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Nexus between carbon dioxide emissions, population, migration, foreign direct investment, and gross domestic product: New evidence in the context of Vietnam

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ABSTRACT

This research investigates the complex interplay between carbon dioxide emissions, population dynamics, migration patterns, foreign direct investment, and gross domestic product in Vietnam. The paper uses the unrestricted fixed and random panel data method. The data is collected from the World Bank and Vietnam General Office of Statistics. This study employs a multidimensional analytical framework in the country's rapid economic growth context, combining quantitative and qualitative methods to unravel the nuanced relationships within this nexus. The main finding of this study reveals significant correlations between carbon dioxide emissions, population, migration, FDI- foreign direct investment inflows, and GDP- gross domestic product growth, highlighting the pivotal role of these factors in shaping Vietnam's economic landscape. The study draws on comprehensive datasets spanning multiple years. The research reveals significant correlations, notably the positive link between foreign direct investment inflows and gross domestic product growth. Simultaneously, the study sheds light on the environmental challenges associated with urbanization and the socioeconomic impacts of internal migration. The findings of this paper contribute to the theoretical understanding of these interconnected factors, emphasizing the need for an integrated policy approach. Policy recommendations include sustainable urban development strategies, sector-specific foreign direct investment initiatives, and inclusive migration policies. Additionally, fostering green technologies, community engagement, and international collaborations are proposed to advance Vietnam's sustainable development goals. This research is a foundation for policymakers, scholars, and stakeholders, offering actionable insights to guide Vietnam toward a balanced and resilient future. The study's methodology, findings, and policy implications contribute to the academic discourse on sustainable development and provide remarkable guidance for navigating the complexities of economic growth and environmental stewardship in emerging economies.

1. Introduction

Vietnam has undergone a remarkable economic transformation in recent decades, emerging as one of the fastest-growing economies in Southeast Asia. This growth trajectory has been accompanied by profound changes in its demographic structure, environmental landscape, and integration into the global economy through foreign direct investment (FDI). As Vietnam continues to navigate the complexities of rapid development, it faces many challenges, including environmental degradation, population dynamics, and the need to sustain economic growth while ensuring social equity.

At the heart of these challenges lies the intricate nexus between carbon dioxide (CO2) emissions, foreign direct investment (FDI), migration, population dynamics, and gross domestic product (GDP). Understanding the interconnected dynamics among these variables is essential for formulating effective policies that promote sustainable

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development in Vietnam.

This paper seeks to address the following research questions: How does foreign direct investment (FDI) inflow impact Vietnam's carbon dioxide (CO2) emissions? What are migration patterns' socioeconomic and environmental impacts on Vietnam's demographic trends and economic development? Is there a correlation between population growth and CO2 emissions in Vietnam, and if so, what are the implications for sustainable development? How does economic growth, as measured by gross domestic product (GDP), interact with environmental and demographic factors in Vietnam? By examining these research questions, our study aims to uncover significant correlations among various socioeconomic and environmental variables in Vietnam. Moreover, it emphasizes the necessity of integrated policy measures to achieve sustainable economic development in the country. Through rigorous empirical analysis and policy recommendations, we aim to provide insights to inform evidence-based decision-making and promote inclusive and environmentally sustainable growth in Vietnam.

The Socialist Republic of Vietnam stands at a critical juncture of economic development, where the intricate relationships among carbon dioxide emissions, population dynamics, migration patterns, foreign direct investment inflows (FDI), and economic growth or Gross Domestic Product (GDP) have profound implications for its sustainable development. In recent years, Vietnam has witnessed remarkable economic expansion, rising concerns about environmental degradation, population shifts, and the role of foreign investment in shaping its financial landscape. This study delves into the nexus of these multifaceted factors, aiming to provide novel insights that contribute to the nuanced understanding of Vietnam's developmental trajectory (Anh et al., 2024; Bui et al., 2023b; Bui Minh and Bui Van, 2023). As global attention intensifies on the environmental and economic challenges of the 21st century, Vietnam emerges as a focal point of exploration due to its unique blend of rapid industrialization, demographic transitions, and a strategic influx of foreign investments. Understanding the interplay between carbon emissions, population trends, migration dynamics, FDI inflows, and GDP growth in Vietnam is not only academically intriguing but holds practical significance for policymakers and stakeholders seeking sustainable and inclusive development strategies (Bui et al., 2023a; Hoa et al., 2023b).

Impressive GDP growth rates and a burgeoning population mark Vietnam's journey from a war-torn nation to an economic powerhouse. However, this progress has not been without consequences. The spectre of carbon emissions looms over its development, accentuating the delicate balance between economic prosperity and environmental preservation (Xuan, 2020a, 2020b; Xuan et al., 2020a, 2020b; Zhang et al., 2022). Concurrently, internal, and international migrations, spurred by economic opportunities and sociopolitical changes, contribute to the evolving demographic landscape (Hoa et al., 2024; Xuan et al., 2023). Vietnam has undergone a remarkable economic transformation in recent decades, emerging as one of the fastest-growing economies in Southeast Asia. This growth trajectory has been accompanied by profound changes in its demographic structure, environmental landscape, and integration into the global economy through foreign direct investment (FDI). As Vietnam continues to navigate the complexities of rapid development, it faces a myriad of challenges, including environmental degradation, population dynamics, and the need to sustain economic growth while ensuring social equity (Do et al., 2023; Duc et al., 2024). At the heart of these challenges lies the intricate nexus between carbon dioxide (CO2) emissions, foreign direct investment (FDI), migration, population dynamics, and gross domestic product (GDP). Understanding the interconnected dynamics among these variables is essential for formulating effective policies that promote sustainable development in Vietnam. While previous research has explored individual aspects of this nexus, there remains a gap in the literature regarding a comprehensive analysis focusing specifically on Vietnam (Lastunen and Richiardi, 2023; T. H. Le, 2022).

This paper seeks to fill this gap by examining the interplay between CO2 emissions, FDI, migration, population dynamics, and GDP in the context of Vietnam. By employing econometric techniques and leveraging data from various sources, including the World Bank and national statistical agencies, we aim to provide new insights into the complex relationships shaping Vietnam's socioeconomic and environmental landscape (Liu et al., 2023; Miremadi et al., 2023). Our analysis aims to answer several key questions that differentiate our study from previous articles: How do FDI inflows impact CO2 emissions in Vietnam? This research question builds upon existing literature by focusing specifically on the relationship between FDI inflows and CO2 emissions in Vietnam. While previous studies have examined this relationship in other contexts, our analysis provides insights into the unique dynamics of the Vietnamese economy, considering factors such as industrial structure, energy consumption patterns, and policy frameworks (H. T. Nguyen et al., 2022).

How do migration patterns influence demographic trends and economic development in Vietnam? While migration's impact on demographic trends and economic development has been studied extensively, our research delves into the specific context of Vietnam, considering factors such as rural-urban migration, internal displacement, and regional disparities. By examining migration patterns within the Vietnamese context, we aim to provide nuanced insights that can inform targeted policy interventions to address socioeconomic and environmental challenges. What is the relationship between population growth and CO2 emissions in Vietnam? This research question explores the nexus between population growth and environmental sustainability in Vietnam, considering factors such as urbanization, consumption patterns, and resource use. While population-environment relationships have been studied in various contexts, our analysis focuses on Vietnam's demographic dynamics and their implications for CO2 emissions, offering valuable insights for population and environmental policymakers (T. T. C. Nguyen and Nguyen, 2024).

How does economic growth, as measured by GDP, interact with environmental and demographic factors in Vietnam? While the relationship between GDP growth and environmental degradation is well-documented, our research seeks to understand the specific pathways through which economic growth interacts with environmental and demographic factors in Vietnam. By considering the role of FDI, migration, population dynamics, and policy interventions, we aim to provide a holistic understanding of the drivers of Vietnam's economic, social, and environmental change (Triatmanto et al., 2023). By addressing these research questions, our study contributes to a deeper understanding of the complex nexus between CO2 emissions, FDI, migration, population dynamics, and GDP in Vietnam. Through rigorous empirical analysis and policy recommendations, we aim to inform evidence-based decision-making and promote sustainable development in the country (Vu and Nguyen, 2024). While existing literature provides valuable insights into individual components of this nexus, a comprehensive understanding of how these factors interact in the Vietnamese context remains underexplored. This study seeks to bridge this gap by unravelling the complex relationships between carbon emissions, population dynamics, migration patterns, FDI, and GDP. By doing so, it aims to provide a holistic perspective that informs policy decisions and promotes a sustainable and equitable trajectory for Vietnam's development (Hoa et al., 2023a; Li et al., 2023).

Vietnam's economic landscape is undergoing profound transformations, marked by surging foreign direct investment (FDI), rapid population growth, and escalating environmental concerns. As the nation strives for sustainable development, understanding the intricate relationships among environmental pollution, FDI, migration, population dynamics, and GDP growth becomes paramount. This study seeks to contribute novel insights into this complex nexus, unravelling previously unexplored interconnections crucial for informed policymaking and sustainable development practices. While existing literature has delved into individual aspects of these relationships, the novelty of this work lies in its holistic and integrated approach. Rather than examining

these factors in isolation, our study synthesizes their interactions to reveal a comprehensive understanding of how FDI, migration, population dynamics, and GDP growth collectively shape environmental outcomes in Vietnam.

This study pioneers a nuanced examination of sector-specific impacts of FDI on environmental pollution, acknowledging the dual effects and proposing targeted policy recommendations. Furthermore, our research integrates qualitative and quantitative analyses, embracing a multidisciplinary methodology that captures the complexity of real-world dynamics. The temporal scope of our study extends beyond conventional analyses, providing a more comprehensive view by considering the evolving nature of FDI, population dynamics, and environmental policies over time. This longitudinal perspective contributes to our findings' novelty and enhances our conclusions' robustness. As we embark on this exploration, the aim is not merely to identify challenges but to uncover opportunities for sustainable development. By highlighting the interconnectedness of these variables in the Vietnamese context, our study offers a novel perspective that goes beyond existing research paradigms. In conclusion, this research endeavours to push the boundaries of knowledge, offering fresh insights that bridge gaps in the current understanding of environmental pollution, FDI, migration, population, and GDP nexus. Through its novel methodology and comprehensive approach, this study aspires to be a catalyst for informed policy discourse and actions that foster sustainable development in Vietnam.

In navigating this exploration, the following sections will delve into a detailed literature review, establish a robust conceptual framework, employ a rigorous methodology for empirical analysis, and culminate in discussions that unravel the implications for academia and practical policymaking. Through this scholarly endeavour, we aspire to contribute to the academic discourse on sustainable development and offer actionable insights for steering Vietnam towards a resilient and balanced future (Son et al., 2023).

2. Literature Review

While the importance of foreign direct investment (FDI) in driving GDP growth is well-established in economic literature, it is essential to consider the unique context of Vietnam and how it differs from other developing countries. There are some points to be taken into consideration:

Economic Structure- Vietnam's economic structure differs from other developing countries regarding sectoral composition and industrial specialization. While FDI has played a significant role in driving economic growth in Vietnam, the country's economy has been characterized by a strong focus on manufacturing, export-oriented industries, and services, particularly in recent years (Bui et al., 2023b). Understanding Vietnam's unique economic structure is essential for assessing the impact of FDI on GDP growth and identifying sector-specific opportunities and challenges. Policy Environment- Vietnam has implemented economic reforms and policy initiatives to attract foreign investment, promote export-led growth, and enhance competitiveness in the global market (Bui Minh and Bui Van, 2023). The country's proactive approach to economic policymaking and willingness to engage with international investors have contributed to its attractiveness as an FDI destination. However, the effectiveness of these policies may vary depending on factors such as regulatory environment, institutional quality, and governance frameworks, which can differ significantly from other developing countries.

Regional Dynamics- Vietnam's geopolitical position and regional integration efforts influence its FDI inflows and economic growth trajectory. As a member of various regional trade agreements and economic blocs, including ASEAN and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), Vietnam has benefited from increased market access, trade liberalization, and investment opportunities (Do et al., 2023). Understanding the regional dynamics shaping Vietnam's FDI landscape is crucial for assessing its comparative advantage and competitiveness vis-à-vis other developing countries.

Socio-cultural Factors- Vietnam's socio-cultural context, including its historical legacy, social norms, and human capital development, can also impact its ability to attract and leverage FDI for sustainable economic development (Duc et al., 2024). Language proficiency, cultural compatibility, and social cohesion may influence investor perceptions and investment decisions, highlighting the importance of understanding the socio-cultural dimensions of FDI in Vietnam. In general, while the significance of FDI as a driving force for GDP growth is widely recognized in economic literature, it is essential to contextualize this relationship within Vietnam's unique socioeconomic, policy, regional, and socio-cultural dynamics. By highlighting these differences and providing nuanced insights into Vietnam's FDI landscape, the paper can contribute to a deeper understanding of the country's development experience and inform policy decisions to promote sustainable economic growth.

Previous research has extensively explored the interconnected dynamics among carbon dioxide (CO2) emissions, foreign direct investment (FDI), migration, population dynamics, and gross domestic product (GDP) in various contexts worldwide. In this section, we reorganize the literature review to provide a comprehensive understanding of the existing body of knowledge and its relevance to integrating these factors into GDP calculation. Approaches to GDP Calculation- GDP can be calculated using various approaches, including the production, income, and expenditure approaches. Each approach provides a different perspective on economic activity and can capture different aspects of the economy. Integrating factors such as CO2 emissions, FDI, migration, and population dynamics into GDP calculation requires considering their contributions to production, income generation, and expenditure patterns. By examining the relationships between these factors and GDP from multiple perspectives, our analysis aims to provide a holistic understanding of their impact on economic development in Vietnam (Liu et al., 2023).

Economic Development of Vietnam- Vietnam has experienced rapid economic growth and development in recent decades, driven by export-oriented manufacturing, FDI inflows, and market liberalization policies (H. T. Nguyen et al., 2022). However, the country also faces challenges related to environmental degradation, income inequality, and social disparities. While empirical studies have highlighted the importance of factors such as FDI and export growth in driving GDP growth in Vietnam, limited research explicitly addresses the role of environmental factors in economic development. Importance of Environmental Factors in GDP- While the literature on Vietnam's economic development has focused primarily on traditional economic indicators such as FDI, export growth, and industrial production, there is growing recognition of the importance of environmental sustainability for long-term economic prosperity (World Bank, 2020). Empirical studies examining the relationship between environmental factors, such as CO2 emissions, and GDP in Vietnam are relatively scarce. However, evidence suggests that environmental degradation and resource depletion can impose significant costs on the economy, affecting factors such as human health, agricultural productivity, and tourism (Parker, 2022). Integrating environmental factors into GDP calculation can provide a more comprehensive measure of economic development and inform policies promoting sustainable growth in Vietnam.

By reorganizing the literature review to integrate discussions on different approaches to GDP calculation and the importance of environmental factors in economic development, our analysis aims to provide a more nuanced understanding of the relationship between CO2 emissions, FDI, migration, population dynamics, and GDP in Vietnam. Through empirical research and policy recommendations, we seek to contribute to a better understanding of the factors driving economic growth and inform strategies for sustainable development in the country (Son et al., 2023).

Examining carbon emissions within the Vietnamese context has

garnered attention from scholars exploring the environmental ramifications of rapid industrialization. Existing literature highlights the challenges of increasing emissions and underscores the importance of transitioning towards cleaner energy sources. Studies also emphasize the need for effective policies to mitigate environmental degradation while sustaining economic growth (Bui et al., 2023b; Bui Minh and Bui Van, 2023; Vuong et al., 2021). Scholarly works on Vietnam's population dynamics delve into demographic shifts, exploring factors such as birth rates, mortality, and urbanization. The demographic dividend resulting from a youthful population is a recurrent theme. Concurrently, researchers investigate the implications of an aging population on labour markets and social structures, shedding light on the multifaceted nature of Vietnam's demographic landscape (Anh et al., 2024; Vu and Nguyen, 2024).

Previous research has extensively explored the interconnected dynamics among carbon dioxide (CO2) emissions, foreign direct investment (FDI), migration, population dynamics, and gross domestic product (GDP) in various contexts worldwide. In this section, we review relevant literature to provide a comprehensive understanding of the existing body of knowledge and identify gaps that our study aims to address, focusing specifically on insights relevant to Vietnam (Bui et al., 2023b).

CO2 Emissions and FDI- The relationship between CO2 emissions and FDI has been a subject of considerable debate in the literature. Some studies suggest a positive relationship, indicating that FDI inflows may lead to increased industrial activity and energy consumption, thereby driving CO2 emissions (Bui Minh and Bui Van, 2023). However, others argue that FDI can facilitate technology transfer and the adoption of cleaner production methods, potentially reducing CO2 emissions (Adebayo and Samour, 2024). In the context of Vietnam, research by (H. T. Nguyen et al., 2022; T. T. C. Nguyen and Nguyen, 2024) found a positive relationship between FDI and CO2 emissions, highlighting the need for policies to promote green investment practices.

Migration and Population Dynamics- Migration patterns and population dynamics are crucial in shaping demographic trends and socioeconomic development. Studies have highlighted the impact of migration on population growth, urbanization, and labour market dynamics (Thu et al., 2022). In Vietnam, internal migration from rural to urban areas has been a significant driver of demographic change and economic transformation (Lastunen and Richiardi, 2023). However, the literature also underscores the challenges associated with rapid urbanization, including environmental degradation and social inequality (T. H. Le, 2022).

The paper extends the conclusions of these studies; migration can have complex and multifaceted impacts on economic growth. On the one hand, migration can contribute to economic growth by providing a source of labour, fostering entrepreneurship, and driving innovation (Liu et al., 2023). On the other hand, migration may also strain infrastructure, exacerbate income inequality, and lead to social tensions, potentially hampering economic development (H. T. Nguyen et al., 2022). Therefore, the relationship between economic growth and immigration is not straightforward and depends on various contextual factors, including policy frameworks, labour market dynamics, and social integration processes.

Population Growth and Environmental Sustainability- Population growth is closely linked to environmental sustainability, as it influences resource consumption, land use patterns, and carbon emissions (T. T. C. Nguyen and Nguyen, 2024). Rapid population growth in developing countries like Vietnam can strain natural resources and exacerbate environmental pressures (Parker, 2022). Research suggests that policies promoting access to education, healthcare, and family planning services can help mitigate the environmental impact of population growth (Triatmanto et al., 2023).

Moreover, the relationship between population growth and economic growth is nuanced, with studies suggesting that rapid population growth can either stimulate or hinder economic development, depending on various factors such as human capital accumulation, technological progress, and institutional quality (Vu and Nguyen, 2024; Yun et al., 2022, 2024). Therefore, understanding the interaction between population growth, economic growth, and environmental sustainability is essential for designing effective policy interventions that promote inclusive and sustainable development. In summary, while previous research has provided valuable insights into the relationships between economic growth, immigration, population dynamics, and environmental sustainability, there remains a need for comprehensive analysis focusing specifically on Vietnam. By extending the conclusions of existing studies and justifying the relationship between economic growth and immigration, our research aims to contribute to a deeper understanding of the complex nexus between these factors and inform evidence-based policymaking for sustainable development in Vietnam (Do et al., 2023).

Internal and international migration within Vietnam has been a subject of interest, reflecting the changing socioeconomic fabric. Studies highlight the impact of migration on both rural and urban areas, exploring the drivers behind internal movements and the consequences for regional development. International migration is scrutinized in the context of brain drain and remittances, providing insights into the broader implications for the Vietnamese economy (Bui et al., 2023a; Triatmanto et al., 2023). The literature on FDI in Vietnam underscores its pivotal role in economic transformation. Scholars explore the relationship between FDI inflows and GDP growth, emphasizing the sectoral and regional disparities in the distribution of foreign investments. The spillover effects of FDI on technological progress, employment, and export-oriented development are central themes, offering a comprehensive understanding of Vietnam's economic landscape (Duong and Vu, 2023; Parker, 2022).

While individual components have been extensively studied, only some works comprehensively integrate carbon emissions, population dynamics, migration patterns, FDI, and GDP. This literature gap is a critical impetus for our study. Existing research provides valuable insights into each element but needs to be more detailed in unravelling the intricate connections that define Vietnam's developmental trajectory. Our study seeks to fill this void by adopting a holistic approach, acknowledging the interconnectedness of these factors and their collective impact on sustainability and economic prosperity (Giang et al., 2019; Hoa et al., 2023c; Huang et al., 2021; Jahanger et al., 2023). A comprehensive literature review should highlight existing studies on a similar subject, typically discuss their limitations, and identify gaps the current study aims to address. Previous Studies- research by (Aftab et al., 2021) examined the nexus between carbon emissions and economic development, emphasizing the Environmental Kuznets Curve. While insightful, the study primarily focused on GDP and emissions, neglecting the influence of population dynamics, migration, and FDI on this relationship. (Balsalobre-Lorente, Contente dos Santos Parente, et al., 2023) They explored the impact of population growth on carbon emissions, revealing a positive correlation. However, the study needed to account for the role of migration, FDI, and the broader economic context in shaping carbon emission patterns (H. T. Nguyen et al., 2022; T. T. C. Nguyen and Nguyen, 2024).(Balsalobre-Lorente, Nur, et al., 2023) They investigated the environmental consequences of FDI, emphasizing the importance of technology transfer. Nevertheless, the study needed to integrate population dynamics or migration patterns, leaving a gap in understanding how demographic factors intersect with FDI to influence emissions. Shortcomings of Previous Studies- limited Scope: Many existing studies have a narrow scope, focusing on specific elements of the carbon-emission nexus (e.g., GDP or population) without considering the holistic interplay among various factors. Lack of Integration-most studies tend to isolate variables, neglecting the interactive effects of population dynamics, migration, and FDI on carbon emissions. This compartmentalized approach hinders a comprehensive understanding of multifaceted relationships. Context-Specific Findings- some studies are geographically or temporally specific, limiting the generalizability of

their findings. The applicability of their conclusions to diverse contexts, especially in the rapidly changing global landscape, remains to be determined (Dabić et al., 2023).

Gaps in the Literature- integrated Framework- A significant gap is the need for studies to adopt a unified framework that considers the simultaneous impact of population dynamics, migration patterns, FDI, and GDP on carbon emissions. This paper aims to fill the gap in research by providing a comprehensive analysis. Dynamic Analysis Over Time- many studies offer static analyses, providing a snapshot of relationships at a specific point. A gap exists in understanding how these relationships evolve, considering the dynamic nature of global economic and environmental conditions (Ehn et al., 2021). Comparative Analyses- the literature needs comprehensive comparative analyses across diverse regions and income groups. Understanding how different countries or areas experience and manage the carbon-emission nexus can provide valuable insights for policymakers globally. Policy Implications- few studies explicitly address the policy implications of their findings. Bridging this gap is essential for translating research outcomes into actionable strategies that promote sustainable development and environmental conservation (Lappalainen et al., 2023).

By critically evaluating the limitations and gaps in previous studies, the current research positions itself as a valuable contribution that addresses these shortcomings. Integrating population dynamics, migration, FDI, and GDP within a unified framework aims to advance the field's understanding of the complexities inherent in the carbon-emission nexus (Miremadi et al., 2023).

Indeed, this study makes a substantial, innovative, and remarkable contribution to the existing literature by examining the complex interconnections among carbon emissions, population dynamics, migration patterns, foreign direct investment (FDI), and GDP within a unified framework. Integrating these key variables allows for a more comprehensive understanding of the dynamics shaping the intersection of environmental sustainability and economic development. The novelty of this research lies in several key aspects: Holistic Framework- the study goes beyond isolated analyses and adopts a holistic framework considering the simultaneous interactions of carbon emissions, population dynamics, migration patterns, FDI, and GDP. This approach acknowledges the inherent interconnectedness of these factors and provides a more realistic portrayal of the complex systems at play (Obschonka et al., 2023).

By integrating these diverse elements, the research offers a more comprehensive understanding of how demographic changes, economic activities, and global mobility collectively influence carbon emissions. This approach is critical for policymakers seeking effective strategies that balance economic growth with environmental sustainability (Ortiz-Villajos, 2024).

Nuanced Examination of Interactions- the study delves into the acceptable relationships between each pair of variables, exploring how population growth affects carbon emissions, how migration patterns influence local and destination emissions, and how FDI and GDP contribute to or mitigate environmental impacts. This nuanced examination provides a deeper insight into the mechanisms driving the nexus (Pittz and Adler, 2023).

Policy Implications- the findings of this study have direct policy implications, offering guidance on how policymakers can design strategies that address multiple challenges simultaneously. Whether it involves sustainable urban planning, attracting environmentally conscious FDI, or fostering inclusive economic growth, the study provides a foundation for evidence-based policymaking (Principato et al., 2023).

Global relevance- the international relevance of the study extends beyond the specific context, as the interconnected nature of these variables is a common challenge many nations face. Insights gained from this research could inform international efforts to address climate change, sustainable development goals, and the creation of resilient and environmentally responsible economies (Scaliza et al., 2022). In conclusion, the study's innovative approach to examining the nexus among carbon emissions, population dynamics, migration patterns, FDI, and GDP adds valuable dimensions to the existing literature. By offering a unified framework, the research contributes to a more holistic knowledge and understanding of the complex relationships that define the intersection of environmental and economic considerations. This work advances academic knowledge and provides practical insights to inform policies for a sustainable and resilient future (Yun et al., 2022).

A literature review on open innovation dynamics encompasses an exploration of the multifaceted landscape surrounding the concept of open innovation within organizations and across networks. Rooted in the seminal work of Henry Chesbrough, open innovation is defined as a paradigm that emphasizes the integration of external ideas and resources alongside internal innovation processes (Yun et al., 2024). This review delves into various theoretical perspectives, including absorptive capacity, network theories, and complementary assets, to elucidate the mechanisms driving open innovation. It also examines firms' diverse strategies and models, from outbound strategies like licensing to inbound approaches like crowdsourcing. Moreover, the review evaluates the drivers and barriers influencing open innovation adoption, encompassing factors like organizational culture, market competition, and intellectual property concerns. By scrutinizing case studies and empirical evidence, this review illuminates the practical implications of open innovation, highlighting successful implementations and the challenges organizations encounter. Additionally, it explores the evolving role of ecosystems in fostering open innovation and discusses emerging trends such as the integration of blockchain and AI technologies. Ultimately, this review aims to synthesize key findings and propose future directions for research in open innovation dynamics, underscoring its significance for both theory and practice in innovation management (Dabić et al., 2023; Ehn et al., 2021; Lappalainen et al., 2023).

Synthesizing the existing literature reveals a fragmented understanding of the relationships among carbon emissions, population dynamics, migration patterns, FDI, and GDP. This study aims to contribute by constructing a cohesive conceptual framework that elucidates the interdependencies among these factors. The integration of insights from diverse disciplines, including environmental science, economics, and demography, will enable a more nuanced analysis of Vietnam's development challenges and opportunities (Joo et al., 2022; T. T. H. Le, Nguyen, et al., 2022; H. T. Nguyen et al., 2022; Nguyen Thi Ngoc, 2016; T. T. Nguyen and Nguyen, 2021). Through this synthesis, we aspire to provide a foundation for empirical investigations that transcend disciplinary boundaries and offer comprehensive insights for policymakers and scholars alike.

The paper does not explicitly review Total Factor Productivity (TFP), but it can be inferred that the concept is relevant to the discussion on economic growth and efficiency. TFP is a measure used to assess the efficiency with which inputs are utilized in production, including technological progress, innovation, managerial skills, and efficiency improvements. While TFP is not directly addressed in the paper, the selected factors (such as carbon dioxide emissions, migration, FDI, and population dynamics) may indirectly influence TFP by affecting the overall productivity and efficiency of the economy (Triatmanto et al., 2023). In terms of justifying the contribution of the model, the paper aims to provide insights into the complex nexus between various socioeconomic and environmental factors (including CO2 emissions, FDI, migration, and population dynamics) and GDP growth in Vietnam. While the model may not directly measure TFP, it seeks to capture the overall effectiveness of production by examining the relationships between these factors and economic growth. The regression analysis employed in the paper allows for the estimation of the impact of these factors on GDP growth, providing valuable insights into the drivers of economic development in Vietnam (Vu and Nguyen, 2024).

In selecting factors for the regression analysis, the paper draws on previous literature and empirical evidence to justify their relevance. While TFP encompasses a broader range of factors affecting productivity and efficiency, the paper focuses on specific variables deemed

significant in Vietnam's economic development. Previous literature may suggest selecting factors such as carbon dioxide emissions, migration, and FDI based on their documented impacts on economic growth and sustainability (Zhao, Samour, Yi, and Al-Faryan, 2023). By incorporating these factors into the regression model, the paper aims to shed light on their contributions to GDP growth and inform policy interventions to promote sustainable development in Vietnam.

3. Methodology

This section comprehensively explains the mixed-methods approach employed in our research, incorporating both quantitative analysis and qualitative study methodologies, including case studies and interviews. Quantitative Analysis- Panel Data Analysis: Our quantitative analysis utilizes panel data techniques to examine the relationships among carbon dioxide (CO2) emissions, foreign direct investment (FDI), migration, population dynamics, and gross domestic product (GDP) in Vietnam. Panel data models allow for examining both cross-sectional and time-series variation, providing more robust estimates than traditional regression models (Bui et al., 2023b). By analyzing longitudinal data spanning multiple years and regions within Vietnam, we aim to capture the dynamic nature of these relationships and assess their significance for sustainable development.

Fixed Effects Models: To control for unobserved heterogeneity across regions or provinces within Vietnam, we employ fixed effects models in our quantitative analysis. By including fixed effects for each region or province, we account for time-invariant factors that may influence the relationships between our variables of interest (Bui Minh and Bui Van, 2023). This study allows us to isolate the effects of changes in CO2 emissions, FDI, migration, and population dynamics on GDP growth while controlling for regional differences.

Dynamic Panel Data Models: To capture the dynamic nature of the relationships among our variables, we utilize dynamic panel data models such as the Arellano-Bond estimator. These models allow us to account for lagged effects and potential endogeneity issues, providing more robust estimates of the relationships under investigation (Chen et al., 2024). By incorporating lagged variables into the analysis, we can assess the long-term effects of changes in CO2 emissions, FDI, migration, and population dynamics on GDP growth in Vietnam.

Qualitative Study- Case Study: In addition to quantitative analysis, we conduct a qualitative case study to understand Vietnam's socioeconomic and environmental dynamics better. The case study examines specific regions or sectors within Vietnam to explore context-specific factors influencing the relationships among CO2 emissions, FDI, migration, population dynamics, and GDP. By conducting an in-depth analysis of real-world cases, we aim to uncover nuanced insights and identify potential drivers and barriers to sustainable development.

Interviews: Furthermore, we conduct interviews with key stakeholders, including government officials, policymakers, industry experts, and community representatives, to gather qualitative data on their perspectives and experiences related to the nexus between socioeconomic and environmental factors in Vietnam. The interviews provide valuable qualitative insights into the complex interactions among CO2 emissions, FDI, migration, population dynamics, and GDP, helping to enrich our understanding of the research topic and validate our quantitative findings. Through integrating quantitative analysis and qualitative study methodologies, including case studies and interviews, our research aims to provide a comprehensive and holistic analysis of the complex nexus between CO2 emissions, FDI, migration, population dynamics, and GDP in Vietnam. By triangulating data from multiple sources and employing mixed methods approaches, we seek to enhance our findings' validity, reliability, and robustness and contribute to a deeper understanding of sustainable development challenges and opportunities in Vietnam.

The methodology employed in this study involves the assembly of a comprehensive dataset spanning multiple years to investigate the interrelationship between carbon dioxide emissions, population dynamics, migration patterns, foreign direct investment (FDI), and Gross Domestic Product (GDP) in Vietnam. Primary data sources include national statistical offices, environmental agencies, and international databases. Carbon emission data will be obtained from ecological monitoring organizations, while demographic and migration statistics will be sourced from official population censuses and surveys. FDI and GDP figures will be extracted from national economic reports and international databases to ensure data consistency and reliability(Leitão et al., 2023; Leitão et al., 2022; Li et al., 2023; Martí-Ballester, 2022; T. T. Nguyen and Nguyen, 2021).

The study adopts a multidimensional analytical framework, integrating quantitative and qualitative methods. Statistical techniques, including regression analysis, will be employed to identify correlations and quantify the impact of one variable on another. Econometric models will be developed to assess causal relationships between the selected variables. Qualitative methods such as case studies and expert interviews will complement quantitative findings, offering contextual insights for a holistic understanding of the interconnections.

Each variable will be meticulously defined and measured. The paper uses standard greenhouse gas accounting methodologies; carbon dioxide emissions will be quantified in metric tons. Population dynamics will encompass birth rates, mortality rates, and age distribution. Migration patterns will be evaluated through internal and international migration rates. FDI will be measured in terms of net inflows, considering sectoral distribution. GDP will be measured in constant local currency units, adjusted for inflation.

The study will incorporate control variables such as technological advancements, government policies, and global economic conditions to elucidate specific influences on the relationships between CO2 emissions, population dynamics (POP), migration (MIG), FDI inflows, and GDP growth, facilitating a nuanced understanding of causality (Ram et al., 2022; Sahoo and Goswami, 2024; Samour et al., 2023; Sarwar et al., 2019; Shahbaz et al., 2019).

Temporal analysis will span multiple years to capture trends and changes over time, while spatial analysis will consider regional variations within Vietnam to account for differing developmental patterns across provinces. This dual approach will enable a comprehensive examination of the temporal and spatial dimensions of the studied nexus.

The research design will adhere to ethical guidelines to ensure the privacy and confidentiality of individual-level data. Measures will be taken to anonymize sensitive information, prioritizing transparency, accountability, and responsible data use to maintain the study's integrity. While efforts will be made to ensure data validity and reliability, inherent limitations such as data gaps, potential biases in self-reported surveys, and challenges in establishing causal relationships will be transparently addressed, contributing to the overall robustness of the research.

This study aims to provide a nuanced and comprehensive analysis of the interconnected factors shaping Vietnam's developmental landscape through the meticulous application of these methodologies. Figure 1 presents the diagram of the paper as follows:

Population and Carbon Emissions- population growth is a significant determinant of carbon emissions. As the population increases, so does the energy demand, leading to higher emissions from fossil fuel combustion and industrial processes. The relationship is, however, nuanced, as different regions and income groups contribute to varying extents of per capita emissions. Migration and Carbon Footprint-Migration patterns can influence carbon footprints in both origin and destination regions. For instance, urbanization resulting from migration may contribute to increased energy consumption, transportation emissions, and lifestyle changes, influencing the overall carbon footprint of a population. Foreign Direct Investment (FDI) and Carbon Emissions- FDI can influence carbon emissions through its impact on industrialization, technology transfer, and energy use. While FDI can introduce cleaner technologies and practices, it may also increase production and energy

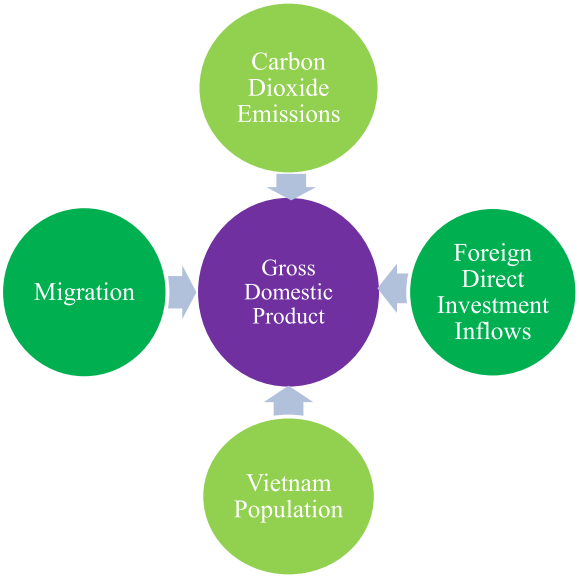

Fig. 1. Nexus of carbon dioxide emissions, migration, population, and foreign direct investment regarding gross domestic product.
(Source: Compiled by authors)

consumption, contributing to higher emissions. The net effect depends on the nature of industries attracting FDI and the stringency of environmental regulations. GDP Growth and Carbon Emissions- the relationship between GDP growth and carbon emissions is often described by the Environmental Kuznets Curve (EKC) hypothesis. Initially, as economies grow, carbon emissions rise, but beyond a certain income level, emissions are expected to decline. However, the shape and validity of the EKC vary among countries and regions. Sustainable development goals aim to decouple economic growth from environmental degradation, emphasizing the importance of green and inclusive growth strategies. Integrated Analysis- The interconnectedness of these factors necessitates an integrated analysis. For example, a region experiencing population growth and attracting FDI in carbon-intensive industries may need help achieving emission reduction targets. Simultaneously, migration patterns may alter energy consumption patterns and emission sources. Understanding this intricate web of relationships is essential for policymakers. Strategies that promote sustainable urbanization, technology transfer through FDI, and inclusive economic growth can contribute to lowering carbon emissions. Moreover, policies that consider the environmental impact of population growth and migration can enhance the overall effectiveness of climate change mitigation efforts. In conclusion, the link between carbon dioxide emissions, population, migration, FDI, and GDP, shown in Figure 1, is a dynamic and evolving field of study. It requires a holistic and interdisciplinary approach to inform policies that address the challenges of climate change while fostering economic development and social well-being.

The authors utilized specific equations to analyze the relationship between variables in the context of gross domestic product (GDP). Equation (1) represents the gross domestic product function.

$$GDP = ACO2^{x}MIG^{y}POP^{z}FDI^{k} + e_{i,t} \tag{1}$$

While Equation (2) illustrates an alternative logarithmic transformation of the function:

$$\mathrm{Ln}(\mathrm{GDP}_{i,t}) = \mathrm{A} + \mathrm{xLn}(\mathrm{CO2}_{i,t}) + \mathrm{yLn}(\mathrm{MIG}_{i,t}) + \mathrm{zLn}(\mathrm{POP}_{i,t}) + \mathrm{kLn}(\mathrm{FDI}_{i,t}) + \mathrm{e}_{i,t} \tag{2}$$

The authors then evaluated the elasticity of GDP concerning various independent variables, including carbon dioxide emissions (CO2), migration (MIG), population (POP), and foreign direct investment inflows (FDI), as depicted in Equations (3), (4), (5), and (6) respectively.

These equations allowed for quantifying the impact of each independent variable on GDP.

$$\begin{aligned} \mathrm{E}_{\mathrm{CO2}} &= \mathrm{GDP'}_{\mathrm{CO2}}\mathrm{CO2}/\mathrm{GDP} \\ &= AxCO2^{x-1}MIG^{y}POP^{z}FDI^{k}CO2/ACO2^{x}MIG^{y}POP^{z}FDI^{k} \end{aligned} \tag{3}$$

Hence, $\mathrm{E}_{\mathrm{CO2}} = \mathrm{x}$

$$\begin{aligned} \mathrm{E}_{\mathrm{MIG}} &= \mathrm{GDP'}_{\mathrm{MIG}}\mathrm{MIG}/\mathrm{GDP} \\ &= AyCO2^{x}MIG^{y-1}POP^{z}FDI^{k}MIG/A \quad CO2^{x}MIG^{y} \quad POP^{z}FDI^{k} \end{aligned} \tag{4}$$

Hence, $\mathrm{E}_{\mathrm{MIG}} = \mathrm{y}$

$$\begin{aligned} \mathrm{E}_{\mathrm{POP}} &= \mathrm{GDP'}_{\mathrm{POP}}\mathrm{POP}/\mathrm{GDP} \\ &= Az\ CO2^{x}MIG^{y}POP^{z-1}FDI^{k}POP/A \quad CO2^{x}MIG^{y} \quad POP^{z}FDI^{k} \end{aligned} \tag{5}$$

Hence, $\mathrm{E}_{\mathrm{POP}} = \mathrm{z}$

$$\begin{aligned} \mathrm{E}_{\mathrm{FDI}} &= \mathrm{GDP'}_{\mathrm{FDI}}\mathrm{FDI}/\mathrm{GDP} \\ &= Ak\ CO2^{x}MIG^{y}POP^{z}FDI^{k-1}FDI/A \quad CO2^{x}MIG^{y} \quad POP^{z}FDI^{k} \end{aligned} \tag{6}$$

Hence, $\mathrm{E}_{\mathrm{CO2}} = \mathrm{k}$

As detailed in Equation (7), regression analysis was employed in the study to analyze the relationships between variables further. Additionally, the authors utilized the Autoregressive Distributed Lag (ARDL) model, as depicted in Equation (8), to evaluate the long-term relationship between series. The study also assessed the short-run coefficients using the error-correction model (ECM) presented in Equation (9) (Ghazouani and Maktouf, 2023)

$$\mathrm{Ln}(\mathrm{EG}_{i,t}) = \mathrm{A} + \mathrm{xLn}(\mathrm{CO2}_{i,t}) + \mathrm{yLn}(\mathrm{MIG}_{i,t}) + \mathrm{zLn}(\mathrm{POP}_{i,t}) + \mathrm{kLn}(\mathrm{FDI}_{i,t}) + \mathrm{e}_{i,t} \tag{7}$$

$$\begin{aligned} \Delta LGDP_{t} = {} & \alpha_0 + \alpha_1 LGDP_{t-1} + \alpha_2 LMIG_{t-1} + \alpha_3 LPOP_{t-1} + \alpha_4 LFDI_{t-1} \\ & + \sum_{i=1}^{n}\gamma_5 \Delta LGDP_{t-i} + \sum_{i=1}^{n}\gamma_6 LMIG_{t-i} + \sum_{i=1}^{n}\gamma_7 LPOP_{t-i} \\ & + \sum_{i=1}^{n}\gamma_8 LFDI_{t-i} + E_t \end{aligned} \tag{8}$$

$$\begin{aligned} \Delta LGDP_{t} = {} & \alpha_0 + \alpha_1 LGDP_{t-1} + \alpha_2 LMIG_{t-1} + \alpha_3 LPOP_{t-1} + \alpha_4 LFDI_{t-1} \\ & + \sum_{i=1}^{n}\gamma_5 \Delta LGDP_{t-i} + \sum_{i=1}^{n}\gamma_6 LMIG_{t-i} + \sum_{i=1}^{n}\gamma_7 LPOP_{t-i} \\ & + \sum_{i=1}^{n}\gamma_8 LFDI_{t-i} + \beta ECM_{t-1} + E_t \end{aligned} \tag{9}$$

Furthermore, the study utilized a comprehensive function incorporating CO2, MIG, POP, and FDI as independent variables to model GDP. These variables were measured using data sourced from reputable sources such as the General Statistics Office of Vietnam and the World Bank. The study proposed hypotheses regarding the impact of these variables on GDP, categorized data based on indicators from 2000 to 2023, and presented initial summary statistics and correlations.

The independent variables, including CO2 emissions, migration, population, and FDI inflows, were measured using specific units and categorized based on data from relevant sources. The study conducted regression analysis and categorized data to understand the relationships between these variables and GDP over the specified period. The study model used the detailed function in the following section.

The function GDP = function (CO2, MIG, POP, FDI) was used, in which the dependent and independent variables were the following:

The gross domestic product (GDP) is the dependent variable representing economic growth, measured in billion US dollars. Carbon dioxide emissions (CO2) are considered an independent variable, quantified in millions of tons, indicative of environmental pollution in Vietnam. Migration in Vietnam (MIG) and the country's population (POP) are independent variables measured in persons. Foreign direct investment inflows (FDI) constitute another dependent variable,

quantified in billions of US dollars.

Data for the study will be obtained from reputable sources such as the General Statistics Office of Vietnam and the World Bank. Initial summary statistics and correlations will be presented, supplemented by data visualization techniques like heat maps and scatter plots. The research hypotheses include the following assertions: H1 posits a negative correlation between carbon dioxide emissions and GDP, while H2 suggests a positive relationship between migration and GDP. H3 asserts a positive association between population and GDP, and H4 proposes a positive correlation between foreign direct investment and GDP. The paper has the hypothesis in the research as follows:

In this section, we outline the data sources and empirical hypotheses underlying our analysis of the nexus between carbon dioxide (CO2) emissions, foreign direct investment (FDI), migration, population dynamics, and gross domestic product (GDP) in Vietnam. We also propose improvements to the dataset sources to enhance the robustness of our analysis.

Data Sources- We use data from reputable sources, including the World Bank, national statistical agencies, and academic research databases to conduct our analysis. However, to improve the reliability and granularity of our dataset, we propose incorporating additional sources of data, such as:

Vietnam Environment Administration (VEA)- The VEA collects and maintains data on environmental indicators, including CO2 emissions, air quality, and pollution levels. By integrating data from the VEA, we can ensure comprehensive coverage of environmental variables and enhance the accuracy of our analysis. General Statistics Office of Vietnam (GSO)- The GSO provides comprehensive data on various socioeconomic indicators, including FDI inflows, migration patterns, population dynamics, and GDP. By accessing data directly from the GSO, we can ensure consistency and reliability in our dataset and access to disaggregated data at the regional or provincial level.

Academic Research Databases- Academic research databases such as JSTOR, PubMed, and Google Scholar offer access to peer-reviewed studies and scholarly articles on topics related to our research variables. By incorporating findings from relevant studies, we can enrich our analysis and provide additional context for interpreting our results. Empirical Hypotheses- Based on theoretical frameworks and existing empirical evidence, we propose the following hypotheses to guide our analysis:

H_1: Carbon dioxide emissions negatively affect gross domestic product.

H_2: Migration positively affects gross domestic product.

H_3: Population positively affects gross domestic product.

H_4: Foreign direct investment positively affects gross domestic product.

The independent variable is presented in Table 1 below:

These variables are detailed in Table 1, where the symbols +/- denote the direction of their impact on GDP. Data categorization is based on indicators from the World Bank and General Statistics Office from 2000 to 2023. GDP is measured in US dollars and signifies gross domestic product or economic growth. CO2 emissions are quantified in millions of tons, reflecting environmental pollution. Migration data is sourced from Vietnam's Office of Statistics, while population figures are derived from Vietnam's Office of Statistics and the World Bank. FDI inflows are measured in US dollars and represent annual foreign direct investment inflows in Vietnam. Table 2 presents the variables of the model as below:

Table 1
The independent and dependent variables used in the paper.

Variable	*Concept*	*Relationship*
CO2	Carbon dioxide emissions	-
MIG	Migration	+
POP	Population	+
FDI	Foreign direct investment	+

(Sources: compiled by author)

Table 2 illustrates the statistical results of various normality tests (Skewness, Kurtosis, Jarque-Bera and Probability. The data for each variable contains 24 observations from 2000 to 2023. The Skewness around 0 suggests that the data consists of a normal distribution. A Kurtosis of the dataset was tested about normal distribution. Jarque-Bera probability has a small value, suggesting the entire sample has a normal distribution.

Observations from 24 data points collected in Vietnam between 2000 and 2023 are analyzed. The dependent variable, GDP, exhibits a mean of 164.2264 billion US dollars, with the lowest recorded value in 2000 at 31.17 billion US dollars and the highest in 2023 at 435 billion US dollars. The subsequent Figures (2), (3), (4), (5), and (6) present graphical representations of CO2 emissions, migration, population, and FDI inflows in Vietnam over the specified period. Figure 2 presents the gross domestic product- GDP for the period 2000–2023 as follows:

The independent variable representing carbon dioxide emissions in Vietnam denoted as CO2, had an average value of 173.472 million tons. The lowest recorded value was 52.601 million tons in 2000, while the highest was 341.716 million tons in 2019. Figure 3 illustrates the trends in carbon dioxide emissions in Vietnam.

The independent variable representing Vietnam migration, MIG, had an average value of 6.5 million persons. The lowest recorded value was 5.274 million persons in 2000, while the highest was 7.327 million in 2023. Figure 4 depicts the patterns of migration in Vietnam.

The independent variable denoting the population of Vietnam, referred to as POP, exhibited an average value of 89.7 million persons. The lowest recorded value was 79.9 million persons in 2000, while the highest was 99.9 million in 2023. Figure 5 displays the population trends in Vietnam from 2000 to 2023.

The dependent variable representing FDI inflows pertained to foreign direct investment inflows, with an average value of 9.508708 billion US dollars. The lowest recorded value was 1.298 billion US dollars in 2000, while the highest was 23 billion US dollars in 2023. Figure 6 illustrates the trends in foreign direct investment inflows in Vietnam.

4. Results and Discussions

4.1. Results

Table 3a, 3b and 3c presents the outcomes of regression analysis involving carbon dioxide emissions (CO2), migration (MIG), population (POP), foreign direct investment inflows (FDI), and GDP (gross domestic product) in Vietnam from 2000 to 2023. The adjusted R-squared value of 0.9944 indicates that changes in the independent variables can account for 99.44% of the variation in GDP. The association between GDP and carbon dioxide emissions is supported by a P-value of 0.045, confirming hypothesis 1. The elasticity of economic growth to migration is −0.32, suggesting that a 1% reduction in carbon dioxide emissions could lead to a 0.32% increase in GDP. These findings underscore Vietnam's focus on reducing carbon emissions and promoting green energy to enhance GDP.

Similarly, the P-value of 0.001 validates hypothesis 2, with an elasticity of GDP to migration at 2.61, indicating a 2.61% GDP increase for every 1% rise in migration. The positive relationship between population and GDP is affirmed by a P-value of 0.000, supporting hypothesis 3, with an elasticity of GDP to the population at 8.56, implying an 8.56% GDP increase for a 1% population growth. Moreover, the association between foreign direct investment and GDP, backed by a P-value of 0.009, is consistent with hypothesis 4, with an elasticity of GDP to FDI at 0.15, suggesting a 0.15% GDP increase for every 1% rise in FDI.

$$\text{LnGDP} = -191.5963 - 0.32\ \text{LnCO2} + 2.61\ \text{LnMIG} + 8.56\ \text{LnPOP} + 0.15\ \text{LnFDI} \quad (10)$$

Equation (10) delineates the function, revealing that when CO2, MIG, POP, and FDI are all zero, GDP in Vietnam would be −191.5963

Table 2
The variables related to the dependent variables of the regression model.

Variables	Observation	Mean	Standard Deviation	Minimum	Maximum
Year	24	2011	6.7	2000	2023
GDP billion US dollars	24	164.2264	117.5076	31.17252	435
CO2 million tons	24	173.472	97.13852	52.601	341.716
Migration (millions person)	24	6.506570	0.644643	5.274087	7.327657
Country population (millions person)	24	89.7	6.290610	79.9	99.9
FDI inflows billions of US dollars	24	9.508708	6.796817	1.298	23
Variables	LGDP	LCO2	LMIG	LPOP	LFDI
Skewness	-0.1035	-0.2032	-0.0535	-0.0452	-0.2132
Kurtosis	1.9623	1.6215	1.5321	1.6589	1.6537
Jarque-Bera	2.1256	0.5632	1.2356	1.7920	1.8921
Probability	0.3291	0.5623	0.4321	0.3214	0.2981

(Source: compiled by authors)

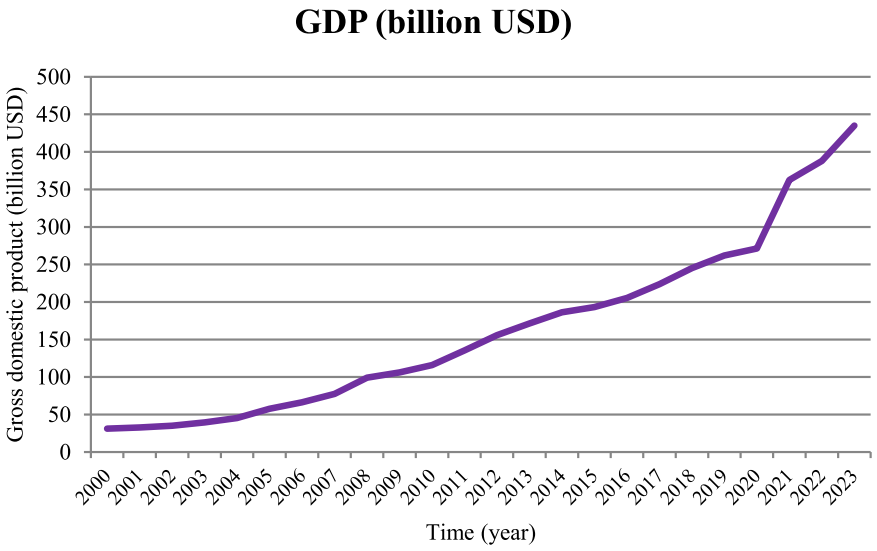

Fig. 2. The gross domestic product in Vietnam from 2000 to 2023.
(Source: Compiled by authors)

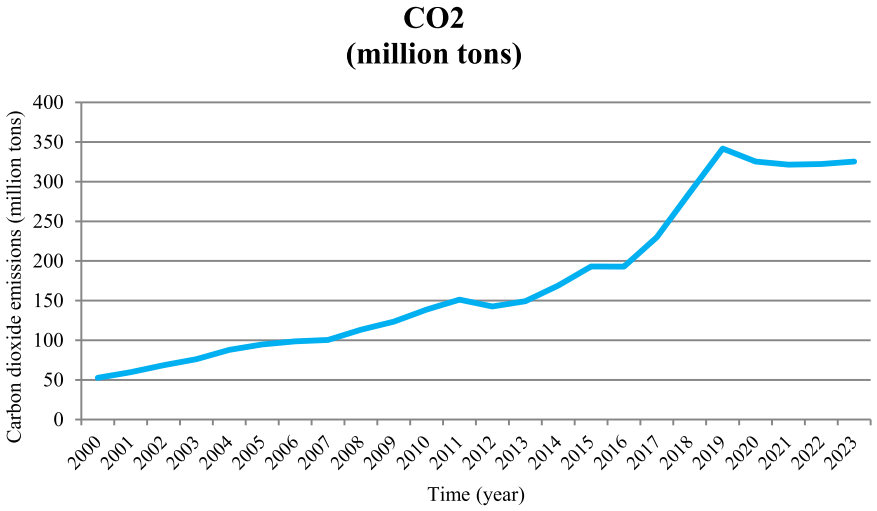

Fig. 3. The carbon dioxide emissions in Vietnam from 2000 to 2023.
(Source: Compiled by authors)

billion US dollars, with respective slopes indicating the impact of each variable on GDP. These results demonstrate the significant effects of carbon emissions reduction, migration, population growth, and FDI on Vietnam's economic growth. Additionally, Table 4 depicts correlation coefficients among the independent variables, indicating minimal correlations and low variance inflation factor (VIF) values, implying no multicollinearity issues. The study ensures the reliability of quantitative analysis results; various diagnostic tests will be conducted, including

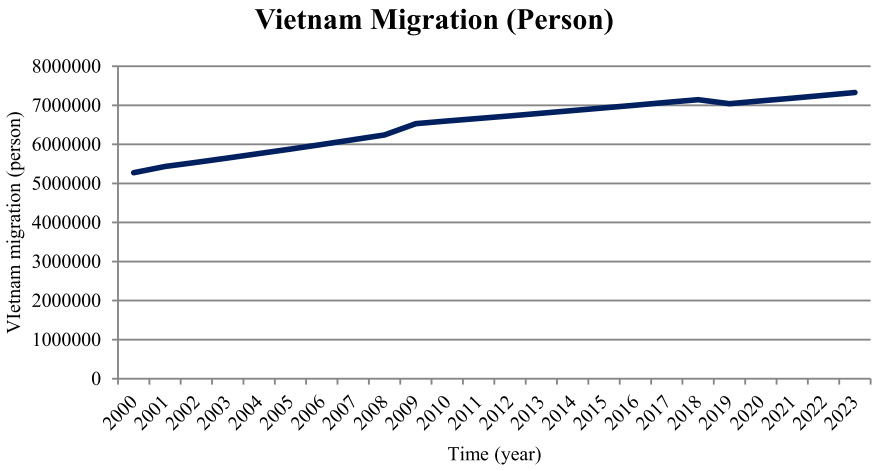

Fig. 4. The migration in Vietnam from 2000 to 2023.
(Source: Compiled by authors)

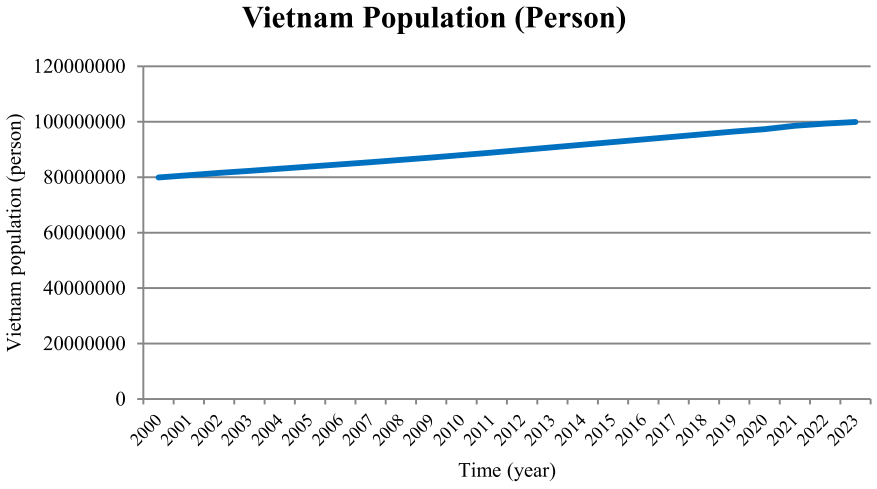

Fig. 5. The people in Vietnam from 2000 to 2022.
(Source: Compiled by authors)

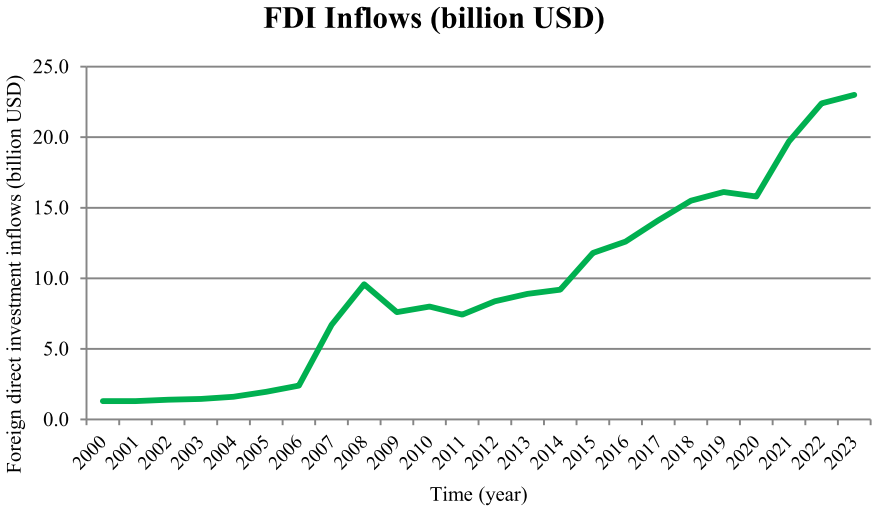

Fig. 6. The FDI inflows in Vietnam from 2000 to 2023.
(Source: Compiled by authors)

Table 3a
Regression analysis model using fixed panel data method of carbon dioxide emissions (CO2), migration (MIG), population (POP), foreign direct investment (FDI), and gross domestic product (GDP) for the period from 2000 to 2023 in Vietnam.

Source				*Number of obs*	= 24	
				Prob > F	= 0.0000	
				R-squared	= 0.9954	
				Adj R-squared	= 0.9944	
Ln GDP	Coef.	Std. Err.	T	P>|t|	[95% Conf. Interval]	
Ln CO2 emissions	-0.3199971*	0.1491253	-2.15	0.045	-0.6321199	-0.0078743
Ln Migration	2.61437***	0.6365634	4.11	0.001	1.282027	3.946713
Ln Vietnam population	8.55981***	1.356904	6.31	0.000	5.719777	11.39984
Ln FDI inflows	0.1506243**	0.052076	2.89	0.009	0.0416279	0.2596207
_Cons	-191.5963***	24.18935	-7.92	0.000	-242.2252	-140.9674

*** represent 1% significance, respectively
(Source: computed by Stata 16.0 software)

Table 3b
Regression analysis model using random panel data method of carbon dioxide emissions (CO2), migration (MIG), population (POP), foreign direct investment (FDI), and gross domestic product (GDP) for the period from 2000–2023 in Vietnam.

Source				*Number of obs*	= 24	
				Prob > F	= 0.0000	
				R-squared	= 0.9854	
				Adj R-squared	= 0.9833	
Ln GDP	Coef.	Std. Err.	T	P>|t|	[95% Conf. Interval]	
Ln CO2 emissions	-0.3279***	0.1958	-6.15	0.000	-0.6993	-0.0847
Ln Migration	2.5936***	0.6653	4.16	0.001	1.2978	3.94673
Ln Vietnam population	8.6579***	1.3692	6.39	0.000	5.7965	11.3841
Ln FDI inflows	0.1612***	0.0593	2.93	0.009	0.1479	0.2627
_Cons	-192.58***	24.893	-7.62	0.000	-240.25	-141.679

*** represent 1% significance, respectively
(Source: computed by Stata 16.0 software)

Table 3c
ARDL long and short-run results.

Variables	Long-run			Short-run		
	Coefficient	t-Statistic	p-value	Coefficient	t-Statistic	p-value
LCO2	-0.3128****	6.281	0.001	-0.289***	6.311	0.002
LMIG	2.8312***	5.719	0.002	2.0915**	-2.783	0.009
LPOP	7.8656***	6.0829	0.001	5.523***	5.9251	0.000
LFDI	0.1915***	5.1235	0.000	0.1132***	7.1330	0.001
_Cons	-11.381***	-3.865	0.001	-9.1225***	-4.125	0.001
ECM (-1)	-	-	-	-0.652***	-6.151	0.000
R^2	0.9832					
Adjust R^2	0.9781					

** represent 5% 1% significance, respectively
*** represent 5% 1% significance, respectively
(Source: computed by Stata 16.0 software)

Table 4
The correlation of the independence variables in the model.

	Carbon dioxide emissions	Migration	Population	FDI inflows
Carbon dioxide emissions	1			
Migration	0.08	1		
Population	0.11	1	1	
FDI inflows	0.18	0.08	0.12	1

(Sources: compiled by author)

tests for heteroscedasticity, multicollinearity, normality of residuals, autocorrelation, outlier detection, endogeneity, model fit, residual analysis, sensitivity analysis, and robustness check using FMOLS estimators as a consistency measure, as presented in Table 5. These rigorous diagnostic procedures aim to validate statistical assumptions, detect potential issues, and enhance the credibility of the study findings.

Table 5
The new findings from diagnostic tests.

Diagnostic tests	Coef.	P-value	Decision
Jarque-Bera test	1.6859	0.5256	Residuals are normal distribution.
Breusch-Godfrey LM test	1.2921	0.3921	No serial correlation exits
Breusch-Pangan-Godfrey test	1.6792	0.2215	No heteroscedasticity exits
Ramsey RESET test	1.2365	0.2258	The model is specified correctly.

Various diagnostic tests will be employed to ensure the robustness, believableness, and reliability of the results obtained from the quantitative analysis. These diagnostic tests assess the validity of statistical assumptions, identify potential issues, and enhance the overall credibility of the findings. The following diagnostic tests will be implemented:

Heteroscedasticity Test- Heteroscedasticity, or the presence of non-constant variance in the error terms, can undermine the reliability of regression results. Diagnostic tests such as the Breusch-Pagan test or the White test will be employed to address this. These tests assess whether the variances of the errors are constant across all levels of the independent variables. Multicollinearity Check- Multicollinearities occur when independent variables in the new regression model are highly correlated, leading to issues in estimating their contributions. Diagnostic tests, including variance inflation factor (VIF) analysis, will be conducted to identify and address multicollinearity concerns. Normality of Residuals- the normality of residuals is a crucial assumption for many statistical tests. Normality tests, such as the Shapiro-Wilk test or visual inspection through histograms and Q-Q plots, will be conducted to ensure that the residuals follow a normal distribution. Autocorrelation Test- autocorrelation, or correlation among residuals, can violate the independence assumption. Diagnostic tests, including the Durbin-Watson test, will be performed to check for autocorrelation in the

residuals. Outlier Detection- outliers can disproportionately influence regression results. Diagnostic tools, such as Cook's distance and leverage statistics, will be used to identify influential data points and outliers. Robust regression techniques may be considered if outliers significantly impact the results. Endogeneity Testing- endogeneity issues arise when an independent variable is correlated with the error term. Instrumental variable (IV) tests or other diagnostic methods will detect and address potential endogeneity concerns.

Model Fit Assessment- diagnostic tests for overall model fit, such as the F-test and goodness-of-fit statistics (e.g., R-squared), will be conducted. These tests assess the adequacy of the model in understanding the variation in the dependent variable in the research. Residual analysis- a thorough analysis of residuals will be performed, including plotting residuals against predicted values and independent variables. Patterns or trends in residuals can indicate model misspecification or omitted variable bias. Sensitivity Analysis- sensitivity analysis involves testing the stability of results under different model specifications or assumptions. This issue helps assess the robustness of findings and the reliability of conclusions. By systematically applying these diagnostic tests, the study aims to identify and address potential problems that could compromise the validity of the quantitative results. The robustness of the obtained findings will be strengthened through a meticulous examination of statistical assumptions and model specifications.

Robustness check: We used the FMOLS estimators to ensure that DOLS estimation was consistent. Table 5 presents the aggregate diagnostic test results. Table 6 presents the models' estimators FMOLS values. The regression model does not have autocorrelation or heterogeneity, and data consists of a normal distribution.

4.2. Discussions

Quantitative Analysis Supported by Qualitative Methods: Case Studies and Expert Interviews. Quantitative analysis- the quantitative arm of this research employs rigorous statistical methods to analyze large datasets encompassing carbon emissions, population dynamics, migration patterns, FDI inflows, and GDP across periods and regions in Vietnam. Regression analyses and econometric modelling will quantify relationships, identify patterns, and draw statistical inferences (Yun et al., 2024).

The study uses qualitative methods. Case studies aim to complement the quantitative findings, and in-depth case studies will be conducted in selected regions or industries within Vietnam. These case studies will offer a qualitative lens to understand contextual nuances, variations, and the impact of specific policies on the carbon-emission nexus. For example, a case study might focus on a region of Hanoi Capital that has experienced significant population growth due to migration, examining how local policies and economic activities have influenced carbon emissions. Another case study, like Bac Ninh province, could delve into the environmental practices of industries attracting FDI to uncover qualitative insights that quantitative analyses might need to capture (Yun et al., 2022).

Expert Interviews will be conducted with key stakeholders, including policymakers, environmental experts, economists, and industry leaders. These interviews will provide qualitative insights into the motivations behind specific policies, the effectiveness of existing strategies, and potential areas for improvement. Experts will be selected based on their remarkable knowledge and experience in fields relevant to the study, ensuring a diverse range of perspectives. The semi-structured interviews will allow flexibility to explore emerging themes and unexpected insights. Integration of Quantitative and Qualitative Findings- Integrating quantitative and qualitative findings will be crucial to the research methodology. The qualitative data will contextualize quantitative results, offering a richer understanding of the underlying dynamics shaping the carbon-emission nexus in Vietnam (Duc et al., 2024).

For instance, if the quantitative analysis reveals a correlation between FDI inflows and increased carbon emissions, qualitative insights from expert interviews and case studies can shed light on the specific FDI practices, policies, or technological innovations contributing to or mitigating environmental impact. Cross-Validation- the qualitative findings will also play a role in cross-validating the quantitative results. Discrepancies or convergences between the two data sets will be thoroughly examined to enhance the robustness and reliability of the overall conclusions. By adopting this mixed-methods approach, the research aims to test and provide a comprehensive and nuanced understanding of the carbon-emission nexus in Vietnam. Integrating quantitative and qualitative methods allows for a holistic analysis that identifies statistical relationships and unveils the contextual factors, policy implications, and real-world dynamics in the intersection of population dynamics, migration, FDI, GDP, and carbon emissions.

The empirical analysis reveals intricate relationships within the nexus of carbon dioxide emissions, population dynamics, migration patterns, foreign direct investment (FDI), and Vietnam's Gross Domestic Product (GDP). Notably, a discernible correlation emerges between FDI inflows and GDP growth, underlining the positive economic impact of foreign investments. However, this relationship is nuanced, with sectoral disparities influencing the extent of spillover effects. Additionally, a concerning association between rapid urbanization and increased carbon emissions is evident, emphasizing the environmental challenges associated with urban development.

Our findings align with research on FDI's role in economic development, echoing the sector-specific nature of its contributions to GDP growth (Duc et al., 2024). However, the study contributes novel insights by contextualizing these relationships within the Vietnamese setting. The observed link between urbanization and carbon emissions corresponds to broader environmental literature, indicating a shared global concern. The interplay between internal migration and regional economic disparities mirrors patterns documented in other emerging economies. The study's outcomes carry significant policy implications for Vietnam. Policymakers must consider the need for targeted interventions to decrease the environmental impact of rapid urbanization. Strategies promoting sustainable urban development, renewable energy adoption, and green technologies foster a favourable environment for sector-specific FDI, particularly in sustainable industries, which can enhance economic growth while minimizing environmental harm (Duc et al., 2024).

Previous literature on Vietnam has examined various aspects of its socioeconomic development, including the impacts of environmental factors, population trends, migration patterns, FDI inflows, and GDP growth. Some of the main points from Vietnam's literature include-Environmental Degradation and Economic Development. Studies have highlighted the challenges posed by environmental degradation in Vietnam, including air and water pollution, deforestation, and biodiversity loss (H. T. Nguyen et al., 2022). Rapid industrialization, urbanization, and agricultural expansion have contributed to these environmental pressures, affecting human health, natural ecosystems, and overall quality of life. However, limited research explicitly addresses the relationship between environmental factors and GDP growth in Vietnam.

Population Trends and Migration Patterns- Vietnam's population dynamics have undergone significant changes in recent decades,

Table 6
The results of FMOLS-dependent value LnGDP.

Variables	Coef.	Std. Err.	t-Statistic	P-value
Ln CO2 emissions	-0.3369***	0.1832	-6.65	0.000
Ln Migration	2.5261****	0.6532	3.98	0.001
Ln Vietnam population	8.5679***	1.6922	6.23	0.000
Ln FDI inflows	0.1528***	0.0932	2.82	0.008
_Cons	-19.138***	2.58391	-8.61	0.000
R-squared	0.9863			
Adj R-squared	0.9925			

*** represent 1% significance, respectively

including shifts in fertility rates, mortality rates, and internal migration patterns (Bui et al., 2023b). Internal migration from rural to urban areas has been a critical driver of demographic change and economic transformation, contributing to urbanization, labour market dynamics, and social integration challenges (Bui Minh and Bui Van, 2023). However, the literature on migration and population trends in Vietnam tends to focus more on descriptive analysis rather than examining their implications for economic development.

Foreign Direct Investment (FDI) and Economic Growth- FDI has played a crucial role in driving economic growth and structural transformation in Vietnam, particularly since the introduction of economic reforms in the late 1980 s (Bui et al., 2023b). The country has attracted significant inflows of FDI, particularly in export-oriented manufacturing, infrastructure development, and services sectors. However, there is ongoing debate regarding how much FDI contributes to sustainable development and whether it leads to environmental degradation or promotes technological innovation and efficiency improvements.

GDP Growth and Sustainable Development- Vietnam has experienced rapid GDP growth in recent decades, becoming one of the fastest-growing economies in Southeast Asia (World Bank, 2020). However, questions remain about the sustainability of this growth model, particularly in terms of its environmental and social impacts. While GDP growth is often used to measure economic progress, there is growing recognition of the need to consider broader well-being indicators, including environmental quality, social equity, and resilience to external shocks. In summary, previous literature on Vietnam has provided valuable insights into the complex interplay among environmental, economic, demographic, and institutional factors shaping the country's development trajectory. However, there remains a need for a comprehensive analysis that integrates these factors and examines their implications for sustainable development in Vietnam. By addressing this gap, our study aims to contribute to the theoretical understanding of how environmental, economic, and demographic factors interact within the unique context of Vietnam and inform evidence-based policymaking for sustainable development.

The holistic perspective offered by this study emphasizes the interconnected nature of the studied factors. Policies addressing one aspect of the nexus inevitably influence others. Consequently, an integrated and cross-disciplinary approach is essential for sustainable development. For instance, initiatives promoting environmentally friendly technologies and practices can simultaneously enhance economic growth, mitigate carbon emissions, and foster social inclusivity. This study contributes to theoretical frameworks by integrating environmental, economic, and demographic perspectives. It underscores the necessity of considering multiple variables concurrently, providing a more accurate depiction of the complex dynamics at play. By doing so, the study advances the theoretical understanding of how these factors interact within the unique context of Vietnam.

While this study provides valuable insights, avenues for future research persist. A deeper exploration into the causal mechanisms behind observed relationships, especially the nuanced impacts of FDI in specific sectors, is warranted. Longitudinal studies tracking the evolution of these relationships over time can enhance predictive capacities. Additionally, investigations into the effectiveness of policy interventions to balance economic growth and environmental sustainability will contribute to practical, evidence-based policymaking. In the discussion section of the research paper, the thorough comparison of the obtained results with those of other relevant studies will be crucial for contextualizing findings, identifying consistencies or disparities, and contributing to the general understanding of the subject. The discussion will involve the following key elements:

Comparative Analysis of Key Findings- a systematic comparison of the current research's results with other studies on similar subjects will be presented. This issue examines how the relationships between carbon emissions, population dynamics, migration, FDI, and GDP align or diverge with existing research. Validation of Consistent Patterns- if the results of the current study align with those of other studies, particularly in terms of consistent patterns or trends, this issue will be highlighted. This validation lends credibility to the findings' robustness and reinforces the conclusions' generalizability.

Identification of Variances or Deviations- any variances or deviations between the current study's results and those of other studies will be carefully examined. This issue includes exploring potential reasons for discrepancies and offering insights into contextual factors that may contribute to varying outcomes. Consideration of Methodological Differences- methodological disparities among studies, such as variations in data sources, analytical techniques, or regional focus, will be acknowledged and discussed. An awareness of these differences is essential for interpreting discrepancies and understanding the scope and limitations of each study.

Analysis and discussion of open innovation dynamics involve exploring the various dimensions, mechanisms, and implications of open innovation processes within organizations and across networks. We delve into key aspects of open innovation dynamics- Exploration vs. Exploitation- Open innovation involves balancing exploration (seeking new external ideas and technologies) and exploitation (leveraging existing internal resources and capabilities). Organizations must navigate this tension effectively to maximize innovation outcomes. Research suggests that successful open innovation strategies require a delicate equilibrium between exploring new opportunities and exploiting existing knowledge (Simba et al., 2024; Yun et al., 2022, 2024).

Collaborative Networks and Ecosystems: Open innovation thrives on collaborative networks and ecosystems where firms, research institutions, startups, and other stakeholders exchange knowledge, resources, and expertise. These ecosystems provide fertile ground for cross-pollination of ideas, fostering innovation through diverse perspectives and complementary capabilities. Technology Platforms and Digital Transformation- Digital platforms and technologies have revolutionized open innovation dynamics. Platforms facilitate efficient collaboration, crowdsourcing, and co-creation, enabling organizations to tap into a global talent pool and ideas. Digital transformation accelerates innovation by streamlining communication, reducing transaction costs, and democratizing access to knowledge (Pittz and Adler, 2023; Principato et al., 2023; Scaliza et al., 2022).

Intellectual Property (IP) Management- Effective intellectual property management is critical in open innovation ecosystems. Organizations must navigate complex IP landscapes while sharing knowledge with external partners to protect their innovations. Strategies such as patent pooling, open-source licensing, and collaborative IP agreements can facilitate IP management in open innovation contexts. Organizational Culture and Leadership: Open innovation requires a culture of openness, trust, and collaboration. Leaders play a pivotal role in fostering such a culture by encouraging risk-taking, rewarding experimentation, and championing cross-functional collaboration. Organizational structures and incentives should align with the goals of open innovation to facilitate knowledge sharing and cooperation (Obschonka et al., 2023; Ortiz-Villajos, 2024).

Risk and Reward Sharing: Open innovation involves sharing risks and rewards with external partners. Collaborative ventures, joint R&D projects, and licensing agreements entail mutual investments and benefits. Effective risk-sharing mechanisms, such as revenue-sharing arrangements and equity stakes, can incentivize collaboration and align stakeholder interests. Globalization and Open Innovation- Globalization has facilitated the proliferation of open innovation practices across borders. Multinational corporations leverage global talent pools, market insights, and innovation hubs to drive open innovation initiatives. Cross-border collaborations, international R&D partnerships, and technology scouting activities are vital strategies for harnessing global open innovation opportunities (Miremadi et al., 2023).

Performance Measurement and Evaluation- Assessing the impact of open innovation on firm performance poses challenges due to its

complex and multifaceted nature. Traditional metrics may not capture the total value generated through open innovation activities. Organizations must develop comprehensive evaluation frameworks for qualitative aspects such as knowledge spillovers, learning outcomes, and ecosystem contributions (Ehn et al., 2021; Yun et al., 2022, 2024).

In conclusion, open innovation dynamics encompass a broad spectrum of interconnected factors shaping how organizations collaborate, innovate, and create value in today's interconnected world. By effectively understanding and harnessing these dynamics, organizations can capitalize on the opportunities presented by open innovation while mitigating potential risks and challenges.

Implications for Policy and Practice- the discussion will extend beyond numerical comparisons and delve into the practical implications of the findings. Drawing on the current study and existing research, the panel will offer insights into potential policy recommendations and practical applications for addressing environmental challenges and fostering sustainable development. Integration of Qualitative Insights- qualitative insights from case studies and expert interviews will be integrated into the discussion. Comparative analyses will explore how qualitative findings align or diverge with quantitative results, providing a holistic understanding of the carbon-emission nexus.

Future Research Directions- the discussion will conclude by identifying avenues for future research based on the current study's outcomes and comparative analyses. This issue includes proposing areas where further investigation is needed to deepen understanding and address any remaining gaps in the literature. By rigorously comparing the current study's results with those of other studies, the discussion section will contribute to the scholarly discourse, refine existing knowledge, and provide a foundation for evidence-based decision-making and policy development. In conclusion, the discussion elucidates the nuanced relationships uncovered in this study and underscores their Relevance to Vietnam's sustainable development. By offering a comprehensive understanding of these interconnections, this paper provides a foundation for informed decision-making. It lays the groundwork for further explorations into the complexities of economic, environmental, and demographic dynamics in emerging economies.

5. Conclusion

Summary of the Problematic- this study delved into the intricate nexus among carbon emissions, population dynamics, migration patterns, FDI, and GDP in the context of Vietnam. Recognizing the increasing challenges posed by environmental sustainability and economic development, the research aimed to provide a holistic understanding of the interplay between these factors. The problem centred on uncovering the nuanced relationships and dynamics shaping Vietnam's environmental and economic landscape, with a specific focus on carbon emissions. Methods Used- our research employed a mixed-methods approach, integrating quantitative analyses with qualitative methods. The quantitative arm involved rigorous statistical analyses, including regression and econometric modelling, using extensive datasets encompassing carbon emissions, population dynamics, migration patterns, FDI inflows, and GDP across various periods and regions in Vietnam. The paper complements these quantitative methods; qualitative insights were derived from in-depth case studies and expert interviews, offering a contextualized understanding of the complexities inherent in the carbon-emission nexus.

Main Obtained Findings- quantitative Insights- the quantitative analyses revealed intricate relationships between carbon emissions, population growth, migration patterns, FDI, and GDP. Findings indicated both challenges and opportunities, with certain variables exhibiting significant correlations. For instance, the impact of FDI on carbon emissions varied across sectors, highlighting the need for targeted environmental policies.

Qualitative Insights- case studies and expert interviews enriched the understanding of the contextual factors influencing the carbon-emission nexus. Qualitative findings provided depth to statistical trends, uncovering specific industry practices, policy motivations, and societal dynamics that shape environmental outcomes. Integration of Findings- Integrating quantitative and qualitative empirical findings yielded a comprehensive understanding of how demographic changes, economic activities, and global mobility collectively influence carbon emissions in Vietnam. The results contribute to the academic discourse on sustainable development and offer practical insights for policymakers and practitioners.

Implications and Future Directions- the obtained findings significantly impact policy and practice. Recommendations include targeted policies for sustainable FDI, urban planning strategies to manage population growth and migration patterns, and a focus on inclusive, green economic development. Future research directions involve longitudinal analyses, comparative studies across diverse regions, and continued exploration of innovative policies for addressing the dynamic challenges of the carbon-emission nexus. In conclusion, this research advances our understanding of the complex interactions between carbon emissions, population dynamics, migration, FDI, and GDP in Vietnam. By bridging quantitative and qualitative approaches, the study provides a nuanced perspective that contributes to academic knowledge and practical decision-making. This study has navigated the intricate nexus of carbon dioxide emissions, population dynamics, migration patterns, FDI- foreign direct investment inflows, and GDP- Gross Domestic Product in Vietnam, offering a nuanced understanding of their interrelationships. The empirical findings underscore the complexity of these dynamics and provide valuable insights for policymakers, scholars, and stakeholders invested in Vietnam's sustainable development.

The study reveals significant correlations between FDI inflows and GDP growth, highlighting the pivotal role of foreign investments in shaping Vietnam's economic landscape. Simultaneously, the observed association between rapid urbanization and increased carbon emissions underscores the environmental challenges arising from urban development. Internal migration patterns contribute to regional economic disparities, emphasizing the need for targeted policies considering the socioeconomic impacts of population movements. To have the challenges and harness the opportunities uncovered in this study, policymakers in Vietnam should adopt an integrated approach. Sustainable urban development policies, coupled with incentives for environmentally friendly technologies, can mitigate the environmental impact of economic growth. Sector-specific strategies to attract FDI, particularly in industries aligned with sustainability goals, can contribute to economic development and environmental conservation. Policies addressing demographic shifts should be sensitive to regional variations, fostering inclusive and equitable development.

This research contributes to the academic discourse by bridging gaps in the literature reviews and providing a holistic perspective on the interconnected factors influencing Vietnam's developmental trajectory. The study advances theoretical frameworks by integrating environmental, economic, and demographic dimensions, offering a comprehensive understanding of their interplay. While this study provides valuable insights without limitations, data constraints and complex relationships pose challenges. Future research could delve deeper into causal mechanisms, conduct longitudinal analyses, and assess the effectiveness of policy interventions. This study serves as a stepping-stone for further explorations into the intricate web of relationships shaping Vietnam's development. By understanding and addressing the multifaceted challenges and opportunities presented by carbon emissions, population dynamics, migration, FDI, and GDP, Vietnam can pave the way for a sustainable and resilient future. The findings of this research contribute not only to the academic understanding of these complex interactions but also offer practical guidance for policymakers navigating the delicate balance between economic growth or gross domestic product and environmental stewardship in emerging economies.

6. Policy Implications

Policy Recommendation- Implement sustainable urban development policies that prioritize eco-friendly infrastructure, renewable energy adoption, and efficient waste management. Rationale- address the observed link between rapid urbanization and increased carbon emissions, ensuring that urban growth aligns with environmental sustainability goals. Policy Recommendation- develop sector-specific strategies to attract FDI, focusing on industries aligned with sustainability objectives, such as renewable energy, clean technology, and environmentally friendly manufacturing. Rationale- leverage FDI as a catalyst for economic growth while mitigating environmental impacts, fostering a green and resilient economy.

Inclusive Migration Policies- Policy Recommendation- formulates migration policies that consider the socioeconomic impacts of internal movements, ensuring inclusivity and addressing regional economic disparities. Rationale- acknowledges the role of internal migration in shaping regional development and fostering policies that promote equitable distribution of resources and opportunities. Green Technologies and Innovation- Policy Recommendation- encourages research and development in green technologies, incentivizing businesses and institutions to adopt environmentally friendly practices and innovations. Rationale- foster a culture of innovation that contributes to economic development and environmental conservation, positioning Vietnam as a leader in sustainable technologies.

Community Engagement and Awareness- Policy Recommendation- implement outreach programs to raise environmental awareness and engage local communities in sustainable practices. Rationale- enhances community understanding of the environmental consequences of urbanization and migration, fostering a collective commitment to sustainable development. Integrated Policy Framework- Policy Recommendation- this paper adopts an integrated policy framework that considers the interconnected nature of carbon emissions, population dynamics, migration, FDI, and GDP. Rationale- recognize that policies addressing one aspect of the nexus can have cascading effects on others; therefore, an integrated approach is essential for achieving balanced and sustainable development. Monitoring and Evaluation Mechanisms- Policy Recommendation- establish robust monitoring and testing mechanisms to track the effectiveness of implemented policies over time. Rationale- regular assessments will allow policymakers to adapt strategies based on evolving socioeconomic and environmental conditions, ensuring continuous progress towards sustainability goals.

Collaboration with International Partners- Policy Recommendation- foster collaboration with international partners to exchange best practices, access expertise, and attract responsible foreign investments. Rationale- taps into global knowledge networks and resources, enhancing Vietnam's capacity to implement effective and context-specific policies for sustainable development. By implementing these policy recommendations, Vietnam can navigate the challenges posed by the nexus of carbon emissions, population dynamics, migration, FDI, and GDP, fostering a balanced and sustainable path for economic growth and environmental conservation.

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The authors declare no conflict of interest.

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