo advisors, and blockchain for emissions tracking (Arner, Gibson, and Barberis, 2020). Dell'Erba (2024) explains that whereas green finance usually suffers from difficulties like high cost, hesitant investors, or regulatory burdens, Green FinTech interposes to undo these limitations via automation, reduced transaction cost, and better resource matching. For example, AI and big data can be employed to characterize crop conditions and provide a better decision-making process for financing in sustainable agriculture (Dovidonis, 2024). Green FinTech also enhances outreach and affordability by offering personalized and scalable products for wider participation in sustainability focused financial systems.

In conclusion this shows the relationship and the need to integrate green finance and Green Fintech to achieve sustainable economic growth. This shows how green finance shows the base of sustainability, green fintech helps to expand the scope through innovation, green financial instruments and inclusiveness. This topic and field is important as it is an emerging field which would help achieve sustainable economic growth.

1.2 Sustainable Economic Growth and the relationship to Green Fintech

The International Institute for Sustainable Development (2022) defines sustainable economic growth as the economic growth that fulfills present social and economic demands and does so in a manner that does not end up compromising future resources. Sustainable development has to involve an equilibrated relationship between social equity, economic viability, and environmental sustainability. The Sustainable financial system forms a part of this balance because it generates, prices, and exchanges financial assets using future demands for an environmentally conscious economy that is also inclusive and accessible in its service delivery. Included among many other categories of finance are climate, green, and sustainable finance, each of which has a distinctive contribution toward sustainability goals (UNEP, 2016).
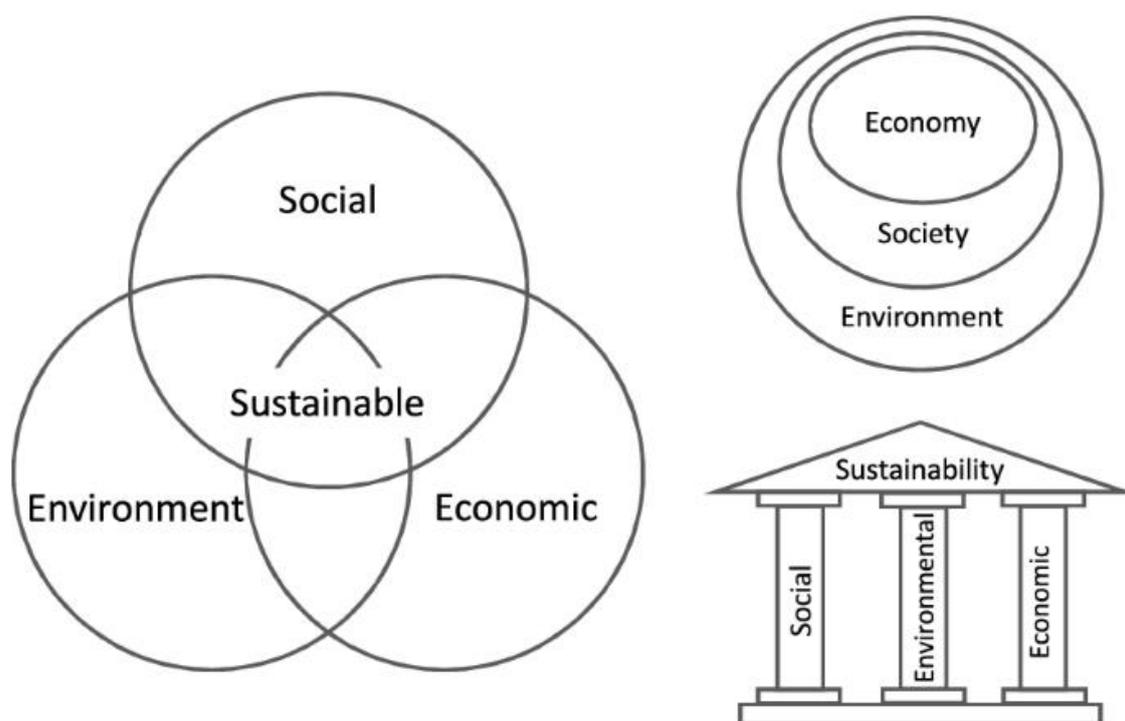
Figure 2: The relationship between social justice, economic viability, and environmental sustainability as pillars of sustainable economic growth (Source: Purvis, Mao and Robinson, 2019)

There are some important elements, each in relation of social justice, environment, and economic growth, that impact sustainable economic growth. GDP is still an important factor where a country can measure their productivity and output.

A measure of sustainable economic growth is also unemployment because it reflects the extent to which an economy is effectively utilizing its human capital an essential component of long-term development. High levels of unemployment imply that labor power is being underutilized, producing lower output levels, thereby reducing consumption and increasing government expenditure on social support. This, introduces economic inefficiencies that work against sustained growth, also increasing equity and social instability (Anghel et al., 2017). With that recognition, global frameworks such as the United Nations' Sustainable Development Goals (SDG), particularly Goal 8, underscore full and productive employment as the cornerstone for fostering inclusive and sustainable economic growth (Barwińska Małajowicz et al., 2023).

Persistent unemployment changes such as poverty, inequality, and civil unrest, which also destabilize economies. This is particularly striking where the unemployed are blamed for criminal activities in developing countries such as Nigeria, where the unemployed are also blamed for social nuisance and for the reduction of economic productivity, all of which directly affect sustainable development (Yusufu, 2014). From the economic perspective, a concept of a rate of sustainable unemployment has been advanced that aims to strike a balance between gaining workforce participation and enabling social welfare systems to maintain themselves so that public resources are not overstretched and labor market efficiency is not compromised (Nikoloski, 2009). Research has, furthermore, shown that the unemployment level correlates in a complex manner with other socioeconomic parameters such as GDP per capita, economic freedom, and life expectancy, while highlighting its part as a cause and effect in sustainable development outcomes (Litvina, 2022).

The main research shows that Gross Domestic Product (GDP) is determined mainly by its four basic components consumption, investment, government spending and net exports, which together indicate the economic performance of a country. GDP growth is supported consistently strong by consumption and government spending, and at the same time, investment plays a crucial role in the long run to sustain such growth (Bătușaru et al., 2023). On the other hand, the effect of net exports is different for each country, since some countries gain a lot from trade surpluses while others suffer from the volatility caused by external shocks (Song, 2023). Moreover, the results of the studies suggest that investments and government spending have strong positive impacts on GDP, but the effect of household consumption might be different in each country depending on the economic structure and policies (Venkatraja, 2014).

It is necessary to adopt environmental and energy indicators, carbon intensity, energy efficiency, and Environmental Performance Indices (EPI), into actions to regulate sustainability.

Green FinTech supports these metrics by funding renewable energy projects and improving the monitoring of environmental effects, which are some of the prime indicators related to energy. (Liu et al., 2022).
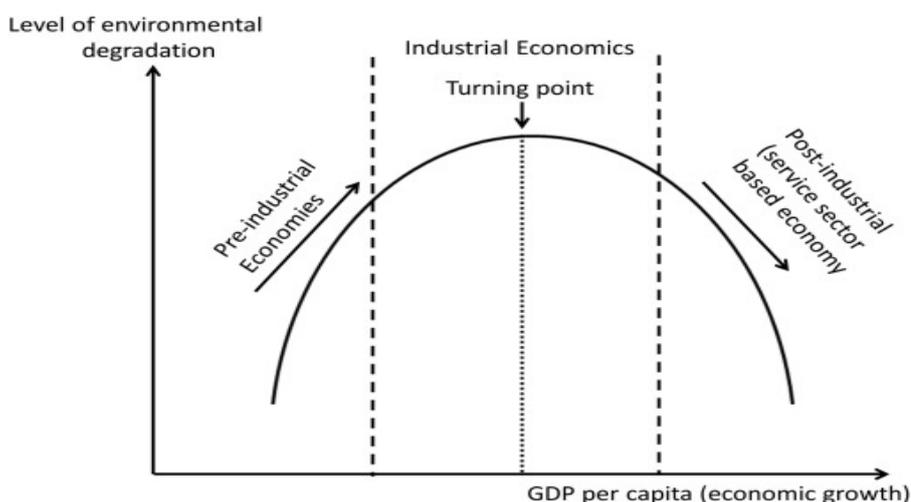
Figure 3: *A graph showing trends in GDP growth and carbon intensity over time to demonstrate decoupling economic growth from environmental degradation (Source: Prasad, 2024)*

The relevance of sustainability indicators depends on financial criteria which ensure inclusion in holistic development. GDP per capita, gross domestic tourism product, and unemployment rates, for example, are Sustainable Development Goals (SDG) indicators that overlap traditional economic statistics to measure the whole impact of economic policies. Both must be adopted by financial institutions: the concepts of the circular economy, that reduce waste and elongate product lifecycles. Align policies and regulations with Green FinTech to motivate financial markets towards sustainability and long term resilience so that growth can happen without compromising future resources (SuárezEiroa et al., 2021).

The relationship between environmental sustainability, social equity, and economic development has important aspects that need to be looked into before concluding the whole debate of their changes in the context of economic growth that is sustainable. The numerous other indicators like the rates of employment or foreign direct investment (FDI) would have been points to show the economy's inclusivity and its integration into the world since GDP, but still, GDP is the most significant measure for a nation's output and productivity considering the economy as a whole. The new financial instrument of Green FinTech, with the help of novel financial

mechanisms such as carbon credit markets and green bonds, is increasing the boundaries by enabling the utilization of resources more efficiently while at the same time reducing the environmental impact (Sadiq et al., 2022).

Also, financing renewable energy investments and tracking environmental impacts on energy efficiency would boost the sustainability aspects of the environmental performance indicators (Ganda, 2022). Integrating the SDGs into the systems means incorporating social and environmental objectives in the development process so that economic growth moves beyond conventional measures into a much stronger and fairer growth trajectory (Chen et al., 2022). All these factors are combined to demonstrate how Green FinTech can generate a culture of continual and balanced economic growth.

"The Organization for Economic Cooperation and Development (OECD), however, has many indicators to judge an economy; among those are unemployment rates, imports and exports, inflation rates, purchasing power parities, interest rates, and production sales" (OECD Main Economic Indicators OECD, n.d.). So much of an economy may refer to terms like system or network as it has hundreds of indicators which at the heart lead to the economy itself as a relationship between those indicators, and this definition is derived from the sum of an overview and the sum of all of them (Dovidonis, 2024). The examined past studies on subjects similar to sustainable economic growth are now concluded to contain the following additional indicators: annual population growth, the unemployment rate as a percentage of labor force, and tourism measured as number of visitors, (Awais et al., 2023) used to measure the economy and its state of growth or decline (Mirza et al., 2023).

One of the most central concepts, in terms of sustainable economies, is the circular economy. The circular model is an alternative to the traditional linear economy. The circular economy emphasizes the significance of utilizing techniques such as recycling, repairing, reusing, ad refurbishing as a means to extending the life cycle of a product (Dovidonis, 2024). This ultimately minimizes waste the model serves as the basis for multinational initiatives to advance the principles of circular economy: greening business practices today will turn today's goods into the tomorrow's resources (Circular Economy, n.d.)

Moreover, research has pointed out the connection between Green FinTech and Sustainable Economic Growth, with the former being beneficial not only for the issuance of green bonds but also for the transparency that goes along with it, thus making sure that the money is going to the right green projects which in turn will lower the greenwashing and hence, increase

the confidence of the investors (Addy et al., 2024). These modern technologies indirectly support the investments into renewable energy and hence, they go hand in hand with the international climate goals (Chen & Chen, 2021). Digital channels are opening up the financial services world to everyone, allowing the sparsely populated and poor areas to take part in the green finance activities, which will in turn give rise to local economic activities and might even help some areas get rid of poverty (Rizwan & Mustafa, 2022). Blockchain along with AI based systems are making the whole sustainability reporting process much easier by providing the real time movement of goods and the compliance of companies to ESG, thus making the market transparent and trustable for the investors (Vergara & Agudo, 2021). Green financial products are not only encouraging the eco-friendly practices but also the innovations that are supporting the sustainable growth for the industry through the government support (Chen et al., 2019).

The literature review was exhaustively carried out, and the most credible authors and their works have been collated into a table (Table 1) to properly address this research with respect to the analysis methods adopted for determining the impacts or relations with the variables applied in defining fintech, green financing, sustainability, and economic growth. Since regression modeling illuminates these relations and their significance, it's also very obvious that many researchers adopt this method for their studies.

Author	Main Focus	Methodology	Variables	Relationship
Vlaso et al.	Impact of digital technologies on environmental financing	Least squares method (LSM) with clustering	Digital technologies such as the Internet, the IoT, artificial intelligence, big data	Positive
Bannikov et al., 2024	Role of blockchain and smart contracts in sustainable management	Perspective model, regression analysis, Markov simulations	Blockchain and smart contracts	Positive
Semenova, Eremina & Skvortsova, 2020	Role of green financing in promoting sustainable economic growth	Regression and cluster analysis	Green financing (green bonds and loans), Economic growth (GDP)	Positive
Ding, Shi & Hao, 2022	Effect of digital financial inclusion and environmental regulation on regional economic growth	Regression analysis	Digital financial inclusion index, environmental regulation intensity, regional economic growth	Positive
Merello et al., 2022	Influence of fintech tools on sustainability profiles of companies	Regression model using GMM estimation	Artificial intelligence (AI), big data, blockchain	Positive
Cevik, 2024	Assessment of fintech's contribution to economic growth through the lens of Schumpeter's theory	Regression model using GMM estimation	Real GDP, digital lending, government spending	Positive
Awais et al., 2023	Relationship between fintech adoption and green economic growth	Regression model using Ordinary Least Squares	Sustainable finance, adoption rate of fintech firms, GDP	Positive
Tao et al., 2022a	Fintech development's role in transitioning to a low-carbon economy	Regression model (2SLS and GMM estimations)	GDP, carbon emissions	Positive

Table 1: *Summary of Empirical Studies on Green FinTech, Sustainable Finance, and Economic Growth (Source: compiled by the author based on the conducted research)*

In summary, the demonstration of how Green FinTech's use of sustainable principles simultaneously with making the transition of Green FinTech into sustainable economic development since it plays a major role in the overlap of social justice and economic viability with nature. This exemplifies how Green FinTech applies the principles of sustainability, not only transitioning but also making the transition to sustainable economic growth. Green FinTech is right in the middle where social justice, economic viability, and environmental sustainability meet and the latter's pursuit becomes sustainable economic growth. Green FinTech is able to use breakthroughs like blockchain and artificial intelligence to improve the accountability, efficiency, and transparency of financial systems. All these attributes are critical for the funding and control of sustainable projects. Thus, it is possible for all economic activities to become sustainable by promoting green financial products such as bonds and carbon markets, thus making sure the funds are really going to the environmentally friendly companies. However, the poor are not only given access to financial services but also encouraged to be active participants in the sustainability efforts through Green FinTech which eventually leads to digital financial inclusion.

1.3 Green FinTech Factors to Enhance Financing Sustainable Economic Growth

Studies have demonstrated and proven that Green FinTech has the potential to be a catalyst for a shift in the system towards a sustainable way of living as long as it is through the economic activities that are guided along the sustainable objectives. This encompasses not only the green financial instruments but also the digital financial inclusion and the technological advancement. All these elements work together to make Green FinTech an integral part of the promotion of the earth's embrace of the circular economy that consequently leads to sustainable economic growth.

Technological innovations. Green Fintech is one of the most important drivers of technological innovation in finance and the circular economy by linking all concepts of resource-efficient sustainable economic growth. New digital solutions of a high degree of novelty are created, such as blockchain and AI, that aim at increasing the transparency of processes and monitoring the management of climate risks through the tracking of sustainability metrics. The investments in such circular businesses, for example, trading carbon credits, funding renewable energy, and setting up platforms for sustainable investing, will thus be facilitated. Blockchain is like a distributed ledger that is constantly growing and through which transactions are permanently recorded and universally accessible to all parties in the network. Kalaiselvan et al. (2024) indicate that one of the major use cases of blockchain technology is in the area of trading carbon credits where it uses unique monitoring and confirmation of each carbon credit to eliminate the

occurrence of fraudulent sale and double counting thus ensuring that only the actual emission reductions get credited. Consequently, the reductions in harmful emissions become recognized and counted for the purpose of compliance with international-level pacts like the Paris Agreement. Furthermore, the blockchain greatly contributes to the enhancement of the global carbon markets by removing the inefficiencies that exist in verification and processing thus fostering wider adoption of the technology among the players in the market.

Xu and Ding (2024) studying has pointed out that blockchain technology plays an indispensable part in the issuance and management of green bonds which are considered flourishing financially sustainable projects investment. By means of blockchain, an unarguable and visible recording is made not only of the fund's allocation but also of the whole spending thus, raising the issue of suspected greenwashing but on the contrary, making accountability easier (Udeh et al., 2024). Dorfleitner and Braun (2019) singled out the significance of blockchain as a tool that could effectively streamline the whole process of monitoring, reporting, and verifying, thus, making green finance markets more transparent and accountable. Besides, this would also allow to monitor, in real-time, the environmental effects of the projects funded by green bonds that are aimed at achieving sustainability goals (Ding, Shi and Hao, 2022). These not only result in cutting out administrative costs but also positively impact investor confidence through the systems of reporting that are both automated and trustworthy (Dar et al., 2024).

Block chain technology is not without its challenges, while it adopts transparency and efficiency in green finance, its implementation and operation can be resource intensive. According to Metawa and Mirza (2022), block chain's reliance on computationally intensive processes, such as proof of work consensus mechanisms, significantly increases energy consumption. Regions where electricity is mainly generated from nonrenewable sources, this high energy use can result in elevated carbon emissions, potentially offsetting its environmental benefits. This emphasizes a negative relationship because block chain's energy demands can weaken its intended involvement to sustainability.

Artificial Intelligence plays a rather vital role in Green FinTech. It optimizes the energy use and enhances the decision-making processes in sustainable investments. This directly contributes to financing sustainable economic growth. AI has the ability to process numerous datasets with speed and accuracy this would help it to identify inefficiencies and propose new energy optimization tactics like integrating renewable energy sources or minimizing energy wastage. Such research as demonstrated by Elias et al. (2024) emphasized that AI based tools have an important role in determining environmental, social, and governance (ESG) factors that in turn, facilitate the

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creation of sustainable investment portfolios onto which financial institutions and investors are focused and make data-driven decisions to ensure that investments align with their sustainability goals while looking for competitive financial returns. The integration of AI into Green FinTech maximizes the overall efficiency of resource use while steering quicker growth of low carbon economy by investing funds into green projects.

Artificial intelligence is rapidly transforming many aspects of daily life, suggesting that it could play a major role in advancing sustainability. However, measuring the resulting productivity improvements at the macro level remains difficult, raising the question of whether AI mirrors the dynamics of the classic "Solow paradox." Drawing on micro-level manufacturing data, Gao and Feng (2023) examine how AI adoption influences firm productivity. Their findings show that a 1% rise in AI penetration is associated with a 14.2% increase in total factor productivity.

Evidence of a positive relationship between AI and sustainable economic growth can be seen by the transformative potential in managing climate risks. For example, AI based predictive analytics and big data can predict environmental impacts and financial risks associated with climate change, which allows the stakeholders to work out mitigation plans and invest in resilient projects. Elias et al. (2024) further argue that AI-enabled platforms streamline green finance operations while reducing costs and improving transparency in the investment process. This, in turn, increases investor confidence, encouraging the flow of capital out of green projects, thereby advancing economic development in the long run.

Green Financial Instruments. Green FinTech have revolutionized the significance of green loans and bonds in supporting sustainable economic development by adding in the features of new financial instruments along with advances in technology. While conventional methods of banks followed credit ratings backed by collateral, Green FinTech based solutions use AI, blockchain, and big data to make access to green finance easier, cheaper, and more transparent. According to Sachs et al. (2019), the green bond has thus come as a propitious instrument for financing environmentally sustainable projects and thus provide an alternative avenue for the achievement of Sustainable Development Goals (SDGs). Unlike traditional bonds that finance public works, green bonds are exclusively directed toward climate-related projects, including renewable energy, energy efficiency, and sustainable infrastructure. This interfacing with FinTech has contributed to lowering issuance costs, tackling risk assessment, and raising investor confidence. The innovation and deployment of green financial instruments not only support sustainability but also stimulate economic development. According to findings by Climent and Soriano (2011), the green bonds represent a key instance with a main spending engine in the economy. The various resources go

to worthwhile thrusts: projects that generate jobs, increase energy efficiency, and advance technology. A stronger, more resilient economy is thus created, side by side with environmental concerns.

Green bonds are increasingly seen as an important finance tool in black-boxing economic and sustainable development. Acting as investment channels for banks, green bonds finance projects in energy conservation, green infrastructure, and sustainable transport, thereby acting as capital wash-away for polluting sectors and clean development in India. The shift captures utmost attention in developing capital for long-term climate and sustainability goals (Anufrijev et al., 2024), (Brzozowska, 2018).

Through a comparative analysis across regions, Madouri (2025) highlights how institutional, economic, and policy factors influence the effectiveness of green finance. Nonetheless, the study confirms that green finance instruments, including green bonds, foster investments in renewable energy, thereby supporting sustainable development.

Moreover, the integration of FinTech brings even more substantive empowerment to green bond operations. Xu and Ding (2024) discussed how FinTech innovations would bring down the cost of developing sustainable products whilst enhancing investor confidence by providing real-time feedback regarding the environmental impact of invested projects. For example, Blockchain technology can deliver transparency and accountability whereby shareholders can track the use of funds and ensure alignment of such use with stated environmental targets. Besides that, AI and big data can crunch the numbers meaningfully to sharpen decision-making and optimize resource allocations toward those green projects worthy of greatest impact.

A positive relationship between green bonds, loans and sustainable economic growth has shown and proven in their ability to channel significant investments into environmentally responsible and friendly project which in this case green bonds have been credited with accelerating the transition to renewable energy by providing a stable source of funding for largescale solar and wind projects. Increased transparency and traceability through FinTech platforms protect and increase institutional and retail investor participation, thereby creating a strong market for sustainable finance.

Apart from generating green environmental imperatives, these bonds actually permeate company operations and make them embed sustainability in their business strategy and innovate on sustainable practices (Maltais & Nykvist, 2020), (Muhammad et al., 2022). They also widen

investor participation by appealing to those who wish to join financial returns with social/environmental values, hence mobilizing private capital for the public good (Tukhtabayev et al., 2024), (Yadav et al., 2024). Green bonds offer a sustainable post-conflict reconstruction and modernization agenda in areas under reconstruction or transition economically, like Ukraine (Klymenko & Ukhnal, 2024), (Shcherbakova, 2023).

Hence, green bonds bring accountability and transparency because issuers occasionally have to deliver reports on the environmental performance of the projects funded. This improves the trust in the market to pave the way for setting higher sustainability standards in the whole financial sector (Paul and Iyelolu, 2024; Bisultanova, 2024; Dar et al., 2024).

Digital financial inclusion has been made possible by Green FinTech tools such as digital wallets and payment systems across the different access channels to financial services for underserved populations. Such digital financial tools are technologies that bypass classical bank infrastructure limitations, enabling affordable and efficient financial services to individuals and communities.

In the opinion of (Arner et al., 2019), digital wallets make it easy for users to transfer money, store it, and make payments, thus allowing them to engaged in sustainable economic activities, even in remote areas that have little banking infrastructure. Payment systems improve the inclusion further by providing a less costly and safe way to transact, promoting economic participation in low income and marginal populations. According to Neville, (2024) digital wallets helps to decrease the need for physical credit and debit cards, thereby reducing plastic waste, and by promoting electronic transactions, such as digital wallets play an important role in creating a sustainable financial environment.

A positive relationship between digital financial inclusion and sustainable economic growth lies in its possible empowerment of individuals to contribute to environmentally sustainable practices. For example, digital financial tools have enabled small scale farmers to adopt renewable energy solutions and sustainable agricultural methods, thus increasing productivity while reducing environmental impacts. Li et al. (2023) argued that this digital financial inclusion encourages the promotion of green innovations through reducing the financing barriers and increasing the much needed resource allocation, thus enabling ecofriendly entrepreneurship and investment. Such advancements are essential for contributing to any larger objective concerning an inclusive and sustainable development, especially in emerging economies.

In conclusion, by including technological advances, green financial instruments and digital financial inclusion, Green FinTech is able to achieve sustainable economic growth and this section shows that technologies like block chain and AI would help to improve the transparency, efficiency and accountability which would help ensure that the funds are focused towards sustainable projects. Also green bonds and loans would help to encourage economic development and raise funds for projects such as renewable energy and ecofriendly initiatives. Tools like digital wallets also would play and important role as this allows and encourage to be environmentally sustainable and as mentioned above reduces the plastic waste. Combining these factors helps Green Fintech to support financial systems and achieve sustainable economic growth.

1.4 Challenges and Knowledge Gaps

Green FinTech has the transformative potential to promote inclusive and low-carbon economic growth. In theory, and with the right chance, the Green FinTech framework uses blockchain, artificial intelligence, and digital finance to transform how sustainability-oriented investments are channeled, making them more efficient, more transparent, and more impactful. However, while the promise is there, after onset barriers are very high, particularly in developing regions. Technological limitations and cybersecurity threats, as well as a regulatory patchwork and weak digital infrastructure, all limit the domains within which Green FinTech may eventually take shape and be most effective. Such challenges tend to result in the slow adoption rate of financial innovation and potentially exert a counterproductive influence on sustainability outcomes. Acknowledging these challenges and resolving them would unleash the full potential of Green FinTech in respect of the global shift toward a sustainable economy.

Challenge Category	Challenge	Authors
Technological & Infrastructure Barriers	Uneven diffusion of FinTech and limited technological maturity constrain Green FinTech development, particularly in emerging economies	**Dar et al. (2024)**
	Green FinTech effectiveness depends on the maturity of the digital economy and supporting infrastructure	**Akberdina et al. (2024)**
Energy Use & AI Sustainability Trade-offs	AI deployment in ESG and sustainability contexts may increase energy consumption and create environmental trade-offs	**Burnaev et al. (2023)**

	AI-driven productivity improvements can raise overall energy demand	**Gao & Feng (2023)**
Cybersecurity, Data Privacy & Trust	Data privacy, data quality, and trust issues limit adoption of data-driven Green FinTech platforms	**Addy et al. (2024)**
	Weak governance in digital financial systems can increase surveillance and data exploitation risks	**Gabor & Brooks (2017)**
Implementation of Green Financial Instruments	Greenwashing and weak accountability mechanisms undermine trust in green finance instruments	**Nassiry (2019)**
	Carbon markets may generate uneven development outcomes and limited local benefits	**McAfee (2016)**
Regulatory Fragmentation & Policy Uncertainty	Lack of harmonized green finance and ESG definitions reduces comparability and investor confidence	**Li et al. (2023)**
	Regulatory inconsistency across jurisdictions constrains blockchain adoption in carbon markets	**Wen & Liu (2023)**
Digital Divide & Social Inclusion	Digital finance can exacerbate exclusion among populations lacking digital access and literacy	**Gabor & Brooks (2017)**
	Accessibility and inclusion remain underexplored challenges in Green FinTech research	**Dar et al. (2024)**

Table 2: Key Challenges and Barriers to the Development of Green FinTech (Source: compiled by the author, based on Addy et al. (2024);Akberdina et al. (2024); Burnaev et al. (2023); Dar et al. (2024); Dar et al. (2024) ;Gabor & Brooks (2017); Gabor & Brooks (2017); Gao & Feng (2023); Li et al. (2023); McAfee (2016); Nassiry (2019); Wen & Liu (2023))

In conclusion green FinTech has emerged as a transformational force fueling sustainable economic growth and fostering financial inclusion and environmentally conscious investments. Technology based innovations such as blockchain and artificial intelligence bring a new level of transparency, accountability, and efficiency to green financing, so that capital is appropriately directed to sustainable projects, including renewable energy projects and circular economy projects. Green financial instruments green bonds and loans in particular far mobilize investments, aiding economic development and addressing critically important environmental concerns. Also, ensuring digital inclusion of financial activities means that this will empower excluded populations to participate in sustainable economic activities and support equitable growth.

On the other hand, an array of technological, regulatory, and cybersecurity barriers stands in the way of Green FinTech realizing its full potential. This, in turn, is compounded by barriers in developing regions such as subpar digital infrastructure, high costs of deployment, and lack of adequate expertise within its ranks, which impede access to critical innovations. Fragmented regulatory frameworks, weak data protection management, and digital exclusion outgrowth ever growing inefficiencies and mistrust from users and investors alike.

To fully unlock the potential of Green FinTech, the global reaction has to be structured in such a way that all the different regulations are harmonized, the digital infrastructure is made accessible, the cybersecurity measures are developed to the highest standards, and all the industries would be cooperating and sharing knowledge with each other. Green FinTech, if systemic issues are solved, can then emerge as a highly scalable and robust solution for fast tracking the transition to a transparent, fair and low-carbon global economy. Eventually, this would lead to a financial ecosystem that besides economic sustainability would also be masking social justice and long-term environmental care as its main priorities.

2. ANALYSIS OF RESEARCH METHODOLOGY FOR ASSESSING THE ROLE OF GREEN FINTECH IN SUSTAINABLE ECONOMIC GROWTH

The literature review included the in-depth investigation of several topics interlinked in order to form an understanding of definitions, measurement, and evaluation of issues involved within the sector. The methodologies used were very diverse and spanned a wide array of methods available.

This research adopts a mixed-methods approach, combining both quantitative and qualitative methodologies to comprehensively examine the role of Green FinTech in financing sustainable economic growth. While multiple linear regression analysis and SWOT analysis represent the primary analytical methods used in this study, they are not the only methodological components. The research also incorporates a systematic literature review, secondary data analysis, and case study analysis to support theoretical development, contextual interpretation, and empirical validation of the findings. By integrating these two approaches, the study gains both quantitative robustness and strategic interpretive depth.

2.1 Key Components of Research Methodology

Research Design

The systematic and structured approach toward research is ever-important in ensuring the successful accomplishment of any scientific project. The research methodology provides a framework and guidelines by which the researcher can choose a research design and technique to be use, so the study can be valid with originality and reliability. It also helps to accurately regenerate the analysis, to test the results, and to see their applicability in further research.

At the core of this process is the research design a high level, conceptual plan that outlines how the research will be conducted. It plays a vital role in addressing the research problem effectively and contributes meaningfully to the chosen topic. Swot analysis and regression analysis is executed depending on the type of configuration of the study. Acting as a plan, the research design will steer the entire process, from collection to treatment of data and its eventual analysis through any suitable method.

Essentially, research methodology is the foundation of any study, providing an objective, coherent, and systematic approach that adds some weight to the existing pool of knowledge.

Research Methods

While research designs offer a broad overview of the chosen approaches and strategies, these methods are more detailed and practical where they involve specific techniques which uses to address the research question. Although there are three main types of research methods which are qualitative, quantitative and mixed, this studies mainly focuses on a mixed approach to analyze the data which would help derive meaningful results.

Data Collection

Data collection refers to the application of various methods to gather the necessary information for solving a research problem. The above-mentioned techniques entail the gathering of unprocessed data like case studies or observation. Conversely, secondary data gathering relies on reviewing of the existing data such as literature. The selection of the most suitable data gathering way is dependent on the specifics of the research question, the research design being used, and the resources available in the existing literature.

Data Analysis Techniques

Once the data are gathered, their meticulous analysis must be performed in order to draw out the insightful ideas. In the case of qualitative analysis, the researchers takes the case study material through a sequence of cleaning, classification, and finding themes to discover the common points, difficulties, and the most effective practices in the Green FinTech sector. By employing this methodology, through a compassionate and detailed interpretation of the technological, financial, and digital innovations, the researchers are able to convey the perspectives of the statistical analysis and the qualitative examination together.

The quantitative part of the study is based on the time frame of 2014 to 2024 in order to see the influence of Green FinTech on the economy's sustainability. The GDP growth rate is used as a proxy for sustainable economic growth in the regression analysis. The unemployment trends are assessed descriptively as a complementary labor market indicator to give more insights on economic resilience and inclusiveness. The independent variables are technology innovations (AI adoption and labor productivity are the proxies), green financial instruments (green bond values and renewable energy are the proxies), and digital financial inclusion (digital payments are the proxy). The data came from trusted macroeconomic databases and national statistical agencies, and the measures were turned into annual percentage changes for the sake of comparison. The regression analysis is used to evaluate the associations among the variables and the sustainable

economic growth, revealing not just the trends but also the ways in which the technical, financial, and digital factors work through the economy's performance.

For the qualitative analysis, this research utilizes case studies as the main method. Case studies allow the researcher to dive deeply into real-world Green FinTech applications and learn about context, difficulties, and the best practices. They reveal a detailed impact of certain policies or inventions on sustainable economic growth that other quantitative methods inside and outside the heuristic approach would not have detected. Besides case studies, SWOT analysis has also been used to determine the internal and external factors affecting the growth of Green FinTech. By pinpointing the main strengths, weaknesses, opportunities, and threats, SWOT analysis adds up to the case study and provides a better qualitative analysis of the industry.

Argumentation for Period Selection (2014–2024)

The decade 2014–2024 was chosen as the period for this research in order to include the most significant years of growth in Green FinTech, green finance, and digital financial inclusion. Around 2014, the global focus on sustainable finance started to increase considerably due to the Paris Agreement (2015) and the UN's SDGs, which made green investment flows and sustainability-driven financial innovations grow significantly (UN, 2015; OECD, 2017).

In addition, this time frame shows the swift spread of financial technologies, such as digital payments, artificial intelligence, and blockchain applications in finance that constitute the technological basis of Green FinTech (Gomber et al., 2018). Moreover, the chosen period includes global economic disturbances, with the COVID-19 pandemic being the most significant one, and thus, it makes possible to study how the factors related to Green FinTech act in times of economic stress and recovery (World Bank, 2022).

The data used in this study is yearly macroeconomic and financial data from chosen economies (mainly EU countries) for the years 2014-2024. The EU is the key sample because it is one of the most developed and controlled surroundings for Green FinTech and sustainable finance, backed by the policy frameworks of the EU Green Deal, EU Taxonomy, and Sustainable Finance Disclosure Regulation (SFDR) (European Commission, 2020).

European Union nations are also characterized by the high adoption of digital finance, the presence of the green bond markets that are quite active, and the continued use of artificial intelligence in the financial sector, making them perfect for the study of the interaction among technological innovation, green finance, and digital financial inclusion (Addy et al., 2024; Vergara

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& Agudo, 2021). Furthermore, the use of data that is both reliable and standardized from organizations such as the World Bank, OECD, Eurostat, and national statistical agencies adds to the strength and validity of the empirical analysis.

2.2. Types of Qualitative analysis

The study primarily highlights this sample and the last ten years, which guarantees the consistency of data, the comparability of institutions, and the relevance of the policies, and it also takes the availability, reliability, and comparability of macroeconomic and sustainability-related data as a huge advantage. Such a method enhances the power of regression analysis and makes it possible for the results to impart policy-relevant insights that are valid for developed as well as emerging economies looking to layer Green FinTech over sustainable economic growth (Semenova et al., 2020; Tao et al., 2022).

Model	Strengths	Limitations	Why SWOT / Case Study Is Better for This Study
Thematic Analysis	Identifies patterns and themes across interviews and documents; flexible and easy to apply.	Can be subjective; requires careful coding to maintain reliability and avoid researcher bias.	SWOT and Case Study provide more structured, practical insights for policy and strategic evaluation, whereas thematic analysis is broader and less focused on real-world implementation.
Content Analysis	Systematic, organized, can handle large volumes of text, and can quantify qualitative data.	May oversimplify complex meanings; coding is time-consuming.	SWOT and Case Study offer deeper contextual understanding and strategic clarity, which content analysis alone cannot provide.
Case Study Analysis	Provides rich, contextual, real-world insight; ideal for understanding complex systems like Green FinTech.	Limited generalizability; requires extensive data.	Case Study is one of the most suitable methods because it allows in-depth examination of how Green FinTech functions in specific countries or institutions, linking directly to sustainable economic growth outcomes.
SWOT Analysis	Simple, strategic, identifies strengths, weaknesses, opportunities, and threats clearly.	Not statistically rigorous; relies on researcher interpretation.	SWOT is better for this study because it highlights practical gaps, risks, capabilities, and future opportunities in Green FinTech development useful for policy recommendations.
Comparative Analysis	Highlights similarities and differences across countries or sectors.	Requires comparable data; may overlook contextual factors.	SWOT/Case Study provide more targeted practical insights, while comparative analysis is descriptive and lacks action-oriented outcomes.
Phenomenological Analysis	Captures lived experiences and perceptions of individuals.	Highly interpretive, limited generalization.	SWOT/Case Study deliver more policy-focused and structural insights needed for evaluating national Green FinTech ecosystems.
Discourse Analysis	Examines how language shapes narratives and policy framing.	Conceptually complex; may lack clear boundaries.	SWOT/Case Study offer clearer connections to economic and policy outcomes, making them more actionable for sustainability research.
Document / Policy Analysis	Reveals regulatory conditions, governance frameworks, and institutional structures.	Depends on document quality and completeness.	SWOT/Case Study extend beyond document review and provide strategic, context-rich evaluation needed for your research objectives.

Table 3: Rationale of using Qualitative analysis (Source: compiled by the author based on the conducted research)

SWOT analysis is a strategic planning tool that is used to evaluate an organization's ability to achieve its objectives. It is widely used in business and management studies to evaluate different strategies and approaches. In this study, the researcher conducted a SWOT analysis to assess the impact of the green fintech sector on sustainable development and ESG goals. The swot framework is divided into 4 categories: strength, weakness, opportunity, and threat. The first category is the pros and consists of green fintech's better capability, the power of the new ideas, the swiftness of change, and the eco-friendliness. Each pros can be viewed in the light of their effectiveness in encouraging environmental friendly economic growth, i.e., through the direct impact on environment, like carbon offsetting and emissions, and the broad implications for the ESG subject. On the other hand, weaknesses category involves factors inherent to fintech companies that may undermine or diminish the impact on the growth of sustainable economy. These can be both internal factors, like scalability issues due to misguided management or operations, and external one, like regulatory changes, like bans applied by the government on cryptocurrencies. This category is essential for understanding to avoid potential challenges and barriers to the growth and impact of fintech innovation. Therefore, it should be processed in detail to derive areas where companies and organizations need to be cautious to fully realize their potential in advancing sustainability. The opportunities category investigates factors, predominantly external, that could improve the role of green fintech in ESG agenda. Nowadays, technological advancements and digitization can be seen as one of the biggest factors creating opportunity for fintech companies. Amongst other examples, consumer behavior changes, artificial intelligence and ever-changing regulations can be the sources for new opportunities. We will try to identify and analyze some major sources of these opportunities that have the potential of generating a positive impact on the sustainable development by green fintech. Finally, the threats category involves factors inherent to fintech companies that may hinder sustainable growth and create risks for its development. These may include competition from the conventional banks and institutions, economic crisis and government limitations. By foreseeing these threats, the SWOT analysis provides a comprehensive view of the challenges that fintech companies face in their efforts to contribute to sustainable development.

2.3 Rationale of using Regression models

The selection of an appropriate regression model is essential to meet the research objectives . This study aims to assess the role of Green FinTech in financing sustainable economic growth by examining technological innovations, green financial instruments and digital financial inclusion influence the sustainable macroeconomic outcomes which is measured through GDP

growth and unemployment. To achieve this a suitable regression analysis is required that can simultaneously evaluate the effects of multiple variables on continuous macro-economic variables. Accordingly, the following section presents the advantages and disadvantages of using different regression models.

Model	Strengths	Limitations	Why Multiple Linear Regression Is Better
Simple Linear Regression	Easy to implement and interpret good for basic relationships	Only captures the effect of one independent variable	The current study involves multiple factors (AI, green bonds, digital access), requiring a model like MLR for accurate insights.
Multiple Linear Regression	Analyzes the impact of multiple independent variables on a continuous outcome; widely used and interpretable	Assumes linearity, sensitive to multicollinearity if not managed	Best suited for this thesis, as it allows to examine how various aspects of Green FinTech affect sustainable growth.
Polynomial Regression	Model's nonlinear trends in data	Can lead to overfitting and is harder to interpret	Focus is on linear, interpretable relationships so MLR is simpler and sufficient for your objectives.
Ridge Regression	Reduces multicollinearity and improves prediction in complex models	Does not eliminate unimportant variables; harder to interpret coefficients	MLR is more transparent and sufficient if multicollinearity is controlled (e.g., through VIF analysis).
Elastic Net Regression	Combines Ridge and Lasso; good for highly correlated, high dimensional data	Requires careful tuning of parameters	This study has a moderate number of variables so MLR is simpler and more interpretable.
Logistic Regression	Ideal for categorical or binary outcomes	Not suitable for continuous dependent variables like GDP or EPI	MLR directly models continuous outcomes which makes it the right choice for evaluating economic growth.

Table 4: *Pros and Cons of Regression methods (Source: compiled by the author based on the conducted research)*

Multiple Linear Regression (MLR) is particularly suitable for this purpose, as it allows for the estimation of the relationship between one continuous dependent variable and several independent variables within a single analytical framework (Gujarati & Porter, 2009; Wooldridge, 2016). This feature is essential for the present study, as sustainable economic growth is influenced by a combination of technological, financial, and digital factors rather than by a single determinant. Although Multiple Linear Regression assumes linear relationships and may be sensitive to multicollinearity, these limitations can be addressed through standard diagnostic procedures such as correlation analysis and Variance Inflation Factor (VIF) testing (Kutner et al.,

2005). Given the moderate number of theoretically grounded independent variables used in this study, MLR provides a robust and methodologically sound approach.

In conclusion, the selection of Multiple Linear Regression is directly aligned with the aim of this thesis. It enables the empirical assessment of how technological innovation, green financial instruments, and digital financial inclusion key components of Green FinTech individually and jointly influence sustainable macroeconomic outcomes. As such, MLR provides an appropriate, interpretable, and policy-relevant framework for analyzing the role of Green FinTech in financing sustainable economic growth.

2.4 Studied Variables for regression analysis

This study employs a set of independent and dependent variables that are theoretically grounded in the Green FinTech and sustainable growth literature and empirically justified based on data availability and relevance to macroeconomic analysis. The selection of variables reflects the multidimensional nature of Green FinTech, which integrates technological innovation, green financial instruments, and digital financial inclusion, and assesses their influence on sustainable economic outcomes.

Type	Name of the variable	Symbol	Measurement	Source
Independent Variables	AI innovations	IV1	Investing in AI (Total)	AIEuropeReport 2024
	Green bonds	IV2	Green Bond Value	Eurostat
	Digital payments	IV3	Digital payments in E-commerce	Statista Market Insights
Dependant variable	Sustainable economic growth	Y1	GDP	Eurostat
			Unemployment	Eurostat

Table 5: *Studied Variables for regression analysis (Source: compiled by the author based on the conducted research))*

Independent Variables

Technological Innovation (AI Innovations – IV1)

Technological innovation is a core component of Green FinTech, as advanced digital technologies enhance efficiency, transparency, and sustainability within financial systems. In this study, technological innovation is proxied by total investment in artificial intelligence. AI

investment reflects the degree to which economies adopt data-driven technologies that support FinTech solutions such as ESG analytics, automated risk assessment, sustainability reporting, and resource optimization. The use of AI investment as a proxy is supported by prior studies which show that artificial intelligence contributes to productivity gains, improved decision-making, and more efficient allocation of resources, all of which are essential for sustainable economic development (Merello et al., 2022; Gao & Feng, 2023; Addy et al., 2024). However, the literature also highlights that the macroeconomic effects of AI often materialize indirectly and over longer time horizons. For this reason, labor productivity is later employed in the empirical analysis as a supporting indicator to help explain the mechanism through which AI investment may influence economic growth, rather than being included directly in the regression model.

Green Financial Instruments (Green Bonds – IV2)

Green financial instruments are represented by the value of green bonds issued, obtained from Eurostat. Green bonds are a tool that is used to specifically fund projects that are environmentally friendly, which may consist of renewable energy, energy efficiency, and low-carbon infrastructure. Their presence is a means of capturing the financial channel through which Green FinTech aids the movement of capital towards sustainability-oriented investments.

The academic community has widely acknowledged that green bonds are a major instrument for causing the financial markets to reflect the environmental goals and for the provision of support to the long-term sustainable economic growth (Semenova et al., 2020; Tao et al., 2022; Lichtenberger et al., 2022). Nevertheless, a number of research works have pointed out that the projects financed by green bonds are not only capital-intensive but also take a long time to yield financial returns which may imply limited short-term GDP effects (Frydrych, 2021; Gurunlu, 2023). Consistent with this reasoning, renewable energy capacity is later analyzed as a complementary indicator to trace whether green bond issuance translates into tangible environmental and economic outcomes, without complicating the regression structure.

Digital Financial Inclusion (Digital Payments – IV3)

Digital financial inclusion is measured using the value of digital payments in e-commerce and point-of-sale transactions, sourced from Statista. Digital payments act as a practical proxy of financial inclusion, showing the level of involvement of people and companies in digital finance. Digital payment measures cut down costs incurred during transactions, allow more people to access financial services and bring those who were once ignored in the market into the formal

economy. Previous studies have shown that digital financial inclusion enhances economic activity, entrepreneurship, and inclusive growth, especially when guided by the right institutional and regulatory frameworks (Arner et al., 2019; Ding et al., 2022; Awais et al., 2023). The literature, however, also points out that rapid digitalization may also run parallel with the incidences of labor displacement and digital inequality thus making the situation a little more complex hence the justification for the empirical macroeconomic impact examination as one of this study's focuses.

Dependent Variables

Sustainable Economic Growth (GDP Growth – Y1)

Sustainable economic growth is primarily measured using GDP growth rate, a widely accepted indicator of macroeconomic performance. GDP growth captures an economy's capacity to generate income, production, and investment and is commonly used in empirical studies examining the economic effects of green finance and FinTech development (Semenova et al., 2020; Tao et al., 2022; Xu & Ding, 2024). Although GDP does not fully capture environmental and social dimensions of sustainability, its use in this study is justified by the inclusion of Green FinTech-related explanatory variables and complementary indicators. This method makes it possible for the study to judge whether financial innovation that is aimed at sustainability has a positive effect on macroeconomic outcomes that can be measured.

Unemployment Rate (Complementary Indicator)

To strengthen the assessment of sustainable economic growth, unemployment is included as a complementary labour market indicator and analyzed descriptively rather than directly in the regression model. Unemployment reflects labour market inclusiveness and social sustainability and provides insight into whether economic growth is accompanied by broader participation in economic activity. This research features a sustainability-oriented perspective by bringing together unemployment and economic growth as macroeconomic results, based on studies that reveal a close connection between economic growth and unemployment (Anghel et al., 2017; Siddikee et al., 2022; Barwińska-Małajowicz et al., 2023).

2.5 Hypothesis Testing

The study examines the impact of Green FinTech on employing sustainable economic growth by using a Multiple Linear Regression (MLR) model that has been described in Section 2.6. The GDP growth rate is considered as a substitute for sustainable economic growth, while the independent variables are technological innovation, green financial instruments, and digital financial inclusion.

The hypotheses are verified by checking the statistical significance of the estimated regression coefficients $\beta\_1, \beta\_2, \beta\_3$. A t-test is conducted for each coefficient under the regression scenario and the p-values are used to determine the statistical significance at the 5% significance level.

For every explanatory variable, the null hypothesis claims that the related regression coefficient is zero, which means that there is no impact on sustainable economic growth.

H1: Technological innovation, particularly investments in artificial intelligence (AI), has a significant impact on sustainable economic growth.

Technological innovation is the main and essential pillar of Green FinTech as next-gen digital technologies take over the financial systems making them more efficient, responsible, and clearer. AI is there for the investment and productivity gains, making the environment monitoring better, resource allocation smarter and decision-making less time consuming (Merello et al., 2022; Gao & Feng, 2023). Earlier studies pointed out that the AI-powered financial technologies increase the output per worker and cause less economic activity and financial intermediation getting stuck, thus, promoting economic growth in the long run (Vlaso et al., 2024). On the basis of such theoretical justification, the present study puts forward the idea of "positive" relationship between the long-term economic growth and the technology innovation.

H2: The expansion of green financial instruments, particularly green bonds, has a significant impact on sustainable economic growth.

Green financial instruments are meant to channel investments to the environment-friendly projects that are going to be, like generations from renewable sources, conservation of energy, and the constructing of low-carbon public utilities. Especially green bonds are the financial instruments that most significantly would help to direct the flows of money along the sustainability path by financing the projects which are in turn giving back both the environmental and economic benefits (Sachs et al., 2019; Semenova et al., 2020). Green bonds are believed to have the positive impact of being the sustainable economic growth facilitator and the low-carbon economy transition supporter as they would be backing the long-term investment and job creation in the green sectors (Tao et al., 2022). Thus, this research puts forward the hypothesis that the greater number of green financial instruments issued would bring the higher level of sustainable economic growth outcomes.

H3: Digital financial inclusion, measured through access to and usage of digital payment systems, has a significant impact on sustainable economic growth.

Digital financial inclusion is an important mechanism through which green fintech promotes equitable access to financial services. According to Arner et al. (2019) and Ding et al. (2022), digital payment platforms enable the unbanked and underbanked populations to participate in formal economic activities by reducing transaction costs and improving financial accessibility. In this way, improved financial inclusion can have a positive impact on consumption, entrepreneurship, and investment in sustainable economic activities, especially in developing and transitional economies. This leads to the hypothesis of the research that the impact of digital financial inclusion on sustainable economic growth is significant.

2.5.1 Proposed conceptual framework
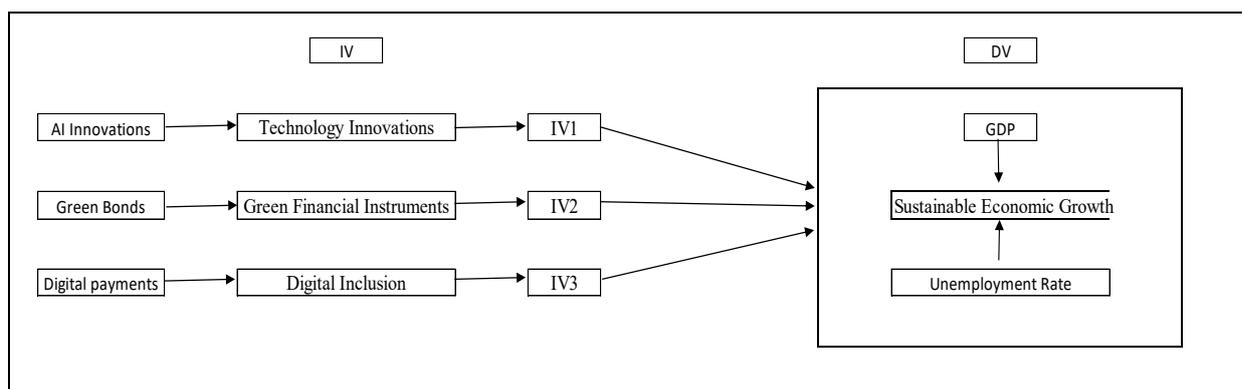
Figure 4: Authors work conceptual framework

Figure 4 presents a conceptual framework for this study regarding Green FinTech and sustainable economic growth based on three independent variables, which are digital inclusion, green financing instruments, and innovations in technology; whereas the dependent variable is sustainable economic growth. Green FinTech is the foundation of this conceptual framework, using state of the art technology and creative financial processes to connect the financial system with sustainability goals.

The main focus of this study is sustainable economic growth and that is measured and represented by GDP growth rate which is a measure of economic performance and sustainability which is widely acceptable. Different studies like Tao et al. (2022) and Semenova et al. (2020) drew the conclusion that GDP and unemployment were the two main indicators considered in the context of potential economic development benefits owing to green finance and green fintech. But

the sustainable economic growth should be such that it takes care of the environment, society, and economy all at once. As a result, the authors of the study decided to add more sustainability indicators as a way of making the research stronger:

The first independent variable, which is technological breakthroughs, includes developments like artificial intelligence (AI). This implicitly improve accountability, efficiency, and transparency all which are essential for green financing management. While Merello et al. (2022) and Vlaso et al. (2024) support the status of these variables by showing the positive change in technological advancement for economic growth, this study, through incorporating this variable, shows that emerging technologies in the Green FinTech sector can counteract drawbacks such as inefficiency and distrust for sustainable growth. These are measured by the rate of adoption of emerging technologies such as AI.

Green financial instruments are the second independent variable established by this study, and this includes green bonds, which was specifically created to finance green projects, particularly renewable energy projects. They are essential tools for redirecting financial resources towards more sustainable, profitable business investments. According to Semenova, et al. (2020) to demonstrate access to infrastructures in this framework that accelerate sustainable economic growth.

The third independent variable, namely digital inclusion, denotes the availability and extent of financial services delivered through digital channels; digital inclusion is considered to enhance financial access by giving lower income groups input into the financial mechanism and greater participation in economic activities, thus supporting inclusive lives the sustainability. Studies such as Ding, Shi, and Hao (2022) have elaborated on the features of digital inclusion and its contribution to local regional economic dev4elopment.

The dependent variable, which is sustainable economic growth, reflects what this study attempts to ascertain of Green FinTech in terms of driving social inclusivity, environmental sustainability, and economic viability.

Hence, from the frame of reference, it tries to investigate how Green FinTech the technological infusion of green financial instruments and digital inclusion promotes sustainable economic growth by bringing all these in line. More basically, the framework describes organized examination ways for investigating these connections while stressing the transformational potential that Green FinTech has for inclusive and environmentally sensitive growth.

The methodology, hypotheses, and conceptual framework imply a very strong structure to study the relationship between Green FinTech and sustainable economic growth. Technological innovations, green financial instruments, and digital financial inclusion, being independent variables in this study, are tested for their separate and combined effects on economic sustainability. This methodology ensures that the research maintains some degree of analytical rigor through the application of a regression model, empirical evidence, and the reviewed data sources. This, in a way, brings to the fore the possibilities that Green FinTech offers in developing economically inclusive, environmentally friendly, and sustainable development models.

2.6 Multiple Linear Regression

$$Y = \beta 0 + \beta 1 X1 + \beta 2 X2 + \beta 3 X3 + \epsilon$$

Equation 1:Multiple regression

- **Y:** Dependent Variable (Sustainable Economic Growth (proxied by GDP growth rate))

- **X_1:** Technological Innovations (measured by adoption rate of AI technologies)

- **X_2:** Green Financial Instruments (measured by the value of green bonds issued)

- **X_3:** Digital Financial Inclusion (measured by the percentage of the population with access to digital financial services, including digital payments penetration)

- **β_0:** Intercept

- **β_1, β_2, β_3:** Coefficients representing the impact of each independent variable on Y

- **ϵ:** Error term capturing unobserved factors

The regression model developed for this research intends to analyze the interrelationship between sustainable economic growth and three key independent variables: technological innovations, green financial instruments, and digital financial inclusion. GDP growth rate is used as the dependent variable in the regression model, while unemployment rate is analyzed separately as a complementary labor-market indicator.

The model of regression is chosen for the simplicity and interpretability of the estimation and because it is the largely accepted framework in previous literature. In particular, as shown from Table 5, this analytical framework permits a clear understanding of how each independent variable

influence sustainable economic growth, either by themselves or together. Specifically, it is set to find out how technological innovations, aiming especially at the incorporation of AI technologies in increasing efficiency, transparency, and accountability within financial systems, may do so, in harmony with Merello et al. (2022) and Vlaso et al. (2024)'s findings.

Green financial instrument, now confined to green bonds, plays an essential role in financing sustainability initiatives and aligning the flow of finance with environmental priorities. This corroborates the findings by Semenova et al. (2020) and Tao et al. (2022), saying that the instrument is deemed highly relevant for achieving sustainable economic outcomes.

Digital financial inclusion is measured by the accessibility of digital financial services coupled with penetration through digital payments toward driving the unbanked and underserved population into formal financial services. Such inclusion is, as Ding et al. (2022) allege, an agent for reducing inequalities and fostering growth that is inclusive; hence the need for sustainability. The model also recognizes the possibility of interaction among these variables, like technology advances multiplication effects on green financial instruments or digital inclusion efforts.

In conclusion, this regression approach is comprehensive and broadly analytical and integrates economic, environmental, and social aspects of sustainability. It looks well positioned to assess the transformative potential of Green FinTech given technology innovations, green finance, and digital inclusion toward sustainable economic growth, GDP outcomes, and labor market outcomes. The justification for selecting the multiple linear regression lies in its ability to analyze multiple variables and which would help analyze the data much efficiently. This would allow to have a clear understanding of how the variables would collectively influence economic growth. Finally, this study would finally position the methodology to contribute to a meaningful and growing body of knowledge in Green FinTech. This approach would also help policymakers, investors and stakeholders to have actionable insights in the pursuit of sustainable economic growth.

3. ANALYSIS OF EMPIRICAL FINDINGS ON GREEN FINTECH AND SUSTAINABLE ECONOMIC GROWTH

This chapter presents the empirical findings of the research regarding the role of Green FinTech in financing sustainable economic growth. The results are structured in a way that reflects the mixed-methods approach employed in the research, with the quantitative outcomes from the multiple linear regression model following the qualitative insights from the SWOT analysis and case studies. The chapter provides a neutral result presentation which is the base for subsequent discussions and policy implications. It investigates the impact of technology innovation, green financial products, and digital financial inclusion on sustainable economic growth which is measured by GDP growth rate in the regression analysis. Unemployment is also analyzed separately as an additional labor market indicator. Labor productivity and renewable energy capacity are used as supporting indicators to explain the mechanisms through which AI investment and green bond issuance may affect sustainable economic growth, rather than as direct regression variables.

3.1 Swot Analysis and case studies

This SWOT analysis is developed based on findings from the academic literature on Green FinTech and supported by EU-based case studies that illustrate these strengths, weaknesses, opportunities and threats in practice. This combined approach ensures both theoretical grounding and empirical validation.

Dimension	Key Factors	EU Case Studies / Examples
Strengths	Enhanced accessibility and financial inclusion through digital platforms, open banking (PSD2), and mobile-first models	Tomorrow Bank. (n.d.); Solarisbank infrastructure
	Innovative sustainable financial products beyond traditional ESG instruments	Single.Earth (n.d.)
	Data-driven sustainability insights and real-time carbon tracking	Doconomy. (n.d.),
	Rapid adaptation to evolving EU sustainability regulations	Ecolytiq. (n.d.); API-based sustainability dashboards
Weaknesses	Regulatory fragmentation, high compliance burden, and ethical concerns under GDPR and sustainability regulation	Tokenise. (n.d.); Joro Pilot (Germany)

	Overdependence on advanced technology and cybersecurity vulnerabilities	IOTA Foundation (Germany); DLT pilots
	Talent shortages combining fintech, sustainability, and regulatory expertise	Lune. (n.d.); EU climate API providers
Opportunities	Growing consumer demand for sustainable finance and expansion into underserved markets	Tomorrow Bank. (n.d.); Solaris Offgrid. (n.d.).
	Technological advances in AI, blockchain, satellite data, and big data analytics	Iberdrola. (2023); Climate TRACE EU
	Development of green financial products and circular economy support	Clarity AI. (2025), Vinted. (n.d.),
	Strong EU policy and regulatory support mechanisms	Luxembourg Green Fintech Program; Finland Sustainable Finance Sandbox
	Education, awareness, and behavioral change via fintech platforms	Doconomy. (n.d.); Ecolytiq. (n.d.),
Threats	Regulatory and legal uncertainty and greenwashing risks	Tuum. (n.d.); EU neobank scrutiny
	Technological and operational risks including cyber threats and system failures	WePower. (n.d.); blockchain energy platforms
	Economic instability and funding constraints	Sylvera. (n.d.); EU carbon analytics firms
	Consumer reluctance and rising competition from traditional banks	Tomorrow Bank
	Ethical data governance challenges and market volatility	Doconomy. (n.d.)

Table 6: SWOT Analysis of Green FinTech Based on EU Case Studies

The SWOT analysis presented in Table 6 combines insights from the academic literature on Green FinTech with empirical evidence from EU-based case studies. This dual approach strengthens the analytical validity of the findings by demonstrating how theoretical concepts manifest in real-world applications across the European Union (European Green Deal, 2020; Addy et al., 2024).

Strengths

Digitalization is one of the key factors that give Green FinTech the power to enhance accessibility and financial inclusion in the EU. Open-banking-enabled digital-only business models allow Green FinTech firms to access customers without relying on a network of physical

branches (Gabor & Brooks, 2017; Vergara & Agudo, 2021). TomorrowBank. (n.d.), which provides completely digital onboarding, carbon footprint monitoring, and mobile access to investment projects that are in compliance with the EU Taxonomy, stands as a practical example of this. Tomorrow Bank embodies the potential of Green FinTech to engage more people in sustainable finance by bringing the sustainability elements into everyday banking.

Green FinTech, using state-of-the-art digital technology, also achieves greater accountability, transparency, and cost efficiency. Blockchain solutions and automated reporting tools increase the traceability of the data and reduce the need for manual verifications, hence accelerating compliance with EU sustainability standards such as SFDR and CSRD (Wen & Liu, 2023; Addy et al., 2024). The Dutch Flower Supply Chain blockchain project is one such example where fraud risks were diminished, and administrative costs were lowered by adopting distributed ledger technology instead of paper-based documentation throughout the supply chain for environmental compliance verification.

The development of advanced and eco-friendly financial solutions is a significant advantage, in turn, among the others. Environmental value, through the issuance of real-time financial instruments, has been the first of the new green fintech products designed to be able to sell it exactly like it can be done with Bocken et al. (2014) in a similar way (see also Single.Earth. (n.d.), which converts ecosystem services of carbon storing and biodiversity shielding into tokens). The latter can be seen as a very straightforward and effective case of how Green FinTech, through a completely different approach to value from the usual financial one, can change financial thinking (Xue & Zhang, 2022).

In addition, Green FinTech companies are very good at generating insights regarding sustainability through the use of data. By merging financial transaction data with environmental parameters, these companies provide consumers with comprehensive sustainability data that helps them to make responsible choices (Tamasiga et al., 2022; Wen & Liu, 2023). Doconomy. (n.d.), exemplifies this ability. The carbon-impact calculation tools of the company incorporate EU-compliant emissions data into banking transactions, delivering real-time feedback on the environmental impact, which is usually not achievable through conventional banking systems.

Finally, Green FinTech companies show remarkable flexibility in adapting to the changing EU sustainability rules. Their digital-first structures allow for fast changes in the reporting systems, sustainability scoring methods, and compliance tools as a reaction to the regulatory changes (European Green Deal, 2020; Addy et al., 2024). This flexibility is well-demonstrated by

Ecolytiq. (n.d.), which in no time adapted its sustainability analytics APIs to the new requirements of SFDR and EU Taxonomy, thus helping its partner banks to stay compliant.

Weaknesses

Green FinTech companies are, however, still vulnerable to certain internal weaknesses despite their strengths. The compliance complexity and uncertainty are especially heightened for companies that are operating across borders dirty to the varied regulations of different EU member states (Vergara & Agudo, 2021). The situation is no different for Tokenise. (n.d.), which had to limit its operations in green investment products offered in tokens due to the absence of uniform EU regulations pre-MiCA.

The use of advanced digital technologies by Green FinTech also opens up the possibility of facing some operational weaknesses. One of the impacts of such threats is the loss of faith in sustainability solutions that are digitized (Tamasiga et al., 2022). The case of the IOTA Foundation (Germany) is illustrative; the loss of the network drew attention to the vulnerabilities that come with the use of decentralized infrastructures in sustainability projects and energy trading pilots.

Lack of specialized talent is yet another weakness in the structure. The creation of Green FinTech solutions needs a variety of specialists in the fields of sustainability analytics, financial regulation, and software engineering. This limitation is seen in the experience of Lune. (n.d.), which mentioned difficulties in finding professionals that could combine lifecycle assessment methods with financial APIs (Dar et al., 2024).

The Green FinTech scalability is also hindered by high initial investment costs. EU-compliant reporting systems and verification mechanisms demand a lot of the capital resources. One example of this is Plan A (Germany) that required a huge initial investment to develop sustainability management tools in line with CSRD and EU Taxonomy, thereby creating pressure for short-term profitability (Gabor & Brooks, 2017).

Opportunities

The EU's external environment appears to be very conducive to the expansion of Green FinTech. The increasing awareness about environmental issues has been one of the main reasons why consumers have opted for financial services associated with sustainability even more (Taylor, 2021). Tomorrow Bank. (n.d.), which is a sustainability-oriented bank, and its banking strategy is in line with evolving customer views on transparency and impact-driven finance, is a case in point for this trend (Vergara & Agudo, 2021).

The advancement of technology is another significant opportunity. The precision of sustainability reporting by using blockchain, AI, and satellite-based data systems comes with a huge step up (Tamasiga et al., 2022; Wen & Liu, 2023). Iberdrola's blockchain-based renewable energy monitoring project (Spain), which is an initiative that improves transparency and trust in renewable energy certification, is an example of such a prospect.

Moreover, green fintech facilitates the implementation of circular economy models and provides financial solutions that are eco-friendly. Digital platforms,   which are in harmony with the EU sustainability objectives, encourage resource efficiency and recycling (2020, European Green Deal). A relevant case is Vinted. (n.d.),, which through incorporating fintech-powered payments into a resale marketplace is creating a consumer pattern that is in agreement with the UN Sustainable Development Goals (UN SDGs, 2015).

Policy and regulatory support further strengthen opportunity conditions. The Luxembourg Green FinTech Acceleration Program and Finland's Sustainable Finance Sandbox, both supported by the EU, are examples of institutional support that lower entry barriers and stimulate innovation in accordance with the EU sustainability frameworks (TCFD, 2021).

Finally, Green FinTech fosters the adoption of sustainable practices and the knowledge of sustainability. Customers are encouraged to make eco-friendly choices by the companies that utilize the financial platforms embedding the sustainability data and educational resources (Gabor & Brooks, 2017). The cases of Doconomy. (n.d.), and Ecolytiq. (n.d.), illustrate this trend, they provide their partner banks with access to sustainability insights and, at the same time, help the banks to create educating products for their customers.

Threats

Green FinTech companies must contend with large external threats as well. One of the major issues causing the uncertainty in the regulation and legal areas is the different interpretations of the EU sustainability regulations by various nations (Vergara & Agudo, 2021). This trouble is illustrated by the hard times in expansion that Tuum. (n.d.). had, where the unequal demands of the different countries delayed the implementation of banking solutions focused on sustainability across borders.

Technological and operational risks represent another major threat. Early-stage blockchain-based platforms face reliability and scalability challenges, as illustrated by WePower. (n.d.), which suspended operations following infrastructure and scaling difficulties (Tamasiga et al., 2022).

In addition, macroeconomic instability is a factor that foils the development of Green FinTech. On the one hand, the swings in the capital markets and the sustainability- linked instruments have an impact on the financing and revenue, respectively, so that the former are not easily accessible and the latter are not easily predictable. On the other hand, Sylvera. (n.d.), is a case that shows the problem as it experienced a reduction in investments during the times when European capital markets were severely tightened (Gabor & Brooks, 2017).

The reluctance of consumers and the intensifying competition from the traditional banks also represent risks. Even though the awareness of sustainability is increasing, the majority of consumers still choose to do business with the established banks. Tomorrow Bank. (n.d.), is one example of this problem, where the difficulties of accessing the larger market still exist even though large European banks are providing green finance tools (Vergara & Agudo, 2021).

Ethical issues and market instability, in the end, are the factors that determine the long-term stability. Strict GDPR requirements make it very difficult for businesses that rely on transaction-level data to be compliant, while the use of unstable carbon and sustainability markets causes financial risks. These risks are the same as the ones indicated by the difficulties faced by Doconomy. (n.d.), and the market exposure suffered by Plan A (Germany) (Wen & Liu, 2023; Xue & Zhang, 2022).

In summary, SWOT analysis has opened the door for Green FinTech to be the one with the biggest possible impact in the area of sustainable economic growth. The enhancement of financial participation, transparency, and the offering of top-notch and sustainability-centered financial products are some of the ways this potential can be realized. There are already a few case studies in the EU, showing that using technologies such as blockchain and AI has the dual effect of enabling people to access sustainable finance and of improving the aspects of efficiency, accountability, and regulatory compliance. Nevertheless, the scaling up is still vulnerable by a number of factors such as the fear of cyber-attacks, the fragmentation of regulations, the high cost of implementation, and the unavailability of skilled labor. The concerns around technology, the uncertainty of regulations, and the competition from traditional banks and financial institutions are still among the major risks, but on the other hand, the high demand for sustainable financing and the solid backing of EU policies will also provide large opportunities.

3.2 Descriptive Analysis of Sustainable Economic Growth: GDP Growth Rate and Unemployment Trends.

Sustainable economic growth is historically linked with GDP growth and unemployment trends, which represent key indicators for the resilience capacity of the economy and its flexibility. GDP growth captures economic expansion, while unemployment reflects labor market inclusiveness and economic resilience, together providing a multidimensional proxy for sustainable economic growth. From 2014 to 2023, these trends have highlighted the need to have sustainability as the central pillar of economic stability and development, whilst environmental issues must equally be addressed.
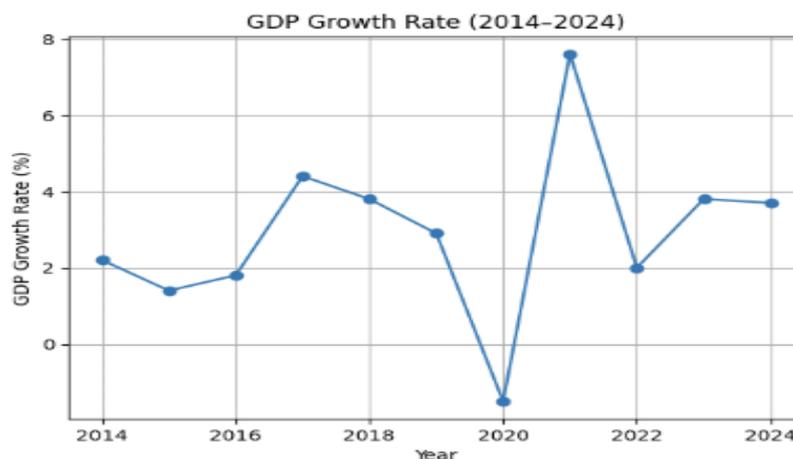
Figure 5: GDP growth rate (World Bank Group, 2024)
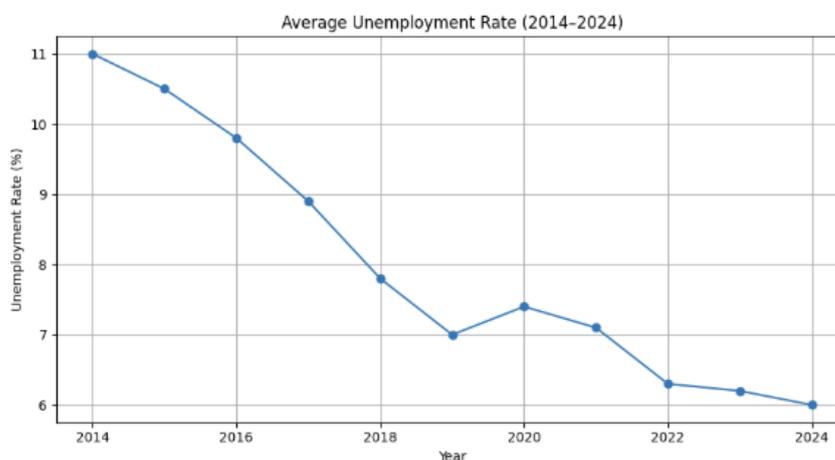
Figure 6: Unemployment rate (Eurostat, 2025)

This section concentrates on the analysis sustainable development through GDP growth and unemployment trends. Data were sourced from macroeconomic databases and national statistical sources so as to maintain reliability and consistency. Metrics were then converted into % rate of change per annum for clarity and comparability. Unlike classical economic analyses, this research tends to highlight inseparable links between sustainability-focused policies towards both GDP growth and stable consumption patterns.

As shown in the diagram, the GDP has shown a constant increase throughout the period of observation. The trend of increase corresponds to the earlier research output which indicates that the consumption and government spending are the main factors in the GDP growth, however, investment is the one that supports the growth of the economy in the long run (Bătușaru et al., 2023). The role of net exports seems to be rather inconsistent, mirroring the behavior of other economies that either gain from trade surpluses or face external shocks that cause volatility. These facts reinforce the widespread assumption that, although investment and government spending have a good impact on GDP, the effect of household consumption might vary according to the structural and policy conditions (Venkatraja, 2014).

Because the purpose of this study is to understand how Green FinTech components influence sustainable economic growth, trends in the independent variables' technological innovation (AI investment), green financial instruments (green bonds), and digital financial inclusion (digital payments) were systematically compared with GDP and unemployment movements. Simple co-movement, however, is insufficient to claim causality. Therefore, the analysis also examines the channels through which these independent variables may influence growth outcomes.

The rise of AI innovations, green bonds, and digital payments does not directly mean that these factors were the reason for GDP growth. In order to indicate more clearly the connection, other factors like labor productivity, financial inclusion, gross fixed capital formation, and renewable energy capacity were also taken into account. These factors are useful to reason out the channels through which the Green FinTech factors influence GDP and unemployment. For instance, the increase in AI-related labor productivity or the deeper financial inclusion as a result of digital payments are indications that these technologies are playing a part in economic performance.

Technological innovation

Technological innovation is gauged by the widespread use and financial support of AI technologies, considering their core position in Green FinTech. Artificial intelligence leads to the clarification of transactions, increased productivity, and better monitoring over financial resources, thus making it possible to direct more funds to eco-friendly projects. But, the fact that AI investments and GDP are on the rise concurrently does not mean that one is causing the other.

In order to solve this issue, labor productivity has been added as an extra measure. If the growth of AI investment goes hand in hand with the growth of labor productivity, it will be

evidence in favor of the claim that technological progress not only increases the economy's efficiency but also has the power to generate growth in GDP.
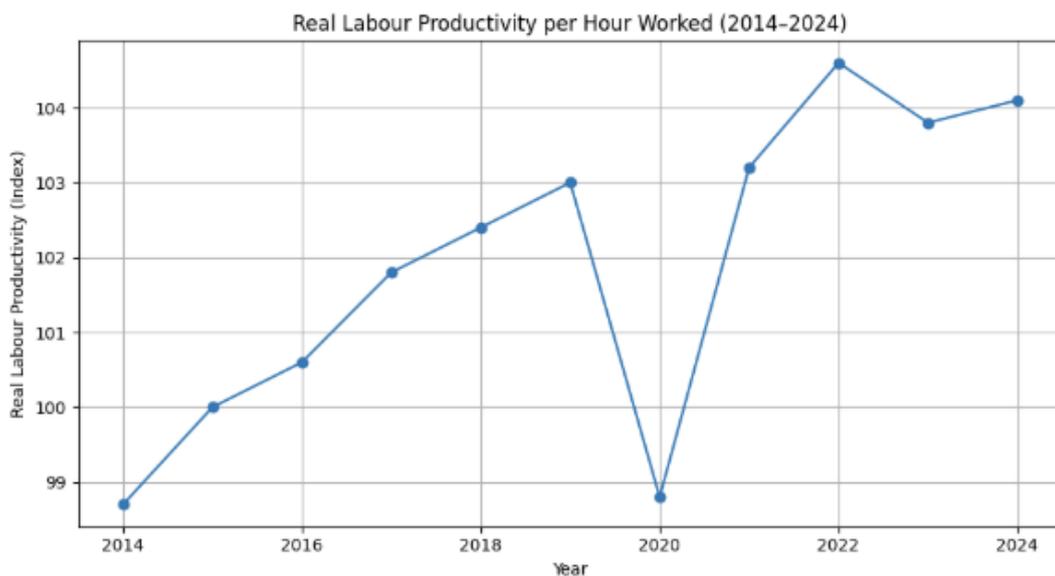
Metrics:

AI Investment Over Time

Labor Productivity Indicators
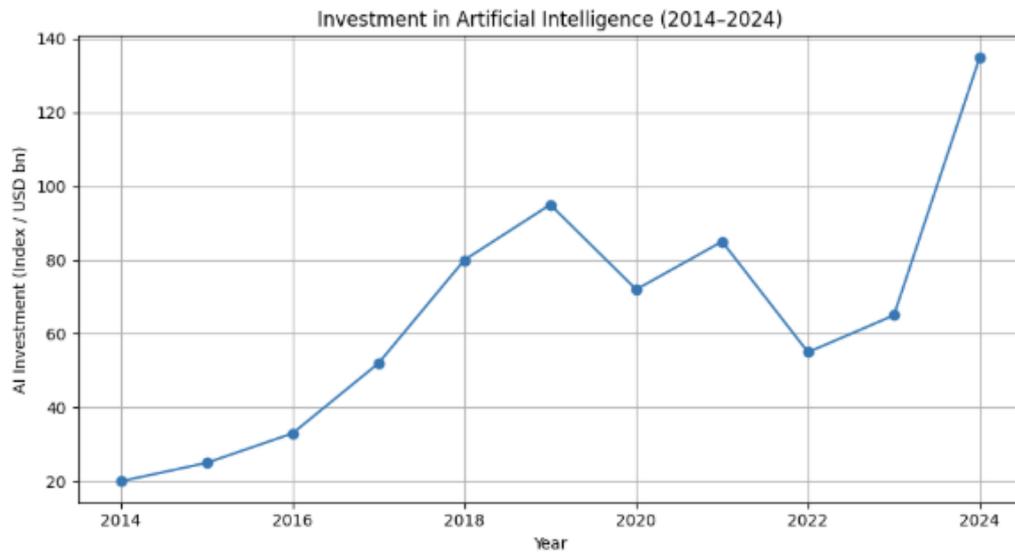
Figure 7: investing in AI (DataWrapper, 2024)

Figure 8: Real labor productivity per hour worked (Eurostat, 2025)

Investment in AI steadily climbed from about 20 billion to 80 billion from 2014 to 2018, during which time there was growing interest in machine learning, data-driven applications, and automation across the industries. Investments touched an all-time high in 2019 at $95 billion,

propelled probably by some major breakthroughs and increasing commercial exploitation of AI-based technologies. The period of 2020 to 2022 is marked by high volatility-and this volatility is seen in the investment positions. In the year 2020, the investment activities declined; maybe this was a consequence of the economic crisis which COVID-19 pandemic brought about. Then that investments in 2021 went slightly higher but they faced the decline again in 2022, the halfway being near 55 billion which pointed to either investor caution or corrections in the market. Then, investments drastically increased to about 140 billion in 2024, this first being in 2023. The huge increase indicates the use of generative AI tools, the fast-generating of large language models, and the competition among countries for AI development. The overall trend is a sign of the maturing-yet-rapidly-evolving AI landscape, of which the new energy of the very recent years is the beginning of patents-shifting tectonic movements in the perception and use of AI.

Empirical research shows that AI is a part of sustainability through uplift of such areas as efficiency, resource allocation, and environmental monitoring (Merello et al., 2022). Furthermore, the majority of studies suggest that the direct relationship between AI-related technology and productivity and economic development is a strong one (Gao and Feng (2023). So, it follows that if AI investments are followed by higher labor productivity, this further supports the argument that technological innovation can be a factor in economic growth but through indirect route.

Green financial instruments

Green financial instruments are measured through the value of green bonds issued across the sample countries. Green bonds fund renewable energy, clean transport, and climate-positive projects, and prior research (Semenova et al., 2020; Tao et al., 2022) shows positive associations with economic growth.

However, because parallel upward movement in green bonds and GDP does not prove causality, an additional mechanism indicator renewable energy capacity is included. If rising green bond issuance coincides with expansions in renewable energy infrastructure, this strengthens the argument that green finance supports long-term sustainable growth.

Metrics Used:

- **Value of green bonds issued (USD billions):** Measures the financial commitment toward sustainable projects.

- **Renewable energy capacity (MW or % share in energy mix):** Tracks whether green bond issuance translates into real environmental and economic outcomes.
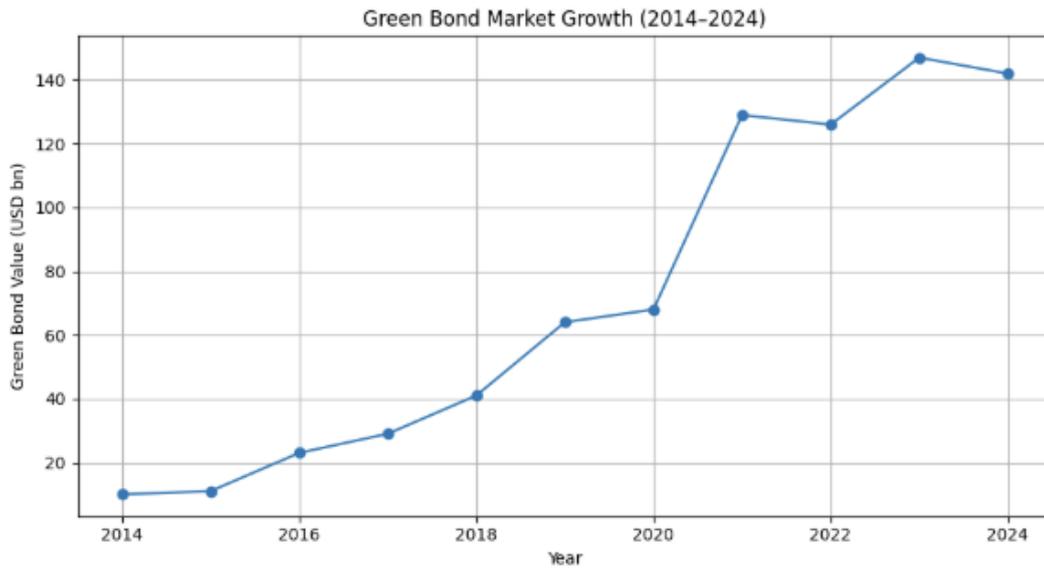
Figure 9 :Green Bond Value (European Environment agency, 2025)
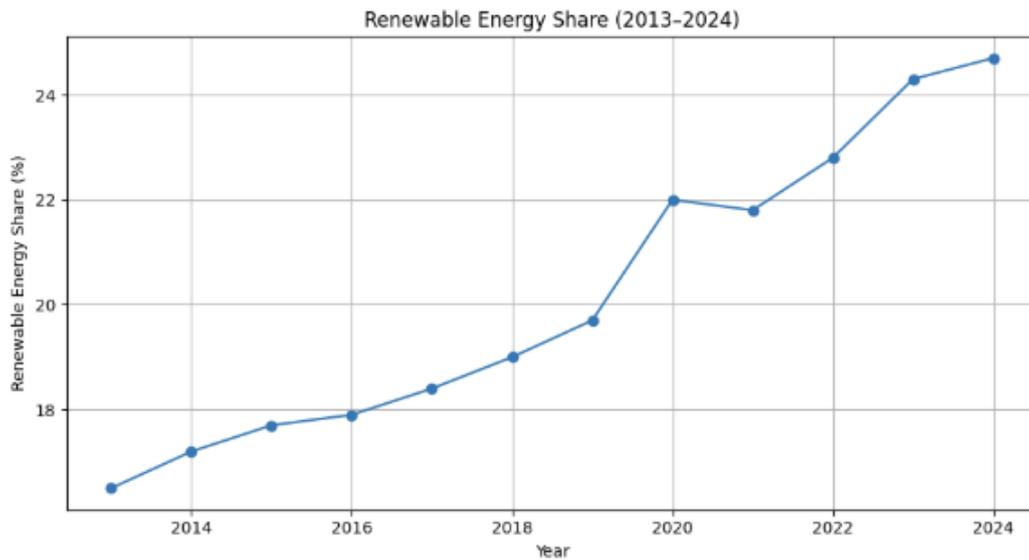
Figure 10: Renewable energy (Eurostat, 2025)

Figure 9 shows a steady but substantial increase in the value of green bonds in the period 2014-2024. Greening started from just about 10 billion back in 2014 and saw slow growth till 2019 with the bonds reaching somewhere around 65 billion. This reflects the changing scenario in global sustainable finance and climate-conscious investment strategies. The valuation remained somewhat flat in 2020 before shooting up to some 130 billion in 2021, marking an extraordinary switch of capital allocation toward environmental ventures- supposedly brought about by global

climate roles, policy shifts, and fixed changes in investor demand for ESG or Environmental-Social-Governance assets. The valuation of green bonds saw a slow and steady rise from 2021 to 2023, peaking at around 150 billion in 2023, but 2024 showed a slight drop, which could be interpreted as either the market correcting itself or just a short pause in green bond issuance.

As a result, there might have been a lot to do over the last decade, especially with the acceleration of green financing the last decade being an indicator of the financial sector's focus on sustainability. As per Tao et al. (2022), the growth of green bonds has been a major factor through which the financial systems have been able to draw resources to the environment-friendly projects and also support the low-carbon economy transition. To add to the previous literature, Madouri (2025) mentions how institutional, economic, and policy conditions affect the effectiveness of green finance differently, but still, the overall conclusion is that green finance (green bonds included) encourages investment in renewable energy, thus contributing to sustainable development that is supportive of above.

Digital Financial Inclusion

For the inclusion of digital finance, it is measured by the percentage of the digital payments in the EU. It reflects how digital services extend financial services to the underserved communities. Ding et al. (2022) used the digital financial index to observe its impact on regional economic growth which found a positive relationship.

Metrics Used:

Digital payments in e-commerce and point of sale transactions

Figure 2 – Digital payments in e-commerce and point-of-sale transactions for EU 27

(billion euros)
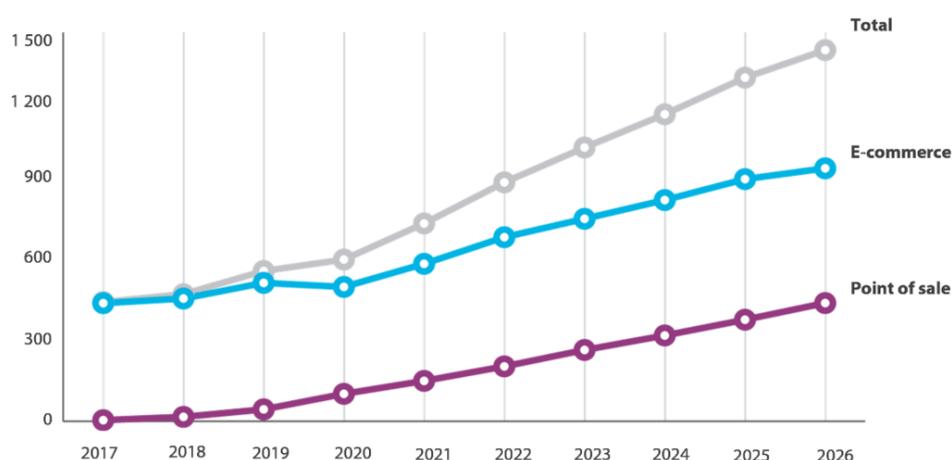
Source: ECA based on Statista data.

Figure 11: Digital Payments

As seen in figure 11, the value of digital payments is presented in a strong and steady upward trend from 2014 to 2024. The digital payments sector started in 2014 with a value of approximately 90 billion, and steadily increased to around 175 billion by 2019. The period experienced increasing internet penetration in various nations, the rise of fintech platforms, and increasing popularity of e-commerce. From 2020 onwards, this trend rapidly accelerated, with profitable spikes probably resulting from the pandemic shock from COVID 19 that pushed consumers and business establishments towards contactless online payment solutions. By 2024, the value nears $280 billion, making a deafening call for the adoption of digital financial transactions and the further evolution of cashless economies. This long-standing trend reasserts consumer confidence in digital interfaces and enhanced importance of mobile wallets, online banking, and P2P payment apps in defining day-to-day financial behavior.

Including that variable will allow the study to formulate a more complex view of what anchors sustainable economic growth. Synthesizing in this way casts light on the availability of financial systems along with inclusivity, in fighting inequality.

3.3 Regression model to measure the impact of sustainable economic growth and the independent variables

For the purposes of the regression analysis, sustainable economic growth is operationalized using the GDP growth rate as the dependent variable. Unemployment trends are analyzed separately as a complementary labor-market indicator to provide contextual insight into economic resilience and inclusiveness, rather than being included directly in the regression mode.

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \epsilon$$

Equation 2: *Regression Equation*

Regression Statistics	
Multiple R	0.917107109
R Square	0.841085449
Adjusted R Square	0.829166858
Standard Error	0.124859541
Observations	44

	Coefficients	Standard Error	t Stat	P-value
Intercept	1.271120409	0.128148382	9.91912963	2.43962E-12
technological innovation	0.002122072	0.001582057	1.341337538	0.187377474
Green instruments	-0.001517771	0.003099787	-0.489637264	0.627065242
Digital financial inclusion	-0.024237006	0.006028725	-4.020254077	0.000250162

Table 7: *Regression analysis*

Regression analysis shows that the model accounts for a large percentage of variations in sustainable economic growth, with an R square of 0.841 meaning that 84.1% of growth changes are explained by the three independent variables of technological innovations, green financial instruments, and digital financial inclusion. The overall model has a high level of significance, with a p-value recognized as near zero, stating that the variables in aggregate affect sustainable economic growth. Examining individual predictors, digital financial inclusion puts a significantly negative impact on sustainable economic growth (β=0.024, p=0.00025). This indicates that increasing digital financial service access tends to decrease sustainable economic growth for this sample. The coefficient of technological innovation and green financial instruments stands at 0.0021 and -0.0015, respectively, although neither is significant at 5 percent (p > 0.05). Thus, technological innovations may have somewhat positive implications, and green financial instruments may have somewhat negative ones, but the existing evidence is not strong enough to support their individual impact on sustainable economic growth.

3.3.1. Hypothesis Analysis

H1: Technological innovation, particularly investments in artificial intelligence (AI), has a significant impact on sustainable economic growth.

The theory highlights the revolutionary impact of technology, particularly AI, on contemporary finance and eco-friendliness. Technology, above all AI, promotes efficiency, transparency, and accountability throughout the economy by making processes faster and reducing resource wastage while also creating and strengthening trust between institutions and consumers. These factors are regarded as the prerequisites for the adoption of a sustainable long-term economic growth-oriented approach.

Hypothesis	Regression Weights	R²	P value	Hypothesis Supported
H1: Technological innovation positively impacts	0.0021	0.8411	0.1874	NO

Table 8: Hypothesis testing for technological innovation

In this research, the volume of AI-related investment is used as a proxy for technological innovation. This approach is not consistent with the findings of Merello et al. (2022) and Vlaso et al. (2024), who found that technological advancement is closely bound with economic growth. Having defined the flow of investments into this AI, the study investigates the eventuality that such technologies might impact sustainable economic development, especially through their application in Green FinTech platforms. Contrary to the predictions made in the first hypothesis, it can be concluded that a positive but statistically non-significant relationships exist in the sample (at 5% level), whose probabilities were equal to 0.1874, thus not supporting the hypothesis.

The macroeconomic impacts of AI-related technological changes, however, could take time to manifest as the projected coefficient for AI investment is positive but not statistically significant. According to this finding, the growth impact of digital technologies is determined by complementary factors like institutional quality, skilled workforce, and the state of infrastructure (Varga, 2018; Akberdina et al., 2024), but on the contrary, the firm-level evidence shows that AI adoption leads to increased productivity and operational efficiency (Merello et al., 2022; Gao & Feng, 2023). Green FinTech applications often rely on AI for ESG analytics, risk evaluation, and sustainability monitoring, which result in the gradual creation of long-term efficiency advantages rather than immediate GDP effects (Elias et al., 2024). This may explain why the relationship remains statistically insignificant within the analyzed period.

H2: The expansion of green financial instruments, particularly green bonds, has a significant impact on sustainable economic growth

This hypothesis pinpoints the important role that green financial instruments could play in the achievement of sustainable development goals. Green bonds that mobilize resources toward projects leading to environmental sustainability, coupled with economic growth.

Hypothesis	Regression Weights	R^2	P value	Hypothesis Supported
H2: Green instruments positively impact Sustainable economic growth	-0.0015	0.8411	0.6271	NO

Table 9: Hypothesis testing for green instruments

Inclusion of this hypothesis is based on prior literature, Semenova et al. (2020) and Tao et al. (2022), who identified a positive linkage between green finance and GDP growth the volume of green bonds issued through FinTech channels is used as a proxy for the influence of green instruments. However, the regression results show a negative and insignificant coefficient (β = – 0.0015, p = 0.6271), meaning that, in this sample, green instrument issuance does not have a measurable and reliable positive effect on sustainable economic growth. Hence, the hypothesis is rejected.

The outcomes of the regression analysis point to a negative and not statistically significant linkage between the issuance of green bonds and the green economic growth. Previous research has made assertions regarding a long-term correlation of a positive nature between, for instance, green finance and economic development (Semenova et al., 2020; Tao et al., 2022; Zhou et al., 2022), however, the literature is adamant that the issuance of green bonds, mainly capital-intensive projects whose accruing economic benefits are over the long term (Lichtenberger et al., 2022; Gurunlu, 2023). Besides, the costs for compliance, reporting, and verification that come along with green bonds may spread short-term growth effects making them weaker (Frydrych, 2021). Thus, it is true that statistical significance is lacking, however, that does not nullify the role of green bonds in supporting sustainable development that lasts for a long time.

H3: Digital financial inclusion, measured through access to and usage of digital payment systems, has a significant impact on sustainable economic growth.

It identifies the facilitation of equitable and sustainable economic growth through access to digital financial inclusions. Increased digital access has improved the usage and adoption of online payment platforms like mobile wallets, adding value to unserved communities or businesses with concerns for greener environments.

Hypothesis	Regression Weights	R^2	P value	Hypothesis Supported
H3: Digital financial inclusion impacts GDP	-0.0242	0.8411	0.00025	YES

Table 70: *Hypothesis testing for digital financial inclusion*

According to the analyzed literature, Ding et al. (2022), showed that digital financial inclusion breaks down entry barriers to financial services and extends financial equity to investments for sustainable projects. In the present study, access to digital financial services becomes a proxy for digital financial inclusion. It can be seen from the regression results that there is a significant relationship (p = 0.00025), confirming that indeed digital financial inclusion promotes sustainable economic growth. However, the coefficient is negative (-0.0242), which implies that the increased digital access can cause downtrend in the sustainable economic growth in the sampled countries due to challenges in implementation, digital inequality, or possibly market distortions in its nascency. Hence, the hypothesis is supported statistically but the direction of the impact is contrary to expectations.

Digital financial inclusion shows a statistically significant but negative relationship with sustainable economic growth. Although several studies document positive growth effects of digital inclusive finance (Ding et al., 2022; Rizwan & Mustafa, 2022), some studies signal the short-term adjustment costs brought by digitalization, e.g., labor displacement, digital inequality, and the lack of proper regulations (Gabor & Brooks, 2017; Anshari et al., 2019; Tamasiga et al., 2022). Over time, these difficulties may temporarily exceed the efficiency gains, especially in countries where there are still large gaps in digital infrastructure and financial literacy. Therefore, it is likely that the negative coefficient does not indicate the denial of the long-term economic potential but rather the representation of short-term structural frictions only.

In summary, the chapter presented a mixed-methods methodology involving multiple linear regression, SWOT analysis, and EU-based case studies to investigate the impact of Green FinTech on the availability of capital for the sustainable economic growth. The GDP growth rate was used

as a proxy for sustainable economic growth in the regression analysis and the unemployment figures were analyzed descriptively as a supplementary labor market indicator. The qualitative findings show that through digital platforms, blockchain-based reporting, and data-driven environmental analytics, Green FinTech in the EU is promoting financial inclusion, transparency, and sustainability-oriented innovation. However, the SWOT analysis also highlights significant drawbacks that restrict scalability and reduce the economic impact in the short term, including but not limited to a lack of skilled labor, regulatory fragmentation, high implementation costs, and cybersecurity risks.

The regression results show that Green FinTech-related variables jointly explain a substantial share of GDP growth variation ($R^2 = 0.841$), which is an indication of their overall importance for eco-friendly economic growth. Financial instruments and technological innovation related to Green have a statistical modest impact, which means that the economic advantages they provide are mostly long-term and dependent upon the existence of suitable institutional and structural conditions. Digital financial inclusion, on the contrary, has a direct correlation with GDP growth that is statistically significant but negative, pointing to the existence of rapid digitalization related short-term adjustment costs, like labor market disruptions and digital inequality. Overall, the results point out that the long run support will be necessary for Green FinTech to show the sustainable economic growth that mainly happens through structural transformation instead of rapid macroeconomic expansion. This support will be in the form of regulatory measures, digital infrastructure, and human capital.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The role of Green FinTech in financing sustainable economic growth was the main subject of this thesis which combined theoretical analysis with empirical investigation. The main objective of the study was to determine the extent to which technology, green finance, and the digitalization of poor people's finance would result in sustainable economic growth, which was primarily indicated by the rise in GDP and supported by the declining unemployment trends. The research objectives were met by conducting a thorough review of existing literature, creating a conceptual framework, and using multiple linear regression analysis for the period of 2014 to 2024.

2. The scientific literature analysis verifies that Green FinTech is an emerging and more and more significant point of contact between green finance and financial technology. Innovations like blockchain and artificial intelligence are pointed out in existing studies as enhancing the attributes of being more transparent, accountable, and efficient in financial systems and thus helping the investments that are directed towards sustainability. Furthermore, the literature discusses the rising significance of green financial instruments, mainly green bonds and green loans, as the means of channeling capital to projects of renewable energy, sustainable infrastructure, and low-carbon transitions in the economy. On the other hand, previous studies have shown that there are still some challenges to be dealt with such as regulatory fragmentation, cybersecurity risks, technological limitations, and digital inequality that hinder the scale and the impact of Green FinTech solutions. All these gaps in the literature make the present study relevant and original.

3. The empirical results of the thesis exhibit that Green FinTech is a multi-faceted and systemic sustainer of sustainable economic growth instead of being merely a one-factor solution. The regression analysis reveals the interaction of the technological innovation, green financial instruments, and digital financial inclusion in such a manner that their combined development is much more significant than their individual effects. This conclusion lends support to the conceptual framework put forth in the study and validates the need for coordination in the technological, financial, and social dimensions for sustainability-oriented growth.

4. Technological innovation, which has been measured by the adoption of artificial intelligence, was considered to have a theoretical importance but only a limited statistical significance in the regression model. This means that advanced technologies, on the one hand, are the basic building blocks for financial efficiency and transparency; on the other hand, the macroeconomic effects of

these technologies may involve time lags and, therefore, might not be directly observable through aggregate indicators like the growth rate of GDP. Likewise, green bonds and green loans did not make any strong statistical contributions to explaining the GDP growth during the period of study. Still, this finding does not deprive them of their economic significance since green investments are usually accompanied by long-term environmental and productivity benefits that are perhaps not completely recognized within a relatively short time frame or through macro-level data.

5. The empirical analysis revealed an important relationship in the negative and statistically significant correlation between digital financial inclusion and GDP growth. The result cannot be considered a contradiction to the advantages of digital inclusion as a whole, rather, it points at the existence of structural limitations like unequal access to digital technology, poor infrastructure, and low levels of digital literacy. Without the presence of supportive conditions, the digital financial services may, at the very start, strengthen the existing inequalities instead of supporting the inclusive and sustainable growth. This finding stresses the need for infrastructure and education complementary investments to be made.

6. This research, however, despite its contributions, is still subject to numerous limitations. The empirical analysis, first of all, is based on annual macroeconomic data from 2014 to 2024, which might not allow to capture the long-term and lagged effects of Green FinTech investments. Furthermore, the lack of available data limited the number of variables that could be chosen and necessitated the use of GDP growth as the main proxy for sustainable economic growth, which may not capture fully environmental and social dimensions. Finally, relying on macroeconomic aggregates might overlook the effects of green finance and technological innovations on specific sectors or individual companies.

7. the research is of the opinion that besides, Green FinTech could be a major driving force in the transition to a sustainable economy by syncing financial innovation with the environmental as well as the social goals. Nonetheless, the overall impact of the particular sector largely depends on the quality of institutions, the lack of regulatory conflicts, the level of technological preparedness, and the presence of inclusive digital frameworks. In short, if the so-called enabling conditions are not met, the quantifiable macroeconomic effect of Green FinTech will still be limited.

Recommendations

1. From the findings of the research, various policy and practical recommendations can be suggested. Government officials should make it a point to invest in digital structure to a greater

extent that will eventually lead to diminishment of digital inequalities and that the digital financial inclusion would be mapped to the economic growth of the country in a sustainable manner. It is very important that there is synergy between reliable internet access expansion, digital services price leveling, and the raising of digital and financial literacy for the Green FinTech sector to be inclusive in its development.

2. Greater regulatory harmonization in green finance and FinTech across different governments and international organizations would be beneficial. The establishment of a single set of ESG standards, green taxonomies, and reporting frameworks would lead to a reduction in compliance costs, an increase in investor confidence, and support for cross-border green investment. Providing clear and uniform regulatory guidance is of utmost importance for the new technologies like blockchain and AI.

3. The financial sector and regulators can still back green financial products through one of the ways the technological verification mechanisms' integration comes. The combination of monitoring systems based on blockchain and AI-led impact measurement tools can bring about more transparency, reduce the risks of greenwashing, and make green bonds and green loans more reliable. All these measures are necessary in order to attract the long-term investment which is required for sustainability projects..

4. Ultimately, integrated Green FinTech ecosystems should consist of public-private partnerships, innovation hubs, and regulatory sandboxes. The collaboration among FinTech firms, banks, tech vendors, and regulators can both fast-track the innovation process and secure the achievement of the financial stability and sustainability objectives on the other hand.

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GREEN FINTECH: THE ROLE IN FINANCING SUSTAINABLE ECONOMIC GROWTH
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Master thesis
Finance and Banking
Vilnius University, Faculty of Economics and Business Administration
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Vilnius, 2026
SUMMARY IN ENGLISH

This master's thesis consists of 57 pages, including 10 charts, 11 figures, and 99 scientific references and case studies.

This Master's thesis examines the contribution of Green FinTech towards financing sustainable economic growth through the combination of green finance principles with technological innovations in finance. It also aims to evaluate the impact of technological innovation, green financial tools, and digital financial inclusion on macroeconomic sustainability. The study is conducted through literature review, conceptual framework development, and empirical analysis.

The objectives of the thesis are to analyze the theoretical foundations of Green FinTech and sustainable economic growth, identify key determinants and challenges in Green FinTech development, justify the applied research methodology, and empirically evaluate the impact of Green FinTech factors on sustainable economic growth. The growth of Gross Domestic Product (GDP) is regarded as the primary indicator of sustainable economic growth, while the unemployment rate is seen as a complementary measure of economic resilience and inclusiveness.

The study takes a mixed-methods strategy that integrates both qualitative and quantitative methods. The qualitative component involves a systematic review of the literature and SWOT analysis to identify the structural strengths, weaknesses, opportunities, and threats in the Green FinTech sector. The quantitative component applies multiple linear regression analysis with yearly macroeconomic and financial data from 2014 to 2024. The independent variables are the adoption of artificial intelligence as an indicator of technological innovation, green bonds issuance as an indicator of green financial instruments, and digital payments as an indicator of digital financial inclusion. The data used were gathered from trustworthy international databases and were processed using the normal econometric techniques.

The results obtained through empirical methods point towards Green FinTech being a multidimensional system that consists of three main components: technological innovation, green financial instruments, and digital financial inclusion, which are interacting in a very complex way. Despite the fact that technological innovation and green financial instruments are theoretically very relevant, only a limited statistical impact on GDP growth is observed for the selected time period, which implies that the economic effects are delayed and there are data constraints. The analysis further shows that there exists a negative and statistically significant correlation between digital financial inclusion and GDP growth, which points out the factors like digital divide, poor infrastructure, and lack of digital skills as the reasons for the negative influence.

The main conclusions drawn in the thesis point out that Green FinTech could be a great ally in the fight against climate change by making financial systems more transparent, efficient, and

inclusive. Nevertheless, its success is going to be closely tied with the availability of regulatory frameworks that support the good, the technological readiness of the party, the cybersecurity standards, and the digital infrastructure that is available to the public. The findings of this Master's thesis can be found in the submitted thesis document, which is going to be a great reference point for policymakers, financial institutions, and researchers who are into sustainable finance and Green FinTech.

ŽALIOSIOS FINANSINĖS TECHNOLOGIJOS: VAIDMUO FINANSUOJANT TVARŲ EKONOMIKOS AUGIMĄ

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Vilnius, 2026

SANTRAUKA LIETUVIŲ

Šį magistro darbą sudaro 57 puslapiai, įskaitant 10 diagramų, 11 paveikslų ir 99 mokslines nuorodas bei atvejų analizę.

Šiame magistro darbe nagrinėjamas žaliųjų finansinių technologijų (angl. Green FinTech) indėlis į tvaraus ekonomikos augimo finansavimą, derinant žaliųjų finansų principus su technologinėmis finansų inovacijomis. Taip pat siekiama įvertinti technologinių inovacijų, žaliųjų finansinių priemonių ir skaitmeninės finansinės įtraukties poveikį makroekonominiam tvarumui. Tyrimas atliekamas atliekant literatūros apžvalgą, konceptualios sistemos kūrimą ir empirinę analizę.

Darbo tikslai – išanalizuoti žaliųjų finansinių technologijų (angl. Green FinTech) ir tvaraus ekonomikos augimo teorinius pagrindus, nustatyti pagrindinius žaliųjų finansinių technologijų plėtros veiksnius ir iššūkius, pagrįsti taikomąją tyrimo metodologiją ir empiriškai įvertinti žaliųjų finansinių technologijų (angl. Green FinTech) veiksnių poveikį tvariam ekonomikos augimui. Bendrojo vidaus produkto (BVP) augimas laikomas pagrindiniu tvaraus ekonomikos augimo rodikliu, o nedarbo lygis – papildomu ekonominio atsparumo ir įtraukties matu.

Tyrime taikoma mišrių metodų strategija, apimanti tiek kokybinius, tiek kiekybinius metodus. Kokybinis komponentas apima sistemingą literatūros apžvalgą ir SWOT analizę, siekiant nustatyti struktūrinius žaliųjų finansinių technologijų sektoriaus stipriąsias ir silpnąsias puses, galimybes ir grėsmes. Kiekybinis komponentas taiko daugybinę tiesinę regresinę analizę su metiniais

makroekonominiais ir finansiniais duomenimis nuo 2014 iki 2024 m. Nepriklausomi kintamieji yra dirbtinio intelekto, kaip technologinių inovacijų rodiklio, diegimas, žaliųjų obligacijų išleidimas, kaip žaliųjų finansinių priemonių rodiklis, ir skaitmeniniai mokėjimai, kaip skaitmeninės finansinės įtraukties rodiklis. Naudoti duomenys buvo surinkti iš patikimų tarptautinių duomenų bazių ir apdoroti naudojant įprastus ekonometrinius metodus.

Empiriniais metodais gauti rezultatai rodo, kad žaliosios finansinės technologijos (angl. Green FinTech) yra daugiamačioji sistema, susidedanti iš trijų pagrindinių komponentų: technologinių inovacijų, žaliųjų finansinių priemonių ir skaitmeninės finansinės įtraukt, kurios sąveikauja labai sudėtingai. Nepaisant to, kad technologinės inovacijos ir žaliosios finansinės priemonės teoriškai yra labai svarbios, pasirinktu laikotarpiu stebimas tik ribotas statistinis poveikis BVP augimui, o tai reiškia, kad ekominis poveikis yra uždelstas ir yra duomenų apribojimų. Analizė taip pat rodo, kad egzistuoja neigiama ir statistiškai reikšminga koreliacija tarp skaitmeninės finansinės įtrauktis ir BVP augimo, kuri nurodo tokius veiksnius kaip skaitmeninė atskirtis, prasta infrastruktūra ir skaitmeninių įgūdžių stoka kaip neigiamos įtakos priežastis.

Pagrindinės baigiamojo darbo išvados rodo, kad žaliosios finansinės technologijos (FinTech) galėtų būti puikus sąjungininkas kovoje su klimato kaita, didinant finansų sistemų skaidrumą, efektyvumą ir įtraukumą. Nepaisant to, jų sėkmė bus glaudžiai susijusi su reguliavimo sistemų, kurios palaiko gėrį, prieinamumu, šalies technologiniu pasirengimu, kibernetinio saugumo standartais ir visuomenei prieinama skaitmenine infrastruktūra. Šio magistro darbo išvadas galima rasti pateiktame baigiamojo darbo dokumente, kuris bus puikus atskaitos taškas politikos formuotojams, finansų įstaigoms ir tyrėjams, besidomintiems tvariais finansais ir žaliosiomis finansinėmis technologijomis.