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The role of green finance in sustainable economic development

SUMMARY

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The thesis examines the role of green finance in promoting sustainable economic development in the member states of the European Union. Its central topic is the capacity of financial resources, fiscal instruments, public policies, private investment, and innovation-oriented funding to support the transition from carbon-intensive economic activity toward a model of development that is environmentally responsible, economically viable, and socially inclusive. Rather than treating green finance as a narrow category of financial products, the thesis adopts a multidimensional perspective. It understands green finance as a system of interrelated financial flows, corrective fiscal measures, investment decisions, regulatory arrangements, and policy incentives that redirect capital toward environmental protection, renewable energy, climate-change mitigation, eco-innovation, and the broader objectives of sustainable development.

This topic is situated within the wider context of climate change, environmental degradation, energy insecurity, and the growing economic cost of severe climate events. Climate change refers to long-term alterations in temperatures and weather patterns, primarily associated with greenhouse-gas emissions generated by the combustion of fossil fuels, industrial activity, transport, deforestation, agriculture, and patterns of production and consumption. Its effects extend far beyond rising average temperatures. Climate change affects public health, food systems, infrastructure, labor productivity, insurance markets, energy supply, tourism, public budgets, and the continuity of business operations. It also creates uneven regional and social burdens. Vulnerable communities and less-developed economies frequently experience greater exposure to climate risks while possessing fewer financial and institutional resources with which to respond.

These conditions establish the economic rationale for climate mitigation, adaptation, and the development of financial instruments that can mobilize capital for sustainable purposes. The costs of inaction are not limited to environmental damage. They include lower productivity, damaged infrastructure, higher health expenditure, disruption of supply chains, fiscal pressure, forced migration, loss of biodiversity, and greater macroeconomic volatility. At the same time, the transition to a low-carbon economy requires substantial investment in renewable energy, energy efficiency, clean transport, resilient infrastructure, environmental protection, research and development, and workforce restructuring. Green finance therefore emerges as a bridge between environmental objectives and the financial resources required to implement them.

The thesis is integrated primarily into the discipline of economics, but its research problem is inherently interdisciplinary. It draws on environmental economics, public finance, financial economics, development economics, energy economics, innovation economics, labor economics, and European economic policy. It also intersects with sustainability studies, climate policy, public administration, and applied econometrics. The contribution of the thesis depends precisely on this interdisciplinary integration, because green finance cannot be adequately evaluated from only one disciplinary angle.

From the perspective of environmental economics, the thesis addresses the problem of negative externalities. Greenhouse-gas emissions, pollution, biodiversity loss, and environmental degradation impose costs on society that are not fully reflected in market prices. Firms and consumers may make decisions based on private costs and benefits while transferring part of the environmental burden to the public. Environmental taxes and other corrective instruments are therefore examined as mechanisms for internalizing external costs. By increasing the cost of pollution or environmentally damaging behavior, fiscal instruments can alter incentives, encourage cleaner production, and

generate public revenue that may be redirected toward environmental programs. However, the thesis also recognizes that environmental taxation has distributional implications. A tax may be environmentally effective while imposing a disproportionate burden on lower-income households. Consequently, environmental policy must be assessed not only in terms of efficiency but also in terms of fairness, social acceptance, and the ability of governments to compensate vulnerable groups.

Within public finance, the thesis studies the allocation of government resources to environmental protection, renewable energy, climate mitigation, and research and development. Public expenditure can correct market failures, provide long-term capital, reduce the risk of innovative projects, and support investments whose social benefits exceed their short-term private returns. Public finance is particularly important in areas such as basic research, infrastructure, environmental restoration, and early-stage technologies, where private investors may be reluctant to assume high uncertainty. Nevertheless, the thesis does not assume that higher public expenditure automatically produces better outcomes. Its empirical analysis is designed to determine whether public funding is associated with sustainable growth, innovation, employment, and lower environmental pressure, and whether the relationship changes across different levels of green-finance development.

Financial economics is relevant because the transition to sustainability requires the reallocation of capital. Green bonds, climate-related funds, sustainability-linked instruments, bank lending, public guarantees, concessional finance, blended finance, and institutional investment can influence which technologies and projects receive funding. The thesis emphasizes that the effectiveness of such instruments depends on transparency, credible classification, monitoring, and the avoidance of greenwashing. Greenwashing occurs when an activity, project, institution, or financial product is presented as environmentally beneficial without sufficient evidence that it produces meaningful environmental improvements. The lack of a universally accepted definition of green finance, together with differences in reporting and taxonomy, makes it difficult to distinguish genuine green investment from reclassified conventional activity. This definitional problem is not merely semantic; it affects data quality, empirical measurement, policy design, investor confidence, and the credibility of the entire green-finance architecture.

The thesis also belongs to development economics because sustainable development requires the simultaneous consideration of economic, environmental, and social outcomes. Economic growth cannot be considered sustainable if it depends on persistent environmental degradation, excessive resource consumption, or widening social inequality. Conversely, environmental policy may be difficult to sustain politically when it undermines employment, energy affordability, or regional development. The research therefore considers the three pillars of sustainability: the economic pillar, the environmental pillar, and the social pillar. These dimensions are represented through variables related to gross domestic product, employment, life expectancy, demographic indicators, greenhouse-gas emissions, environmental taxation, and other measures available for the European Union member states.

Energy economics forms another major disciplinary foundation. The European transition to renewable and low-carbon energy is motivated by both climate objectives and energy-security considerations. Dependence on imported fossil fuels exposes economies to geopolitical conflict, supply disruption, and price volatility. Investment in renewable energy and energy efficiency may therefore produce multiple benefits: lower emissions, greater supply diversification, reduced exposure to external shocks, technological upgrading, and the creation of new industries. However,

energy transitions are capital intensive and uneven across countries. Member states differ in their energy mix, industrial structure, fiscal capacity, infrastructure, natural-resource endowment, and political priorities. The thesis accordingly rejects the assumption that identical policies will generate identical results throughout the European Union.

Innovation economics is central to the thesis because technological progress is one of the principal channels through which green finance can influence sustainable development. Eco-innovation includes new products, production processes, energy technologies, materials, organizational practices, and circular-economy solutions that reduce environmental harm or use resources more efficiently. Financing innovation involves both public and private actors. Public research and development may support foundational knowledge and reduce technological uncertainty, while private investment may commercialize technologies and bring them to scale. The relationship between the two sources of finance can be complementary, substitutive, or even counterproductive if incentives are poorly designed. The thesis therefore investigates whether public and private funding reinforce one another, whether excessive reliance on one source crowds out the other, and whether the effect varies across the distribution of green-finance development.

Labor economics is integrated through the examination of employment changes associated with green finance and renewable energy. The green transition is often expected to create jobs in renewable energy, construction, energy efficiency, environmental services, research, engineering, and related supply chains. At the same time, it can reduce employment in fossil-fuel extraction, conventional power generation, and carbon-intensive industries. The net effect depends on the speed of transition, the quality of new jobs, the skills of the workforce, regional mobility, labor-market institutions, and the availability of education and retraining. The thesis studies whether green finance contributes directly to employment or operates indirectly through renewable-energy investment, innovation, and structural change. It also considers income inequality and financial development as factors that may condition labor-market outcomes.

European studies and European economic policy provide the institutional setting. The European Union has developed an extensive policy framework for climate neutrality, sustainable finance, emissions reduction, renewable energy, and environmental regulation. EU institutions seek to coordinate national policies while recognizing that member states differ substantially in economic development and administrative capacity. The thesis focuses on all twenty-seven EU member states and, in one chapter, compares them with non-EU European countries. It also distinguishes between Old Member States and New Member States where this division is analytically useful. This approach allows the research to investigate whether participation in the European Union and access to common policies and funding mechanisms are associated with stronger progress in green finance and sustainable development.

The thesis is also a work of applied econometrics. Its substantive claims are evaluated through panel-data methods, quantile-based estimators, long-run cointegration estimators, and causality tests. The use of several methods reflects the complexity of the research problem. Average effects alone may conceal important differences between countries at low, medium, and high levels of green-finance development. Cross-country data may also involve unobserved heterogeneity, heteroskedasticity, serial correlation, cross-sectional dependence, endogeneity, and non-stationary variables. The thesis therefore employs multiple estimators to assess the robustness of the results and to examine relationships from different statistical perspectives.

The central conceptual innovation of the thesis is its refusal to reduce green finance to one indicator. Because there is no single standardized definition or universally available dataset, the thesis operationalizes green finance through several channels. These include government expenditure on environmental protection, environmental taxes, public investment in renewable energy, investment in climate-change mitigation, and fiscal and financial policy strategies. Each proxy captures a distinct function. Government environmental expenditure represents a direct public commitment to environmental goals. Environmental taxes capture both the correction of harmful behavior and the generation of revenue. Renewable-energy investment reflects the financing of the clean-energy transition. Climate-mitigation investment represents financial support for reducing emissions and climate risk. Fiscal and financial policies capture the broader institutional framework that enables or constrains sustainable investment.

This multidimensional approach is theoretically appropriate because green finance functions as an ecosystem rather than as an isolated instrument. A renewable-energy project may depend on public infrastructure, private lending, tax incentives, research funding, credible regulation, skilled labor, and a stable long-term policy signal. Environmental taxation may encourage firms to innovate, but innovation will occur only if firms have access to finance, technology, and markets. Public investment may catalyze private investment, but it can also crowd it out if subsidies are poorly targeted. Financial development may increase access to capital, yet it may also reinforce carbon-intensive investment when environmental criteria are weak. By studying multiple channels, the thesis is able to identify both positive spillovers and institutional inefficiencies.

In summary, the thesis belongs to a broad interdisciplinary field centered on green finance and sustainable development. Its economic core is complemented by environmental, fiscal, financial, technological, labor-market, energy, and European-policy perspectives. This integration is necessary because the green transition involves simultaneous changes in capital allocation, taxation, innovation, energy production, employment, public policy, and institutional governance. The research topic is therefore both academically significant and practically relevant to the design of a credible, efficient, and socially balanced European transition toward climate neutrality.

The primary purpose of the thesis is to evaluate the impact of green finance on sustainable economic development in the European Union. The study seeks to determine whether the financial and fiscal mechanisms associated with the green transition are producing the expected environmental, economic, social, technological, and labor-market effects. Its purpose is not limited to identifying whether green finance exists or whether the volume of funding has increased. Instead, the thesis investigates how green finance operates, through which channels it affects development, under what conditions it becomes effective, and why apparently sustainable investments may produce mixed or even adverse outcomes.

The thesis is grounded in the proposition that the effectiveness of green finance depends on more than the availability of capital. Financial resources must be allocated through coherent institutions, supported by appropriate fiscal and regulatory frameworks, directed toward credible projects, and evaluated against transparent environmental and socioeconomic criteria. The same volume of funding can generate different outcomes depending on the design of the instrument, the institutional capacity of the receiving country, the maturity of the technology, the structure of the energy market, the interaction between public and private actors, and the quality of monitoring. Accordingly, the research moves beyond the assumption that all funding labeled as green necessarily contributes to sustainable development.

A central purpose is to fill a gap in the literature created by the absence of a standardized definition of green finance and the tendency of many studies to represent it through a single variable. The thesis responds to this limitation by using a set of proxies that reflect different dimensions of the green-finance system. Government expenditure on environmental protection is used to represent public financial commitment to environmental objectives. Environmental taxes represent a corrective and revenue-generating instrument. Public investment in renewable energy reflects support for the clean-energy transition. Investments in climate-change mitigation represent the financing of measures intended to reduce climate risks and emissions. Fiscal and financial policy strategies represent the institutional support that shapes the effectiveness of these instruments. The purpose of this design is not to claim that any one proxy fully measures green finance, but to analyze the specific channels through which green finance is implemented.

The first major objective is to examine the relationship between green finance and the three pillars of sustainability. The economic pillar concerns growth, productive capacity, and employment. The social pillar concerns population well-being and demographic outcomes, represented in the thesis through indicators such as life expectancy and the crude birth rate. The environmental pillar concerns greenhouse-gas emissions, environmental taxation, and the protection of natural resources. This objective is important because a policy may perform well in one dimension while producing weaker or adverse effects in another. For example, environmental investment may reduce emissions over time but create short-term fiscal pressure. A tax may improve environmental incentives while worsening inequality. Renewable-energy expansion may generate employment while also requiring substantial public support. The thesis therefore evaluates sustainability as a combination of outcomes rather than as a single environmental target.

The second objective is to assess whether green finance supports economic growth together with social and environmental progress. This formulation is deliberately demanding. Sustainable development requires more than a trade-off in which environmental gains are purchased through persistent social or economic deterioration. The thesis investigates whether green-finance instruments can contribute to a mutually reinforcing process in which environmental protection, innovation, employment, and economic development advance together. Where the results are mixed, the study seeks to identify possible explanations, including delayed effects, inefficient allocation, inadequate policy coordination, and differences in national development levels.

A third purpose is to analyze the relationship between green finance and public and private funding for innovation. Eco-innovation is essential to the transition because established technologies and production processes may not be sufficient to meet climate-neutrality objectives. However, innovation finance is characterized by uncertainty, long development periods, and uneven returns. Public funding may stimulate research that the market would otherwise underprovide, while private investment may bring discipline, commercialization capacity, and scalability. The thesis examines whether public and private funding are complementary or whether one source can suppress the effectiveness of the other under certain conditions. This objective responds to the need for a balanced financing structure rather than an automatic preference for either public or private capital.

A fourth purpose is to determine how economic development influences public and private eco-innovation. Wealthier economies may possess greater fiscal capacity, deeper capital markets, stronger research institutions, and more advanced infrastructure. At the same time, economic growth based on carbon-intensive activity can increase environmental pressure and lock in existing technologies. The thesis therefore examines the direction and strength of the relationship rather than

assuming that higher gross domestic product automatically produces greener innovation. It also considers whether the relationship changes at different levels of green-finance development.

A fifth objective is to compare the progress and trends of green finance in EU and non-EU European countries. The European Union presents a distinctive institutional environment characterized by common policy objectives, regulatory coordination, funding programs, and sustainability strategies. Comparing EU members with non-EU countries helps evaluate whether this institutional framework is associated with faster or more visible progress. The comparison also provides a basis for assessing whether the EU's leadership is reflected in measurable outcomes rather than only in policy ambition. The thesis does not treat EU membership as a guarantee of effectiveness; instead, it uses comparative evidence to examine where progress is strongest and where financial instruments appear inefficient.

A sixth purpose is to explore the labor-market consequences of green finance. Public discussion often associates the green transition with job creation, but the relationship is complex. Green finance may create employment indirectly by supporting renewable energy, innovation, infrastructure, and environmental services. It may also contribute to job displacement in fossil-fuel and carbon-intensive industries. The thesis investigates whether green finance has a direct effect on employment, whether its influence is concentrated at particular quantiles, and whether job quality, income inequality, and financial development modify the relationship. This objective helps connect climate policy with the social legitimacy of the transition.

A seventh purpose is to identify the fiscal and financial policy conditions that support sustainable development. Financial instruments do not operate in isolation from taxation, regulation, public administration, and institutional quality. The thesis therefore seeks to formulate policy recommendations concerning environmental taxes, public funding, private incentives, transparency, reporting, taxonomy, and regulatory oversight. Particular attention is given to the need for policy flexibility. The EU member states differ in income, industrial structure, energy dependence, pollution levels, fiscal space, and administrative capacity. A uniform policy can therefore produce uneven burdens or weak results. The study aims to identify principles that can guide differentiated but coherent national strategies.

The thesis also seeks to identify best practices in the design and combination of green-finance instruments. Its purpose is not to select one universally superior instrument. Rather, it evaluates how instruments can be combined to create an efficient policy mix. Public investment may be necessary to initiate a market, while private capital may be needed for scale. Environmental taxation may improve incentives, while targeted transfers may protect lower-income groups. Renewable-energy finance may reduce dependence on imported fuels, while research funding may improve future competitiveness. The optimal combination depends on economic conditions and may need to be adjusted over time.

Another purpose is to contribute to the measurement of green finance. Because the concept remains ambiguous, empirical studies often use different indicators and reach conclusions that are difficult to compare. The thesis demonstrates both the value and the limitation of proxy-based analysis. Its multidimensional strategy generates a broader view than a single-indicator approach, but it also reveals the need for a harmonized composite measure. By documenting the limitations of existing data and proxies, the thesis supports future efforts to create standardized definitions, key performance indicators, reporting practices, and greenwashing-detection mechanisms.

The general research aim can therefore be stated as follows: to determine how a multidimensional system of green financial instruments, public and private investment, environmental taxation, eco-innovation, renewable-energy finance, and fiscal-financial policy contributes to sustainable economic development in the European Union, while accounting for country heterogeneity, nonlinear effects, institutional limitations, and the distributional consequences of the transition.

The thesis is organized as a cumulative and interconnected investigation of green finance. Its five substantive chapters examine distinct dimensions of the concept while contributing to a common analytical framework. Each chapter focuses on a different green-finance channel, uses a country-level panel dataset, and applies econometric methods suited to its research questions. This structure reflects the thesis's central argument: green finance is not a single instrument with one uniform effect, but a network of public expenditure, taxation, renewable-energy finance, climate-mitigation investment, innovation funding, and policy support.

The chapters are linked conceptually, yet each has a specific function. Chapter 1 establishes the broad relationship between green finance and the three pillars of sustainability. Chapter 2 focuses on the interaction between green finance and public and private eco-innovation. Chapter 3 develops a comparative perspective by examining progress in EU and non-EU European countries. Chapter 4 studies labor-market transformation and employment. Chapter 5 integrates fiscal and financial policy support and translates the empirical findings into policy recommendations. The final conclusions synthesize the results, identify limitations, and propose directions for future research.

Chapter 1: Green finance and the three pillars of sustainability

The first chapter provides the foundation for the empirical analysis by examining how green finance relates to economic, environmental, and social sustainability. Green finance is operationalized primarily through national government expenditure on environmental protection. This proxy reflects the public sector's financial commitment to environmental quality and climate-related objectives. The chapter recognizes, however, that public expenditure does not capture the full range of private green financing. It is therefore interpreted as one important dimension of green finance rather than as a comprehensive measure.

The chapter addresses two principal objectives. The first is to examine the differing effects of green-finance instruments on the economic, environmental, and social pillars of sustainability. The second is to assess whether green finance supports economic growth while also advancing social and environmental outcomes. The dataset covers the twenty-seven EU member states over the period 2012–2022. This balanced or near-balanced panel provides cross-country and time-series variation while maintaining a common European institutional context.

The economic pillar is represented through indicators related to gross domestic product and employment. The social pillar is represented through life expectancy and the crude birth rate. The environmental pillar includes variables related to greenhouse-gas emissions and environmental taxation. By using several indicators, the chapter avoids the reduction of sustainable development to GDP growth or emissions alone. It also permits the identification of tensions among policy goals.

The chapter employs pooled ordinary least squares, fixed-effects models, random-effects models, panel-corrected standard errors, and the generalized method of moments. The progression across estimators is designed to test whether the results remain stable when country heterogeneity, error structure, and potential endogeneity are treated differently. The findings reported in the source material indicate a mixed relationship between green finance and the sustainability indicators. The social and economic indicators do not display an unambiguously positive association with

government environmental expenditure. This result suggests that public environmental spending may involve delayed effects, may be responding to existing environmental or social problems, or may not yet be allocated with sufficient efficiency to generate immediate measurable benefits.

The importance of Chapter 1 lies in its rejection of a simplistic "more green finance equals more sustainability" interpretation. Instead, it shows that the relationship is conditional and potentially nonlinear. The chapter establishes the need for the more focused analyses that follow. If average relationships are mixed, it becomes necessary to investigate the mechanisms through which funding affects innovation, energy transition, and employment.

Chapter 2: Corrective fiscal instruments, green finance, and public-private eco-innovation

The second chapter examines the interaction between green finance and innovation, with particular attention to public and private research and development. Within the operational framework of the thesis, environmental taxation represents a corrective and revenue-generating green-finance instrument. Environmental taxes place a price on environmentally harmful activity and can create incentives for firms and consumers to modify behavior. They can also provide revenue that supports environmental programs, innovation, or social compensation. Nevertheless, taxation differs from direct investment because its primary effect may operate through incentives rather than through the immediate financing of a specific asset.

The chapter addresses three objectives: to evaluate the relationship between green finance and public and private innovation funding; to analyze the influence of economic development on eco-innovation; and to determine whether green finance contributes to innovation. The empirical sample includes all twenty-seven EU member states over the period 2010–2021.

The methodological core of the chapter is the method of moments quantile regression, supplemented by panel causality analysis. A quantile approach is particularly appropriate because the relationship between green finance and innovation may differ among countries at low and high levels of green-finance development. An average coefficient can conceal such differences. For example, public support may be ineffective at early stages when institutions and markets are underdeveloped but become productive after a threshold is reached. Conversely, a policy that is useful for countries beginning the transition may have diminishing returns in more advanced systems.

The findings reported in the source material support the presence of heterogeneous effects. At lower stages of green-finance development, public research and development investment appears to have a suppressing or stifling relationship with the green-finance measure. At higher levels, the relationship becomes positive and statistically significant. This pattern is consistent with the possibility that institutional maturity, accumulated infrastructure, or policy coordination is necessary before public innovation funding generates its full effect.

The chapter also reports a predominantly negative relationship between private innovation investment and green finance. This finding should not be interpreted as proof that private investment is inherently harmful. It may indicate substitution between public and private sources, measurement differences, timing mismatches, risk aversion, or an inefficient policy environment in which private investment is not directed toward genuinely transformative activity. The chapter therefore emphasizes the need for balance and coordination. Public finance should catalyze private investment rather than replace it, while private finance should complement long-term public objectives rather than focus only on short-term returns.

The analysis further identifies negative relationships between green finance and greenhouse-gas emissions, and between green finance and economic growth in some model specifications. The

negative association with emissions is consistent with the environmental objective of green finance. The negative association with economic growth may reflect transition costs, reverse causality, policy responses to weak growth, or the fact that the benefits of innovation and environmental investment arise over longer periods than the available sample captures. Chapter 2 therefore contributes an important message: the effectiveness of green finance depends on the stage of development and the interaction between funding sources.

Chapter 3: Renewable-energy finance and the comparison between EU and non-EU European countries

The third chapter broadens the geographical and temporal scope of the thesis. Its principal green-finance dimension is public investment in renewable energy, which reflects progress in financing the clean-energy transition. The analysis covers the twenty-seven EU member states and nineteen non-EU European countries over the period 2000–2022. This longer panel makes it possible to examine trends across different institutional environments and stages of economic development.

The chapter has two principal objectives. First, it identifies disparities in the development and trajectory of green finance between EU and non-EU countries. Second, it assesses the areas in which sustainable-development initiatives are most visible. The comparison is designed to test whether the EU's coordinated policy framework and access to common financing mechanisms are associated with stronger progress than is observed outside the Union.

The chapter uses method of moments quantile regression and causality analysis. The quantile design again allows the effect of explanatory variables to differ across the distribution of the outcome. This is important in a heterogeneous sample that includes advanced economies, transition economies, resource-dependent countries, and states with different regulatory relationships to the European Union.

The source material reports that EU countries generally move toward sustainability and clean energy more rapidly than non-EU European countries. This result is consistent with the EU's greater policy coordination, funding availability, and regulatory pressure. However, the chapter also finds that the speed of progress is not proportionate to the scale of financial support. In other words, considerable funding has been allocated, but the observed outcomes suggest that financial instruments are not always sufficiently targeted or calibrated to maximize their positive spillovers.

The chapter further examines public and private investment in the circular economy and innovation. It reports a weak relationship between public and private research-and-development funding and circular-economy investment in some models, as well as a significant inverse relationship between green finance and private circular-economy investment in another specification. It also reports a positive relationship between private circular-economy investment and greenhouse-gas emissions. Such a result may appear counterintuitive, but it can arise when investment is concentrated in highly industrialized economies with greater initial emissions, when projects are classified as circular without producing immediate reductions, or when the environmental effect is delayed.

An additional result is that, when public investment in green innovation is high, the contribution of private circular-economy investment becomes less significant. This finding strengthens the thesis's argument that the public-private balance must be managed carefully. A large public role can be necessary, especially in early stages, but it should be structured to mobilize rather than displace private capital. Chapter 3 therefore interprets the EU's progress as real but incomplete. Institutional membership and funding matter, yet they do not automatically guarantee efficient allocation or rapid environmental improvement.

Chapter 4: Green finance, renewable energy, and labor-market transformation

The fourth chapter studies the labor-market effects of the green transition. Its green-finance dimension is investment in climate-change mitigation, representing the contribution of private and other financial resources to sustainable development. The sample includes the twenty-seven EU member states over the period 2010–2023. The chapter examines how green finance, renewable energy, income inequality, financial development, and the fossil-fuel sector relate to employment.

The chapter addresses two objectives: to explore the changes produced by green finance in the labor market and to determine its effect on employment trends. The use of employment as an outcome connects the environmental transition with social and political sustainability. Climate policy is more likely to receive durable public support when it generates accessible, high-quality jobs and when transition costs are distributed fairly.

The econometric strategy includes Dynamic Ordinary Least Squares, Fully Modified Ordinary Squares, Canonical Cointegration Regression, method of moments quantile regression, conventional quantile regression, and causality tests. The long-run estimators are used to evaluate cointegrating relationships among non-stationary variables, while quantile estimators identify differences across the employment distribution or other conditional quantiles.

The chapter concludes that green finance and renewable energy contribute positively to job creation. Financing clean-energy projects and innovation expands demand for labor in construction, engineering, manufacturing, maintenance, research, environmental services, and related activities. The quality of employment further strengthens this effect. The chapter also finds that the fossil-fuel sector has only a limited effect on job creation in the analyzed specifications.

A particularly important finding is that the direct positive effect of green finance on employment is significant mainly at the lowest quantile. This suggests that green finance does not create employment uniformly or exclusively through a direct channel. Its broader effect may operate through renewable-energy expansion, technological innovation, infrastructure development, and changes in industrial structure. The result also implies that countries or labor markets starting from weaker employment conditions may receive the largest immediate benefit.

The chapter identifies income inequality as a major threat to employment growth. Inequality can reduce access to education and retraining, weaken aggregate demand, intensify the distributional burden of environmental taxes, and reduce public acceptance of climate policy. Financial development is also found to impede labor-market growth in some models, indicating that a larger financial sector is not automatically aligned with productive green investment. This finding reinforces the need to evaluate the direction of financial flows, not only their volume.

Chapter 5: Fiscal and financial policy support for sustainable development

The fifth chapter integrates the fiscal and financial policy dimensions of the thesis. It examines the supporting factors that can strengthen green finance and formulates policy recommendations for sustainable development and climate transition. The sample includes the twenty-seven EU member states over the period 2010–2023. The methodological framework includes Dynamic Ordinary Least Squares, Fully Modified Ordinary Squares, and method of moments quantile regression.

The chapter's first objective is to investigate the conditions and policy strategies that support sustainable fiscal and financial development. Its second objective is to provide effective recommendations for advanci ng the climate transition. Unlike the preceding chapters, which focus more narrowly on particular channels, Chapter 5 synthesizes the relationships among taxation, public expenditure, private finance, regulatory design, transparency, innovation, and national circumstances.

The chapter emphasizes the potential role of environmental taxation, but it argues that such taxation should be designed progressively. The burden should reflect household income and vulnerability rather than relying only on broad country-income classifications. A progressive environmental-tax structure, accompanied by targeted compensation, can reduce the risk that climate policy worsens inequality. This is important because the labor-market analysis identifies inequality as a serious constraint on employment growth.

The chapter also argues for flexible policy design. Member states differ in economic development, energy dependence, industrial structure, fiscal capacity, and exposure to climate risk. Uniform instruments may therefore be inefficient or politically unsustainable. Common European objectives should be implemented through adaptable national pathways that preserve comparability and accountability while allowing instruments to respond to country-specific conditions.

A further focus is standardization. The thesis calls for a common definition of green finance, a harmonized taxonomy, standardized reporting, and measurable performance indicators. These elements are necessary to improve cross-country comparison, identify greenwashing, and evaluate whether public and private funds reach their intended objectives. The chapter also discusses regulatory oversight. It supports effective monitoring but warns that multiple overlapping supervisory bodies can create duplication, inconsistency, and enforcement errors. Oversight should therefore be coordinated and based on a common reporting architecture.

The chapter proposes stronger incentives for both public and private actors. Private institutions may face reputational or regulatory consequences for greenwashing, while public-sector misclassification or ineffective spending may receive less scrutiny. The thesis therefore recommends clearer accountability for public funding, including defined timelines, measurable objectives, and transparent reporting. Mandatory or rule-based funding commitments may be useful where voluntary action is insufficient, provided that they are accompanied by evaluation and periodic adjustment.

Final conclusions, limitations, and future research

The concluding section integrates the results of all five chapters. It emphasizes that green finance has meaningful potential but does not operate automatically. Positive effects are observed in emissions reduction, renewable-energy development, and job creation, yet several relationships are mixed, negative, nonlinear, or dependent on the level of development. The conclusion therefore shifts attention from the quantity of green finance to the quality, composition, timing, and institutional governance of financial flows.

The thesis also presents its limitations. These include restricted data availability, short time series for some instruments, missing country observations, reliance on proxies, the absence of a universally accepted green-finance definition, the difficulty of measuring greenwashing, and the limitations inherent in the econometric methods used. The analysis is also geographically concentrated on Europe and does not provide a full comparison with North America, Asia, or other regions. Short-term disruptions such as the COVID-19 pandemic and the Russia–Ukraine conflict are not separately modeled in all chapters, even though they may influence energy markets, public expenditure, and investment behavior.

Future research is directed toward the construction of a standardized composite green-finance indicator, a measurable greenwashing index, more detailed regional classifications, firm-level analysis, broader international comparisons, and econometric strategies that address cross-country spillovers, endogeneity, structural breaks, and temporal dynamics. This concluding structure ensures

that the thesis does not present its results as final or universal. Instead, it positions them as a contribution to an evolving field in which measurement, data, and institutions are still developing.

The thesis applies a quantitative, comparative, and longitudinal research methodology. Its empirical strategy is based on panel data covering European countries over multiple years. Panel data are appropriate because they combine cross-sectional variation between countries with temporal variation within countries. This structure permits the analysis of how green-finance indicators and sustainability outcomes change over time while controlling, to varying degrees, for national characteristics that are difficult to observe directly.

The methodological design follows the thesis's multidimensional conceptual framework. Because green finance does not have a universally standardized definition, the research does not rely on one aggregate measure. Instead, each chapter selects an operational proxy related to the mechanism under investigation. Government expenditure on environmental protection represents public financial commitment. Environmental taxes represent corrective fiscal policy and revenue generation. Public investment in renewable energy represents financial support for the clean-energy transition. Investments in climate-change mitigation represent private and broader financial contributions to sustainability. Fiscal and financial policy variables represent institutional support. The use of distinct proxies allows the thesis to study specific channels, but it also requires caution when comparing chapter results because the indicators are not interchangeable.

The country coverage is centered on the twenty-seven EU member states. Chapter 1 uses data for 2012–2022. Chapter 2 covers 2010–2021. Chapter 3 uses the broadest period, 2000–2022, and extends the sample to nineteen non-EU European countries. Chapters 4 and 5 cover 2010–2023. The different periods reflect data availability and the conceptual focus of each chapter. Although a common period would simplify comparison, restricting every model to the shortest available series would discard valuable information.

The chapter-specific design therefore prioritizes the largest credible sample for each research question.The empirical variables are selected to represent green finance and its hypothesized outcomes or transmission channels. Sustainable development is measured through economic, environmental, and social indicators. Innovation variables distinguish public and private research-and-development funding. Renewable-energy and circular-economy variables represent structural transformation. Employment, job quality, income inequality, and financial development capture labor-market and social conditions. Greenhouse-gas emissions provide an environmental outcome. Gross domestic product is used as a measure of economic scale or development, while environmental taxes may operate as both a green-finance proxy and a policy variable depending on the chapter.The analysis begins from a general panel-regression framework in which an outcome for country i in year t is explained by one or more green-finance indicators and a set of control variables. The precise specification differs by chapter. The basic model allows the research to estimate the sign, magnitude, and statistical significance of the relationships. However, panel data create methodological challenges that make reliance on a single estimator inappropriate. The thesis therefore applies several complementary techniques.

Pooled ordinary least squares is used as a baseline estimator in Chapter 1. Pooled ORDINARY LEAST SQUARES treats the observations as part of a common sample and estimates an average relationship without explicitly modeling country-specific effects. Its advantage is simplicity and interpretability. Its limitation is that unobserved country characteristics may be correlated with the explanatory variables. Economic institutions, geography, policy culture, industrial structure, and

energy resources can influence both green finance and sustainable-development outcomes. If such factors are omitted, pooled ORDINARY LEAST SQUARES coefficients may be biased.The fixed-effects model addresses part of this problem by allowing each country to have its own time-invariant intercept. It effectively contrOrdinary Least Squares for unobserved national characteristics that do not change over the sample period. The estimator focuses on within-country variation: whether changes in green finance within a country are associated with changes in the outcome. Fixed effects are useful when unobserved country characteristics are correlated with the regressors. Their limitation is that they do not estimate the effects of variables that do not vary over time and can be less efficient when within-country variation is limited.The random-effects model treats country-specific effects as random components that are uncorrelated with the explanatory variables. When this assumption is valid, random effects can use both within-country and between-country variation and may be more efficient than fixed effects. The assumption is strong, however. If the unobserved national effect is correlated with green-finance variables, the estimates may be inconsistent. The use of both fixed and random effects enables model comparison and provides evidence on the sensitivity of the results to alternative assumptions.Panel-corrected standard errors are employed to improve statistical inference when panel residuals exhibit heteroskedasticity and contemporaneous correlation across countries. European economies are interconnected through trade, financial markets, common regulation, energy networks, and shared shocks. Consequently, the error terms of national models may not be independent. PCSE does not eliminate all forms of cross-sectional dependence, but it provides standard errors that are more robust than conventional estimates under certain panel conditions.The generalized method of moments is used to address dynamic relationships and potential endogeneity. Endogeneity may arise when causality runs in both directions. For example, green finance may influence economic development, while more-developed economies may allocate more funds to green objectives. Government expenditure may reduce emissions, but high emissions may also induce governments to increase expenditure. The generalized method of moments uses internal instruments, commonly lagged values of the variables, to estimate relationships when regressors may be endogenous. It can also include lagged dependent variables to capture persistence. The method is valuable but sensitive to instrument selection, sample size, and specification. Too many or weak instruments can undermine the validity of the estimates.Method of moments quantile regression is a central technique in Chapters 2, 3, 4, and 5. Conventional regression focuses on the conditional mean of the dependent variable. Quantile regression estimates relationships at different points of the conditional distribution. This distinction is crucial for a heterogeneous group of countries. A determinant may have a negative effect at low levels of green-finance development, no effect near the median, and a positive effect at high levels. Such a pattern would be obscured by a single average coefficient. MMQR is designed to estimate conditional location and scale effects while accommodating unobserved heterogeneity. Its use allows the thesis to identify threshold-like behavior and distributional asymmetry.

Conventional quantile regression is also used in the labor-market chapter. It provides an additional perspective on how explanatory variables affect different portions of the employment distribution. Comparing quantile estimators helps evaluate whether the direction of the results is robust and whether direct effects are concentrated among countries with weak, intermediate, or strong labor-market outcomes.

Dynamic Ordinary Least Squares, Fully Modified Ordinary Squares, and Canonical Cointegration Regression are applied where the analysis concerns long-run relationships among non-stationary

variables. Economic and financial series often exhibit trends. A regression between trending variables can appear statistically significant even when no meaningful relationship exists. Cointegration analysis asks whether a stable long-run equilibrium relationship connects the variables despite short-run deviations.

Dynamic Ordinary Least Squares addresses endogeneity and serial correlation in cointegrating regressions by including leads and lags of the first differences of the explanatory variables. Fully Modified Ordinary Squares modifies the estimator to correct for serial correlation and endogeneity in the long-run covariance structure. Canonical Cointegration Regression transforms the data so that the transformed errors are asymptotically uncorrelated with the regressors. The use of all three methods in Chapter 4 provides a robustness framework for the estimated long-run relationship between green finance, renewable energy, and employment.

Panel causality analysis is used to examine predictive direction. The thesis refers to the Dumitrescu and Hurlin approach, which is suitable for heterogeneous panels. Rather than assuming that every country has the same causal relationship, the method permits coefficients to differ across cross-sectional units.The use of causality tests is especially relevant to green finance. A negative contemporaneous correlation can be difficult to interpret because governments may increase environmental expenditure in response to worsening pollution. Causality analysis can help distinguish whether green finance precedes changes in emissions, whether emissions precede green-finance allocation, or whether feedback operates in both directions. Similar questions arise for innovation, economic growth, and employment.

The methodology also incorporates comparative grouping. The thesis examines all EU member states and, where relevant, differentiates Old Member States from New Member States. Chapter 3 extends the comparison to non-EU European countries. These groupings are intended to capture institutional and developmental differences. Older member states generally have longer exposure to common European policies and may possess deeper financial markets and stronger administrative capacity. Newer member states may have different industrial structures, energy systems, and investment needs. Non-EU countries provide an external benchmark for evaluating the effect of the EU policy environment.The methodology is subject to important limitations. The first is data availability. Green finance is a relatively new field, and comparable country-level data are limited. Some instruments have short series, missing observations, or inconsistent definitions. This restricts sample size and may reduce statistical power. The second limitation is measurement. Environmental taxes, government expenditure, and renewable-energy investment each capture only part of green finance. Environmental taxes may reflect the cost of pollution and revenue objectives more than direct investment in clean capital. Government expenditure does not measure private finance. Climate-mitigation investment may not capture every relevant project.

A third limitation concerns endogeneity and cross-country spillovers. Although the generalized method of moments , cointegration estimators, and causality tests address some problems, no observational method can eliminate every source of bias. EU countries are economically and institutionally connected, so a policy in one state may affect another through investment, technology, energy trade, or regulation. Methods that assume cross-sectional independence may therefore be imperfect. A fourth limitation is structural change. The COVID-19 pandemic, energy-market disruption, and the Russia–Ukraine conflict may alter relationships during the sample period. Unless modeled explicitly, such events can affect coefficients and complicate interpretation.

The original contribution of the thesis lies first in its multidimensional treatment of green finance. Much of the empirical literature represents green finance through one indicator, such as green bonds, renewable-energy investment, environmental taxation, or public environmental expenditure. The thesis argues that no single variable is sufficient because green finance operates through several interconnected channels. It therefore studies public expenditure, corrective taxation, renewable-energy finance, climate-mitigation investment, public and private innovation, labor-market effects, and fiscal-financial policy support within a unified research program. This design provides a broader explanation of how capital allocation and public policy contribute to the green transition.

A second original feature is the integration of the three pillars of sustainability with innovation, energy, employment, and policy. The thesis does not evaluate green finance exclusively through emissions or renewable-energy capacity. It asks whether environmental finance is associated with economic performance, social outcomes, technological change, and employment. This is important because a transition can be environmentally effective yet socially unequal, or economically dynamic yet insufficiently decarbonizing. By examining several outcomes, the thesis contributes to a more demanding understanding of sustainability.

The results of Chapter 1 indicate that the relationship between green finance and sustainability is mixed. Government expenditure on environmental protection does not produce uniformly positive contemporaneous effects across the economic, social, and environmental indicators. The reported results include negative relationships between the green-finance proxy and selected social and economic variables. This finding is original and relevant because it challenges an overly optimistic assumption that public expenditure classified as environmental automatically improves every dimension of sustainability.

Several interpretations are possible. Environmental expenditure may be reactive: governments may spend more when environmental conditions are already deteriorating. The benefits of infrastructure, restoration, energy transition, and prevention may also appear after a longer lag than the available period captures. Expenditure can be inefficiently allocated, fragmented across institutions, or directed toward compliance rather than transformation. In addition, countries at different development levels may obtain different returns from the same nominal amount of spending. The chapter's principal conclusion is therefore not that public green finance is ineffective, but that its effects depend on timing, composition, governance, and national context.

Chapter 2 contributes evidence of nonlinear relationships between green finance and innovation funding. At lower quantiles of green-finance development, public research-and-development investment is reported to have a suppressing relationship, whereas the association becomes positive and significant at higher levels. This result implies that the productivity of public innovation finance may depend on a threshold of institutional maturity. Research infrastructure, administrative capacity, market demand, private-sector absorptive capacity, and regulatory consistency may be necessary before public spending generates strong green-finance outcomes.

The predominantly negative relationship between private innovation investment and the green-finance measure is another important result. It suggests that public and private finance are not automatically complementary. Private capital may avoid high-risk or long-horizon projects, concentrate on incremental improvements, or respond to incentives that do not fully reflect environmental benefits. Alternatively, greater public involvement may displace private funding. The thesis concludes that policy should focus on the architecture of co-financing. Public funding should

reduce risk, support early-stage research, create infrastructure, and establish credible long-term demand, while private capital should contribute commercialization, scale, and operational discipline.

The negative relationship between green finance and greenhouse-gas emissions reported in Chapter 2 supports the environmental rationale of the instruments. However, the negative association with economic growth in some specifications shows that transition costs and benefits may not be synchronized. Sustainable investment can require high initial expenditure, the retirement of carbon-intensive assets, changes in production, and regulatory compliance. Benefits may emerge through avoided damage, technological competitiveness, and energy security over a longer horizon. The result therefore supports a dynamic rather than static evaluation of green finance.

Chapter 3 provides a comparative contribution by showing that EU countries generally advance toward sustainability and clean energy faster than non-EU European countries. This finding supports the relevance of EU institutions, common objectives, regulatory coordination, and access to financing. Nevertheless, the chapter also concludes that progress is not as rapid as the volume of funding and the level of policy ambition might imply. The EU's comparative leadership is therefore relative rather than complete.

The chapter's results concerning circular-economy and innovation investment reveal possible inefficiencies in fund allocation. The weak relationship between public and private research funding, the inverse relationship between green finance and private circular-economy investment in one model, and the positive association between private circular-economy investment and emissions all indicate that labels and expenditure categories do not guarantee environmental effectiveness. A country may invest heavily in activities described as circular while remaining highly industrialized and emissions intensive. Projects may also take time to affect emissions. The thesis uses these findings to argue for outcome-based monitoring rather than reliance on nominal funding volumes.

The finding that high public investment can reduce the statistical importance of private circular-economy investment further illustrates the need for balance. Public funding may dominate markets, create dependency, or concentrate resources in projects that would have received private finance without support. Conversely, insufficient public involvement may leave socially valuable projects unfunded. The contribution of the thesis is to identify this balance as an empirical question rather than an ideological preference.

Chapter 4 produces some of the clearest positive results. Green finance and renewable energy are associated with job creation, while the fossil-fuel sector has a limited effect on employment in the reported models. This supports the argument that the green transition can be an employment strategy as well as an environmental policy. Investments in clean energy and innovation create demand across several sectors and skill levels. The result also supports policies for education, vocational training, regional adjustment, and labor mobility so that workers can access emerging opportunities.

At the same time, the chapter finds that the direct positive effect of green finance is significant mainly at the lowest quantile. This result refines the general job-creation claim. Green finance appears to function through indirect channels and to provide the greatest immediate benefit where employment conditions are relatively weak. Its effect may depend on the existence of renewable-energy projects, infrastructure, innovation systems, and implementation capacity. The finding encourages policymakers to evaluate complete investment chains rather than expecting financial allocation alone to create jobs.

Income inequality emerges as a major obstacle to employment growth. This is a highly relevant conclusion for the design of a just transition. Lower-income households are more exposed to energy-price increases and may have less access to retraining, efficient housing, clean transport, or green investment opportunities. If environmental taxes and transition costs are regressive, public support may decline. The thesis therefore connects social policy directly to green-finance effectiveness. Compensation, progressive taxation, targeted investment, and access to training are not secondary welfare measures; they are conditions for a politically durable transition.

The reported negative effect of financial development on labor-market growth in some models is also significant. A more-developed financial sector can support green investment, but it can also channel resources toward real estate, speculative activity, or established carbon-intensive firms. The thesis concludes that financial depth should not be treated as equivalent to sustainable financial development. The composition and destination of credit matter. Regulatory incentives, disclosure rules, taxonomy, and prudential supervision should encourage finance to support productive and environmentally credible activities.

Chapter 5 translates the empirical evidence into policy conclusions. One central recommendation is the development of progressive environmental taxation. Environmental taxes can internalize pollution costs, but their design should reflect household income and vulnerability. Revenue recycling can reduce labor taxes, finance clean infrastructure, support low-income households, or fund retraining. A progressive structure can preserve environmental incentives while limiting inequality and maintaining public acceptance.

Another conclusion is that policy must be adaptable. The thesis rejects a uniform approach that ignores national conditions. EU member states differ in income, pollution intensity, energy dependence, industrial composition, climate exposure, and fiscal capacity. Common targets and reporting standards are necessary, but the instrument mix should be calibrated to national circumstances. A coal-dependent economy, a service-oriented economy, and a country with abundant renewable resources cannot follow identical transition pathways at the same speed and cost.

The thesis strongly supports standardization of the green-finance concept. A harmonized definition and taxonomy would improve data comparability, investment classification, and policy evaluation. Standardization should be accompanied by common key performance indicators that measure not only the amount of finance but also environmental additionality, emissions reductions, energy savings, innovation outcomes, and social effects. This contribution is especially relevant because the thesis's own reliance on proxies demonstrates how definitional ambiguity constrains empirical research.

Greenwashing is identified as a major threat to the positive spillovers of green finance. Misclassification can redirect scarce capital, undermine investor confidence, and create an exaggerated impression of progress. The thesis therefore recommends a measurable framework for identifying greenwashing, stronger verification, and consistent reporting obligations. Public institutions should be subject to accountability as well as private firms. Government programs labeled as green should disclose objectives, beneficiaries, implementation timelines, and measurable outcomes.

The thesis also recommends coordinated regulatory oversight. Oversight agencies should use a common reporting architecture and avoid unnecessary duplication. Fragmented supervision can create contradictory guidance, enforcement gaps, and administrative costs. Effective oversight

requires clear institutional responsibility, comparable indicators, accessible data, and the capacity to impose corrective action where claims are misleading or funds are misallocated.

The relevance of the thesis to academic research is substantial. It provides evidence that green-finance relationships are heterogeneous and nonlinear. This finding supports the use of quantile methods and cautions against conclusions based only on average effects. It also demonstrates the value of combining short-run panel models with long-run cointegration estimators and causality analysis. The methodological contribution is not the invention of a new estimator, but the coordinated application of several techniques to a multidimensional research problem.

The thesis also contributes through comparative scope. The inclusion of all EU member states provides a comprehensive view of the Union, while the comparison with nineteen non-EU European countries offers an external benchmark. The division between Old and New Member States, where applicable, recognizes that EU integration, institutional capacity, and economic structure may influence the effectiveness of green finance. This comparative design can inform future studies of regional convergence and policy transfer.

For policymakers, the research is relevant because it shows that funding volume is an insufficient performance measure. Decision-makers need to know whether instruments reduce emissions, mobilize private capital, stimulate innovation, create employment, and protect vulnerable groups. The thesis supports periodic evaluation and adjustment. Instruments should be retained, redesigned, or discontinued based on observed outcomes rather than political labeling.

The limitations reported in the thesis are themselves a contribution because they define a future research agenda. Data scarcity and inconsistent definitions restrict cross-country comparison. Some member states do not report complete information, and recently introduced instruments have short time series. The use of environmental taxes as a green-finance proxy may capture corrective and revenue effects more strongly than investment in clean capital. The absence of a standardized greenwashing indicator prevents the direct measurement of misclassification. The European focus also limits global generalization.

Methodological limitations include endogeneity, small-sample sensitivity, lag selection, cross-sectional dependence, and the assumptions of the causality tests. ORDINARY LEAST SQUARES may be biased when regressors are endogenous. The generalized method of moments can be sensitive to instrument proliferation. PCSE may not address every form of cross-country dependence. The Dynamic Ordinary Least Squares, Fully Modified Ordinary Squares and CCR depend on correct cointegration specification and can be affected by limited samples. Dumitrescu–Hurlin causality may be distorted if spillovers and common shocks are not adequately modeled. The thesis acknowledges these limitations rather than presenting the estimates as definitive causal effects.

Future research should construct a harmonized composite index of green finance that combines public expenditure, private investment, sustainable debt, renewable-energy finance, climate-mitigation funding, innovation support, and corrective fiscal measures. The index should distinguish the source of finance, the use of proceeds, and the verified outcome. It should also permit decomposition so that researchers can identify which component drives an observed relationship.

A second future direction is the development of a greenwashing indicator. Such an indicator could compare reported environmental claims with measurable outcomes, taxonomy alignment, capital expenditure, emissions trajectories, and independent verification. A reliable measure would improve empirical estimates by separating genuine green finance from nominal classification.

A third direction is more detailed geographical analysis. Dividing the EU only into Old and New Member States may conceal important regional structures. Future research could examine Nordic, Baltic, Central and Eastern European, Mediterranean, and Western European groups, or construct clusters based on energy mix, income, institutional quality, and pollution intensity. Broader comparisons with the United States, Canada, Asia, and other regions would help evaluate the EU's global leadership.

A fourth direction is firm-level research. Country-level data cannot fully identify how private firms allocate capital, respond to regulation, or engage in greenwashing. Firm-level balance sheets, bond issuance, lending relationships, emissions, patents, and investment data could provide a more precise account of the private sector's role. Sector-level analysis could also distinguish renewable energy, transport, construction, manufacturing, agriculture, and financial services.

A fifth direction is the explicit modeling of shocks and structural breaks. The COVID-19 pandemic, energy-price crises, and the Russia–Ukraine conflict altered fiscal policy, energy security, supply chains, and investment incentives. Future studies could use interaction terms, regime-switching models, event studies, or structural-break tests to determine whether green-finance relationships changed during these periods.

The overall conclusion is that green finance is necessary but not sufficient for sustainable economic development. It can reduce emissions, support renewable energy, stimulate innovation, and create employment, but its effectiveness depends on institutional maturity, instrument design, public-private coordination, social equity, transparency, and continuous evaluation. The thesis rejects both excessive optimism and excessive skepticism. Green finance has transformative potential, yet that potential is realized only when financial resources are integrated into coherent economic, environmental, social, and technological strategies.

The principal contribution to the field can therefore be summarized in four points. First, the thesis provides a multidimensional operational framework for green finance. Second, it demonstrates empirically that effects differ across sustainability dimensions, countries, quantiles, and time horizons. Third, it identifies public-private balance, inequality, standardization, and policy flexibility as central conditions of effectiveness. Fourth, it develops policy implications that connect climate finance with innovation, employment, energy security, and social justice.

In practical terms, the thesis argues for a European green-finance system that is transparent, comparable, outcome oriented, and adaptable. Public and private funding should be coordinated rather than treated as substitutes. Environmental taxation should internalize external costs without imposing an excessive burden on vulnerable households. Renewable-energy and innovation finance should be evaluated according to measurable additionality. Regulatory frameworks should prevent greenwashing and reduce reporting fragmentation. National strategies should reflect local conditions while remaining consistent with common European objectives.

The relevance of these conclusions extends beyond the European Union. Every economy attempting a green transition faces the problem of mobilizing capital, measuring impact, managing distributional consequences, and coordinating public and private action. The European evidence offers lessons about both the benefits of institutional coordination and the risks of inefficient allocation. The thesis thus contributes to the broader international discussion on how financial systems can support climate neutrality without sacrificing economic resilience or social cohesion.