Fecha de recepción: 26 de septiembre de 2024
Fecha de aceptación: 24 de junio de 2025
Disponible en línea: 31 de julio de 2025

Vol. 12 N.º 2
Julio - Diciembre del 2025
pp. 1- 44

HISTORIA ECONÓMICA, EMPRESARIAL Y DEL PENSAMIENTO
TIEMPO & ECONOMÍA

Sugerencia de citación: Yangailo , T. (2025). Interconnected Dynamics: The Role of ICT, Air Transport, Freshwater Resources, and Migration in Regional Economic Growth Across Central Europe and the Baltics, Europe and Central Asia, Latin America and the Caribbean, the Middle East and North Africa, South Asia, and Sub-Saharan Africa. *tiempo&economia, 12*(2), 1-44. https://doi.org/10.21789/24222704.2124

DOI:
https://doi.org/10.21789/24222704.2124

Interconnected Dynamics: The Role of ICT, Air Transport, Freshwater Resources, and Migration in Regional Economic Growth Across Central Europe and the Baltics, Europe and Central Asia, Latin America and the Caribbean, the Middle East and North Africa, South Asia, and Sub-Saharan Africa

Dinámicas interconectadas: El papel de las TIC, el transporte aéreo, los recursos hídricos y la migración en el crecimiento económico regional en Europa central y el Báltico, Europa y Asia central, América Latina y el Caribe, Oriente Medio y el Norte

de África, Asia meridional y África subsahariana

Tryson Yangailo
Independent Researcher,Zambia
https://orcid.org/0000-0002-0690-9747
ytryson@yahoo.com

ABSTRACT

This study examines the complex relationships among information and communication technology (ICT), air transport, freshwater resources, economic growth, and migration patterns in different regions of the world from 2000 to 2022. Drawing on data from the World Bank, the study employs Jamovi software for descriptive statistics, correlation analysis, and regression, complemented by ANOVA techniques to assess the significance of the differences across regions. Regions such as East Asia and the Pacific show robust economic benefits from high levels of ICT adoption and extensive air connectivity, which are positively correlated with GDP growth and trade in services. In contrast, regions such as Sub-Saharan Africa and South Asia exhibit significantly lower levels of ICT adoption and air transport efficiency, contributing to the challenges in their economies and to their increasing out-migration rates. The study also reveals that increased Internet use is driving economic growth, while access to freshwater resources has emerged as a critical determinant of both economic health and migration strategies. Notably, the study finds that areas with better freshwater management policies are better positioned to mitigate migration pressures caused by economic instability. The implications of these findings underscore the need for policymakers to adopt a holistic approach that integrates ICT development, transportation infrastructure improvements, and sustainable water management to stimulate economic growth and mitigate migration pressures. Recommendations to policymakers include targeted investments in ICT

and transport systems, as well as policies aimed at improving local economic opportunities. In addition, future research should explore the qualitative factors influencing these relationships and expand the geographic scope to better understand the dynamics at play. This study contributes to the existing literature on the subject by elucidating the interconnectedness of these critical factors and providing insights for effective regional development strategies.

Keywords: Information and communication technology (ICT); Economic growth; Air transport; Migration patterns; Freshwater resources; Economic history.

JEL Codes: O33; F22; L93; Q25; O18.

RESUMEN

Este estudio examina las complejas relaciones entre las tecnologías de la información y la comunicación (TIC), el transporte aéreo, los recursos hídricos, el crecimiento económico y los patrones migratorios en diferentes regiones del mundo entre 2000 y 2022. Basándose en datos del Banco Mundial, el estudio emplea el software Jamovi para la estadística descriptiva, el análisis de correlación y la regresión, complementados con técnicas de ANOVA para evaluar la importancia de las diferencias entre regiones. Regiones como Asia Oriental y el Pacífico muestran sólidos beneficios económicos gracias a la alta adopción de las TIC y a una amplia conectividad aérea, áreas que se correlacionan positivamente con el crecimiento del PIB y el comercio de servicios. En contraste, regiones como África Subsahariana y Asia Meridional presentan niveles significativamente menores de adopción de las TIC y de eficiencia del transporte aéreo, lo cual contribuye a los continuos desafíos en sus economías y al aumento de las tasas de emigración. El estudio también revela que un mayor uso de internet impulsa el crecimiento económico, mientras que el acceso a los recursos hídricos se ha convertido en un factor determinante tanto del bienestar económico como de las estrategias migratorias. Cabe destacar que el estudio concluye que las zonas con mejores políticas de gestión de los recursos hídricos están mejor posicionadas para mitigar las presiones migratorias causadas por la inestabilidad económica. Las implicaciones de

estos hallazgos subrayan la necesidad de que los responsables políticos adopten un enfoque holístico que integre el desarrollo de las TIC, las mejoras en la infraestructura de transporte y la gestión sostenible del agua para estimular el crecimiento económico y mitigar las presiones migratorias. Las recomendaciones a los responsables políticos incluyen inversiones específicas en TIC y sistemas de transporte, así como políticas orientadas a mejorar las oportunidades económicas locales. Además, las investigaciones futuras deberían explorar los factores cualitativos que influyen en estas relaciones y ampliar el alcance geográfico para tener una mejor comprensión de las dinámicas en juego. Este estudio contribuye a la literatura existente sobre el tema al dilucidar la interconexión de estos factores críticos y proporcionar perspectivas para estrategias eficaces de desarrollo regional.

Palabras clave: Tecnologías de la información y la comunicación (TIC), Crecimiento económico; Transporte aéreo; Patrones migratorios; Recursos hídricos; historia económica.

Códigos JEL: O33; F22; L93; Q25; O18.

Introduction

The rapid advancement of information and communications technology (ICT) has revolutionized today's economies and has emerged as a critical catalyst for creativity, efficiency, and global connectivity. Understanding the complex interactions between ICT, air travel, freshwater resources, GDP development, and migration is critical as countries increasingly incorporate ICT into their economic frameworks. A growing body of research, as noted by Fernández-Portillo et al. (2020), emphasizes the diverse consequences of ICT in different economic situations, underscoring the importance of these interactions. The impact of ICT on economic performance is not uniform and tends to vary depending on the economic level of a country. As numerous scholars have argued, the economic context plays a significant role (Nchake & Shuaibu, 2022; Awad & Albaity, 2022).

Recent studies have underscored the pivotal role of air connectivity in fostering economic growth, cultural exchange, and global integration (Yarde & Zhang, 2024). Within this ever-changing landscape, air travel is now recognized as a critical element of economic growth, promoting tourism and trade while fostering regional integration (Duval, 2013; Zhang & Graham, 2020; Balsalobre-Lorente et al., 2021). At the same time, maintaining agricultural production and economic health depends on the availability and management of freshwater resources, especially in the face of climate change and increasing water scarcity (Rock, 1998; Kundzewicz, 2007). Furthermore, a wide range of economic, social, and political factors influence migration patterns, making them essential to understanding the dynamics of regional development (Akanbi, 2017; Podra et al., 2020).

Given this context, this study examines how ICT, air transport, freshwater management, and migration collectively shape economic growth by integrating these dimensions. By addressing gaps in existing literature—particularly the lack of integrated analyses—this research provides a comprehensive framework for understanding regional disparities and policy implications.

Research Objectives

1. To examine the relationship between ICT adoption and economic growth.
2. To assess the impact of freshwater resource management on regional economic growth, with a focus on disparities between water-rich and water-scarce regions.
3. To analyze migration patterns in relation to economic conditions, ICT engagement, and transport infrastructure.
4. To offer recommendations for policymakers based on the integrated analysis of ICT, air transport, freshwater resources, and migration.

Significance of the Study

This study is significant because it bridges gaps between previously siloed analyses of ICT, air transport, freshwater resources, and migration. While earlier research has explored the socio-economic impacts of transport infrastructure (Raicu et al., 2021) and the impact of climate change and energy transitions on migration (Łukaniszyn-Domaszewska et al., 2025), this study synthesizes these dimensions into a unified analytical framework.

It is important as it provides a thorough examination of how freshwater resources, migration patterns, air travel, ICT, and other related factors influence regional economic development. Although these determinants have been studied separately in previous research, their combined effects on regional disparities and economic growth have received comparatively little attention. By examining the relationship between ICT adoption and air transport infrastructure, this study offers valuable insights into how transport connectivity and technological innovation interact to shape migration patterns and economic performance in different geographic areas.

The study also explores the sometimes-overlooked link between freshwater resources and economic growth, examining how natural resource management can either hinder or promote regional prosperity. The findings contribute to the current discourse on how sustainable development plans can be designed to alleviate the burden of migration and improve the stability of local economies. In addition, this research provides policymakers with useful insights to help create targeted initiatives that address the unique needs of different regions, especially in developing countries with inadequate ICT and transportation infrastructure.

Finally, by integrating technological, infrastructural, and environmental factors into a single framework, this study contributes to our understanding of the complex drivers of regional development and

provides a more nuanced view of how these elements interact to shape migration and economic growth.

Literature Review

The Role of ICT in Economic Development

A substantial body of research underscores the importance of ICT in promoting economic development. Studies consistently demonstrate that ICT adoption and economic growth are positively correlated, highlighting the importance of ICT infrastructure and human capital development (Fernández-Portillo et al., 2020; Keček et al., 2019). For instance, Nath & Liu (2017) show that the growth of international trade in services—particularly in the financial, transportation, and insurance sectors—is strongly influenced by ICT development. Similarly, Luong & Nguyen (2021) highlight the transformative potential of ICT in different economies, noting that elements such as broadband access and mobile subscriptions are key drivers of trade in services. Recent work by Pradhan et al. (2021) further illustrates how ICT infrastructure, when integrated with urbanization and transport systems, can enhance overall economic performance. While ICT boosts economic growth in high- and low-income countries, Appiah-Otoo & Song (2021) find that low-income countries tend to benefit more significantly from the ICT revolution. In the context of Central Asia, Shodiev et al. (2021) argue that ICT adoption and infrastructure investment is essential for regional development.

Air Transport and Economic Growth

The link between economic growth and air transport has received considerable attention in the literature. Yarde & Zhang (2024) introduce innovative metrics—such as passenger flow directionality and geographical localization—to evaluate the socioeconomic impacts of air connectivity. Scholars have demonstrated that improved air connectivity promotes investment, trade, and tourism, which in turn enhance regional development and integration (Duval, 2013; Balsalobre-Lorente et al., 2021;

Zhang & Graham, 2020). According to Baltaci et al. (2015), there is a positive correlation between the number of operational airports and the frequency of their traffic, which means that an efficient air transport infrastructure is also essential for regional economic growth. In addition, Zhang & Graham (2020) find that economic development affects the causal relationship between air travel and economic performance, with less developed economies having a stronger mutual influence. Furthermore, Yao & Yang (2012) note that the expansion of air travel is inversely correlated to ground transportation—particularly high-speed rail—but positively associated with economic growth and industrial structure. Similarly, Nguyen (2024) emphasizes the importance of the resilience of air transport in promoting economic growth through tourism.

Freshwater Resources and Economic Health

Freshwater resources are essential to both human well-being and economic growth. Research suggests that water scarcity, agricultural production, and overall economic health are critically linked (Rock, 1998; Kundzewicz, 2007; Wilson & Carpenter, 1999). Nechifor-Vostinaru (2018) uses a global computable general equilibrium model to examine how demand-driven water deficits affect economic development and reveals that water allocation strategies affect the trade-off between GDP and food security. His findings emphasize that using sustainable water management techniques that consider the needs of agriculture and the economy is essential. Rani (2025) underscores the importance of the land-water connection in South Asia, where rapid urbanization and climate change are putting additional strain on resources. According to Kundzewicz (2007), addressing water scarcity by reducing demand, increasing efficiency, and building resilience to floods and droughts is key to achieve sustainable development.

Migration Dynamics and Economic Implications

Understanding migration patterns and their connection to regional development is fundamental as they are shaped by the complex interactions of political, social, and economic forces. Studies such as Akanbi (2017) and Podra et al. (2020) show that migration can have both positive and negative effects on economic growth and human development. Their findings emphasize on the urgency of governments developing policies

that address the issues raised by migration. According to Łukaniszyn-Domaszewska et al. (2025), climate-induced migration interacts with energy transitions and socio-economic disparities, forcing decision-makers to produce integrated policy responses. Arora (2014) demonstrates the dual nature of the impact of migration on economies, revealing that, in addition to negative effects, skilled migration can increase productivity and contribute to GDP growth in host countries. Furthermore, Rayevnyeva et al. (2023) examine the relationship between GDP and migration, highlighting the reciprocal effects and their implications for forecasting.

Interconnectedness of ICT, Air Transport, Freshwater Resources, and Migration

Although these issues have mostly been considered separately in previous studies, there is a growing awareness of how interconnected they are. For example, Raihan et al. (2022) show how economic growth, urbanization, and energy use have an impact on CO_2 emissions. They also demonstrate the parallel dynamics between transportation, information and communication technology (ICT), and environmental sustainability. The relationship between ICTs, air transport, freshwater resources, economic growth and migration calls for an integrated approach to policy formulation. Air transport promotes economic growth through trade and tourism, which in turn can influence migration patterns. Similarly, ICTs can influence migration by facilitating policymakers the acquisition of information about economic prospects (Adedoyin et al., 2020; Onifade et al., 2022). In addition, the management of freshwater resources has a major impact on migration decisions, as it is crucial for economic activity. Research by Adedoyin et al. (2020) highlights the importance of air transport in supporting tourism-driven economic expansion and thus influencing migration dynamics.

Addressing Gaps in the Literature

Despite the significant amount of research on these topics, the available literature tends to examine ICT, air travel, freshwater resources, and migration dynamics in isolation, ignoring the complex relationships that exist among them. The contribution of adopting ICT to foster economic growth has been extensively studied (Fernández-Portillo et al., 2020; Nath & Liu, 2017). However, little is known about how ICT adoption

has an impact on other important drivers of development, such as natural resource management and air transport infrastructure, especially in different regional contexts. Research such as Appiah-Otoo & Song (2021) recognize the economic benefits of ICT in developing countries but do not explore the possibility that ICT could reduce migratory pressures by stabilizing local economies.

Similarly, research has shown how important air travel is for regional economic development through increased connectivity and trade (Duval, 2013; Baltaci et al., 2015). However, little is known about the relationship between air travel and trade in ICT goods, as well as the impact of improved transport infrastructure on migration patterns. Most studies tend to focus on either migration or economic growth separately (Akanbi, 2017; Podra et al., 2020), providing little information on how ICT and transportation together affect regional differences in migration patterns and economic performance.

Furthermore, although freshwater resources are considered essential for economic growth (Kundzewicz, 2007; Nechifor-Vostinaru, 2018), there is a lack of studies examining the negative relationship between GDP growth and freshwater availability. This neglect raises concerns about possible inefficiencies in resource management and on how they may exacerbate economic problems in the region, especially when combined with inadequate ICT infrastructure and air transport networks.

By using an integrated methodology to examine the links between ICT, air travel, freshwater resources, and migration patterns, this study aims to fill these gaps. It deepens our understanding of the relationship between ICT adoption and migration, especially in areas with low ICT implementation, by examining the correlations between ICT adoption and both economic growth and migration trends. The study also examines the relationship between air travel and ICT goods trade, providing information on how an enhanced transit infrastructure can foster both domestic and international trade, thereby influencing migration patterns and regional economic development.

Overall, by providing a comprehensive examination of the regional dynamics among ICT, transportation, economic growth, and migration, this study fills a significant gap, offering new insights into how these variables interact to influence development outcomes in different regions.

Methodology

This study employs a quantitative research design to examine the connections between freshwater resources, air travel, information and communication technology (ICT), economic growth, and migration patterns across seven key regions: Central Europe and the Baltic States, East Asia and the Pacific, Europe and Central Asia, Latin America and the Caribbean, the Middle East and North Africa, South Asia, and Sub-Saharan Africa. World Bank data statistics are the source of the data used in the analysis, which covers the years from 2000 to 2022. This broad geographic coverage enables reliable comparisons among different economic environments and development issues.

This study's variable analysis encompasses a wide range of indicators that are essential for understanding regional dynamics. These include the percentage of people using the Internet compared to the total population, exports of ICT goods as a percentage of all goods exported, and imports of ICT goods as a percentage of all goods imported. Air transport metrics are also analyzed, including the number of people transported, the amount of freight transported (measured in million tonne-kilometers), and the number of registered airline departures worldwide. Along these factors, the study examines net migration statistics, annual GDP growth percentage, ICT services exports as a percentage of services exports (balance of payments), renewable inland freshwater resources per capita (in cubic meters), and total renewable inland freshwater resources (in billion cubic meters).

The study employes the user-friendly statistical analysis interface of the Jamovi software for data analysis. A variety of statistical methods are applied to assess the relationships between variables. While correlation analyses show the direction and intensity of correlations between the

important variables, descriptive statistics provide an overview of the data. Linear regression models are used to assess the impact of ICT, air travel and freshwater resources on migration trends and economic growth. In addition, an analysis of variance (ANOVA) is employed to compare means across areas, highlighting variations in ICT participation, air travel, and economic performance.

The ANOVA is particularly helpful in determining whether there are statistically significant differences between the means of the variables across the selected regions. This method adds important insights to the overall analysis by providing a deeper understanding of how regional differences manifest in terms of ICT adoption, transport capacity, and economic impact.

Through the application of these methodological techniques, the study seeks to clarify the intricate relationships among the variables found, providing a thorough understanding of the factors that influence migration patterns and regional development.

Results

Descriptive Statistics and Regional Overview of ICT, Air Transport, Freshwater Resources, Economic Growth, and Migration Trends

Table 1 presents the descriptive statistics for several indicators related to renewable freshwater resources, air travel, ICT goods and services, GDP growth, and net migration across six regions. The analysis reveals notable disparities in technology, transportation, and economic performance, offering an overview of the current conditions in each region.

Table 1. Descriptive Statistics of ICT, Air Transport, Freshwater Resources, Economic Growth, and Migration Trends

	Region	ICT goods exports (% of total goods exports)	ICT goods imports (% total goods imports)	Individuals using the Internet (% of population)	Air transport, passengers carried	Air transport, freight (million tonne-km)	Air transport, registered carrier departures worldwide	Renewable internal freshwater resources per capita (cubic meters)	Renewable internal freshwater resources, total (billion cubic meters)	ICT service exports (% of service exports, BoP)	GDP growth (annual %)	Net migration
Mean	Central Europe and the Baltics	9.70	10.5	54.0	2.92e+7	170	361970	2182	228	8.48	3.34	135695
	East Asia & Pacific	25.9	21.9	36.8	7.02e+8	56017	5.87e+6	4241	9227	4.68	4.83	-2279
	Europe & Central Asia	5.79	8.54	55.6	6.70e+8	40950	6.86e+6	7294	6454	9.91	1.87	1.28e+6
	Latin America & Caribbean	8.14	11.8	39.5	1.69e+8	5045	2.07e+6	21635	12662	5.49	2.35	-636201
	Middle East & North Africa	1.69	3.91	32.3	1.34e+8	17853	1.06e+6	537	210	0.00	3.55	403058
	South Asia	1.43	6.96	11.1	8.07e+7	2013	742721	1102	1810	41.7	5.76	-1.92e−6
	Sub-Saharan Africa	0.531	5.41	11.4	3.37e+7	2378	512585	4200	3530	4.19	4.04	-522135
Median	Central Europe and the Baltics	9.52	10.4	59.1	2.53e+7	154	405656	2387	250	7.77	3.94	-107546
	East Asia & Pacific	26.0	22.3	37.3	6.33e+8	60231	6.32e+6	4607	10106	3.96	4.95	9227
	Europe & Central Asia	4.89	7.84	60.2	6.15e+8	41731	6.94e+6	7959	7071	9.58	2.13	1312672
	Latin America & Caribbean	7.58	11.6	39.3	1.40e+8	5194	1.84e+6	23308	13868	5.07	2.57	-535370
	Middle East & North Africa	1.73	5.05	27.8	1.14e+8	16737	1.00e+6	568	230	0.00	3.94	398806
	South Asia	1.36	7.39	7.16	7.89e+7	1825	714804	1176	1982	41.8	6.50	-2181786
	Sub-Saharan Africa	0.598	5.29	7.60	2.81e+7	2216	421479	4484	3854	5.08	4.20	-495797
Standard deviation	Central Europe and the Baltics	1.32	0.786	24.0	1.68e+7	71.2	126147	690	72.1	4.18	2.68	1.13e+6
	East Asia & Pacific	1.52	2.01	22.4	3.66e+8	17358	2.72e+6	1353	2911	2.51	1.65	390567
	Europe & Central Asia	1.58	1.48	23.1	2.83e+8	11316	2.01e+6	2310	2036	2.94	2.52	365809
	Latin America & Caribbean	1.16	0.988	24.2	8.14e+7	1343	688165	7002	3995	1.26	3.02	330098

Interconnected Dynamics: The Role of ICT, Air Transport, Freshwater Resources, and Migration in Regional Economic Growth Across Central Europe and the Baltics, Europe and Central Asia, Latin America and the Caribbean, the Middle East and North Africa, South Asia, and Sub-Saharan Africa

Tryson Yangailo

	Region	ICT goods exports (% of total goods exports)	ICT goods imports (% total goods imports)	Individuals using the Internet (% of population)	Air transport, passengers carried	Air transport, freight (million tonne-km)	Air transport, registered carrier departures worldwide	Renewable internal freshwater resources per capita (cubic meters)	Renewable internal freshwater resources, total (billion cubic meters)	ICT service exports (% of service exports, BoP)	GDP growth (annual %)	Net migration
	Middle East & North Africa	1.77	3.70	24.4	8.01e+7	10725	501338	184	66.4	0.00	2.53	806519
	South Asia	0.563	1.54	11.9	5.28e+7	780	388494	363	571	4.21	2.71	942902
	Sub-Saharan Africa	0.253	1.50	10.8	1.67e+7	947	216577	1555	1114	2.36	1.96	213190
Minimum	Central Europe and the Baltics	7.29	9.07	7.06	0.00	0.00	0.00	0.00	0.00	3.08	-3.51	-181600
	East Asia & Pacific	23.3	17.9	5.63	0.00	0.00	0.00	0.00	0.00	2.14	-0.145	-552288
	Europe & Central Asia	4.32	6.60	13.1	0.00	0.00	0.00	0.00	0.00	5.67	-5.46	422101
	Latin America & Caribbean	6.44	9.40	3.89	0.00	0.00	0.00	0.00	0.00	4.30	-6.65	-1043018
	Middle East & North Africa	0.00	0.00	1.72	0.00	0.00	0.00	0.00	0.00	0.00	-4.02	-1699850
	South Asia	0.746	4.12	0.00	0.00	0.00	0.00	0.00	0.00	26.8	-4.58	-3523806
	Sub-Saharan Africa	0.00	0.00	0.514	0.00	0.00	0.00	0.00	0.00	0.00	-1.97	-1031994
Maximum	Central Europe and the Baltics	12.9	12.6	86.2	6.99e+7	351	566402	2449	250	16.4	6.59	5316792
	East Asia & Pacific	28.6	25.7	75.6	1.42e+9	76282	1.06e+7	5009	10106	10.2	7.61	539479
	Europe & Central Asia	9.13	12.0	87.9	1.18e+9	58442	9.22e+6	8284	7071	16.1	6.52	2002467
	Latin America & Caribbean	10.2	13.3	77.6	3.05e+8	6647	2.90e+6	26627	13868	9.04	7.00	-139806
	Middle East & North Africa	4.84	9.31	75.5	2.76e+8	34622	1.84e+6	718	230	0.00	7.84	1807308
	South Asia	2.80	10.1	42.9	1.91e+8	3447	1.48e+6	1411	1985	47.4	8.76	-302152
	Sub-Saharan Africa	0.832	7.34	33.6	6.62e+7	4295	876670	6034	3884	7.02	6.60	34532

Regional Overview

Central Europe and the Baltics show comparatively higher average percentages of ICT goods exports (9.70%) and imports (10.5%), as well as a significantly higher proportion of individuals using the Internet (54.0%). Air transport metrics indicate moderate activity, with nearly 29.2 million passengers carried and substantial freight capacity (170 million tonne-kilometers). The region enjoys a robust GDP growth rate of 8.48% and a positive net migration figure of approximately 135,695 individuals, highlighting its economic vitality and attractiveness as a destination for migrants.

In contrast, East Asia and the Pacific reports the highest levels of ICT goods exports (25.9%) and imports (21.9%), yet has a relatively low Internet usage rate of 36.8%. The region is the world's leader in air transport, carrying some 702 million passengers, and ranks first in freight transport, totaling 56,017 million tonne-kilometers. However, GDP growth in this region is moderate, at 4.68%, and net migration is negative (-2,279), indicating potential out-migration possibly linked to economic conditions or competitive labor markets abroad.

Europe and Central Asia report a moderate share of ICT goods exports (5.79%) and imports (8.54%), while maintaining a high Internet penetration rate (55.6%). The region performs strongly in air transport, carrying about 670 million passengers. GDP growth is relatively high at 9.91%, and the region has a substantial net migration inflow of 1.28 million, indicating its status as a net recipient of migrants—likely due to favorable economic conditions.

The Latin America and Caribbean region reports comparatively lower levels of ICT exports (8.14%) and imports (11.8%), and a modest Internet penetration rate of 39.5%. Air transport activity in the region is significant, with approximately 169 million passengers carried, but its GDP growth is comparatively low at 5.49% and its net migration is significantly negative (-636,201), indicating economic challenges that drive residents to seek opportunities abroad.

The Middle East and North Africa region reports the lowest exports (1.69%) and imports (3.91%) of ICT goods and has a low Internet penetration rate of 32.3%. Despite a moderate GDP growth rate of 3.55%, its net migration is positive at 403,058, indicating that while its economic growth is not robust, the region still attracts migrants due to several reasons—including job opportunities or socio-political conditions.

South Asia ranks lowest across several indicators, with ICT goods exports at just 1.43% and Internet usage at just 11.1%. Air transport activity is also limited, with about 8.07 million passengers carried. Despite a relatively high GDP growth at 41.7%, net migration is close to zero (-1.92e-6), indicating minimal population movement—possibly reflecting economic constraints and limited migration opportunities.

Sub-Saharan Africa similarly reports low figures for exports (0.531%) and imports (5.41%) of ICT goods, and a low Internet usage rate of 11.4%. The region carries about 33.7 million passengers by air, indicating moderate connectivity. GDP growth is 4.19% and net migration is also negative (-522,135), highlighting economic challenges and the potential for out-migration as residents seek better opportunities abroad.

This analysis of descriptive statistics across regions highlights significant disparities in ICT adoption, transport connectivity, and economic conditions. Understanding these dynamics is crucial for formulating strategies to improve regional development and migration policies. Future research should explore the interrelationships among these variables to better understand the factors influencing economic growth and migration trends in different regions.

Correlations among ICT, Air Transport, Freshwater Resources, and Economic Indicators

Table 2 presents the correlation coefficients among key indicators, including ICT goods and services, air transport, renewable freshwater resources, GDP growth and net migration. The correlations provide insight

into the interrelationships among these variables and help identify patterns that may shape regional economic performance and migration trends.

Correlations among ICT Indicators

The correlation between ICT goods exports and imports is exceptionally strong ($r = 0.952$, $p < .001$), indicating that regions with high levels of ICT exports also tend to import these goods extensively. This relationship suggests that a thriving ICT sector is closely linked to active participation in global trade networks, driving both exports and imports.

There is a positive correlation between the proportion of individuals using the Internet and both exports of ICT goods ($r = 0.230$, $p < .01$) and imports of ICT goods ($r = 0.214$, $p < .01$). This correlation suggests that as Internet access expands, trade in ICT goods tend to increase. This finding highlights the critical role of Internet connectivity in driving economic participation in the digital economy.

Air Transport Relationships

Air transport indicators show significant correlations with both ICT goods exports and imports. Specifically, the number of air transport passengers carried is positively correlated with ICT goods exports ($r = 0.530$, $p < .001$) and ICT goods imports ($r = 0.499$, $p < .001$). These suggest that increased passenger transport capacity may enhance trade by improving regional connectivity and access to global markets.

Air freight indicators also show significant correlations with ICT indicators, particularly with ICT goods exports ($r = 0.640$, $p < .001$) and imports ($r = 0.575$, $p < .001$). These strong correlations suggest that regions with greater freight capacity leverage this advantage to engage in more extensive ICT goods trade, underscoring the critical role of efficient transportation infrastructure in promoting economic growth.

Freshwater Resources and Economic Indicators

The correlation between per capita and total renewable inland freshwater resources exhibits mixed results. While total renewable

freshwater resources have a positive correlation with ICT goods imports ($r = 0.536$, $p < .001$) and exports ($r = 0.459$, $p < .001$), its correlation with GDP growth is negative ($r = -0.286$, $p < .001$). These correlations suggest that while freshwater resources may have a positive impact on trade, they are not necessarily correlated with economic growth—indicating potential inefficiencies or that economic development usually over-relies on other factors.

Interestingly, GDP growth is negatively correlated with net migration ($r = -0.280$, $p < .001$). This negative correlation suggests that as GDP growth increases, net migration tends to decrease, indicating a potential link between economic opportunities and the individuals' decisions to migrate. Conversely, there is a positive correlation between net migration and individuals' use of the Internet ($r = 0.450$, $p < .001$), suggesting that an enhanced access to Internet may facilitate the exchange of information related to migration opportunities, thereby influencing individuals' decisions to migrate.

Table 2. Correlation Matrix of ICT, Air Transport, Freshwater Resources, and Economic Indicators

		ICT goods exports (% of total goods exports)	ICT goods imports (% total goods imports)	Individuals using the Internet (% of population)	Air transport, passengers carried	Air transport, freight (million tonne-km)	Air transport, registered carrier departures worldwide	Renewable internal freshwater resources per capita (cubic meters)	Renewable internal freshwater resources, total (billion cubic meters)	ICT service exports (% of service exports, BoP)	GDP growth (annual %)	Net migration
ICT goods exports (% of total goods exports)	Pearson's r	—										
	df	—										
	p-value	—										
ICT goods imports (% total goods imports)	Pearson's r	0.952 ***	—									
	df	159	—									
	p-value	< .001	—									
Individuals using the Internet (% of population)	Pearson's r	0.230 **	0.214 **	—								
	df	159	159	—								
	p-value	0.003	0.006	—								
Air transport, passengers carried	Pearson's r	0.530 ***	0.499 ***	0.385 ***	—							
	df	159	159	159	—							
	p-value	< .001	< .001	< .001	—							
Air transport, freight (million tonne-km)	Pearson's r	0.640 ***	0.575 ***	0.303 ***	0.905 ***	—						
	df	159	159	159	159	—						
	p-value	< .001	< .001	< .001	< .001	—						
Air transport, registered carrier departures worldwide	Pearson's r	0.500 ***	0.479 ***	0.358 ***	0.976 ***	0.887 ***	—					
	df	159	159	159	159	159	—					
	p-value	< .001	< .001	< .001	< .001	< .001	—					
Renewable internal freshwater resources per capita (cubic meters)	Pearson's r	0.109	0.219 **	0.013	0.096	-0.041	0.184 *	—				
	df	159	159	159	159	159	159	—				
	p-value	0.168	0.005	0.870	0.227	0.602	0.020	—				
Renewable internal freshwater resources, total (billion cubic meters)	Pearson's r	0.459 ***	0.536 ***	-0.003	0.457 ***	0.376 ***	0.515 ***	0.851 ***	—			
	df	159	159	159	159	159	159	159	—			
	p-value	< .001	< .001	0.972	< .001	< .001	< .001	< .001	—			
ICT service exports (% of service exports, BoP)	Pearson's r	-0.260 ***	-0.148	-0.162 *	-0.142	-0.251 **	-0.160 *	-0.237 **	-0.236 **	—		
	df	159	159	159	159	159	159	159	159	—		
	p-value	< .001	0.061	0.040	0.071	0.001	0.042	0.002	0.003	—		
GDP growth (annual %)	Pearson's r	0.034	0.020	-0.391 ***	-0.089	-0.051	-0.135	-0.286 ***	-0.201 *	0.230 **	—	
	df	159	159	159	159	159	159	159	159	159	—	
	p-value	0.673	0.806	< .001	0.259	0.519	0.088	< .001	0.011	0.003	—	
Net migration	Pearson's r	0.147	0.027	0.450 ***	0.410 ***	0.426 ***	0.450 ***	-0.040	0.020	-0.534 ***	-0.280 ***	—
	df	159	159	159	159	159	159	159	159	159	159	—
	p-value	0.063	0.729	< .001	< .001	< .001	< .001	0.617	0.802	< .001	< .001	—

Note. * p < .05, ** p < .01, *** p < .001

The correlation matrix reveals complex relationships among ICT indicators, air transport metrics, freshwater resources, GDP growth, and net migration. Such correlations suggest that improving citizens ICT capabilities and transportation infrastructure can significantly enhance regional economic performance and shape migration trends. Furthermore, the interplay between freshwater resources and economic growth suggests that policymakers should consider multiple factors when addressing economic development and resource management.

ANOVA Analysis

Table 3 presents the results of the Welch's one-way ANOVA, which examines the disparities among economic and ICT-related indicators across regions. The analysis revealed significant differences across all the metrics examined, with p-values less than 0.001 for all variables, indicating that the mean differences in ICT goods exports, ICT goods imports, air transport metrics, GDP growth, Internet usage, renewable freshwater resources, and net migration across regional groups are statistically significant.

Table 3. One-Way ANOVA of Regional Disparities in ICT, Air Transport, Economic Growth, Internet Usage, Freshwater Resources, and Migration

	F	df1	df2	p
ICT goods exports (% of total goods exports)	1270.61	6	63.2	< .001
ICT goods imports (% total goods imports)	202.45	6	67.2	< .001
Air transport, passengers carried	48.32	6	65.0	< .001
GDP growth (annual %)	6.46	6	68.1	< .001
Individuals using the Internet (% of population)	24.90	6	67.3	< .001
Air transport, freight (million tonne-km)	180.90	6	59.0	< .001
Air transport, registered carrier departures worldwide	79.82	6	64.3	< .001
Renewable internal freshwater resources per capita (cubic meters)	126.06	6	63.2	< .001
Renewable internal freshwater resources, total (billion cubic meters)	163.97	6	64.1	< .001
Net migration	89.94	6	66.6	< .001

ICT Goods Exports and Imports

The results show a highly significant difference in ICT goods exports across regions ($F(6, 63.2) = 1270.61$, $p < .001$), indicating that some regions have a much higher engagement in ICT trade than others. Particularly,

regions such as East Asia and the Pacific exhibit a significantly higher average exports rate compared to others such as Sub-Saharan Africa, which reported the lowest average rate (0.531%) of the total goods exports.

Similarly, there is a significant difference in ICT goods imports ($F(6, 67.2) = 202.45$, $p < .001$.), which underscores the regional disparities in participation in ICT trade. Once again, East Asia and the Pacific leads with a higher average import rate, while Sub-Saharan Africa shows a lower level of engagement, mirroring the trends in exports.

Air Transport Dynamics

Air transport metrics also revealed significant differences across regions, particularly for the number of passengers carried ($F(6, 65.0) = 48.32$, $p < .001$) and the volumes in freight transported ($F(6, 59.0) = 180.90$, $p < .001$). East Asia and the Pacific reported the highest volume of passengers and freight carried, which is critical to their economic activity—indicating that a well-developed transportation infrastructure supports trade and economic development.

Economic Performance and Internet Usage

Indicators of GDP growth revealed significant regional differences ($F(6, 68.1) = 6.46$, $p < .001$), indicating that economic performance varies significantly across regions. South Asia reported the highest average GDP growth at 5.761%, while Europe and Central Asia reported lower figures, underscoring the potential influence of regional economic policies and conditions on growth rates.

In addition, the indicators of Internet access ($F(6, 67.3) = 24.90$, $p < .001$) reflect significant disparities in digital access across regions. Central Europe and the Baltics had the highest average Internet access rates, which may correlate with enhanced economic opportunities and ICT infrastructure.

Freshwater Resources and Migration Trends

The significant differences in renewable internal freshwater resources per capita ($F(6, 63.2) = 126.06$, $p < .001$) underscore the importance of water resource availability for economic development. Latin America and the Caribbean led the way with an average of 21,635.177 cubic meters, demonstrating its significantly greater access to freshwater resources, while the Middle East and North Africa reported the lowest values.

Finally, net migration indicators ($F(6, 66.6) = 89.94$, $p < .001$) revealed significant differences in migration patterns across regions. Central Europe and the Baltics reported the highest net migration figures, while regions such as Latin America and the Caribbean and South Asia show negative net migration, indicating a complex interplay between economic conditions, migration policies, and individuals' decisions to relocate.

Table 4. Group Descriptives

	Region	N	Mean	SD	SE
ICT goods exports (% of total goods exports)	Central Europe and the Baltics	23	9.696	1.323	0.2758
	East Asia & Pacific	23	25.918	1.522	0.3173
	Europe & Central Asia	23	5.790	1.575	0.3284
	Latin America & Caribbean	23	8.140	1.156	0.2411
	Middle East & North Africa	23	1.687	1.771	0.3692
	South Asia	23	1.434	0.563	0.1174
	Sub-Saharan Africa	23	0.531	0.253	0.0528
ICT goods imports (% total goods imports)	Central Europe and the Baltics	23	10.454	0.786	0.1638
	East Asia & Pacific	23	21.917	2.014	0.4199
	Europe & Central Asia	23	8.537	1.477	0.3080
	Latin America & Caribbean	23	11.818	0.988	0.2060
	Middle East & North Africa	23	3.913	3.705	0.7725
	South Asia	23	6.962	1.537	0.3205
	Sub-Saharan Africa	23	5.405	1.500	0.3127
Air transport, passengers carried	Central Europe and the Baltics	23	2.92e+7	1.68e+7	3.51e+6
	East Asia & Pacific	23	7.02e+8	3.66e+8	7.64e+7
	Europe & Central Asia	23	6.70e+8	2.83e+8	5.90e+7
	Latin America & Caribbean	23	1.69e+8	8.14e+7	1.70e+7
	Middle East & North Africa	23	1.34e+8	8.01e+7	1.67e+7
	South Asia	23	8.07e+7	5.28e+7	1.10e+7
	Sub-Saharan Africa	23	3.37e+7	1.67e+7	3.48e+6
GDP growth (annual %)	Central Europe and the Baltics	23	3.335	2.676	0.5580
	East Asia & Pacific	23	4.828	1.648	0.3437
	Europe & Central Asia	23	1.874	2.515	0.5245
	Latin America & Caribbean	23	2.350	3.023	0.6304
	Middle East & North Africa	23	3.549	2.528	0.5271
	South Asia	23	5.761	2.710	0.5651
	Sub-Saharan Africa	23	4.040	1.959	0.4084
Individuals using the Internet (% of population)	Central Europe and the Baltics	23	54.041	24.011	5.0067
	East Asia & Pacific	23	36.818	22.415	4.6738
	Europe & Central Asia	23	55.585	23.089	4.8143
	Latin America & Caribbean	23	39.541	24.155	5.0366
	Middle East & North Africa	23	32.338	24.365	5.0805

	Region	N	Mean	SD	SE
	South Asia	23	11.085	11.935	2.4886
	Sub-Saharan Africa	23	11.369	10.789	2.2496
Air transport, freight (million tonne-km)	Central Europe and the Baltics	23	170.400	71.181	14.8422
	East Asia & Pacific	23	56016.660	17358.147	3619.4239
	Europe & Central Asia	23	40950.278	11316.421	2359.6369
	Latin America & Caribbean	23	5045.089	1342.850	280.0036
	Middle East & North Africa	23	17852.865	10725.035	2236.3244
	South Asia	23	2012.829	780.189	162.6807
	Sub-Saharan Africa	23	2377.926	946.560	197.3714
Air transport, registered carrier departures worldwide	Central Europe and the Baltics	23	361969.864	126146.684	26303.4020
	East Asia & Pacific	23	5.87e+6	2.72e+6	567602.9768
	Europe & Central Asia	23	6.86e+6	2.01e+6	419029.5486
	Latin America & Caribbean	23	2.07e+6	688164.957	143492.3129
	Middle East & North Africa	23	1.06e+6	501338.470	104536.2974
	South Asia	23	742720.507	388494.150	81006.6300
	Sub-Saharan Africa	23	512585.214	216576.527	45159.3277
Renewable internal freshwater resources per capita (cubic meters)	Central Europe and the Baltics	23	2182.430	689.775	143.8279
	East Asia & Pacific	23	4241.383	1353.349	282.1927
	Europe & Central Asia	23	7294.162	2309.681	481.6018
	Latin America & Caribbean	23	21635.177	7002.358	1460.0925
	Middle East & North Africa	23	536.685	184.171	38.4023
	South Asia	23	1101.809	363.037	75.6984
	Sub-Saharan Africa	23	4199.967	1554.850	324.2086
Renewable internal freshwater resources, total (billion cubic meters)	Central Europe and the Baltics	23	228.453	72.087	15.0311
	East Asia & Pacific	23	9226.811	2911.451	607.0796
	Europe & Central Asia	23	6453.866	2036.473	424.6339
	Latin America & Caribbean	23	12661.819	3995.342	833.0865
	Middle East & North Africa	23	210.437	66.402	13.8457
	South Asia	23	1810.338	571.240	119.1118
	Sub-Saharan Africa	23	3530.390	1114.083	232.3023
Net migration	Central Europe and the Baltics	23	135695.348	1.13e+6	235937.2699
	East Asia & Pacific	23	-2278.870	390566.578	81438.7612
	Europe & Central Asia	23	1.28e+6	365809.097	76276.4695
	Latin America & Caribbean	23	-636201.348	330098.102	68830.2123

Region	N	Mean	SD	SE
Middle East & North Africa	23	403058.348	806518.915	168170.8189
South Asia	23	-1.92e−6	942901.667	196608.5887
Sub-Saharan Africa	23	-522135.348	213189.912	44453.1695

Overall, the results from the descriptive statistics analysis highlight the pronounced regional disparities among ICT goods exports and imports, air transport capacity, economic growth, Internet access, freshwater resources and migration trends. The significant p-values across all metrics suggest that regional factors play a critical role in shaping these outcomes, providing important insights for policymakers seeking to improve economic performance and connectivity in global trade. Understanding these dynamics is critical for targeting policies that can bridge the gaps between regions and promote sustainable growth.

Regression Analysis on GDP Growth

Table 5 summarizes the model fit for the linear regression analysis conducted to assess the impact of several factors on GDP growth. The model exhibits a moderate fit with an R^2 value of 0.317, indicating that about 31.7% of variance in GDP growth that can be explained by the predictors included in the model. The overall model test was statistically significant ($F(10, 150) = 6.95$, $p < .001$), indicating that at least one predictor makes a significant contribution to the model.

Table 5. Model Fit Measures

				Overall Model Test			
Model	R	R^2	Adjusted R^2	F	df1	df2	p
1	0.563	0.317	0.271	6.95	10	150	< .001

Table 6 show the omnibus ANOVA test results for each predictor included in the model. Of the variables examined, only Internet access (% of population) and air transport passengers carried were statistically significant, with p-values of less than 0.001 and 0.035, respectively. In particular, the Internet access variable had a significant F-value of 28.438, indicating a strong relationship with GDP growth. In contrast, the other predictors, including ICT goods exports and imports, air freight, and net migration, did not show significant relationships with GDP growth, as evidenced by their high p-values.

Table 6. Omnibus ANOVA Test Results

	Sum of Squares	df	Mean Square	F	p
ICT goods exports (% of total goods exports)	6.0716	1	6.0716	1.11469	0.293
ICT goods imports (% total goods imports)	0.0183	1	0.0183	0.00337	0.954
Individuals using the Internet (% of population)	154.8996	1	154.8996	28.43800	< .001
Air transport, passengers carried	24.7676	1	24.7676	4.54707	0.035
Air transport, freight (million tonne-km)	1.7967	1	1.7967	0.32985	0.567
Air transport, registered carrier departures worldwide	8.4529	1	8.4529	1.55187	0.215
Renewable internal freshwater resources per capita (cubic meters)	2.5125	1	2.5125	0.46127	0.498
Renewable internal freshwater resources, total (billion cubic meters)	19.6618	1	19.6618	3.60970	0.059
ICT service exports (% of service exports, BoP)	5.7514	1	5.7514	1.05589	0.306
Net migration	2.4585	1	2.4585	0.45136	0.503
Residuals	817.0388	150	5.4469		

Note. Type 3 sum of squares

Table 7 provides detailed estimates of the model coefficients for each predictor affecting GDP growth. The intercept is significant ($p < .001$), indicating a baseline level of GDP growth. The results show that individuals using the Internet had a negative effect on GDP growth (estimate = -0.05347, $p < .001$), indicating that higher Internet penetration may not be directly correlated with growth, possibly due to other underlying factors. Conversely, the variable air transport (passengers carried) showed a positive impact (estimate = 6.88e-9, $p = 0.035$), indicating that an increased passenger transport indicator promotes economic activity. However, other predictors, including exports and imports of ICT goods, did not yield significant estimates, reflecting the complexity of their relationship with GDP growth.

Table 7. Model Coefficients - GDP growth (annual %)

Predictor	Estimate	SE	t	p	Stand. Estimate
Intercept	5.21538	0.6158	8.4692	< .001	
ICT goods exports (% of total goods exports)	0.10008	0.0948	1.0558	0.293	0.3033
ICT goods imports (% total goods imports)	0.00752	0.1296	0.0580	0.954	0.0162
Individuals using the Internet (% of population)	-0.05347	0.0100	-5.3327	< .001	-0.5170
Air transport, passengers carried	6.88e-9	3.22e-9	2.1324	0.035	0.8229
Air transport, freight (million tonne-km)	-1.60e−5	2.78e-5	-0.5743	0.567	-0.1306
Air transport, registered carrier departures worldwide	-4.78e−7	3.84e-7	-1.2457	0.215	-0.4966
Renewable internal freshwater resources per capita (cubic meters)	6.67e-5	9.82e-5	0.6792	0.498	0.1798
Renewable internal freshwater resources, total (billion cubic meters)	-3.07e−4	1.62e-4	-1.8999	0.059	-0.5481
ICT service exports (% of service exports, BoP)	0.02161	0.0210	1.0276	0.306	0.1055
Net migration	-1.80e−7	2.68e-7	-0.6718	0.503	-0.0754

Data Summary and Assumption Checks

Table 8 shows Cook's Distance, which assesses the impact of individual data points on the overall model fit. An average Cook's Distance value of 0.00981 suggests that there are no extreme outliers, as all values remain within a reasonable range, with a maximum of 0.230. This resulting value means that the data points are not unduly influencing the results of the model.

Table 8. Cook's Distance

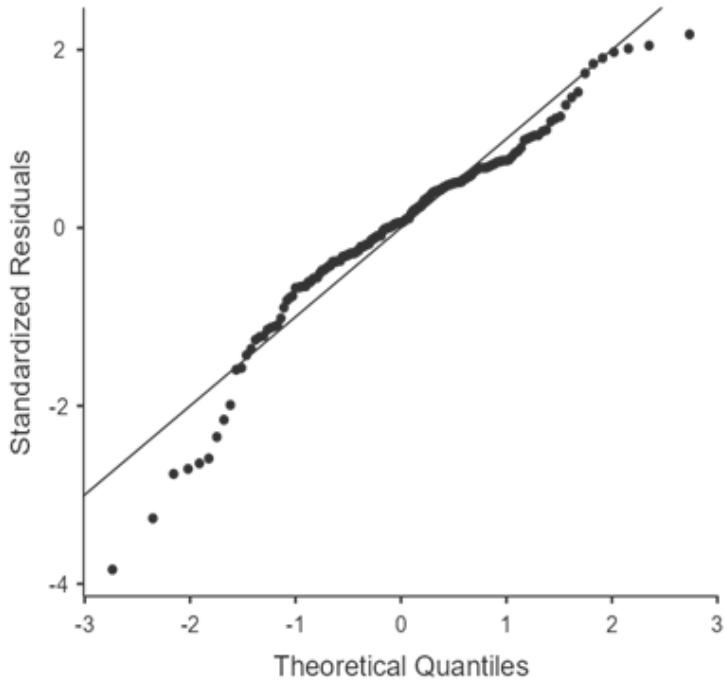
			Range	
Mean	Median	SD	Min	Max
0.00981	0.00161	0.0287	1.40e-7	0.230

In addition, Table 9 presents the results of the Durbin-Watson test for autocorrelation, which yields a statistic of 1.90 with a p-value of 0.218. This result indicates that there is no significant autocorrelation in the residuals, which is one of the main assumptions of the linear regression.

Table 9. Durbin–Watson Test for Autocorrelation

Autocorrelation	DW Statistic	p
0.0409	1.90	0.218

Figure 1. Q-Q Plot



Regression Analysis on Net migration

The regression analysis provides significant insight into the relationship between various factors and their impact on net migration. The overall model fit measures presented in Table 10 indicate a strong model with an R value of 0.799, suggesting a substantial correlation between the predictors and net migration. The R^2 value of 0.639 indicates that approximately 63.9% of the variance in net migration can be explained by the model, indicating robust explanatory power. The adjusted R^2 value of 0.615 further confirms the validity of the model, as it considers the number

of predictors included in the analysis. The F-statistic of 26.6 with a p-value of less than 0.001 indicates that the overall model is statistically significant.

Table 10. Model Fit Measures

				Overall Model Test			
Model	**R**	**R^2**	**Adjusted R^2**	**F**	**df1**	**df2**	**p**
1	0.799	0.639	0.615	26.6	10	150	< .001

The results of the omnibus ANOVA test (Table 11) provide a detailed view of the individual contributions of each predictor. Among the significant predictors, ICT goods imports had a notable negative relationship with net migration, with a p-value of 0.010, suggesting that higher imports potentially discourage migration. The variable of individuals using the Internet emerged as a strong positive contributor to net migration ($p < 0.001$), consistent with the notion that greater Internet accessibility encourages migration through improved communication and information sharing. In addition, the air transport variable related to passengers carried also showed a significant positive association ($p < 0.001$), suggesting that increased air travel capacity facilitates migration opportunities.

Table 11. Omnibus ANOVA Test

	Sum of Squares	df	Mean Square	F	p
ICT goods exports (% of total goods exports)	1.70e+12	1	1.70e+12	3.374	0.068
ICT goods imports (% total goods imports)	3.43e+12	1	3.43e+12	6.819	0.010
Individuals using the Internet (% of population)	6.51e+12	1	6.51e+12	12.957	< .001
Air transport, passengers carried	6.33e+12	1	6.33e+12	12.589	< .001
Air transport, freight (million tonne-km)	1.21e+11	1	1.21e+11	0.240	0.625
Renewable internal freshwater resources per capita (cubic meters)	3.19e+11	1	3.19e+11	0.635	0.427
Renewable internal freshwater resources, total (billion cubic meters)	2.01e+11	1	2.01e+11	0.400	0.528
ICT service exports (% of service exports, BoP)	2.45e+13	1	2.45e+13	48.644	< .001
GDP growth (annual %)	2.27e+11	1	2.27e+11	0.451	0.503
Air transport, registered carrier departures worldwide	1.49e+13	1	1.49e+13	29.703	< .001
Residuals	7.54e+13	150	5.03e+11		

Note. Type 3 sum of squares

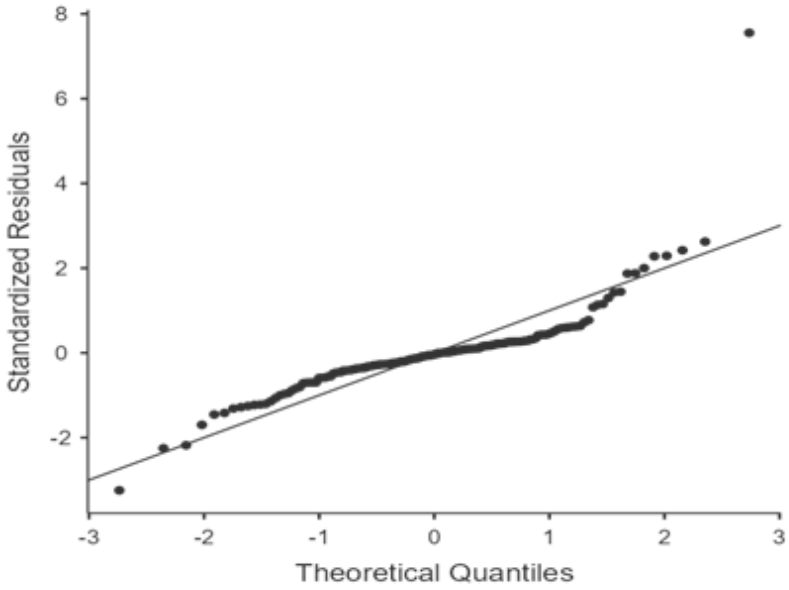
For ICT service exports, the analysis revealed a highly significant negative relationship ($p < 0.001$), suggesting that higher levels of service exports may be correlated with lower net migration. This negative relationship could be interpreted as a trend in which more skilled workers remain in the country, leading to a decrease in emigration. Conversely, the variable measuring the number of departures by registered airlines worldwide also exhibited a strong positive relationship with net migration ($p < 0.001$), supporting the idea that a higher number of departures enables and encourages migration flows.

The coefficients presented in Table 12 provide further insight into the nature of these relationships. For example, individuals using the Internet had a coefficient of 11,473.30, indicating that for every percentage increase in Internet users, net migration is expected to increase significantly. Conversely, ICT goods imports had a negative coefficient of -100,563.78, illustrating the inverse relationship mentioned above. The variable representing air passengers carried had a negative coefficient, indicating that increases in this factor may be inversely related to net migration, although its significance is notable in the context of overall trends.

Table 12. Model Coefficients - Net migration

Predictor	Estimate	SE	t	p	Stand. Estimate
Intercept	281167.65206	226298.782	1.242	0.216	
ICT goods exports (% of total goods exports)	52508.05696	28586.297	1.837	0.068	0.3806
ICT goods imports (% total goods imports)	-100563.77808	38511.717	-2.611	0.010	-0.5169
Individuals using the Internet (% of population)	11473.30443	3187.448	3.600	< .001	0.2654
Air transport, passengers carried	-0.00339	9.55e-4	-3.548	< .001	-0.9703
Air transport, freight (million tonne-km)	-4.14273	8.448	-0.490	0.625	-0.0811
Renewable internal freshwater resources per capita (cubic meters)	-23.76055	29.828	-0.797	0.427	-0.1532
Renewable internal freshwater resources, total (billion cubic meters)	-31.39130	49.653	-0.632	0.528	-0.1340
ICT service exports (% of service exports, BoP)	-38860.61452	5571.817	-6.974	< .001	-0.4540
GDP growth (annual %)	-16640.39179	24768.569	-0.672	0.503	-0.0398
Air transport, registered carrier departures worldwide	0.58370	0.107	5.450	< .001	1.4503

Figure 2. Q-Q Plot



Discussion

The results underscore pronounced regional differences in terms of the use of ICT goods and services, reinforcing the findings from the existing literature, which emphasize the role of economic development in shaping the impact of ICT on economic growth. Fernández-Portillo et al. (2020) noted that regions such as East Asia and the Pacific exhibit strong ICT trade—export and import—, which have facilitated their integration into the global economy. Conversely, regions such as Sub-Saharan Africa and South Asia exhibit lower participation, consistent with previous findings advocating for targeted interventions to enhance competitiveness (Nchake & Shuaibu, 2022). These disparities highlight the need for digital inclusion, a recurring theme in previous studies that link uneven ICT access to different levels of economic progress across regions.

The significant variation in air transport metrics support the conclusions of previous studies, which stated that well-developed transport networks are critical for regional economic growth (Nguyen, 2024; Baltaci et al., 2015). The literature emphasizes the role of air transport in promoting

trade, tourism, and investment, and the current findings support the notion that improved infrastructure, particularly in regions such as East Asia and the Pacific, promotes economic activity. These findings expand beyond the work of Zhang & Graham (2020) by suggesting that air transport infrastructure not only promotes physical connectivity but also ICT trade, suggesting that investment in this sector has broader economic benefits.

The relationship between economic growth and ICT infrastructure is consistent with previous findings that underscore that digital access can serve as a driver of growth (Rahman et al., 2021; Awad & Albaity, 2022). However, the nuanced findings related to GDP growth and net migration provide a contrast to some claims in the literature, particularly regarding the role of migration in economic development (Akanbi, 2017). While migration has often been portrayed as a positive force for growth, the current finding suggests that robust local economies may reduce the need for out-migration, adding complexity to this relationship.

The negative correlation between renewable freshwater resources and economic growth raises critical questions about the role of natural resources, echoing concerns raised in previous studies (Rock, 1998; Kundzewicz, 2007). This finding contrasts with the common narrative linking resource abundance to strong economic performance, suggesting that inefficiencies or overreliance on other economic sectors may be at play.

The migration patterns identified in this analysis are consistent with previous research highlighting economic opportunity as a key driver of migration (Arora, 2014; Podra et al., 2020). However, the strong positive correlation between Internet access and net migration provides new insights into how digital connectivity influences migration decisions, particularly in regions where ICT is well integrated. This finding extends previous studies by showing how improved connectivity not only drives economic growth, but also facilitates access to information about opportunities abroad, thereby influencing migration patterns.

Moreover, the correlation between higher ICT goods imports and lower net migration suggests that improving local economic conditions through ICT can reduce out-migration. This correlation challenges the conventional view that migration is associated with economic distress and suggests that ICT can play a stabilizing role in local economies, an issue that has been underexplored in the existing literature.

The regression analysis provides deeper insights into the factors influencing GDP growth and net migration. The positive impact of Internet use on both economic growth and migration is consistent with studies by Tee et al. (2020) and Shodiev et al. (2021). However, the negative relationship between ICT penetration and GDP growth suggests the presence of moderating factors, such as infrastructure quality or policy frameworks, which require further examination. This complex correlation supports the argument of Fernández-Portillo et al. (2020) regarding the heterogeneous impact of ICT across regions and highlights the need for more nuanced research on the variable effect of ICT on economic growth.

Gaps Covered by This Study

This study fills several critical gaps in the existing literature, particularly on the complex relationships between ICT goods and services, air transport, economic growth, and migration trends in different regions. While previous studies have often treated these elements in isolation, this study takes a more integrated approach and examines how these factors interact with each other. For example, the study examines interregional differences in ICT use and air travel, an area that is often overlooked. Previous studies have focused on either high- or low-income regions, without offering comprehensive cross-regional comparisons. By looking at regions as diverse as East Asia and the Pacific, Sub-Saharan Africa, and South Asia, this research provides insights into the varying degrees of ICT integration and economic development, filling a significant gap in understanding global dynamics.

In addition, this study addresses the underexplored link between ICT and migration dynamics. While the literature on migration often examines economic drivers, it rarely focuses on how ICT use shapes migration patterns. The findings here show that higher ICT imports can help stabilize

local economies and thereby reduce out-migration, a novel contribution to the literature. Another critical gap addressed is the relationship between air transport and ICT trade, which has not been thoroughly examined in previous research. This study shows that improving air transport infrastructure can significantly increase trade in ICT goods, providing new evidence on the positive impact of transport networks on global trade.

Finally, the study sheds light on the complex relationship between renewable freshwater resources and economic growth, challenging the conventional wisdom that resource-rich regions automatically enjoy better economic outcomes. The negative correlation between resource availability and growth suggests inefficiencies or over-reliance on other factors, adding a new level of understanding to the role of natural resources in shaping regional economic development.

Policy Implications and Recommendations

The findings of this study have several important policy implications for governments and international organizations seeking to promote regional economic development and more effectively manage migration flows. A key recommendation is to promote digital inclusion. The study clearly shows that regions with higher Internet usage and greater access to ICT goods experience more significant economic growth. Policymakers, particularly in sub-Saharan Africa and South Asia, should prioritize investments in digital infrastructure to make Internet access more affordable and accessible. In addition, improving digital literacy and fostering ICT innovation will help bridge the digital divide and promote more inclusive economic development.

Investing in transport infrastructure is another key policy recommendation. The strong link between air transport and economic growth highlights the importance of well-developed airports, cargo facilities and air traffic management systems. Countries, particularly in regions with underdeveloped transport networks, should focus on improving air connectivity to facilitate both domestic and international trade. By investing in transport infrastructure, regions such as sub-Saharan Africa can improve their integration into global markets, fostering ICT trade

and overall economic performance, much as East Asia and the Pacific has done.

In terms of migration, the results suggest that improving local economic stability through ICT can reduce out-migration. Higher ICT goods imports, indicating stronger local economies, correlate with lower migration pressures. Governments should therefore develop policies that encourage local job creation, particularly in the ICT sector. Supporting small and medium-sized enterprises (SMEs) and encouraging entrepreneurship can provide local opportunities that discourage individuals from seeking better prospects abroad, contributing to a more stable migration dynamic.

The study also calls for a rethinking of how regions manage natural resources, particularly of renewable freshwater. The negative correlation between resource abundance and economic growth suggests that simply having natural resources does not automatically lead to prosperity. Policymakers in resource-rich regions should focus on sustainable resource management and invest in technologies that improve resource efficiency. This approach will help ensure that natural wealth contributes to long-term economic stability rather than serving as a crutch for inefficient development practices.

Given the diversity of regional outcomes, it is clear that tailored regional strategies are needed. There is no single formula that can be applied universally. For example, East Asia and the Pacific can afford to focus on developing their already advanced transport and ICT infrastructure, while sub-Saharan Africa may need to address more fundamental issues such as basic infrastructure and digital literacy. Regional strategies should therefore be context-specific, considering each region's unique economic conditions, political environment, and infrastructure constraints.

Finally, international cooperation is critical to fostering the global benefits of ICT and aviation. Trade agreements that reduce ICT-related tariffs and bilateral partnerships that improve transport infrastructure can

facilitate greater connectivity between regions. Multilateral organizations, such as the World Trade Organization (WTO) and the International Civil Aviation Organization (ICAO), can provide platforms for this collaboration and help low-income regions access the financial and technical support

needed to close development gaps. By adopting these policies, governments can harness the potential of ICTs and aviation to promote sustainable economic growth, manage migration, and foster balanced regional development.

Table 12. Study Summary

Metric	Findings	Regions Comparative	Policy Implications	Recommendations	Additional Insights
ICT Adoption	Positive correlation between ICT adoption and economic growth; low-income countries benefit more.	East Asia and the Pacific show high ICT engagement; Sub-Saharan Africa and South Asia lag behind.	ICT investments are crucial for enhancing economic performance, especially in developing regions.	Increase investments in ICT infrastructure and human capital development, focusing on digital inclusivity.	Emphasizes the transformative potential of ICT.
Air Transport Infrastructure	Enhanced air connectivity facilitates trade and investment; varies by economic development levels.	East Asia has well-developed air transport networks, while regions like Sub-Saharan Africa face challenges in connectivity.	Development of air transport infrastructure is essential for regional economic growth and integration.	Prioritize infrastructure projects that improve air transport connectivity to boost trade and tourism.	Highlights the role of air transport in economic resilience.
Freshwater Resources	Water scarcity negatively impacts agricultural productivity and overall economic health.	Regions with abundant freshwater resources, like Central Europe, show better economic health compared to arid regions.	Sustainable water management practices are needed to balance agricultural and economic needs.	Implement efficient water management strategies and invest in water conservation initiatives.	Links water management to regional development.
Migration Patterns	Favorable economic conditions attract migrants; high ICT imports may reduce net migration.	Regions with strong economies attract migrants, while poorer regions see higher emigration rates.	Migration policies should address economic disparities and support local economic development to mitigate outward migration.	Develop policies that enhance local job opportunities and facilitate access to information about economic prospects.	Explores the dual nature of migration impacts on economies.
Integrated Analysis of Variables	Interconnectedness of ICT, air transport, freshwater resources, and migration influences economic outcomes.	Recognizes differences in how regions leverage these variables for development.	Comprehensive approaches are required for effective policy formulation to address these interdependencies.	Encourage collaboration among sectors (ICT, transport, environment) to develop holistic strategies for regional growth.	Advocates for a unified framework in regional development.

Conclusion

This study offers a comprehensive analysis of the relationships among information and communication technology (ICT), air transport, freshwater resources, economic growth, and migration patterns across global regions . Drawing on a robust World Bank dataset spanning 2000 to 2022, the findings reveal significant regional disparities in ICT adoption, transportation infrastructure, and economic performance. The analysis underscores the critical role of ICT in driving economic growth, particularly in developing regions where improved digital access can foster trade and investment.

The relationship between air transport and economic activity emerges as a key driver of regional integration and connectivity. Regions with well-developed air transport infrastructure exhibit a positive correlation with economic growth, underscoring the importance of continued investment in transport systems. In addition, the findings indicate that freshwater resources are vital to sustainable economic development, for which effective management is essential to support agricultural productivity and address water scarcity challenges.

Migration patterns, shaped by the interplay of these variables, reflect the economic opportunities available across regions. The study demonstrates that improved ICT access and air connectivity can facilitate migration decisions, often leading to increased out-migration from economically disadvantaged regions. Conversely, regions with strong local economies—supported by effective ICT and transportation systems—are more likely to retain their populations.

Overall, the findings underscore the need for policymakers to adopt a holistic approach that considers the interconnectedness of ICT, transport, freshwater resources and migration dynamics. Targeted interventions aimed at expanding ICT infrastructure, enhancing transport networks and promote sustainable freshwater management can support regional development and mitigate migration pressures.

Study Limitations and Recommendations for Future Research

Despite the comprehensive nature of this study, several limitations must be acknowledged. First, reliance on secondary data from the World Bank may raise data quality issues, particularly for certain regions where data availability is limited or inconsistent. In addition, the study focuses primarily on quantitative analysis, which may overlook qualitative factors that also influence economic development and migration dynamics. Future research could benefit from incorporating qualitative methods, such as case studies or interviews, to gain deeper insights into the socio-economic contexts of specific regions.

Another limitation is the time frame of the analysis, which, although covering two decades, may not fully capture the rapid changes in ICT and transport. Future studies should consider more recent data and explore the impact of emerging technologies, such as artificial intelligence and big data analytics, on economic growth and migration trends.

In addition, this study primarily examines the direct relationships between variables without considering potential mediating or moderating factors that may influence these dynamics. Future research should examine the role of variables such as education, political stability, and economic policies as potential moderators of the relationships examined in this study.

Finally, future research should not only expand the geographic scope but also examine the complex interplay of qualitative and quantitative factors that shape regional development. By addressing these limitations and exploring new dimensions, subsequent studies can provide more nuanced recommendations to policymakers aimed at promoting sustainable economic growth and addressing migration challenges in a rapidly evolving global landscape.

References

Adedoyin, F. F., Bekun, F. V., Driha, O. M., & Balsalobre-Lorente, D. (2020). The effects of air transportation, energy, ICT and FDI on economic growth in the industry 4.0 era: Evidence from the United States. *Technological Forecasting and Social Change*, *160*, 120297. https://doi.org/10.1016/j.techfore.2020.120297

Akanbi, O. A. (2017). Impact of migration on economic growth and human development: Case of Sub-Saharan African countries. *International Journal of Social Economics*, *44*(5), 683-695. https://doi.org/10.1108/IJSE-07-2015-0190

Appiah-Otoo, I., & Song, N. (2021). The impact of ICT on economic growth-Comparing rich and poor countries. *Telecommunications Policy*, *45*(2), 102082. https://doi.org/10.1016/j.telpol.2020.102082

Arora, H. K. (2014). International Migration: Trends and Economic Benefits. *International Journal of Business & Economics Perspectives*, *9*(1).

Awad, A., & Albaity, M. (2022). ICT and economic growth in Sub-Saharan Africa: Transmission channels and effects. *Telecommunications Policy*, *46*(8), 102381. https://doi.org/10.1016/j.telpol.2022.102381

Balsalobre-Lorente, D., Driha, O. M., Bekun, F. V., & Adedoyin, F. F. (2021). The asymmetric impact of air transport on economic growth in Spain: fresh evidence from the tourism-led growth hypothesis. *Current issues in tourism*, *24*(4), 503-519. https://doi.org/10.1080/13683500.2020.1720624

Baltaci, N., Sekmen, O., & Akbulut, G. (2015). The relationship between air transport and economic growth in turkey: Cross-regional panel data analysis approach. *Journal of Economics and Behavioral Studies*, *7*(1 (J)), 89-100. https://doi.org/10.22610/jebs.v7i1(J).566

Duval, D. T. (2013). Critical issues in air transport and tourism. *Tourism geographies*, *15*(3), 494-510. https://www.tandfonline.com/doi/abs/10.1080/14616688.2012.675581

Fernández-Portillo, A., Almodóvar-González, M., & Hernández-Mogollón, R. (2020). Impact of ICT development on economic growth. A study of OECD European union countries. *Technology in Society*, *63*, 101420. https://doi.org/10.1016/j.techsoc.2020.101420

Keček, D., Boljunčić, V., & Milković, M. (2019). Effects of final expenditures on ICT goods and services on the Croatian domestic output and imports–the input-output approach. *Economic research-Ekonomska istraživanja*, *32*(1), 531-544. https://doi.org/10.1080/1331677X.2018.1556109

Kundzewicz, Z. W. (2007). Global freshwater resources for sustainable development. *Ecohydrology & Hydrobiology*, *7*(2), 125-134. https://doi.org/10.1016/S1642-3593(07)70178-7

Łukaniszyn-Domaszewska, K., Mazur-Włodarczyk, K., & Łukaniszyn, M. (2025). Unveiling the Interrelations Between Migration, Climate Change, and Energy Transitions in the Context of Socioeconomic Disparities. *Energies*, *18*(7), 1625. https://doi.org/10.3390/en18071625

Luong, T. A., & Nguyen, T. H. (2021). The impact of ICT on service trade. *The Singapore Economic Review*, *66*(04), 1073-1086. https://doi.org/10.1142/S021759082049003X

Nath, H. K., & Liu, L. (2017). Information and communications technology (ICT) and services trade. *Information Economics and Policy*, *41*, 81-87. https://doi.org/10.1016/j.infoecopol.2017.06.003

Nchake, M. A., & Shuaibu, M. (2022). Investment in ICT infrastructure and inclusive growth in Africa. *Scientific African*, *17*, e01293. https://doi.org/10.1016/j.sciaf.2022.e01293

Nechifor-Vostinaru, V. (2018). *Modelling freshwater resources use and the economic impacts of demand-driven water scarcity* (Doctoral dissertation, UCL (University College London)).

Nguyen, C. V. (2024). Air Transport Resilience, Tourism and Its Impact on Economic Growth. *Economies*, *12*(9), 236. https://doi.org/10.3390/economies12090236

Onifade, S. T., Gyamfi, B. A., Bekun, F. V., & Altuntaş, M. (2022). Significance of air transport to tourism-induced growth hypothesis in E7 economies: exploring the implications for environmental quality. *Tourism: An International Interdisciplinary Journal*, *70*(3), 339-353. https://doi.org/10.37741/t.70.3.1

Podra, O., Levkiv, H., Koval, G., Petryshyn, N., & Bobko, U. (2020). The impact of migration processes on the economy of Ukraine: Trends, reasons, consequences. *Journal of the Geographical Institute "Jovan Cvijic", SASA*, *70*(2), 171-179. https://doi.org/10.2298/IJGI2002171P

Pradhan, R. P., Arvin, M. B., & Nair, M. (2021). Urbanization, transportation infrastructure, ICT, and economic growth: A temporal causal analysis. *Cities*, *115*, 103213. https://doi.org/10.1016/j.cities.2021.103213

Rahman, H. U., Ali, G., Zaman, U., & Pugnetti, C. (2021). Role of ICT investment and diffusion in the economic growth: a threshold approach for the empirical evidence from Pakistan. *International Journal of Financial Studies*, *9*(1), 14. https://doi.org/10.3390/ijfs9010014

Raicu, S., Costescu, D., Popa, M., & Dragu, V. (2021). Dynamic intercorrelations between transport/traffic infrastructures and territorial systems: From economic growth to sustainable development. *Sustainability*, *13*(21), 11951. https://doi.org/10.3390/su132111951

Raihan, A., Muhtasim, D. A., Pavel, M. I., Faruk, O., & Rahman, M. (2022). Dynamic impacts of economic growth, renewable energy use, urbanization, and tourism on carbon dioxide emissions in Argentina. *Environmental Processes*, *9*(2), 38. https://doi.org/10.1007/s40710-022-00590-y

Rani, S. (2025). Land and Water Nexus: Exploring the Interplay of Resources in South Asia: An Introduction. In *Land and Water Nexus in South Asia* (pp. 1-48). Springer, Cham. https://doi.org/10.1007/978-3-031-87429-1_1

Rayevnyeva, O., Stryzhychenko, K., & Matúšová, S. (2023). Impact of Migration Processes on GDP. *Engineering Proceedings*, *39*(1), 86. https://doi.org/10.3390/engproc2023039086

Rock, M. T. (1998). Freshwater use, freshwater scarcity, and socioeconomic development. *The Journal of Environment & Development*, *7*(3), 278-301. https://doi.org/10.1177/107049659800700304

Shodiev, T., Turayey, B., & Shodiyev, K. (2021). ICT and economic growth nexus: Case of central Asian countries. *Procedia of Social Sciences and Humanities*, *1*, 155-167. https://doi.org/10.21070/pssh.v1i.37

Tee, B. A., Tham, S. Y., & Kam, A. J. Y. (2020). The role of ICT in ASEAN-5's services exports: A panel study. *Malaysian Journal of Economic Studies*, *57*(1), 1-19. https://doi.org/10.22452/MJES.vol57no1.1

Wilson, M. A., & Carpenter, S. R. (1999). Economic valuation of freshwater ecosystem services in the United States: 1971–1997. *Ecological applications*, *9*(3), 772-783. https://doi.org/10.1890/1051-0761(1999)009[0772:EVOFES]2.0.CO;2

Yao, S., & Yang, X. (2012). Air transport and regional economic growth in China. *Asia-Pacific Journal of Accounting & Economics*, *19*(3), 318-329. https://doi.org/10.1080/16081625.2012.667458

Yarde, K., & Zhang, C. (2024). Socio-economic Impact of Air Connectivity. In *Strategies for Sustainable Air Services Development* (pp. 23-44). Routledge. https://doi.org/10.4324/9780429260681-2

Zhang, F., & Graham, D. J. (2020). Air transport and economic growth: a review of the impact mechanism and causal relationships. *Transport Reviews*, *40*(4), 506-528. https://doi.org/10.1080/01441647.2020.1738587

.