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A literature review of recent causality analyses between air transport demand and socio-economic factors

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Abstract

This paper reviews scientific papers that analyze causal relationship between air transport demand and relevant socio-economic indicators to provide a comprehensive review of the relevant socio-economic factors to consider while forecasting air transport demand. More accurate forecasting would contribute to the optimization of the transport and technological processes of airline operations in post-crisis periods. Due to the pandemic of the COVID-19 virus and the imposed travel restrictions, the air transport industry faced a deep economic crisis and a consequently reduced demand that is more intense than any previous recession. It is of utmost importance to find more accurate short-term forecasting model that would help airlines navigate more steadily through the uncertainty recession periods. Authors reviewed papers from Web of Science database, from 2010 until the end of 2021, finding 19 relevant papers investigating causality between air transport demand and socio-economic factors. In most of the papers GDP was used as proxy to economic growth, and number of passengers flown (domestic and/or international) is used as a proxy to air transport demand. After reviewing papers, authors propose the use of multivariate approach, using more socioeconomic factors in the future studies, using quarterly data (if not monthly), and the use of revenue passenger kilometers as a proxy for air transport demand.

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Keywords: air transport demand; causality; COVID-19; forecasting; passenger air transport

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1. Introduction

Quantifying the future demand for air transport is a prerequisite for planning all airline activities and technological processes at the tactical and strategic level: flight schedule planning, crew planning, maintenance planning, fleet planning, revenue management, as well as management and marketing. The importance of forecasting demand in air transport takes on an even more significant role during crisis events and recessions.

Demand forecasting methods are divided into two basic groups: qualitative methods and quantitative methods. Qualitative methods are used when little or no quantitative data is available, but there is sufficient qualitative knowledge about the occurrence for which the prediction is made. Qualitative methods include executive judgment, market research and Delphi techniques. Quantitative methods are applicable when sufficient quantitative historical information about the occurrence is available. Quantitative methods analyze the occurrence movement in the past (expressed in numerical values) and the factors that influenced such movement, and then quantify the dependencies between them. Forecasting is then based on the appropriate extension of the current trend. In general, quantitative demand forecasting methods are divided into two groups: time series analysis methods used for short-term forecasts in a stable environment and regression analyzes that include one or more independent variables affecting demand.

The COVID-19 pandemic is one of the events with a significant impact on the air transport industry, stronger than previous crisis events such as the terrorist attack on the USA in 2001, the SARS epidemic in 2003 or the global financial crisis in 2008. In the first wave of the COVID-19 pandemic, between March and June 2020, around 17,000 aircraft were grounded globally (Gudmundsson et al 2021). After previous recessions, which made an impact on the air transport industry, air traffic growth remained fairly stable in the medium and long term, but the decline caused by the COVID-19 pandemic is unprecedented. To reduce the spread of the virus, countries around the world have introduced various restrictions that have included the suspension of domestic and international travel.

The purpose of this paper is to review the previous scientific literature on passenger air transport demand and its relationship between socio-economic indicators. What indicators were previously examined, for which time series, is there any causality and if there is, then in which direction that causality is significant. Causality is frequently mentioned concept in various studies related to forecasting. If the inclusion of a specific indicator(s) into the forecasting model could help predict the variation of transport demand, then the indicator should be incorporated in the proposed forecasting model.

The paper is organized in sections: in Section 2 authors introduce review methodology applied in the paper. In Section 3 authors explains the correlation between GDP and air transport demand, while in section 4 authors analyze the selected papers, and a discussion follows in Section 5. Section 6 concludes the key findings and propose future research opportunities.

2. Methodology

With the attempt to review related literature on causal relationship between air transport demand and socio-economic factors, a systematic literature review of the relevant papers was undertaken, and following review methodology has been adopted. The search was conducted on the “Web of Science” – WoS. Figure 1 shows the search methodology to find relevant articles – the step-by-step employment of filters in the search for relevant papers.

Subject areas such as transportation, economics, geography, tourism, and leisure are the major areas in which relevant research has been published. Papers related to Environment were excluded from the search, using filters in WoS database. Applying qualitative selection papers related to delay propagation, CO_2 emissions, airport infrastructure and transportation in general were also excluded from the review. Papers, selected by the authors, were

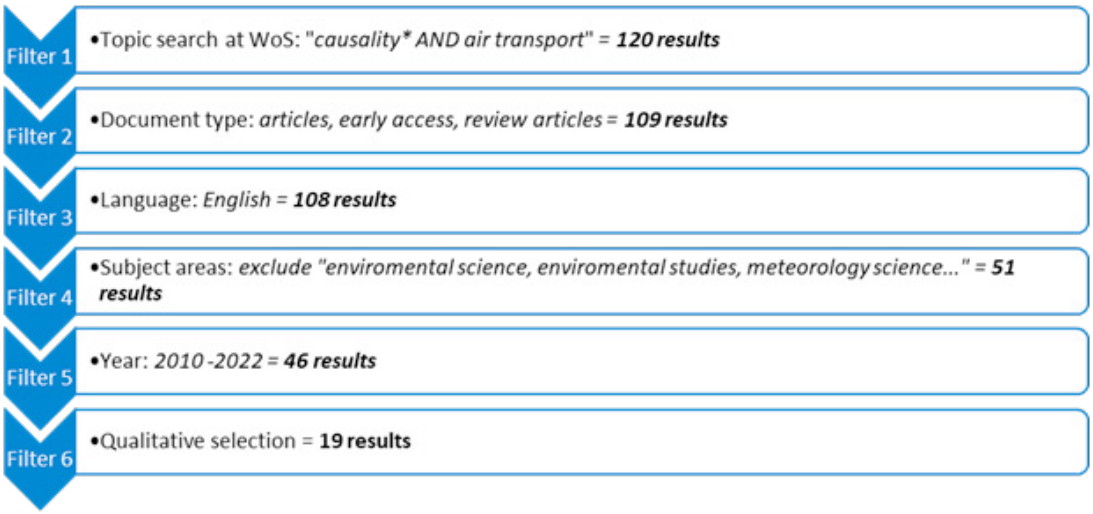

Fig. 1. Search methodology

considered in the analysis based on the research: determination of causality between the passenger air transport and various socio-economic indicators.

3. Relationship between GDP and air transport demand

The demand for air transport is closely related to socio-economic indicators. The factors influencing the growth of air traffic are manifold and intricate, operating at global, regional, and local level. Among the widely recognized socio-economic indicators are gross domestic product (GDP), income, population, and tourism. Gross domestic product refers to the overall market value of all final goods and services produced within a country during a given time frame. The rise in prosperity leads to an amplified demand for air travel through two seemingly distinct but interconnected channels. Firstly, enhanced economic activity fosters a greater need for business travel, and secondly, it stimulates air cargo operations in both origin and destination markets. Also, economic prosperity decreases unemployment, and a concurrent increase in household income which affects the amount of discretionary income. There is a very strong correlation between the annual growth rates of world GDP and the growth rates of air transport,

Fig. 2. Annual growth rates of world GDP and the growth rates of revenue passenger kilometres

measured in revenue passenger kilometers, illustrated in the figure 2 (Airlines for America, 2023 and World of Bank, 2023). The relationship between air transport demand and world GDP is approximately two to one (Doganis, 2002). GDP is the most used indicator in the analysis of air transport demand. In causality analysis of air transport demand at the national level, either GDP (Pacheco and Fernandes, 2017 and Hu et al., 2015), or GDP per capita (Hakim and Merkert, 2019 and Akinyemy, 2018), is often chosen. The level of industrial and economic activity in each country, as well as the overall nature of international trade, are largely dependent upon the world economic climate and the rate of economic growth. Even though the GDP is most used factor to determine economic activity of a country or region, there are numerous socio-economic indicators that can cause air travel demand: unemployment rate, trade levels, personal saving rate, aviation fuel prices, population, cost, and production index, etc. In addition to socio-economic indicators, the demand for air transport can also be determined by special events, for example, military conflicts, terrorist attacks, sporting events such as FIFA World Cup, public health crises such as SARS, and geo-activities such as volcanic eruptions or earthquakes.

4. Analysis of the reviewed studies

Numerous scientific papers, shown in Table 1, confirm the causal relationship between the demand for air transport and various socio-economic indicators in various countries. The methodology applied in these works is mostly based on the analysis of causality of time series, better known as Granger causality (Granger, 1969 and Engel and Granger, 1987).

Fernandes and Pacheco (Fernandes and Pacheco, 2010) used Granger's causality analysis on revenue passenger kilometers and GDP monthly data to establish relationship between air transport demand and economic growth in Brazil. Authors found unidirectional Granger causal relationship between economic growth and domestic air transport demand in Brazil, with short term high elasticity. Van de Vijver et al. (2014) analyzed intraregional trade levels and air passenger travel on Asia-Pacific country pairs. To determine the relationship between export and import levels compared to air passenger transport (through city-pair scheduled seats) they have used Time Series Cross Section Granger causality analysis. The research found no significant causality between region's most developed economies, but there was an often-significant causality between air passenger connections to trade between more developed and less developed countries (e.g., Australia – Thailand). By applying Granger causality analysis on total airport passenger movements and real aggregate taxable income Baker et al. (2015) found strong short- and long-run bidirectional causality between regional air passenger transport and local economy in Australia. Van de Vijver et al. (2015) analyzed annual data from European NUTS-2 regions: number of passengers traveled by air and employment rate and established that the influence of air transport on employment is more significant than in the other direction. In their paper, Jankiewicz and Huderek-Glapska (2016) identified the most important common and specific factors, using Multidimensional Comparative Analysis, that affect the greatest influence on air transport in Central and Eastern European (CEE) Countries: Poland, Czech Republic, Slovakia, Lithuania, Latvia, Estonia, Hungary, and Slovenia.

To determine causality between economic growth and air transport, Hakim and Merkert (2016) have used annual panel data of South Asian countries from 1973 to 2014: total number of air passengers, volume of air freight and GDP. Authors found significant unidirectional causality from GDP to air passenger traffic and air freight volume, using Granger causality analysis. Brida et al. (2016) used Johansen cointegration analysis and Granger Causality test to analyze quarterly GDP data and number of air passengers flown in Mexico. Results of their study confirm that air transport expansion plays a significant role in the long run economic growth of the country. Rahman Khan et al. (2017) used panel Fully Modified Least Square Regression (FMOLS) with Granger causality analysis on annual data for 19 tourist – oriented countries to establish causality between tourism indicators, air freight volumes, air transport passengers carried, transport services, travel services and trade openness (as a percentage of GDP). Their study found significant causality between the transportation and tourism index, which confirms the bidirectional relationship of inbound tourism index with air transportation.

Rajeha and Zhong (Rajeha and Zhong, 2018) tested the causal relationship between air passenger traffic and GDP in Singapore, using annual data from 1980 to 2015. By employing Engel-Granger procedure, Johansen-Juselius cointegration methodology and Granger causality test authors found no long run co-integration relationship but only short run unidirectional causality heading from air passenger traffic to GDP. Kiraci and Bakir (2019) used GDP and air passengers carried annual data of 70 various countries, differentiating them by their income level on "high, upper-

middle, lower-middle and low". They used two different analyses to examine causality between air transport and economic growth: Konya panel causality test, Emirmahmutoğlu & Köse panel causality test, founding that there is a bidirectional causal relationship between GDP and air transport but is varies by the country income level. Balli et al. (2018) employed Granger causality analysis using monthly data to investigate the relationships among inbound tourist data, the number of economy-class seats from the origin country to New Zealand, and bilateral trade factors involving New Zealand and its trading partners (Australia, Canada, China, Hong Kong, Japan, Korea, Singapore, and USA). The authors discovered that the influence of bilateral trade connections on the quantity of airline economy seats is constrained and demonstrates statistical significance solely in relation to the availability of such seats between New Zealand and its five primary trading partners: Australia, China, Japan, Singapore, and the United States.

Costa et al. (2019) used linear regression with two or three independent variables on annual data from Brazil to determine whether main drivers of supply and demand for passenger air transport in local markets differ between those markets. By using Autoregressive distributed lag cointegration approach and Granger short- and long-run causality tests Akinyemi (2019) determined GDP and index of manufacturing production are determinants of air travel in the short- and long-run.

Tolcha et al. (2020) tested (annual) data from six sub-Saharan African countries with cointegration and Granger causality analysis. They found that elasticities of interaction between economic development and air transport demand vary between countries in the short- and long-run frameworks. Using annual Sri Lanka data of total air passengers carried and GDP, Higgoda and Madurapperuma (2020) employed Johansen cointegration and Granger causality analysis and determined short-run unidirectional causality from economic growth to air transport. They also found that air transport does not play a significant role in the promotion of Sri Lanka's economic growth – no bidirectionality.

In their paper Balsalobre-Lorente et al. (2021) tested Spain GDP, air transport, renewable energy use, urbanization process, and social globalization annual data from 1971-2015 with Diks and Panchenko non-parametric causality test and determined that air transport and GDP are key predictors of each other.

Fernandes et al. (2021a) tested causality between employment rate in tourism sector and air transport in Brazil. Employing Granger causality analysis, they have established substantial bidirectional short- and long-turn causal relationship between employment in tourism and air transport. Also, their test showed higher employment elasticity to international than domestic air travel. Fernandes et al. (2021b) used Granger causality analysis to investigate causality between domestic passenger air transport and GDP of small regional municipalities in Amazon region (Brazil). The results of the analysis show bidirectionality between economy and air transport in short and long-run.

Tsui et al. (2021) tested monthly scheduled airline seat capacity data and tourist arrivals in Hong Kong using cointegration analysis and Granger causality analysis. They found bidirectional causality between scheduled airline seat capacity and tourist arrivals - results reflect the heterogeneity across different markets.

Table 1. Summary of reviewed papers in WoS database from 2010 – 2021

Author(s)	Data analyzed	Country	Period	Methodology
Fernandes and Pacheco (2010)	Monthly data: Domestic RPK and GDP	Brazil	1966 – 2006	Granger's causality analysis
Van de Vijver et al. (2014)	Annual data: Intraregional trade levels and air passenger travel on country pairs	Asia-Pacific countries	1980 – 2010	Time Series Cross Section (TSCS) Granger causality analysis
Baker et al. (2015)	Annual data: total airport passenger movements and real aggregate taxable income	Australia	1985 – 2010	Granger's causality analysis
De Vivjer et al. (2016)	Annual data: number of air passengers and employment rate	European NUTS-2 region	2002 – 2011	Time Series Cross Section (TSCS) Granger causality analysis

Jankiewicz and Huderek-Glapska (2016)	Quarterly data: Population, land covered, GDP per capita, number of air passengers, passengers per population, airport density	CEE countries	2002 – 2013	Multidimensional Comparative Analysis
Hakim and Merkert (2016)	Annual data: number of air passengers, volume of air freight in ton-km and GDP	8 SAARC countries	1973 – 2014	Granger's causality analysis
Brida et al. (2016)	Quarterly data: GDP and number of air passengers	Mexico	1995 – 2013	Johansen cointegration analysis and Granger Causality analysis
Rahman Khan et al. (2017)	Annual data: tourism indicators, air freight volumes (ton-km), air transport passengers carried, transport services, travel services and trade openness (% of GDP)	19 tourists – oriented countries	1990 – 2014	Panel FMOLS cointegrating regression for robust inferences and Granger causality analysis
Raheja and Zhong (2018)	Annual data: Air passenger traffic and GDP	Singapore	1980 – 2015	Engel-Granger analysis, Johansen-Juselius cointegration analysis and Granger causality analysis
Kiraci and Bakir (2019)	Annual data: Air transport and economic growth based on income level	70 countries	1990 – 2016	Konya panel causality analysis, Emirmahmutoğlu & Köse panel causality analysis
Balli et al. (2018)	Monthly data: inbound tourists, direct scheduled airline economy-class seats, bilateral trade factors	New Zealand	1998 – 2015	Granger causality analysis
Costa et al. (2019)	Annual data: Commodity volume, commodity price, ASKs, RPKs, tariff levels, GDP, GDP per capita, total population, unemployment rate	Brazil	2002 – 2016	Linear regression with two or three independent variables
Akinyemi (2019)	Annual data: GDP, index of agricultural production, index of manufacturing production and consumer price index-and domestic air travel demand	Nigeria	1982 – 2005	Autoregressive distributed lag (ARDL) cointegration analysis and Granger causality analysis
Tolcha et al. (2020)	Annual data: Population, GDP per capita, education index, foreign direct investment, balance of payments, official exchange rate, number of tourists, number of passengers, air cargo volumes	6 South African countries	1981 – 2018	Cointegration analysis and Granger causality analysis
Higgoda and Madurapperuma (2020)	Annual data: total air passenger carried and GDP	Sri Lanka	1983 – 2019	Johansen cointegration analysis and Granger causality analysis
Balsalobre-Lorente et al. (2021)	Annual data: GDP, air transport, renewable energy use, urbanization process, and social globalization	Spain	1971 – 2015	Nonlinear autoregressive distributed lag (N-ARDL), non-parametric causality analysis

Fernandes et al. (2021_1)	Monthly data: employment rate, domestic air passengers and international air passengers	Brazil	2006 – 2018	Granger causality analysis
Fernandez et al. (2021_2)	Annual data: domestic air passenger and the GDP of small municipalities in Amazon region	Brazil (Amazon region)	2011 – 2016	Granger causality analysis
Tsui et al. (2021)	Monthly data: airline scheduled capacity and tourist arrivals for the city's key tourist source markets.	Hong Kong	2008 – 2018	Cointegration analysis and Granger causality analysis

5. Discussion

Reviewed studies have examined the causality between air transport and economic growth, yet the results pertaining to the direction of causality have exhibited diversity. While certain studies have identified a unidirectional relationship, indicating that air traffic influences economic growth, others have reported a bidirectional causal association between the two. It can be observed that most of the data analyzed were annual data, mainly due to the availability of public data sets on year basis, and due to the convenience of analyzing annual sets of time series. With more granular data – monthly observations, or at least quarterly, causality analysis could be more precise, which could provide more robust estimate while predicting future demand. Data used in observed papers are various – GDP is mostly used as proxy for economic growth, and number of passengers carried is a common variable to determinate demand of air transport. However, there are numerous data sets various authors use as economic factors: trade levels, income, commodity volume, commodity price, investments rate, exchange rate (…); social factors: population, employment rate, unemployment rate, education index, index of agricultural production, index of manufacturing production (…); and air transport factors: revenue passenger kilometers, available seat kilometers, scheduled capacity, domestic and/or international number of passengers carried, air cargo volume, scheduled economy-class seats offered (…). Many of these papers also compare two or maximum 12 time series to determine causality, and most of used methodology is based on Granger causality, with few exceptions where authors used regressions analysis (FMOLS, N-ARDL, ARDL…) or Multidimensional Comparative Analysis.

In some papers, bidirectional relationship between air transport activity and economic growth was not determined which confirms that there is spatial dimension in causality analysis. In the papers that analyze two variables a bivariate nature of Granger causality test used in analysis is a limitation – further analyses should consider additional socio-economic factors since GDP is not the only factor of passenger air transport demand. By expanding the analyses to more variables, it would give a more detailed and comprehensive insight to the air transport demand and what causes its growth (or fall).

Air transport is highly influenced with GDP and employment fluctuations, with tourism having the strong role in generating transport. An analysis of the sensitivity of the aviation industry in the context of economic activity fluctuations would be interesting direction of research. Cyclical fluctuations caused by global recessions have a significant influence on the activities of the airline industries, due to the obvious drop of demand in those critical periods. After analyzing papers on causality between air transport and socioeconomic factors, authors propose, for future research, also reviewing factors such as: personal income, household income, inflation rate, foreign investment rate, productivity rate, international trade, foreign debt, real estate sale dynamics, fuel price, inbound and outbound tourism, hotel occupancy index, etc…

Airline industry is characterized by demand, which is derived from numerous socio-economic factors. The in-depth study of those factors is important to proper demand forecasting. Broadly speaking, tactical or operational decisions derive from traffic demand forecasts. Aircraft scheduling, maintenance planning, route planning, fleet acquisition and capacity offer, with a range of strategic decisions all depend on forecasting demand.

6. Conclusion

In an era where airline operating margins are notoriously thin, forecasting air transport demand on each air transport market is essential for strategic planning in the airline industry. Improvements in the forecasting ability would translate into improvements of flight schedule planning, crew planning, maintenance planning, fleet planning, revenue management, as well as airline management and marketing which would lead to increased profitability to the airline.

Given the substantial evidence establishing a causal relationship between air transport demand and numerous socio-economic factors, the authors propose a deeper and more detailed investigation into this relationship, as well as improvements in forecasting based on these findings. They suggest conducting a study using diverse datasets that represent economic growth and the social state of the observed market, while also utilizing monthly data to provide more reliable estimations. Furthermore, the authors recommend the use of revenue passenger kilometers as a substitute measure for passenger air transport demand, as it is an industry metric that reflects the number of kilometers traveled by paying passengers, thus defining the actual demand for air transport. By implementing these recommendations, the authors aim to enhance the depth and accuracy of their analysis, allowing for a more comprehensive understanding of the link between air transport demand and socio-economic factors. Building upon these suggestions, the authors plan to expand their analysis in future research by examining other relevant databases. The objective is to encompass a broader range of studies investigating various socio-economic indicators in relation to air transport performance. This approach will ensure a more comprehensive exploration of the topic and determine if any missing information needs to be researched and analyzed. Such an approach will enable the authors to draw more robust conclusions and provide valuable insights for further investigations in the field of air transport and its connection to socio-economic factors.

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