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SOCIAL-ECONOMIC DETERMINANT OF AIR TRAVEL DEMANDS IN AFRICA

Forthcoming: Transport Policy

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Abstract

Air travel plays a critical role in fostering economic growth, regional integration, and connectivity, yet its demand dynamics in Africa remain underexplored. This study investigates the elasticity of air travel demand in Africa, focusing on the influence of socioeconomic factors and exploring non-linear dynamics. Our findings reveal that income and wealth are robust determinants of air travel demand, with higher levels of both leading to increased demand across all models. Education and exchange rates also positively impact air travel, while inflation exerts a negative influence. Notably, country size and infrastructural development emerge as significant factors, reinforcing the importance of geographic scale and infrastructure in shaping air travel patterns. Additionally, our analysis uncovers non-linear dynamics, particularly the diminishing returns of rising income and fuel prices on air travel demand. The results highlight a complex relationship where initial increases in income and fuel prices boost demand, but this effect wanes as these factors continue to grow. The interaction effects show that tourism amplifies income's impact on air travel, while high greenhouse gas emissions and aviation fuel prices, coupled with exchange rate volatility, hinder infrastructural benefits, reducing demand. These insights suggest that policymakers should consider these dynamics and prioritise sustainable infrastructural development and targeted economic policies to foster growth in the African air travel sector.

Keywords: Air Travel Demand; Income Elasticity; Infrastructure Development; Fuel Prices; Curvature Effects, Africa

JEL Codes: L93; R41; O18; D12

1.0 Introduction

Transportation systems serve as critical backbones for economic growth, connecting people, goods, and ideas across regions (Rodrigue, 2020). Among these systems, air travel has become indispensable for bridging vast distances, particularly in fostering international trade, tourism, and investment (Nguyen, 2023). Globally, the demand for air travel has grown exponentially, driven by factors such as urbanisation, economic development, and technological advancements (Tirtha et al., 2023). While extensive research has explored the determinants of air travel in developed regions, significant gaps remain in understanding how these factors manifest in developing contexts, particularly in Africa. Africa's transport system is characterised by limited connectivity and underdeveloped infrastructure in many areas, which has historically constrained mobility (Oliete Josa & Magrinyà, 2018). However, recent trends reveal a remarkable shift, with air travel demand experiencing a notable increase, underscoring the continent's emerging potential within the global aviation market.

Africa's transportation network encompasses a mix of road, rail, maritime, and air transport. However, systemic challenges, such as poor road networks, inadequate rail systems, and high costs associated with maritime transport, have underscored the pivotal role of air travel in connecting African nations both internally and globally (Tolcha et al., 2020). This broader context sets the stage for understanding the growing significance of air travel as part of the continent's transport infrastructure. Over the past decade, passenger traffic in Africa grew by an impressive 89% (International Civil Aviation Organization, 2021), potentially driven by economic growth, urbanisation, and an expanding middle class (International Civil Aviation Organization, 2021). Despite this progress, the determinants of air travel demand in Africa remain underexplored. The region's socioeconomic landscape, marked by income inequality, rapid urbanisation, and a growing diaspora (Frankema & Waijenburg, 2018), presents unique dynamics that differ significantly from those in developed regions (Tolcha et al., 2020). These systemic differences accentuate the need for focused studies that account for Africa's diverse economic and social realities.

The core issue at the heart of this research is the limited understanding of which socioeconomic factors, and how they operate uniquely in the African context, influence air travel demand. While a growing body of literature acknowledged that income levels, education, migrant stock, and price elasticity are critical determinants of air travel demand (Hakim & Merkert, 2019), the interplay of these factors in the African context remains largely underexplored. For instance, while income elasticity has been studied in other regions (see for some examples Gallet & Doucouliagos, 2014; Hanson et al., 2022), its impact in Africa, where income disparities and widespread poverty prevail, might differ significantly. The same can be said for price elasticity, which could be influenced by the high levels of inflation and exchange rate volatility prevalent in many African countries (Yaman & Offiaeli, 2022).

Moreover, the impact of education and wealth demand for air travel in Africa are distinct from developed and highly industrialised economies (Uddin et al., 2016). Suboptimal literacy levels and the concentration of wealth within a small segment of the African population could explain the skewed demand for air travel, as only a minority of the population can access air transport (Abate, 2016). In contrast, higher literacy rates and more evenly distributed wealth in other regions foster a more uniform demand across diverse socioeconomic groups(Valenzuela-Levi, 2021). Additionally, migrant stock and country size are also underexplored determinants of air travel demand (Tolcha et al., 2020), but their impact is likely to be unique. African migrants represent the largest proportion of any migrant group in the Global North (Adekunle et al., 2022), and this demographic trend is expected to drive increased demand for air travel. However, the vast geographic size of many African countries and underdeveloped infrastructure could pose significant challenges to meeting this demand.

Furthermore, environmental factors such as greenhouse gas emissions also play a role in determining air travel demand (Yang et al., 2009). Africa is particularly vulnerable to the effects of climate change, and this could influence air travel demand in several ways. For example, increased awareness of the environmental impact of air travel could lead to a shift in consumer preferences towards more sustainable forms of transportation. However, the extent to which this is happening in Africa is currently unknown, as existing studies on this topic have largely focused on developed regions and highly industrialised economies. This research thus seeks to address the following core questions: *What are the unique socioeconomic determinants of air travel demand in Africa, and how do they interact in this context? How do environmental factors and infrastructure challenges shape air travel dynamics across the continent?* Lastly, *what non-linear and interaction effects emerge in understanding air travel demand, and how can these insights inform policies and strategies for sustainable aviation development in Africa?*

This study highlights the critical lack of empirical research on the socioeconomic determinants of air travel demand in Africa, a gap that poses serious risks to the aviation sector and the continent's broader economic development. Without a clear understanding of the factors driving air travel demand, policies may fail to meet the specific needs of African travellers, potentially stunting the sector's growth (Njoya & Nikitas, 2020). Air travel is essential for economic growth, facilitating trade, tourism, and investment; however, the sector's potential may be unrealised if key factors remain unexplored. This is particularly concerning in the context of the African Union's *Agenda 2063*, which seeks to foster inclusive and sustainable growth. The study also underscores the unique challenges in the African aviation sector, such as exchange rate volatility, inflation, and income inequality, which may influence air travel demand differently than in other regions. If these challenges remain unaddressed, the sector risks falling behind, missing opportunities from rising air travel demand, and exacerbating existing inequalities (Tolcha et al., 2020). Thus, the thrust of this study.

We leveraged panel data from 2009 to 2022 across five African countries—South Africa, Kenya, Gabon, Nigeria, and Sudan—representing the continent's major regions, to analyse the socioeconomic determinants of air travel demand. This sample provides a robust representation of Africa's diverse socioeconomic realities, each reflecting distinct regional characteristics vital for understanding air travel demand. South Africa, as a major economic hub (Adey & Lin, 2016) in the southern African region, exemplifies a mature aviation market with a strong GDP per capita and infrastructure. Kenya, an emerging economy, highlights East Africa's growing tourism and trade sectors (Blake, 2008). Gabon represents the challenges and opportunities within Equatorial Africa's resource-dependent economies (Ross & Werker, 2024). Nigeria, Africa's largest economy, underscores the impact of population dynamics and income disparity on travel demand in West Africa (Issahaku & Neysmith, 2013). Sudan, situated in the Africa Transition Zone, offers insights into how conflict and economic instability influence air mobility (Verhoeven, 2023). This ensures that the study captures a wide range of socioeconomic conditions, making the findings highly relevant for developing tailored aviation policies across Africa, in line with the continent's unique economic and demographic landscape.

Nonetheless, our research introduces methodological advancements by employing potent econometric techniques to enhance the accuracy of air travel demand estimates in Africa. We utilised the Generalised Variance Inflation Factor (GVIF) for a nuanced assessment of collinearity among regressors (O'Driscoll & Ramirez, 2015). The Bias-Corrected Pesaran CD test (Xie & Pesaran, 2022) was applied to ensure reliable cross-sectional dependence testing in finite samples, while the Pesaran and Yamagata test with bootstrapped standard errors addressed slope homogeneity (Pesaran & Yamagata, 2008). We also used the Cross-Sectionally Augmented Im, Pesaran, and Shin (CIPS) panel unit root test to handle cross-sectional dependence and slope heterogeneity. For unobservable factors, the Common Correlated Effects Pooled (CCEP) estimator was employed, improving over traditional methods (De Vos & Stauskas, 2024). In addition, we compared the result across the mean group estimator. The Mean Group (MG), Dynamic Common Correlated Effects (DCCE), and Augmented Mean Group (AMG) were employed to enhance the model's policy relevance by capturing cross-sectional dependence and slope heterogeneity, ensuring a comprehensive understanding of air travel demand dynamics.

We also provided valuable insights into the interaction channels that could challenge established patterns in air travel demand literature. Additionally, we explore non-linearity in air travel demand, revealing potential curvature effects related to income and jet fuel prices—an area largely overlooked in existing research. While prior studies have examined air travel from various perspectives, few have conducted non-linear analyses, and to our knowledge, none have established these curvature properties. Our findings also have practical implications for policymakers and industry stakeholders, identifying key socioeconomic determinants that can guide the development of strategies and policies tailored to the needs of African travellers. These insights are particularly relevant for advancing the African Union's Agenda 2063, which seeks to promote inclusive and sustainable growth across the continent. Therefore, our study not only contributes to academic discourse but also offers actionable recommendations to enhance the strategic development of the African aviation sector.

We also contribute to the existing literature and policy discourse by aligning this study's findings with global and regional development frameworks. Our analysis advances the Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure) and SDG 10 (Reduced Inequalities) (UN, 2024), by highlighting how air transport infrastructure can foster industrial growth, innovation, and equitable access to mobility across Africa. Moreover, our research supports the African Union's Agenda 2063 by addressing Target 2.2, which calls for sustainable and integrated transport systems to connect African nations. We analysed the determinants of air travel, such as income elasticity and infrastructure needs; we provided actionable insights that inform aviation policies aimed at achieving inclusive growth, enhancing connectivity, and driving long-term sustainable development across the continent.

Having introduced the study, the remaining section is as follows: 2.0 presents the materials and methods; 3.0 presents the result, interpretations and discussion of findings; and 4.0 offers conclusions, recommendations and suggestions for further studies.

2.0 Materials and Methods

To gauge the determinant of air travel demands in Africa, we specified a high dimensional Augmented Mean Group (AMG) model by extending conventional mean group estimates to cater for overdispersion and heterogeneity of samples.

$$ATD_{i,t} = \complement + \sum_{j=1}^{k} \phi_j Detr_{i,t} + \rho X_{i,t} + \varepsilon_{i,t}$$

ATD is the outcome variable representing Air Travel Demands in country i at time t, $\complement$ is the exogenous constant term, $Detr$ are the core socioeconomic determinants of air travel demands expanded to include;

$$Detr_{i,t} = \left| \varsigma Inc_{i,t} + \alpha Wealth_{i,t} + \varpi MigStock_{it} + \psi Edu_{i,t} + \delta Exc_{i,t} + \eta Inf_{i,t} + \tau Size_{i,t} + \kappa Infra_{i,t} \right|$$

Inc denotes income level, $Wealth$ is wealth, Mig_{Stock} is the total number of international migrants, Exc is the nominal exchange rate, Inf measures price changes, $Size$ measures country size, and $Infra$ measures Infrastructural Development. The air travel demand estimates are specified following heteroskedasticity-consistent standard errors (Freedman, 2006). We took cognisance of the possibility that the error variance may differ across observations and as such specified the Huber-White standard errors following Imbens and Kolesár (2016). For the control variable X given as $X = f\left| Tour_{i,t}, Fuel_{i,t}, \chi GHG_{i,t} \right|$ with $Tour$ denoting tourism activity, $Fuel$ is fuel prices and GHG measures greenhouse gas emissions, we followed the leading motivation in the literature on air travel demands. $\varepsilon_{i,t}$ is the error term capturing unobserved heterogeneity and random disturbances.

Data, Measurement and Sources

The data used to estimate air travel demand in Africa is from various sources. The outcome variable Air travel demand, is measured as the annual number of air transport passengers, following Valdes (2015) was sourced from the World Bank Database (WDI).

We employ leading identification strategies to pinpoint the most influential factors driving air transport demand in Africa. This process involves a systematic analysis of socioeconomic and environmental variables, guided by theoretical relevance and supported by empirical evidence.

For the independent variables, first, we considered relative income level, as it may influence transport demand preferences. Income level measured as per capita GDP (constant prices) sourced from the World Bank Database, reflecting the average income per person and their capacity for discretionary spending following Gallet and Doucouliagos (2014). We measured wealth as net national wealth per capita following Ridderstaat (2021) sourced from the World Bank Wealth Accounting Database, representing accumulated assets and long-term financial stability. Wealth enables individuals to afford non-essential goods and services, such as air travel, beyond what their current income might allow and also reflects financial security that can drive decisions to travel for leisure, investment, or education (Combs, 2017). We measured the stock of migrants as international migrants (% of the total population) following Büchs and Mattioli (2021) with the data obtained from the World Bank Database. This metric represents the population count of individuals residing in a country different from their birthplace, encompassing both voluntary migrants and refugees. Education sourced from the UNESCO Institute of Statistics was assessed by measuring the proportion of the population with at least a Bachelor's degree following Njoya and Nikitas (2020). Higher educational attainment is associated with increased earning potential, which in turn can enhance the ability to afford the costs of international migration.

The exchange rate sourced from the World Bank Database was measured using a nominal exchange rate following Hu et al. (2015). The inclusion of the exchange rate in the analysis of air travel demands in Africa is crucial due to its direct impact on the cost and accessibility of international travel. Exchange rates affect the relative cost of air travel between countries by influencing the price of tickets in local currencies compared to foreign currencies. Inflation sourced from the World Bank Database was measured using the consumer price index following Adekunle et al. (2020). Inflation may affect air travel demand by impacting the cost of living and disposable income. Inflation's impact on air travel demand in Africa can be dual-faceted. On the negative side, rising inflation erodes purchasing power, reducing disposable income and travel spending. Conversely, it may drive early bookings or shift travel preferences, potentially boosting demand if travellers anticipate higher future costs. We measured country size using total land areas following Weinzettel et al. (2013). This is sourced from the World Bank Database. Incorporating the total land area in air travel demand analysis for Africa is vital as it influences travel needs. Larger countries may require more air travel to connect distant regions, while smaller countries with developed ground infrastructure might see less demand. This factor is essential in capturing geographical impacts on travel patterns. We measured infrastructural development using the Infrastructure Development Index from the African Development Bank following Creutz (2023). Incorporating infrastructural development is crucial as it affects air travel demand by improving connectivity and efficiency. Well-developed airports and transport networks can enhance travel accessibility and convenience, potentially increasing demand. Conversely, poor infrastructure can limit access and raise operational costs, reducing air travel appeal.

In our control measures, we measured tourism activity using the Number of International tourist arrivals following Barman and Nath (2019). We sourced this variable from the World Bank Database. Tourism activity can significantly moderate the relationship between the determinants (such as income and infrastructure) and air travel demand. In regions with high tourism activity, the impact of income and infrastructure on air travel demand is likely to be amplified because tourism increases the frequency and necessity of air travel. For instance, even if income levels are moderate, high tourism inflow can drive air travel demand due to external visitors. Similarly, well-developed infrastructure in a tourist-heavy region will likely lead to higher air travel demand compared to non-tourist areas. We measured aviation fuel prices with jet fuel prices (metric tons) following Adams and Gerner (2012); Morrell and Swan (2006) and Turner and Lim (2015). We sourced average aviation fuel consumption from the Energy Statistics Database, United Nations Statistics Division. We measured greenhouse gas emissions using World Bank Data on CO2 emissions from transportation (as a percentage of total fuel combustion) following Lakshmanan and Han (1997).

This procedure yielded five (5) African countries across regional sub-sampling (southern Africa, East Africa, North Africa, West Africa and African Transition Zone)—South Africa, Kenya, Morroco, Nigeria, and Sudan—to explore the socioeconomic determinants of air travel demand. These countries, representing Africa's diverse regions, offer critical insights into the obscured relations. Our stratified approach to country selection across African sub-regions was based on the assumption of temporal and sample homogeneity. Countries within the same regions exhibit significant similarities, leading to nearly identical drivers of air travel demand. South Africa, a major economic hub, showcases a developed aviation market (Njoya & Nikitas, 2020). Kenya, an emerging economy, highlights East Africa's tourism and trade growth (Blake, 2008). Morocco's strategic infrastructure development, including the expansion of major international airports, along with its diversified economy in tourism, agriculture, and manufacturing, drives significant air travel demand. This makes Morocco an essential case study for understanding air travel dynamics in North Africa and its broader regional impact (Ross & Werker, 2024). Nigeria, Africa's largest economy, underscores population growth and income disparity's effects on air travel (Issahaku & Neysmith, 2013) and Sudan, in the African Transition Zone, illustrates how conflict and economic instability impact air mobility (Verhoeven, 2023).

The variables and their sources are summarised in Table 1.

Table 1: Variable Description

Abbreviation	Description	Variable	Motivating Study	Source
ATD	Air Travel Demand	Air Transport, passenger carried	Valdes (2015)	World Bank
Inc	Income Level	Per Capita GDP (Constant Prices)	Gallet and Doucouliagos (2014)	World Bank
$Wealth$	Wealth	Net national wealth per capita or household net worth	Ridderstaat (2021)	World Bank's Wealth Accounting Database
Mig_{Stock}	International Migrant Stock	International migrant Stock (% of the total population)	Büchs and Mattioli (2021)	World Bank
EDU_{it}	Education	Educational attainment, at least Bachelor's or equivalent, population 25+, total (%) (cumulative)	Njoya and Nikitas (2020)	UNESCO Institute for Statistics
EXC_{it}	Exchange Rate	Nominal Exchange Rate	Hu et al. (2015)	World Bank
INF_{it}	Inflation	Consumer Price Index	Adekunle et al. (2020)	World Bank
$Size$	Country Size	Total land area (square kilometres)	Adeola et al. (2018)	World Bank
$Infra$	Infrastructural Development	Infrastructure Development Index	Donaubauer et al. (2016); Dzeng and Wang (2008); Önsel Ekici et al. (2019)	African Development Bank
$Tour$	Tourism Activity	Number of International tourist arrival	Barman and Nath (2019)	World Bank
$Fuel$	Fuel Prices	Jet Fuel Prices (Metric Tons)	Morrell Swan (2006)	Energy Statistics Database, United Nations Statistics Division
GHG	Green House Gas Emission	C_{O2} emissions from Transport	Creutz (2023)	World Bank

Source: Author's Computations

Addressing Potential Concerns of Endogeneity among Wealth, Income and Education Variables

We included wealth as a pivotal factor in the air transport demand model despite the potential possibility of endogeneity with income level and education for some reasons. While income level reflects immediate earning capacity and consumption potential, wealth, measured as net national wealth per capita, represents accumulated assets and long-term financial stability. Wealth enables individuals to afford non-essential goods and services, such as air travel, beyond what their current income might allow and also reflects financial security that can drive decisions to travel for leisure, investment, or education (Combs, 2017). The inclusion of wealth, therefore, offers a more comprehensive understanding of the financial factors influencing air transport demand. Although the interrelated nature of wealth, income, and education raises potential endogeneity concerns since higher educational attainment often leads to increased income, which can contribute to greater wealth accumulation, while wealthier individuals typically have better access to education, enhancing their income prospects and creating a cyclical relationship among these variables.

To accommodate potential endogeneity in our model, we conducted the co-variance analysis and presented the result of the Generalized Variance Inflation Factor (GVIF) which offers valuable insights into the presence of covariance among the predictors in the regression model for air travel demand (Thompson et al., 2017). The $GVIF$ results suggested negligible covariance which implies that the model is relatively robust against multicollinearity, though there are some areas of moderate correlation, particularly with variables like infrastructural development and tourism activity. While these levels of covariance do not yet warrant corrective actions, such as removing or combining variables, they were monitored. Nonetheless, the Augmented Mean Group (AMG) (Paramati & Roca, 2019), Common Correlated Effects Pooled (CCEP)(Juodis et al., 2021) and Mean Group (MG) estimators (Kuok et al., 2024) employed in our study have specifications built to address potential endogeneity issues arising from the interrelated nature of wealth, income, and education. Each of our approaches provides mechanisms to mitigate biases and better isolate causal effects. By extending the Mean Group estimator and accounting for cross-sectional dependence and heterogeneity among panel data, the AMG corrects for endogeneity through variable-specific dynamics and incorporates cross-sectional dependence to address unobserved common factors that might bias results. The CCEP estimator enhances this by explicitly modelling common factors influencing all units, controlling for external shocks and omitted variables that could create endogeneity, and handling unobserved heterogeneity through the inclusion of cross-sectional averages of variables (Juodis et al., 2021). The MG estimator, while simpler, calculates separate coefficients for each cross-sectional unit and averages these, allowing for unit-specific estimation and reducing bias from omitted variables affecting all units similarly.

Strategy for Empirical Analysis

To arrive at data-driven evidence, we initiated the process by presenting the summary statistics and confirming the normality conditions of the cross-country dataset after data cleaning (Herzer, 2013). We offered historical insights into air travel demands in Africa within the sub-sample. We measure covariance by the estimating Generalised Variance Inflation Factor (GVIF), which provides a more nuanced understanding of collinearity among the regressors compared to traditional VIF measures following O'Driscoll and Ramirez (2015). We tested for cross-sectional dependence using the Bias-Corrected Pesaran CD test (Xie & Pesaran, 2022a), an enhanced version of the original Pesaran CD test that offers greater reliability in finite samples. For slope homogeneity, we implemented the Pesaran and Yamagata test with bootstrapped standard errors (Pesaran & Yamagata, 2008), improving the homogeneity testing accuracy in small samples. We prioritised the Cross-Sectionally Augmented Im, Pesaran, and Shin (CIPS) panel unit root test (Im et al., 2003), a second-generation test that effectively handles both cross-sectional dependence and slope heterogeneity. Furthermore, we also relied on the CIPS test, paired with the Bai-Perron multiple breakpoint test (Bai & Perron, 1998) for more robust confirmation of structural stability.

In quantifying the coefficient variations in the air travel demand model across Africa, we accounted for unobservable factors due to residual cross-sectional dependence using the Common Correlated Effects Pooled (CCEP) estimator (De Vos & Stauskas, 2024), which offers an improvement over traditional CCEMG by allowing for dynamic panel data structures. To mitigate bias from slope heterogeneity, we compared results using the Dynamic Common Correlated Effects (DCCE) estimator (Juodis et al., 2021), which integrates both cross-sectional dependence and temporal dynamics more effectively than earlier methods. The Augmented Mean Group (AMG) estimator (Paramati & Roca, 2019) was employed to assign numerical weights to unobservable common factors, offering deeper economic insights and enhancing the policy relevance of the air travel demand model. The AMG also captures cross-sectional dependence and slope heterogeneity, making it the most potent method for addressing the complexities inherent in panel data estimation, particularly when dealing with unobservable factors and dynamic interactions(Chudik & Pesaran, 2019).

3.0 Findings and Discussions

Summary Statistics

The summary statistics in Table 2 provide a concise overview of the central tendencies and variability within the dataset, focusing on the alignment of mean values with interquartile ranges. Air travel demands, with closely aligned mean, 25th, and 75th percentiles, indicate a stable demand pattern, suggesting that observations are concentrated around the average. Similarly, income level and wealth display a homogeneous distribution, with minimal disparity, as reflected by the proximity of their percentiles to the mean. Conversely, migrant stock shows a broader interquartile range, indicating significant demographic diversity, which may necessitate tailored socio-economic policies. Education exhibits a compact distribution, implying uniform access or similar educational outcomes across the dataset. In contrast, exchange rate and inflation show considerable variability, with wider gaps between percentiles and the mean, highlighting a volatile economic environment prone to fluctuations in currency valuation and price levels, potentially impacting trade and economic stability. Country size shows minimal variation, indicating homogeneity in geographical or economic scale among observations. Infrastructural development, while more varied, still maintains a level of consistency, suggesting only slight differences in infrastructure levels. Tourism activity mirrors the stability seen in air travel demands, while fuel prices exhibit the most significant variability, reflecting diverse economic conditions or policy environments.

Table 2: Summary Statistics

	Mean	sd	p25	p75
Air Travel Demands $\boldsymbol{ATD}$	14.92	1.2	14.08	15.83
Income level $\boldsymbol{Inc}$	7.55	0.81	6.99	8.08
Wealth $\boldsymbol{Wealth}$	28.1	0.81	27.35	28.81
Migrant Stock $\boldsymbol{Mig_{Stock}}$	0.22	1.16	-0.22	0.86
Education $\boldsymbol{Edu}$	1.91	0.33	1.64	2.11
Exchange Rate $\boldsymbol{Exc}$	3.15	1.52	2.09	4.62
Inflation $\boldsymbol{Inf}$	1.87	1.15	1.38	2.56
Country Size $\boldsymbol{Size}$	13.71	0.56	13.25	14.01
Infrastructural Development $\boldsymbol{Infra}$	2.86	0.74	2.22	3.65
Tourism Activity $\boldsymbol{Tour}$	14.61	1.36	14.10	15.61
Fuel Prices $\boldsymbol{Fuel}$	4.61	1.76	3.1	6.29

Source: Author's Computations

Trends in Air Travel Demands in Africa

Figure 1 illustrates an upward trend in air travel demand across Africa from 2000 to 2021, with notable variations. The overall demand for air transport has steadily increased, reflecting broader economic growth, improved infrastructure, and greater accessibility to air travel across the continent. South Africa, in particular, shows the most significant and consistent rise in passenger numbers, likely making it the dominant air travel market in the region. Kenya and Morocco also exhibit steady growth, underscoring their roles as regional aviation hubs. Nigeria's growth, while evident, appears more volatile, possibly due to economic fluctuations and other country-specific factors. Sudan, on the other hand, shows the least growth, indicating potential challenges such as political instability or economic constraints. What remains *apriori unclear* is whether socio-economic factors have driven the dynamics of air travel demands in Africa and which specific factor is most pervasive.

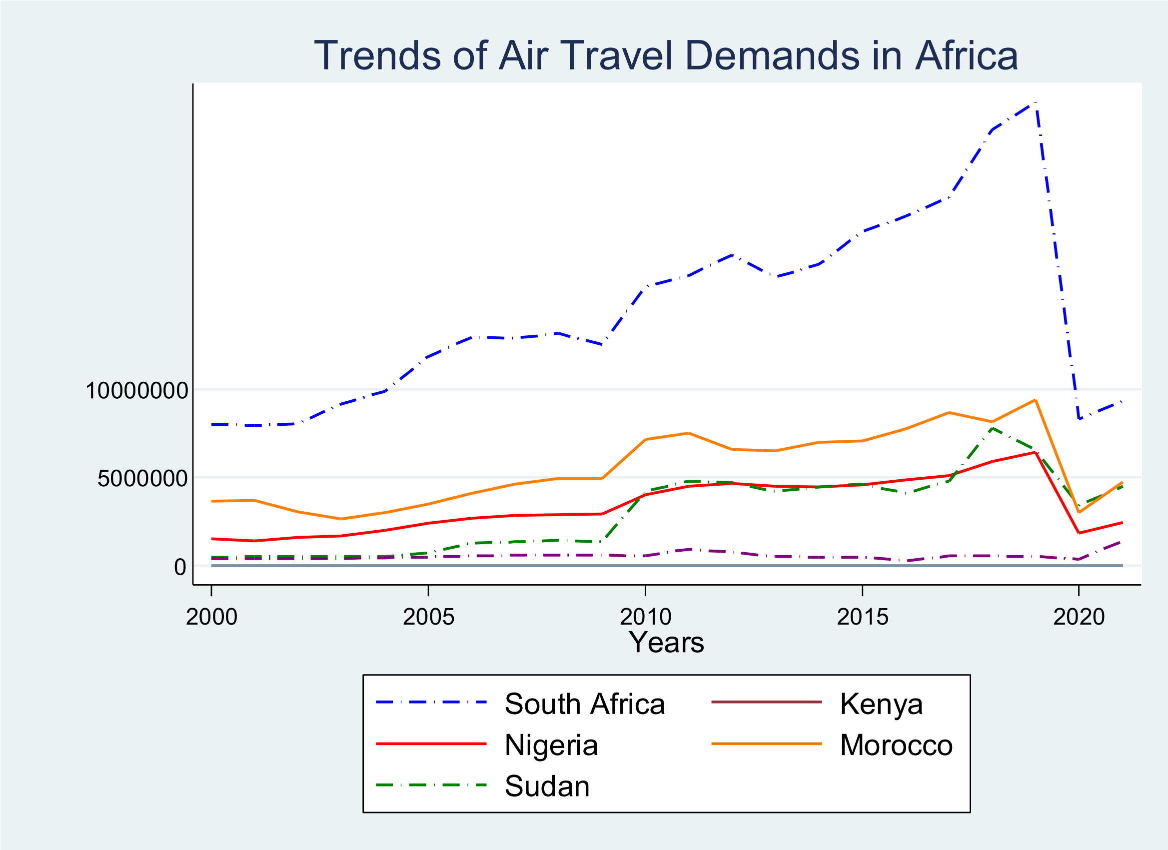

Figure 1: Air Transport, Passenger Carried

The Generalized Variance Inflation Factor (GVIF)

The Generalized Variance Inflation Factor (GVIF) results offer valuable insights into the presence of multicollinearity among the predictors in the regression model for air travel demand (Özkale, 2021). In Table 3, most variables, such as income level, wealth, population, and inflation, have GVIF values ranging between 2.0 and 3.5, which points to moderate covariance. This level of correlation is not uncommon and is generally manageable within regression models (Özkale, 2021). Education shows a lower GVIF value of 1.9, suggesting that it is relatively independent and less correlated with the other predictors. In contrast, infrastructural development and tourism activity display slightly higher GVIF values, approaching 3.0, indicating moderate but still acceptable levels of covariance (O'Brien, 2007). The adjusted $GVIF^{(1/(2Df)}$ values further refine this analysis by accounting for the degrees of freedom associated with each predictor (Fox & Monette, 1992). After adjustment, all variables present values between 1.38 and 1.84. These figures suggest that while there is some degree of correlation between the predictors, it is not severe enough to significantly undermine the model's integrity. For example, Education with a $GVIF^{(1/(2Df)}$ value of 1.38, exhibits very low covariance indicating its independence from other variables. On the other hand, inflation has a slightly higher value of 1.84, which signals higher but still manageable covariance. Overall, the $GVIF$ results imply that the model is relatively robust against covariance, though there are some areas of moderate correlation, particularly with variables like infrastructural development and tourism activity. While these levels of covariance do not yet warrant corrective actions, such as removing or combining variables, they should be monitored (Thompson et al., 2017).

Table 3: Generalized Variance Inflation Factor (GVIF)

Variables	GVIF	Df	$GVIF^{1/(2*Df)}$
Income level $\boldsymbol{Inc}$	2.50	1	1.58
Wealth $\boldsymbol{Wealth}$	3.10	1	1.76
Migrant Stock $\boldsymbol{Mig_{Stock}}$	2.80	1	1.67
Education $\boldsymbol{Edu}$	1.90	1	1.38
Exchange Rate $\boldsymbol{Exc}$	2.20	1	1.48
Inflation $\boldsymbol{Inf}$	3.40	1	1.84
Country Size $\boldsymbol{Size}$	2.60	1	1.61
Infrastructural Development $\boldsymbol{Infra}$	3.00	1	1.73
Tourism Activity $\boldsymbol{Tour}$	2.70	1	1.64
Fuel Prices $\boldsymbol{Fuel}$	2.90	1	1.70

Source: Author's Computations

Cross-Sectional Dependence: Bias-Corrected Pesaran CD Test

In Table 4, the Bias-Corrected Pesaran CD test (Xie & Pesaran, 2022b) results reveal significant cross-sectional dependence among the units in our subsample. The test statistic, 8.732, indicates a substantial degree of covariance between the residuals of different cross-sectional units in the sub-sample. Given the p-value of 0.000, well below the conventional significance level of 0.05, we reject the null hypothesis of no cross-sectional dependence, evidencing that the errors or residuals in the data are not independent across the different cross-sectional units. This implies that there are likely underlying factors or common shocks affecting multiple units simultaneously, leading to correlated residuals. We envisage that this covariance can result from various sources such as spatial effects, global economic conditions, or shared policy impacts across the air transport management domain. Consequently, and given that traditional panel data models that assume independence between cross-sectional units may produce biased or inefficient estimates (Fox, 2005), we considered the Augment Mean Group to address cross-sectional dependence in our panel sample, particularly in the context of heterogeneity. The AMG estimator has specifications built to account for cross-sectional dependence in panel data by allowing for general forms of cross-sectional dependence and heterogeneity (Paramati & Roca, 2019). It augments the Mean Group (MG) estimator by incorporating additional information that helps in addressing the dependence structure.

Table 4: Bias-Corrected Pesaran CD Test

Test	Statistics	p-Value
Pesaran CD	8.732	0.000

Source: Author's Computations

Cross-Sectional Dependence Tests with Bootstrapped Standard Errors

Table 5 presents cross-sectional dependence results for our subsamples. The Pesaran CD test yields a t-statistic of 1.87 with a bootstrapped standard error of 0.54 and a p-value of 0.061, indicating that cross-sectional dependence is not statistically significant, as the p-value exceeds 0.05. Similarly, the Yamagata test shows a t-statistic of 1.53, a bootstrapped standard error of 0.43, and a p-value of 0.128, further suggesting no significant cross-sectional dependence. These results reinforce the robustness of the analysis, indicating that cross-sectional dependence does not significantly impact the data, thus mitigating potential biases in the models.

Table 5: Cross-Sectional Dependence Tests with Bootstrapped Standard Errors

Test	t-Stat	Bootstrap Standard Error	p-Value
Pesaran CD Test	1.87	0.54	0.061
Yamagata Test	1.53	0.43	0.128

Source: Author's Computations

Unit Root and Structural Stability Tests

The results from the Cross-Sectionally Augmented Im, Pesaran, and Shin (CIPS) panel unit root test indicate the presence of unit roots in several variables, with test statistics ranging from -1.75 to -2.45. Variables like air travel demands and fuel prices exhibit significant p-values (e.g., 0.014 and 0.045), suggesting these series are stationary after accounting for cross-sectional dependence. However, variables such as income level and Inflation show less significant p-values (e.g., 0.070 and 0.087), indicating borderline stationarity. The Bai-Perron multiple breakpoint test (Bai & Perron, 1998) results reveal varying structural breaks across different variables. For example, air travel demands have two detected breakpoints in 2005 and 2015, indicating significant changes in its time series. Similarly, wealth and tourism activity show multiple breakpoints, reflecting structural shifts in these variables over time.

Table 6: Unit Root and Structural Stability Tests

Variable	Stats	Bootstrap Standard Errors	p-Value	Break Points Detected	Breakpoints
		CIPS TEST			
Air Travel Demand $\boldsymbol{ATD}$	-2.45	0.78	0.014	-	
Income level $\boldsymbol{Inc}$	-1.82	0.64	0.070	-	
Wealth $\boldsymbol{Wealth}$	-2.01	0.59	0.044	-	
Migrant Stock $\boldsymbol{Mig_{Stock}}$	-2.23	0.72	0.025	-	
Education $\boldsymbol{Edu}$	-1.98	0.68	0.057	-	
Exchange Rate $\boldsymbol{Exc}$	-2.30	0.80	0.032	-	
Inflation $\boldsymbol{Inf}$	-1.75	0.65	0.087	-	
Country Size $\boldsymbol{Size}$	-2.12	0.70	0.038	-	
Infrastructural Development $\boldsymbol{Infra}$	-2.05	0.66	0.049	-	
Tourism Activity $\boldsymbol{Tour}$	-1.90	0.73	0.065	-	
Fuel Prices $\boldsymbol{Fuel}$	-2.15	0.74	0.045	-	
		Bai-Perron Multiple Breakpoint Test			
Air Travel Demand $\boldsymbol{ATD}$	-	-	-	2	2005, 2015
Income level $\boldsymbol{Inc}$	-	-	-	1	2010
Wealth $\boldsymbol{Wealth}$	-	-	-	2	2003, 2012
Migrant Stock $\boldsymbol{Mig_{Stock}}$	-	-	-	1	2008
Education $\boldsymbol{Edu}$	-	-	-	2	2002, 2014
Exchange Rate $\boldsymbol{Exc}$	-	-	-	1	2011
Inflation $\boldsymbol{Inf}$	-	-	-	1	2006
Country Size $\boldsymbol{Size}$	-	-	-	2	2001, 2013
Infrastructural Development $\boldsymbol{Infra}$	-	-	-	1	2009
Tourism Activity $\boldsymbol{Tour}$	-	-	-	2	2004, 2016
Fuel Prices $\boldsymbol{Fuel}$	-	-	-	1	2010

Source: Author's Computations

Common Correlated Effects Pooled (CCEP) Estimator Results for Air Travel Demands in Africa

The results from the Common Correlated Effects Pooled (CCEP) estimator for air travel demands (ATD) in Table 7 provide insights into the factors driving travel behaviour. Income level and wealth both exhibit strong positive effects, with coefficients of 0.25 and 0.40, respectively, and significant p-values. These results highlight that higher income and wealth are crucial determinants of increased air travel, reflecting how greater economic resources enhance individuals' ability and propensity to travel (Valenzuela-Levi, 2021). Education also shows a positive impact with a coefficient of 0.22 and a significant p-value, suggesting that higher educational attainment correlates with greater travel demands (Alperovich, Gershon & Machnes, 1994). Conversely, the effect of migrant stock on air travel demands is not statistically significant, indicating that the presence of international migrants does not notably influence travel demand in this context. The exchange rate positively impacts travel demands, with a coefficient of 0.08 and a significant p-value, suggesting that variations in currency value can affect travel affordability and preferences (Yaman & Offiaeli, 2022). Inflation, although marginally significant, exhibits a negative coefficient of -0.15, implying that rising prices may dampen travel demand by increasing costs and reducing disposable income. Country size and infrastructural development both significantly enhance air travel demands, with coefficients of 0.30 and 0.20, respectively. This indicates that larger countries and those with better infrastructure are more likely to experience higher levels of travel (Kuok et al., 2024). Overall, these findings underscore the importance of economic resources and infrastructure in influencing air travel, while also highlighting the nuanced effects of inflation and exchange rate fluctuations.

Table 7: Common Correlated Effects Pooled (CCEP) Estimator Results for Air Travel Demands in Africa

Dependent Var. Air Travel Demand ATD	Coeff	SE	t-Stat	p-Value
Incomhe level Inc	0.25	0.06	4.17	0.0000
Wealth $Wealth$	0.40	0.07	5.71	0.0000
Migrant Stock Mig_{Stock}	0.12	0.09	1.33	0.183
Education Edu	0.22	0.08	2.75	0.006
Exchange Rate Exc	0.08	0.04	2.00	0.046
Inflation Inf	-0.15	0.08	-1.88	0.061
Country Size $Size$	0.30	0.06	5.00	0.000
Infrastructural Development $Infra$	0.20	0.07	2.86	0.004

Source: Author's Computations

Mean Group Estimators Results for Air Travel Demands in Africa

Table 8 presents the result of the elasticity of the air travel demand in Africa to socioeconomic factors across the Mean Group (MG), Dynamic Common Correlated Effects (DCCE), and Augmented Mean Group (AMG). The income level is consistently positive and significant across all estimators, with coefficients ranging from 0.15 in the MG model to 0.20 in the DCCE model, and 0.18 in the AMG model, suggesting that higher income levels are strongly associated with increased air travel demand, and thus indicating that as individuals' disposable income rises, their propensity to travel by air increases, reflecting the luxury and necessity aspects of air travel in the region (Gallet & Doucouliagos, 2014). Wealth also shows a robust positive impact on air travel demand across all models. The coefficients, which range from 0.35 in the MG model to 0.42 in the DCCE model, highlight that wealthier populations are more likely to engage in air travel. This finding underscores the importance of economic well-being in facilitating travel, particularly in African countries where wealth disparities may significantly influence access to air travel similar to the findings in the work of Alperovich, Gershon and Machnes (1994).

Migrant stock has a smaller but still significant positive effect on air travel demand, with coefficients ranging from 0.08 to 0.12. This suggests that regions with higher migrant populations tend to have higher air travel demands, possibly due to the necessity of travel for family visits or economic reasons (Gillen & Hasheminia, 2013). However, the effect size indicates that while migration is a factor, it is not as dominant as income or wealth in driving air travel demand. We also documented that education positively correlates with air travel demand, with the significance of this variable reflecting the idea that higher education levels may lead to greater awareness and capacity to travel by air (Boonekamp et al., 2018). The coefficients are consistently positive across all models, ranging from 0.20 in the MG model to 0.25 in the DCCE model, further reinforcing the role of education in promoting travel and mobility. The exchange rate also positively impacts air travel demand, suggesting that more favourable exchange rates, such as a stronger local currency, can increase air travel by making it more affordable for residents to travel abroad or within the region (Chi, 2020, 2024; Day, 1986). This is evident from the coefficients ranging from 0.10 in the MG model to 0.14 in the DCCE model, highlighting the sensitivity of air travel demand to exchange rate fluctuations.

Inflation shows a negative effect on air travel demand, with coefficients ranging from -0.12 in the MG model to -0.10 in the DCCE model. This negative relationship indicates that higher inflation, which typically leads to increased costs of goods and services, can deter air travel by making it less affordable for consumers (Meo et al., 2018). Country size is another significant factor positively influencing air travel demand. Larger countries tend to have higher air travel demand, likely due to greater distances between major cities and the necessity for efficient transportation (Sun & Lin, 2019). The coefficients, which range from 0.25 in the MG model to 0.30 in the DCCE model, underscore the importance of geographic scale in determining travel patterns. Infrastructural development also has a positive and significant impact on air travel demand, with coefficients ranging from 0.15 in the MG model to 0.18 in the DCCE model. This suggests that improvements in infrastructure, such as airport facilities and transportation networks, play a crucial role in facilitating air travel, making it more accessible and appealing to travellers (Miller & Clarke, 2007).

Table 8: Mean Group Estimation Result For Air Travel Demands in Africa

Variable	Mean Group (MG)	DCCE	Augmented Mean Group
Income level $\boldsymbol{Inc}$	0.15(0.05)*	0.20(0.04)***	0.18(0.06)***
Wealth $\boldsymbol{Wealth}$	0.35(0.07)***	0.42(0.06)***	0.40(0.09)***
Migrant Stock $\boldsymbol{Mig_{Stock}}$	0.08(0.03)**	0.12(0.04)***	0.10(0.05)**
Education $\boldsymbol{Edu}$	0.20 (0.06)***	0.25(0.05)***	0.22(0.007)***
Exchange Rate $\boldsymbol{Exc}$	0.10(0.04)	0.14(0.05)***	0.12(0.04)**
Inflation $\boldsymbol{Inf}$	-0.12(0.05)***	-0.10(0.04)**	-0.11(0.06)*
Country Size $\boldsymbol{Size}$	0.25(0.05)***	0.30(0.06)***	0.28(0.07)***
Infrastructural Development $\boldsymbol{Infra}$	0.15(0.05)**	0.18(0.05)***	0.17(0.06)
	Diagnostics		
Sargan-Hansen Test	$p = 0.125$	$p = 0.110$	$p = 0.102$
Number of Observation	110	110	110
R-Squared	0.58	0.63	0.61
Robustness Check	Pass	Pass	Pass

Note: The coefficients are presented in the table with standard errors in parenthesis; $* < 0.01, ** < 0.05, *** < 0.10$

Source: Author's Computations

We conducted diagnostics and robustness checks to confirm the reliability of these findings. The Sargan-Hansen test results show no significant overidentification issues, confirming that the models are well-specified and that the instruments used are valid. The AMG and DCCE models offer a more refined and nuanced analysis by accounting for dynamic correlations and unobserved heterogeneity (Juodis et al., 2021), providing deeper insights into the determinants of air travel demand in Africa.

Interaction Effects and Moderating Variables

In additional analysis to test channels of interactions, the models were estimated, incorporating robust standard errors. Several control variables were included to isolate the effects of the interaction terms. Deterministic trends in air travel demand across the regions were also controlled. The coefficients with p-values below 0.05 were considered statistically significant, indicating a strong level of confidence in the results. The key findings in Table 9 reveal that tourism significantly amplifies the effect of income on air travel demand, suggesting that in regions with higher tourism activity, increases in income lead to a stronger positive impact on air travel (Becken & Carmignani, 2020). The interaction between infrastructural development and greenhouse gas emissions indicates that high emissions mitigate the benefits of infrastructure improvements, leading to a reduced positive impact on air travel demand (Schafer & Victor, 1999). Furthermore, the analysis shows that high aviation fuel prices, when coupled with exchange rate volatility, have a compounded negative effect on infrastructure development (Fridström & Thune-Larsen, 1989). This results in delays or reductions in infrastructure projects, ultimately leading to a decrease in air travel demand, particularly in regions where such infrastructure is crucial for connectivity (Miller & Clarke, 2007).

Table 9: Interaction Effects and Moderating Variables

Channels of Interactions	Interactive Terms	Coeff	t-Stat	p-Value	Findings
Income – Tourism Channel	$Inc * Tour$	0.35	2.98	0.0003	Tourism activity significantly amplifies the impact of income on air travel demand. Higher tourism increases the income effect.
Infrastructure Development - GHG Emission Channel	$Infra * GHG$	-0.20	-2.45	0.015	The interaction between infrastructural development and GHG emissions negatively impacts air travel demand, indicating that high GHG emissions mitigate the benefits of infrastructure improvements.
Aviation Fuel Prices - Exchange Rate Channel	$Fuel * Exc$	0.42	-3.12	0.002	High aviation fuel prices coupled with exchange rate volatility have a compounded negative effect on infrastructure development, leading to reduced air travel demand due to delays or scale-backs in infrastructure projects.

Source: Author’s Computations

Exploring Non-Linear Dynamics: Does Air Travel Demand Show Curvature Effects from Income and Fuel Prices?

In Table 10, we presented the result of non-linear dynamics and curvature effects. The significance of the quadratic terms indicates the presence of a curvature effect (Saayman & Botha, 2017). The coefficient for income level squared reveals a diminishing return effect, indicating that as income rises, the additional impact on air travel demand decreases. This suggests that while higher income generally increases air travel demand, the rate of this increase slows down as income continues to grow, reflecting a non-linear relationship (Kumar & Patel, 2023). Similarly, the coefficient for fuel price squared also points to a negative curvature effect. As fuel prices increase, their influence on air travel demand is less pronounced, meaning that the sensitivity of air travel demand to fuel price diminishes at higher price levels. These results highlight the non-linear dynamics between income, fuel prices, and air travel demand, demonstrating that the relationships are more complex than what linear models might suggest. This analysis underscores the importance of considering these curvature effects to fully understand how varying levels of income and fuel prices impact air travel demand.

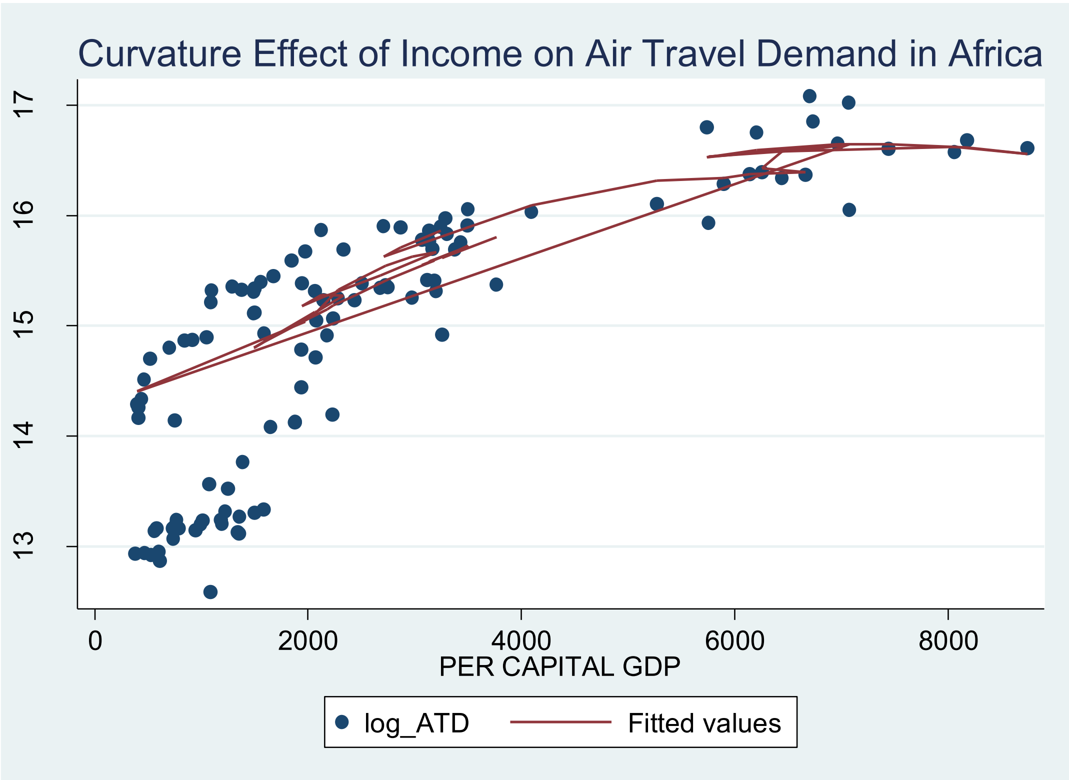

Figure 2: Curvature Effect of Income on Air Travel Demands in Africa

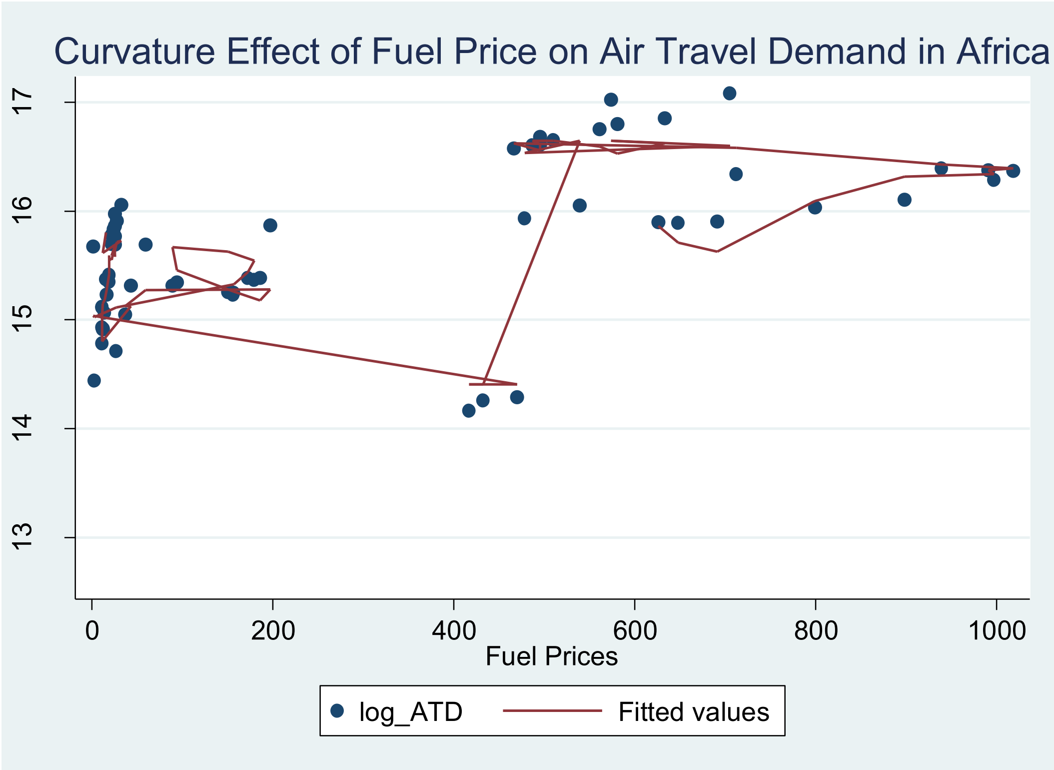

Figure 3: Curvature Effect of Fuel Price on Air Travel Demands in Africa

Table 10: Non-Linear Dynamics and Curvature Effects

Variable	Coeff	t-Stats	p-Value	Interpretations
Constant	13.87	76.79	0.000	Base Level of Air Travel Demand
Income	0.001	7.59	0.000	Positive Linear Efecr of Income
Income Squared	$\rho = -4.67$	-4.61	0.000	Negative Curvature Effect from Income
Fuel Price	0.001	2.16	0.035	Positive Linear Effect of Fuel Prices
Fuel Price Squared	$\delta - 9.83$	-1.91	0.041	Negative Curvature Effect on Fuel Prices
Model $\boldsymbol{R^2}$	0.8339			Model Explains 83.39% of Variance
Adjusted $\boldsymbol{R^2}$	0.8222			Adjusted for Number of Predictors
F-Stats	71.53		0.0000	Overall Model of Significance

Source: Author's Computations

4.0 Conclusions, Recommendations and Suggestions for Further Studies

The empirical analysis underscores the pivotal role of socioeconomic factors in driving air travel demand in Africa, revealing that income levels, wealth, education, and infrastructural development significantly boost demand. Additionally, tourism amplifies the income effect on air travel, while inflation and fuel prices, particularly when exacerbated by exchange rate volatility, exert downward pressure on demand. The presence of curvature effects in income and fuel prices indicates non-linear relationships, where the marginal impacts of rising income and fuel prices diminish at higher levels. This complexity highlights the necessity for a nuanced understanding of the factors influencing air travel demand in the region.

Given these findings, policymakers should prioritise strategies that enhance economic growth, particularly in increasing disposable income and reducing wealth disparities, as these are key drivers of air travel demand. Investment in educational infrastructure should be a focal point, as higher education levels are linked to increased air travel propensity. Additionally, fostering tourism through targeted policies could further stimulate air travel, while managing inflation and stabilising fuel prices will be crucial to sustaining growth in the sector. Addressing the environmental impact of air travel, particularly in relation to greenhouse gas emissions, should also be integrated into infrastructure development plans to mitigate negative externalities.

Future research should explore the long-term sustainability of air travel demand in Africa, considering the potential impacts of climate change and evolving economic conditions. Furthermore, examining the interplay between digitalisation and air travel demand could provide insights into emerging trends in the aviation sector.

References

Abate, M. (2016). Economic effects of air transport market liberalization in Africa. *Transportation Research Part A: Policy and Practice*, *92*, 326–337. https://doi.org/10.1016/j.tra.2016.06.014

Adams, Z., & Gerner, M. (2012). Cross hedging jet-fuel price exposure. *Energy Economics*, *34*(5), 1301–1309. https://doi.org/10.1016/J.ENECO.2012.06.011

Adekunle, I. A., Kalejaiye, T. G., Ogundade, A. O., Ogede, J. S., & Soyemi, C. O. (2020). Engendering macroeconomic policy for gender equality in sub-Saharan Africa. *Asian Women*, *36*(4), 113–136. https://doi.org/10.14431/AW.2020.12.36.4.113

Adekunle, I. A., Tella, S. A., & Ogunjobi, F. O. (2022). Remittances and the future of African economies. *International Migration*, *60*(5), 252–270. https://doi.org/10.1111/IMIG.12951

Adeola, O., Boso, N., & Evans, O. (2018). Drivers of international tourism demand in Africa. *Business Economics*, *53*(1), 25–36. https://doi.org/10.1057/S11369-017-0051-3/TABLES/4

Adey, P., & Lin, W. (2016). Geographies of Air Transport in Africa: Aviation's 'Last Frontier''.' *The Geographies of Air Transport*, 247–266. https://doi.org/10.4324/9781315557779-17

Alperovich, Gershon; Machnes, Y. (1994). The role of wealth in the demand for international air travel. *Journal of Transport Economics and Policy*, *28*(May), 163–173. https://www.jstor.org/stable/20053033?casa_token=3NDfx2gskN8AAAAA%3Al8jCZjGXtsjZLCzYInyr6ERcRIPFqY1vKmKafE0YC9ve8CS-tfCmxdxe_eFM0kZH61C1s2TgHX3lFkS1Wz3d9MwIWJBNMzRWd8sJl_QqvXbc33LwNl2jPQ

Bai, J., & Perron, P. (1998). Estimating and Testing Linear Models with Multiple Structural Changes. *Econometrica*, *66*(1), 47. https://doi.org/10.2307/2998540

Barman, H., & Nath, H. K. (2019). What determines international tourist arrivals in India? *Asia Pacific Journal of Tourism Research*, *24*(2), 180–190. https://doi.org/10.1080/10941665.2018.1556712

Becken, S., & Carmignani, F. (2020). Are the current expectations for growing air travel demand realistic? *Annals of Tourism Research*, *80*, 102840. https://doi.org/10.1016/J.ANNALS.2019.102840

Blake, A. (2008). Tourism and income distribution in East Africa. *International Journal of Tourism Research*, *10*(6), 511–524. https://doi.org/10.1002/JTR.702

Boonekamp, T., Zuidberg, J., & Burghouwt, G. (2018). Determinants of air travel demand: The role of low-cost carriers, ethnic links and aviation-dependent employment. *Transportation Research Part A: Policy and Practice*, *112*, 18–28. https://doi.org/10.1016/J.TRA.2018.01.004

Büchs, M., & Mattioli, G. (2021). Trends in air travel inequality in the UK: From the few to the many? *Travel Behaviour and Society*, *25*, 92–101. https://doi.org/10.1016/J.TBS.2021.05.008

Chi, J. (2020). The impact of third-country exchange rate risk on international air travel flows: The case of Korean outbound tourism demand. *Transport Policy*, *89*, 66–78. https://doi.org/10.1016/J.TRANPOL.2020.01.012

Chi, J. (2024). Asymmetric effects of economic policy uncertainty and exchange rates on international air travel demand: The case from Hong Kong. *Journal of Air Transport Management*, *114*, 102503. https://doi.org/10.1016/J.JAIRTRAMAN.2023.102503

Chudik, A., & Pesaran, M. H. (2019). Mean group estimation in presence of weakly cross-correlated estimators. *Economics Letters*, *175*, 101–105. https://doi.org/10.1016/J.ECONLET.2018.12.036

Combs, T. S. (2017). Examining changes in travel patterns among lower wealth households after BRT investment in Bogotá, Colombia. *Journal of Transport Geography*, *60*, 11–20. https://doi.org/10.1016/J.JTRANGEO.2017.02.004

Creutz, K. (2023). Multilateral Development Banks as Agents of Connectivity: the Asian Development Bank (ADB) and the Asian Infrastructure Investment Bank (AIIB). *East Asia*, *40*(3), 335–356. https://doi.org/10.1007/S12140-023-09408-6/TABLES/1

Day, A. E. (1986). Impact of exchange rates on air travel. *International Journal of Hospitality Management*, *5*(3), 115–119. https://doi.org/10.1016/0278-4319(86)90003-4

De Vos, I., & Stauskas, O. (2024). Cross-section bootstrap for CCE regressions. *Journal of Econometrics*, *240*(1), 105648. https://doi.org/10.1016/J.JECONOM.2023.105648

Donaubauer, J., Meyer, B. E., & Nunnenkamp, P. (2016). A New Global Index of Infrastructure: Construction, Rankings and Applications. *The World Economy*, *39*(2), 236–259. https://doi.org/10.1111/TWEC.12290

Dzeng, R. J., & Wang, S. S. (2008). An analysis of infrastructure development based on national competitiveness perspectives. *Construction Management and Economics*, *26*(1), 47–61. https://doi.org/10.1080/01446190701670381

Fox, J. (2005). Linear Models, Problems. *Encyclopedia of Social Measurement, Three-Volume Set*, *2*, 515–522. https://doi.org/10.1016/B0-12-369398-5/00165-1

Fox, J., & Monette, G. (1992). Generalized collinearity diagnostics. *Journal of the American Statistical Association*, *87*(417), 178–183. https://doi.org/10.1080/01621459.1992.10475190

Frankema, E., & Waijenburg, M. V. (2018). Africa rising? A historical perspective. *African Affairs*, *117*(469), 543–568. https://doi.org/10.1093/AFRAF/ADY022

Freedman, D. A. (2006). On The So-Called "Huber Sandwich Estimator" and "Robust Standard Errors." *The American Statistician*, *60*(4), 299–302. https://doi.org/10.1198/000313006X152207

Fridström, L., & Thune-Larsen, H. (1989). An econometric air travel demand model for the entire conventional domestic network: The case of Norway. *Transportation Research Part B: Methodological*, *23*(3), 213–223. https://doi.org/10.1016/0191-2615(89)90004-0

Gallet, C. A., & Doucouliagos, H. (2014). The income elasticity of air travel: A meta-analysis. *Annals of Tourism Research*, *49*, 141–155. https://doi.org/10.1016/j.annals.2014.09.006

Gillen, D., & Hasheminia, H. (2013). Estimating the demand responses for different sizes of air passenger groups. *Transportation Research Part B: Methodological*, *49*, 24–38. https://doi.org/10.1016/J.TRB.2012.11.004

Hakim, M. M., & Merkert, R. (2019). Econometric evidence on the determinants of air transport in South Asian countries. *Transport Policy*, *83*, 120–126. https://doi.org/10.1016/j.tranpol.2017.12.003

Hanson, D., Toru Delibasi, T., Gatti, M., & Cohen, S. (2022). How do changes in economic activity affect air passenger traffic? The use of state-dependent income elasticities to improve aviation forecasts. *Journal of Air Transport Management*, *98*, 102147. https://doi.org/10.1016/J.JAIRTRAMAN.2021.102147

Hashem Pesaran, M., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, *142*(1), 50–93. https://doi.org/10.1016/J.JECONOM.2007.05.010

Herzer, D. (2013). Cross-Country Heterogeneity and the Trade-Income Relationship. *World Development*, *44*, 194–211. https://doi.org/10.1016/J.WORLDDEV.2012.09.014

Hu, Y., Xiao, J., Deng, Y., Xiao, Y., & Wang, S. (2015). Domestic air passenger traffic and economic growth in China: Evidence from heterogeneous panel models. *Journal of Air Transport Management*, *42*, 95–100. https://doi.org/10.1016/J.JAIRTRAMAN.2014.09.003

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, *115*(1), 53–74. https://doi.org/10.1016/S0304-4076(03)00092-7

Imbens, G. W., & Kolesár, M. (2016). Robust Standard Errors in Small Samples: Some Practical Advice. *The Review of Economics and Statistics*, *98*(4), 701–712. https://doi.org/10.1162/REST_A_00552

International Civil Aviation Organization. (2021). *Air transport, passengers carried - Data*. World Bank - Data. https://data.worldbank.org/indicator/IS.AIR.PSGR?end=2021&start=2010

Issahaku, P. A., & Neysmith, S. (2013). Policy implications of population ageing in West Africa. *International Journal of Sociology and Social Policy*, *33*(3), 186–202. https://doi.org/10.1108/01443331311308230/FULL/PDF

Juodis, A., Karabiyik, H., & Westerlund, J. (2021). On the robustness of the pooled CCE estimator. *Journal of Econometrics*, *220*(2), 325–348. https://doi.org/10.1016/J.JECONOM.2020.06.002

Kumar, N. N., & Patel, A. (2023). Nonlinear effect of air travel tourism demand on economic growth in Fiji. *Journal of Air Transport Management*, *109*, 102402. https://doi.org/10.1016/J.JAIRTRAMAN.2023.102402

Kuok, R. U. K., Koo, T. T. R., & Lim, C. (2024). Air transport capacity and tourism demand: A panel cointegration approach with cross-sectionally augmented autoregressive distributed lag (CS-ARDL) model. *Tourism Economics*, *30*(3), 702–727. https://doi.org/10.1177/13548166231178355

Lakshmanan, T. R., & Han, X. (1997). Factors underlying transportation CO2 emissions in the U.S.A.: A decomposition analysis. *Transportation Research Part D: Transport and Environment*, *2*(1), 1–15. https://doi.org/10.1016/S1361-9209(96)00011-9

Meo, M. S., Chowdhury, M. A. F., Shaikh, G. M., Ali, M., & Masood Sheikh, S. (2018). Asymmetric impact of oil prices, exchange rate, and inflation on tourism demand in Pakistan: new evidence from nonlinear ARDL. *Asia Pacific Journal of Tourism Research*, *23*(4), 408–422. https://doi.org/10.1080/10941665.2018.1445652

Miller, B., & Clarke, J. P. (2007). The hidden value of air transportation infrastructure. *Technological Forecasting and Social Change*, *74*(1), 18–35. https://doi.org/10.1016/J.TECHFORE.2004.03.011

Morrell, P., & Swan, W. (2006). Airline Jet Fuel Hedging: Theory and Practice. *Transport Reviews*, *26*(6), 713–730. https://doi.org/10.1080/01441640600679524

Nguyen, Q. H. (2023). The causality between air transport and economic growth: Empirical evidence from regions in Asia. *Research in Transportation Business and Management*, *47*. https://doi.org/10.1016/j.rtbm.2023.100948

Njoya, E. T., & Nikitas, A. (2020). The role of air transport in employment creation and inclusive growth in the Global South: The case of South Africa. *Journal of Transport Geography*, *85*, 102738. https://doi.org/10.1016/J.JTRANGEO.2020.102738

O'Brien, R. M. (2007). A caution regarding rules of thumb for variance inflation factors. *Quality and Quantity*, *41*(5), 673–690. https://doi.org/10.1007/S11135-006-9018-6/METRICS

O'Driscoll, D., & Ramirez, D. E. (2015). Response surface designs using the generalized variance inflation factors. *Cogent Mathematics*, *2*(1), 1053728. https://doi.org/10.1080/23311835.2015.1053728

Oliete Josa, S., & Magrinyà, F. (2018). Patchwork in an interconnected world: the challenges of transport networks in Sub-Saharan Africa*. *Transport Reviews*, *38*(6), 710–736. https://doi.org/10.1080/01441647.2017.1414899

Önsel Ekici, Ş., Kabak, Ö., & Ülengin, F. (2019). Improving logistics performance by reforming the pillars of Global Competitiveness Index. *Transport Policy*, *81*, 197–207. https://doi.org/10.1016/J.TRANPOL.2019.06.014

Özkale, M. R. (2021). The red indicator and corrected VIFs in generalized linear models. *Communications in Statistics: Simulation and Computation*, *50*(12), 4144–4170. https://doi.org/10.1080/03610918.2019.1639740

Paramati, S. R., & Roca, E. (2019). Does tourism drive house prices in the OECD economies? Evidence from augmented mean group estimator. *Tourism Management*, *74*, 392–395. https://doi.org/10.1016/J.TOURMAN.2019.04.023

Ridderstaat, J. (2021). Households' Net Financial Wealth as a Determinant of Tourism Demand Cycles: Evidence from US Travel to Selected Caribbean Destinations. *Journal of Travel Research*, *60*(3), 564–582. https://doi.org/10.1177/0047287520925174/ASSET/IMAGES/LARGE/10.1177_0047287520925174-FIG3.JPEG

Rodrigue, J.-P. (2020). The Geography of Transport Systems. *The Geography of Transport Systems*. https://doi.org/10.4324/9780429346323

Ross, M. L., & Werker, E. (2024). Diversification in resource-rich Africa, 1999–2019. *Resources Policy*, *88*, 104437. https://doi.org/10.1016/J.RESOURPOL.2023.104437

Saayman, A., & Botha, I. (2017). Non-linear models for tourism demand forecasting. *Tourism Economics*, *23*(3), 594–613. https://doi.org/10.5367/TE.2015.0532/ASSET/IMAGES/LARGE/10.5367_TE.2015.0532-FIG4.JPEG

Schafer, A., & Victor, D. G. (1999). Global passenger travel: implications for carbon dioxide emissions. *Energy*, *24*(8), 657–679. https://doi.org/10.1016/S0360-5442(99)00019-5

Sun, Y. Y., & Lin, P. C. (2019). How far will we travel? A global distance pattern of international travel from both demand and supply perspectives. *Tourism Economics*, *25*(8), 1200–1223. https://doi.org/10.1177/1354816618825216/ASSET/IMAGES/LARGE/10.1177_1354816618825216-FIG5.JPEG

Thompson, C. G., Kim, R. S., Aloe, A. M., & Becker, B. J. (2017). Extracting the Variance In flation Factor and Other Multicollinearity Diagnostics from Typical Regression Results. *Basic and Applied Social Psychology*, *39*(2), 81–90. https://doi.org/10.1080/01973533.2016.1277529

Tirtha, S. D., Bhowmik, T., & Eluru, N. (2023). Understanding the factors affecting airport level demand (arrivals and departures) using a novel modeling approach. *Journal of Air Transport Management*, *106*, 102320. https://doi.org/10.1016/J.JAIRTRAMAN.2022.102320

Tolcha, T. D., Bråthen, S., & Holmgren, J. (2020). Air transport demand and economic development in sub-Saharan Africa: Direction of causality. *Journal of Transport Geography*, *86*, 102771. https://doi.org/10.1016/J.JTRANGEO.2020.102771

Turner, P. A., & Lim, S. H. (2015). Hedging jet fuel price risk: The case of U.S. passenger airlines. *Journal of Air Transport Management*, *44–45*, 54–64. https://doi.org/10.1016/J.JAIRTRAMAN.2015.02.007

Uddin, G. A., Alam, K., & Gow, J. (2016). Population age structure and savings rate impacts on economic growth: Evidence from Australia. *Economic Analysis and Policy*, *52*, 23–33. https://doi.org/10.1016/J.EAP.2016.08.002

UN. (2024). *GOAL 9: Industry, innovation and infrastructure | UNEP - UN Environment Programme*. UN Environment Programme. https://www.unep.org/topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-9-industry

Valdes, V. (2015). Determinants of air travel demand in Middle Income Countries. *Journal of Air Transport Management*, *42*, 75–84. https://doi.org/10.1016/j.jairtraman.2014.09.002

Valenzuela-Levi, N. (2021). The rich and mobility: A new look into the impacts of income inequality on household transport expenditures. *Transport Policy*, *100*, 161–171. https://doi.org/10.1016/J.TRANPOL.2020.10.002

Verhoeven, H. (2023). Surviving revolution and democratisation: the Sudan armed forces, state fragility and security competition. *The Journal of Modern African Studies*, *61*(3), 413–437. https://doi.org/10.1017/S0022278X23000174

Weinzettel, J., Hertwich, E. G., Peters, G. P., Steen-Olsen, K., & Galli, A. (2013). Affluence drives the global displacement of land use. *Global Environmental Change*, *23*(2), 433–438. https://doi.org/10.1016/J.GLOENVCHA.2012.12.010

Xie, Y., & Pesaran, M. H. (2022a). A Bias-Corrected Cd Test for Error Cross-Sectional Dependence in Panel Data Models with Latent Factors. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4198155

Xie, Y., & Pesaran, M. H. (2022b). A Bias-Corrected Cd Test for Error Cross-Sectional Dependence in Panel Data Models with Latent Factors. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4198155

Yaman, F., & Offiaeli, K. (2022). Is the price elasticity of demand asymmetric? Evidence from public transport demand. *Journal of Economic Behavior & Organization*, *203*, 318–335. https://doi.org/10.1016/J.JEBO.2022.09.005

Yang, C., McCollum, D., McCarthy, R., & Leighty, W. (2009). Meeting an 80% reduction in greenhouse gas emissions from transportation by 2050: A case study in California. *Transportation Research Part D: Transport and Environment*, *14*(3), 147–156. https://doi.org/10.1016/J.TRD.2008.11.010