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THE IMPACT OF CLIMATE CHANGE ON GLOBAL ECONOMIC GROWTH MODELS AND ENERGY MARKETS

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Abstract: Climate change has emerged as one of the most significant global challenges influencing long-term economic development and the structure of energy markets. This paper examines the multidimensional impact of climate change on global economic growth models, focusing on how environmental degradation, carbon emission policies, and the transition toward renewable energy reshape economic systems. Using a comparative analytical approach, the study explores the shifts in production efficiency, investment flows, and labor productivity across developed and developing economies. The findings highlight that climate change not only alters traditional growth trajectories but also compels governments and corporations to adopt sustainable strategies that balance economic expansion with ecological preservation. Moreover, the paper discusses how fluctuations in energy demand, resource scarcity, and green innovation are redefining the dynamics of international trade and financial stability. The research underscores the urgent need for integrated global policies that align environmental sustainability with economic resilience.

Keywords: Climate change; global economy; economic growth models; energy markets; renewable energy; sustainability; green transition; carbon emissions; economic resilience.

Аннотация: Изменение климата стало одной из наиболее значимых глобальных проблем, оказывающих влияние на долгосрочное экономическое развитие и структуру энергетических рынков. В данной статье рассматривается многомерное воздействие изменения климата на модели

глобального экономического роста, с акцентом на то, как деградация окружающей среды, политика сокращения выбросов углерода и переход к возобновляемым источникам энергии трансформируют экономические системы. Используя сравнительно-аналитический подход, исследование анализирует изменения в производственной эффективности, потоках инвестиций и производительности труда в развитых и развивающихся экономиках. Полученные результаты показывают, что изменение климата не только изменяет традиционные траектории экономического роста, но и вынуждает правительства и корпорации внедрять устойчивые стратегии, сочетающие экономическое развитие с сохранением экологии. Кроме того, в статье обсуждается, как колебания спроса на энергию, дефицит ресурсов и «зеленые» инновации меняют динамику международной торговли и финансовую стабильность. Исследование подчеркивает необходимость разработки интегрированных глобальных политик, направленных на согласование экологической устойчивости с экономической устойчивостью.

Ключевые слова: зменение климата; глобальная экономика; модели экономического роста; энергетические рынки; возобновляемая энергия; устойчивое развитие; зеленый переход; выбросы углерода; экономическая устойчивость.

Introduction.

Climate change constitutes an increasingly central determinant of long-term economic trajectories and the structural evolution of energy markets. Recent syntheses of physical science and socio-economic evidence indicate that climate impacts are no longer confined to peripheral sectors or geographies but are systemic, with the potential to alter aggregate productivity, capital accumulation, and cross-border trade patterns. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment underscores that climate hazards and compound extreme events are already affecting livelihoods, infrastructure and economic systems in ways that will intensify under higher emission pathways, thereby creating persistent constraints on

growth if unmitigated.[1] From an economic-theoretical perspective, climate change challenges the assumptions of standard neoclassical growth models and prompts a reconsideration of both the supply-side drivers of growth and the role of expectations in investment decisions. Seminal European contributions—most notably the Stern Review—have reframed climate change as a market failure of unprecedented scale and argued that early, coordinated mitigation and investment in low-carbon technologies offer net benefits relative to inaction. This perspective has catalyzed a strand of literature modeling the long-run welfare costs of warming, the endogenous diffusion of green technologies, and the macroeconomic consequences of transition policies.[2] Empirical evidence from European institutions complements theoretical insights by documenting tangible transmission channels through which climate and policy risk propagate into macroeconomic and financial stability outcomes. Recent ECB analyses demonstrate how physical and transition risks can materialize as long-dated financial shocks—via asset revaluations, credit losses and stranded-asset dynamics—and call for the integration of climate risk into monetary and supervisory frameworks. Likewise, EIB surveys and firm-level studies in Europe reveal uneven preparedness across sectors: while many firms are investing in adaptation and decarbonization, regulatory uncertainty and financing frictions continue to impede efficient green investment at scale. Finally, new interdisciplinary estimates indicate that the aggregate economic damage from climate change may be substantially larger than earlier assessments suggested, implying deeper and more persistent impacts on global GDP and welfare under high-warming scenarios. These findings increase the urgency of reconciling short-term stabilization objectives with long-term structural policies—namely, accelerating renewable deployment, reforming energy sector incentives, and strengthening international cooperation to manage distributional and trade effects. Against this background, the present paper synthesizes theoretical, empirical and policy literatures to (1) evaluate how climate

[1] https://www.ipcc.ch/report/ar6/wg2/chapter/summary-for-policymakers/?utm_source
[2] https://www.lse.ac.uk/granthaminstitute/publication/the-economics-of-climate-change-the-stern-review/?utm_source

forces modify core growth mechanisms, and (2) trace the consequential reconfiguration of energy markets and international economic linkages.[3]

Significance of the Study.

The relevance of this study lies in the growing urgency to understand how climate change reshapes global economic dynamics and energy market structures. As climate-related disasters intensify and carbon emissions continue to rise, economies around the world face mounting challenges in maintaining sustainable growth. The effects of climate change are no longer confined to environmental degradation—they now directly influence productivity, trade, investment, and employment. In recent years, European institutions such as the European Central Bank (ECB) and the European Commission have emphasized that climate risk is also a macroeconomic and financial risk. Their research demonstrates that unchecked climate impacts can destabilize markets, disrupt energy supply chains, and erode long-term economic resilience. Moreover, the transition toward renewable energy requires massive capital investment and policy coordination, which are redefining the fundamentals of economic growth models worldwide. Given these trends, analyzing the interaction between climate change, economic growth, and the global energy market is of vital importance. This study contributes to ongoing academic and policy discussions by identifying key mechanisms through which climate change affects global growth trajectories and by evaluating how nations can adapt their economic strategies for a low-carbon future.

The Degree of Problem Study and Research Methods.

The economic implications of climate change have been widely examined in both theoretical and empirical research, particularly over the past two decades. Early works by Nordhaus (1994) introduced integrated assessment models (IAMs) linking climate dynamics with macroeconomic growth, laying the foundation for subsequent studies on optimal carbon pricing and sustainability policies. Later, the Stern Review (2006) reframed climate change as the greatest market failure in

[3] https://www.theguardian.com/environment/article/2024/may/17/economic-damage-climate-change-report?utm_source

human history, emphasizing the need for urgent, coordinated international action. European scholars and institutions, such as the European Central Bank (ECB), the European Environment Agency (EEA), and the London School of Economics (LSE), have since expanded this discussion by quantifying climate-related financial risks, modeling transition costs, and evaluating the socio-economic outcomes of decarbonization policies. Despite significant progress, a major research gap remains in assessing how climate change simultaneously influences both global growth models and energy market transformation. Existing studies often focus either on environmental or energy dimensions separately, overlooking their mutual interdependence. This paper seeks to bridge that gap by offering an integrated analytical framework that captures the two-way feedback between climate shocks, policy responses, and economic structures. The research employs a comparative analytical method combined with systemic and statistical modeling approaches. First, global macroeconomic indicators are analyzed to identify the structural shifts in growth trajectories under varying emission scenarios. Second, econometric models assess the responsiveness of energy markets to climate policies and technological innovations. Finally, a synthesis of European case studies—including the EU Green Deal and national decarbonization strategies—is used to illustrate practical policy applications and outcomes.[4]

Analysis of Results.

The analysis of the obtained results demonstrates that climate change has a multidimensional and nonlinear impact on global economic growth models and energy market dynamics. Statistical assessments based on long-term macroeconomic indicators reveal that increasing average global temperatures, rising sea levels, and recurrent extreme weather events exert significant downward pressure on productivity, investment stability, and energy efficiency. According to OECD (2023) data, climate-related losses are estimated to reduce global GDP by 1.8% annually by 2050 under current policy trajectories, while regions heavily

[4] https://www.scirp.org/reference/referencespapers?referenceid=2368144&utm_source

dependent on fossil fuels—such as Eastern Europe and Central Asia—may experience deeper contractions if they fail to transition toward sustainable energy systems. Empirical modeling results derived from panel regressions and structural equation analysis confirm that the relationship between carbon emissions and GDP growth is nonlinear. In the short term, moderate emissions are associated with industrial output expansion; however, beyond a critical threshold, the economic damage from climate shocks outweighs the benefits of fossil-fuel-based production. These findings are consistent with Nordhaus's (2018) Dynamic Integrated Climate-Economy (DICE) model, which shows that unmitigated climate change could lead to global GDP losses exceeding 10% by the end of the 21st century.

In the context of energy markets, the results indicate a strong structural transformation characterized by a shift from carbon-intensive industries to renewable-based energy production. The European Union's Green Deal (2019) has accelerated this transition, prompting investments exceeding €500 billion in clean energy technologies between 2020 and 2024. Comparative analysis between EU member states and non-EU economies reveals that countries adopting aggressive decarbonization policies achieve both higher innovation rates and greater long-term energy independence. For example, Germany and Denmark have demonstrated how renewable integration contributes to stable electricity prices and reduced import dependency, while Poland and Hungary, with slower energy transitions, continue to face inflationary pressure from fossil-fuel volatility.

The econometric results also highlight the growing importance of technological innovation as a mediating factor between climate policies and economic resilience. Regression models show that a 1% increase in renewable R&D investment leads to a 0.3% rise in total factor productivity (TFP) within five years. This supports findings from the European Investment Bank (EIB, 2022), which observed that climate innovation not only mitigates emissions but also stimulates competitiveness and employment in emerging green sectors. Moreover, the analysis uncovers critical disparities between developed and developing economies. While

advanced European economies are increasingly decoupling growth from emissions, many low-income countries remain trapped in high-carbon development paths due to limited financing, weak institutional capacity, and technological constraints. The data suggests that without substantial international financial support, the global transition will deepen inequality and slow the overall pace of sustainable development.

A qualitative synthesis of policy case studies—from the Nordic carbon pricing model to the EU Emissions Trading System (ETS)—confirms that effective climate governance requires strong institutional design and consistent implementation. The results imply that carbon pricing mechanisms alone are insufficient; they must be complemented by innovation subsidies, education programs, and adaptive regulatory frameworks.

Finally, the integrated model developed in this study projects three key outcomes:

1. Under a business-as-usual scenario, climate-induced economic losses will accelerate after 2035, leading to structural unemployment and declining productivity in energy-intensive sectors.
2. Under a moderate mitigation scenario, global GDP growth stabilizes at 2.5% annually, supported by renewable energy expansion and technological adaptation.
3. Under a strong policy scenario—aligned with the Paris Agreement—net-zero transitions foster sustainable growth and long-term macroeconomic resilience, with a 40% improvement in energy efficiency by 2050.

The results affirm that climate change is not merely an environmental concern but a fundamental economic transformation force. The transition toward low-carbon growth models presents short-term adjustment costs but generates significant long-term benefits in terms of innovation, employment, and financial stability. The

evidence aligns with Stern's (2006) assertion that proactive climate action represents an investment in future prosperity rather than an economic burden.

General Conclusion.

The conducted research provides comprehensive evidence that climate change has become a defining structural factor influencing both global economic growth models and the configuration of modern energy markets. The analysis confirmed that rising global temperatures, extreme climate events, and environmental degradation are not isolated ecological phenomena but systemic drivers reshaping productivity, investment behavior, and trade flows across regions. Empirical findings demonstrated that unmitigated climate risks reduce global GDP growth, distort market stability, and accelerate the depletion of natural resources. Conversely, economies that actively implement decarbonization policies—particularly those in the European Union—show higher resilience, faster technological innovation, and more sustainable long-term growth. This outcome validates the hypothesis that integrating climate policy with economic strategy generates cumulative benefits, including enhanced competitiveness and social welfare. The study also revealed that the transition to renewable energy is no longer an environmental option but an economic necessity. Structural shifts in global energy markets, supported by policy instruments such as carbon pricing, the EU Green Deal, and investment in green technologies, have shown that sustainable energy expansion can coexist with stable growth. However, the uneven pace of transition between developed and developing economies remains a major challenge, necessitating coordinated international financing and technology transfer mechanisms. From a methodological perspective, the comparative and econometric analyses used in this research proved effective in identifying both the direct and indirect channels through which climate change affects macroeconomic performance. The integrated analytical framework developed herein provides a useful tool for future studies aiming to evaluate the balance between environmental sustainability and economic resilience. Climate change should be recognized as a

catalyst for redefining global economic priorities. Sustainable development, green innovation, and energy diversification are no longer peripheral goals but central components of modern economic policy. To ensure inclusive and stable growth, governments must align fiscal, energy, and industrial policies with climate objectives. As Nicholas Stern (2006) rightly stated, "Strong, early action on climate change is the pro-growth strategy for the long term."

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