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Criticality of a regional airport development to mitigate covid-19 economic effects

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**ARTICLE INFO**

**ABSTRACT**

The current COVID-19 crisis is having major impact on businesses across the world. This Insight focuses on investment in transport infrastructure as one of the key tools to enforce employment, businesses afloat and to maintain the productive capacity of the economy as well as maintain, and possibly increase, the attractiveness as business location. The challenges associated with the delivery and operation of complex transport infrastructure projects in today’s marketplace have been well documented in recent years. Decision making in planning and management of new transport infrastructure projects is complicated due to the different stakeholders involved in decision process, especially for restricted economic conditions and financing assumptions, where the project business plan performance is strongly related to regional development prospects. The paper provides an evaluation framework based on an ex-ante assessment framework of a new airport economic impact concentration to business ecosystem on one hand and the diversity of economic impact to business ecosystem on the other in the post COVID-19 era. The approach is essential to provide key messages to national governments, decision makers and stakeholders regarding the contribution of an airport investment towards regional economic development in terms of contribution to business ecosystem after COVID-19 pandemic. The case study adopted to illustrate the application of this methodology is a new regional airport with high seasonal traffic characteristics on the island of Crete in Greece, one of the most attractive tourist destinations in South-east Mediterranean.

1. Introduction

Until the Coronavirus “COVID-19” that was first identified in Wuhan, China, in December 2019 and rapidly began to spread across the world, in what was to be declared a global pandemic by the World Health Organization (WHO) on 11th March 2020, air transport showed continuous signs of growing trends during last years. According to IATA’s latest 20-Year Air Passenger Forecast Report (IATA, 2018), 7.8 billion passengers were expected to travel in 2036, nearly doubling of the 4 billion air travelers expected to fly in 2018. The prediction is based on a 3.6% average Compound Annual Growth Rate (CAGR). In Europe, according to Euro Control (E-C) latest report (E-C, 2018), by 2040 there will be 16.2 million flights, 53% more flights than in 2017. After March 2020 the dramatic drop in air transport according to ICAO, 2020 latest data will have for year 2020 (Jan – Dec) an overall reduction equal with 51% of seats offered by airlines; with 2,877 to 2,888 million passengers and with USD 389 to 391 billion potential loss of gross passenger operating revenues of airlines. The dramatic drop in demand for passenger air transport (and freight, to a lesser extent) due to the COVID-19 pandemic and containment measures is threatening the viability of many firms in both the air transport sector and the rest of the aviation industry, with many jobs at stake (ICAO, 2020). During and after, the current COVID-19 crisis, investment in transport infrastructure offers a strong backbone to enforce employment and improve business ecosystem and maintain the productive capacity of the economy. Increasing air transport capacity and investing in airports has been confirmed as a high risk in such circumstance especially for isolated and low-population-density regions where economic stability and growth heavily depends by tourism and aviation development (Dimitriou, 2017). This is especially more crucial for economies based on tourist sector (Dimitriou and Sartzetaki, 2018; Lu, 2011). Consequently, there is a risk that a significant share of the predicted growth in air transport demand will be left unaddressed if existing airports do not expand and/ or new airports are not built to meet this demand (Hoti et al., 2007). In these regions, aviation business risks that affect airport planning and project financing lead to difficulties to support decisions for increase of...
capacity (Dimitriou et al., 2017). The key challenge is that the complexities of current financing schemes and the uncertainty in economy mean that decision making for investments in new infrastructure projects such as airports, has to be made within a complicated, and high-risk economic framework in terms of project financing conditions and regional economy risks (Dimitriou, 2016). Decision makers have recognized the contribution of air transport investment to the economy (Dimitriou et al., 2017; Vickerman, 2008; Santos et al., 2014). Governments and authorities therefore rightly acknowledge the benefit of investments in transport infrastructure projects in order to achieve socioeconomic goals. In principle, the stakeholders of all functions of transport, economic, social and environmental system involved in decision process consider different perspectives. In terms of diversity of the decision maker’s expectations, this may lead to conflicts in planning and implementation of strategic plans (Dimitriou, 2016). In the decision-making process, alongside economic impact analysis, there is need for quantitative tools to be used not only to provide the economic impact of a new project to decision makers but also to give a tool for the managing of strategy-based decisions by monitoring goals and objectives, such as Key Performance Indicators (KPIs), where a series of ratios and indexes are taken into consideration to define results to support decisions and define results. The paper focuses on an evaluation framework based on a three-level methodology, which makes use of a combination of ex ante assessment airport economic impact methodologies and a series of new key performance indicators introduced to review the project economic performance in a given business ecosystem as analytically presented in Methodology section. The objective of the paper is to give an evaluation tool to support decisions towards airport development projects in order to enforce post COVID-19 economic recovery. The case study focused on new airport in Crete, in Greece which is one of the most attractive tourist destinations in south-east Mediterranean. Conventional wisdom is to present a systematic approach appropriate to apply in relevant projects, providing the essential tool to support decisions to enforce economic stimulus in the post-COVID-19 world.

The paper is organized as follows: Following from this introduction, the key literature sources and concept analysis are presented, along with a description of the methodology assessment framework. The case study is applied in the next section. This results in a comprehensive assessment through the incorporation of the appropriate KPIs. The paper finally outlines the conclusions and references.

2. Literature review

A wide range of empirical results and ex-post assessments in the literature highlights the importance of transport infrastructure projects’ economic impact on regional development (Dimitriou et al., 2015; Miller et al., 2015; Mackie et al., 2014; Kiel et al., 2014). Crescenzi and Rodríguez (2012) highlight that transport infrastructure has represented one of the milestones that led to development and cohesion in the European Union (EU) and examined the contribution of transport infrastructure investments to regional economic growth in the EU between 1990 and 2004. The results of a panel data regression analysis indicate very high returns on infrastructure investments, highlighting critical issues about the opportunity costs of more transport infrastructure investments across most Western European nations. Investment decisions in transport infrastructure are made under uncertainty over future impacts. The goal of the ex-ante appraisal of the effectiveness of transport infrastructure projects is to minimize this uncertainty and it plays a crucial role in any case of decision making and selecting transport infrastructure projects for funding. Kelly et al. (2015) analyzed the impact of 10 large transport projects located in eight different countries that are financed by European Union Cohesion mechanisms and found that there is a clear need to improve the quality and consistency of ex ante analysis, especially in the fields of capital cost estimation, travel demand modelling, and risk analysis. Transport project ex-ante evaluations identify those limitations for such projects: they are capital intensive and require long preparation periods; have very long pay-back periods during which risks (un)intentionally from the evaluation may arise or market trends may alter.

The scientific literature frequently discusses questions if Cost-Benefit Analysis (CBA) or Multi-Criteria Decision-Making (MCDM) is the appropriate appraisal tool in transport decision-making, or a combination of both. The field of transport infrastructure investment appraisal where the methodologies of CBA and MCDM have been evolved, offer appropriate opportunity for examining general methodological problems as well.

CBA is utilized as an analytical method that is used frequently in ex-ante analysis and is applied to investments in transport infrastructures in order to provide a tool to decision makers before going on a decision (Dimitriou et al., 2015, Eliasson et al., 2012; Rus et al., 2004). Based on a survey of a number of case studies where CBA plays an important role in decision making, Mackie et al. (2014) present the role and use of CBA in the transport planning process and consider whether CBA appraisal results actually influence decisions or have many limitations. According to Mackie et al. (2014), the most important advantage with for CBA is that it is overcomes structural and process-related limitations and biases in decision making. On the other hand, the main argument against CBA is that “CBA is found to be inadequate to incorporate and assess multiple, often conflicting objectives, criteria and attributes like environmental and social issues which are usually intrinsically difficult to quantify”.

Especially for some impacts of transport policies it is as yet hardly possible to put monetary values on them, for other effects (e.g., intangible impacts such as agglomeration effects), the monetization is highly questionable according to Macharis and Bernardini, 2015; Beria et al., 2012; Guhnemann et al., 2012). Finally in CBA, as it has been shown by several authors (Laird et al., 2014, Nash 2010), prices are taken equal or a broadly approximate to marginal social cost, since the underlying assumption holds that perfect competition prevails on the secondary markets. That is, CBA conceptually excludes the appraisal of secondary markets from transport analysis.

The multi-criteria analysis (MCA) typically starts with the identification of criteria against which to test transport policy options. Next, the different criteria are weighted or scored to arrive at a ranking of options. Raul et al. (2009) defined a group of strategic objectives and KPIs that provide information as to whether the objectives and targets are being reached. Owyong et al. (2001) identified the KPIs required to achieve sustainability objectives in developing countries and proposed an analytical decision model and a structured methodology for sustainability appraisal in infrastructure projects with an analytical process for multicriteria decision-making and performance KPIs.

Transportation Research Board (TRB, 2008) identifies that the quantification benefits as part of the CBA methods for air transport infrastructure impact are calculated through economic impact analysis. Economic impact analyses usually employ two methods for determining economic impacts. The first is input–output (I/O) analysis. IO models are based on inter-industry data to determine how effects in one industry will impact other industries (Santos et al., 2015). Based on this concept, multipliers are calculated and used to estimate the economic impact caused by a change in final demand. IO models estimate the structural changes in the economy in terms of linkages between economic sectors when an exogenous change such as a new project takes place (Reis et al., 2009). The most common use of the IO model is to evaluate the impact of exogenous changes in the external components on the interdependent components and on private and public impacts (Carreras et al., 2002). The other method used for economic impact analyses is based on economic simulation models. These are more complex econometric and General Equilibrium Models (GGE). They are based on the concept of IO analysis, and in addition, they forecast the impacts caused by future economic, price, and demographic changes (Dimitriou et al., 2017). Gudmundsson et al. (2014) studied how development constraints at major hub airports cause spillovers with wide implications for how air transport systems scale. The results highlight that congestion spillover effects can occur,
not only, to spatially close airports near Heathrow airport, but also to more distant airports. This finding supports the notion that airline strategies drive the geographical patterns of air traffic and capacity requirements at airports. Lu (2011) compared the economic benefits from airport operation with the negative side effects such as environmental costs by using Input Output analysis and concluded that the economic benefits generated from the airport outweigh the negative side effects. Selner et al., 2010, used an econometric endogenous growth model to estimate the impact of air accessibility on GDP and investment growth based on a regression approach on a sample of 15 European countries for the period 1993 and 2006 and predicted the economic effects of an increase in capacity at Vienna International Airport, highlighting the high elasticity of air connectivity with GDP and investment growth. Kiel et al. (2014) analyzed the way the impact of investments in transport infrastructures can be measured by using different indicators such as changes in employment and GDP.

Both CBA and MCDM employ as input the impacts estimates of the transport infrastructure investment compared to a ‘do-nothing’ or ‘business as usual’ scenario. Thus, both appraisal methods are strongly dependent on transportation model results (including the often-large uncertainties in these results) and both have to deal with the inherent future uncertainty (related to the assumed reference scenario(s)). MCDM uses the perceptions of decision-makers/stakeholders to weight and, subsequently, to aggregate project impacts into one single number, with high uncertainty (e.g., Beria et al., 2012; Browne and Ryan, 2011).

Considering the limitations and constraints indicated above, it is questionable whether appraisal results based on above methods actually influence decisions. A number of studies have investigated this question, many of them finding limited impact of appraisal results on investment decisions. For example, Eliasson, Börjesson, Odeck, and Welde (2015) found no correlation between costs, benefits or any other variable and the investment decisions of the Norwegian Government or Road Administration. Moreover, several researchers have studied the relation between the results of CBA studies and decisions on infrastructures using quantitative analyses (Nellthorp, 2000; Eliasson et al., 2015; Odeck, 2010). The broad picture is that these studies show that there is no significant statistical relation between the monetized effect estimations in CBA studies and decision making on transport infrastructure.

3. Methodology framework

New investments in a capital-intensive project as an airport needs to be carefully managed to ensure the success of new investment decisions. Putting performance measurement systems in place can be an essential way of keeping track of the progress of the investment. It gives vital information about what’s happening now, and it also provides the starting point for a system of target-setting that will help implement strategies for growth. The new capital investment needs to be closely and carefully managed to ensure new investment decisions and expansion plans. Putting performance measurement systems in place can be an essential way of keeping track of the progress of the investment in economic development. It gives vital information about what’s happening now. It also provides the starting point for a system of target-setting that will support the contribution of the investment towards economic recovery.

The framework supports a comprehensive assessment framework and sets out the business benefits of investment economic impact measurement and target-setting. The assessment framework provides quantitative results to support decision for transport infrastructure investment into the context of the added value of these investments into the post COVID-19 economic recovery. The aim is to give an integrated methodology framework divided in three levels to evaluate the contribution of a transport infrastructure project in the achievement of goals and targets of a nation towards economic recovery. The proposed assessment methodology framework is developed in three levels as depicted in Fig. 1: The paper focuses on 2nd (project economic impact appraisal) and 3rd level (targets coverage).

- Planning impact: Deriving metrics and data collection methods to monitor impact. The 1st level is the determination of the national socioeconomic goals and targets, the income growth, the employment growth and the business sectors enlargement;  
- Estimating impact: Conducting due diligence pre investment. The 2nd is the appraisal of the impact caused by the transport infrastructure project, thus the estimation of the new income generated, the new jobs generated and the new business development and

![Fig. 1. Three level analysis to define the economic impact stimulus of an airport development to limit long terms COVID-19 effects to business ecosystem.](image)
3.1. 2nd level: Appraisal of the economic impact caused by the airport development

Investing in an airport boosts economic activity in the region it serves. This economic activity flows through other parts of the regional economy as constructing and operating the infrastructure increases the requirements for goods and services from industries in the supply chain. The impacts arising as a result of airport development can be divided into four distinct categories: (1) direct, (2) indirect, (3) induced (4) catalytic. (Reis and Ruas, 2009). Direct from On-airport employment is created by the activities and services generated on-site at the airport (for example, fixed-based operators). For example, Vasigh et al. (2013) highlight that indirect impact is generated from off-site economic activities that are directly related to the onsite activities (for example, travel agencies, retail, and fuel suppliers). Induced impact is caused by the increase in employment and income generated from direct and indirect impact. The induced impact on the national or regional economy is estimated by multipliers based on IO analysis, which is used to estimate how the change in demand for one business sector affects other sectors and the economy as a whole. Especially as regards tourism, airports fulfill important functions in regional economic development in relation to the tourism sector. These spin-off effects are materializing in the tourism and travel and trade industries and are termed the catalytic impact. (ACI, 2015, ATAG, 2018). For the purpose of this paper and the case study, an airport spin-off or catalytic effects is in estimated as the tourist’s total expenditures on travel by air.

3.1.1. Direct and indirect impact assessment

Direct impacts include both on-airport and visitor-related impacts. On airport impacts are the benefits associated with businesses located at the airport that are involved or related to the provision of air transport services. These impacts include the employment, payroll, and spending of businesses (including average annual capital project expenditures) such as airlines, fixed base operators, government entities, and others. Visitor-related impacts are attributed to the expenditures of travelers that come to region by commercial airline. Visitor expenditures support employment and payroll in service-related industries such as lodging, food and beverage, retail found in surrounding region. To avoid double counting of benefits, visitor spending on aviation-related goods provided is not included in the direct impact. Instead, it is included in the catalytic impact.

The Indirect contribution to employment is quantified as the total number of jobs in the region that support the air transport activity, including the suppliers to air transport, for example, jobs linked to aviation fuel suppliers; facilities management and construction companies; the providers of products sold in airport retail shops, and a wide variety of supporting activities related to the air transport services sector (call centers, IT, accountancy, etc.). These activities exist because of the aviation business in the region. The aviation suppliers’ firms include:

- Air Transport Business suppliers such as offsite fuel suppliers, Maintenance and repair, Airport rental and landing fees, Marketing and advertising, Food and beverage suppliers commercial interactions and IT and communications.
- Ground based infrastructure (airports) and services, such as Facilities management and maintenance companies, Producers of the products goods for the airport retail shops-outlets and Food and beverage suppliers.

The direct and indirect impacts for on-airport tenants and airport suppliers were established primarily through surveys and benchmarking in other airports for both construction and operational period. The primary data were collected were:

- The type of aviation activity conducted by the on-airport tenant for the direct and the suppliers for indirect
- The number of full-time and part-time personnel employed by the on-airport tenant and in supply chain firms
- The total estimated annual wages and benefits paid to the on-airport employees and suppliers employees
- The total amount spent for the construction period

To calculate the direct and indirect impact, the technological coefficients were derived from the original input–output table by dividing each element of the intermediate demand sub-table by the total sector specific production. Whenever the final demand of the jth product changes by one unit and the demand of all other products remains constant, the jth sector will change its production level by one unit to satisfy this new demand. This change in production level will affect the level of primary inputs which is measured by the direct coefficients.

3.1.2. Induced impact assessment

The Induced impact is referred to the employment and income generated from the expenditures of the direct and indirect employees. Therefore, induced contribution captures the secondary impacts to the economy as direct/indirect sales, and payroll impacts are circulated to supporting industries through multiplier effects. The induced contribution on regional economy is estimated based on I-O analysis, based on the concept of multipliers is used to construct disaggregated multipliers based on IO national tables. IO tables can provide a complete picture of the flow of products and services in an economic system for a given year, clarifying the relationship between producers and consumers and the exchange of goods and services among economic sectors. This illustrates all monetary market transactions not only between businesses but also between them and the final demand sectors (i.e. consumers, government, investment, exports, etc.). Therefore, the measurement of the impact as a result of new airport development can be defined by the increase in employment (jobs) and income growth. The IO assessment in the paper involves two steps: In the first, the additional jobs created by the new airport are estimated, while in the second, the additional income is calculated (Correa et al., 2001).

The estimation results of the IO model is an ‘nxn’ matrix of multipliers that embodies n production sectors per unit of final consumption of commodities produced by n industry sectors that can provide the induced effects by means of the Leontief matrix (Dimitriou and Sartzetaki, 2017). The modelling formulation of the IO model in matrix form can be defined as:

\[ X = (I - A)^{-1} Y_f, \]

where, I is the n x n unit matrix; X is the final production vector for the economy; Y_f is the vector for the final demand of the economy; A is the matrix of technological coefficients. The technical coefficient a_{ij} is defined as the amount of production for sector i that sector j requires to produce one unit of output. Finally, \((I - A)^{-1}\) is the n x n matrix of IO multipliers, or the Leontief inverse.

In order to focus on the multiplier effects of exogenous changes in final demand, such as a new investment on the domestic economy, we
use the domestic input output table that exclude imported intermediate inputs from the cross-sectoral transactions. In the same manner, the final demand components in the domestic input–output tables include the domestic and foreign demand of domestically produced products. Given that the sectoral gross output is the sum of the value of the primary and intermediate (domestically produced or imported) inputs, it follows that our calculation of the technical coefficients (a_ij) implicitly treats the use of imported intermediates as a leakage from the domestic production system.

The Symmetric Input-Output Tables (SIOT) for the year 2015 at basic prices compiled according to the European System of National and Regional Accounts (ESA), 2010 were used, available from Eurostat and the Hellenic Statistical Authority (Bank of Greece, 2020). Employment data by sector were available for the year 2015 from ELSTAT (ELSTAT, 2020).

These tables are compiled according to the European System of Accounts ESA 2010 (Regulation (EU) No 549/2013 of the European Parliament and of the Council) and are consistent with the respective annual national figures. The data are presented using NACE Rev. 2 in 64 industries and under the Classification of Product by Activity (CPA) 2008 in 38 products.

Since the results of impact analysis are usually based on data collected in the selected base year the outcomes of input–output study are static. Air transport is particularly sensitive to the changes in local and global economic environment. The situation on aviation market can vary significantly between study periods. Analysis conducted during the peak year may overstate test results and conversely conducting economic study during the recession may underestimate the size of the effects.

The National Input Output table was derived into the case study area (Crete) regional input–output table, based on adjustment of the national technical coefficient to reflect the structure of regional production and their relationships with all the sectors of the regional economy. For this purpose, the Simple Location Quotient (SLQ) was employed to compare a regional sector share in relation to the regional production with the national share with reference to the national production.

\[
SLQ = \frac{PV_{S,h}}{RVP} \frac{RVP_{S,h}}{NPV}
\]

Where: \(PV_{S,h}\) is the production value of the sector \(i\) in the Crete region; \(RVP\) is the production value of the Crete region; \(RVP_{S,h}\) is the production value of the sector \(i\) in Greece and \(NPV\) is the total production of the country.

### 3.1.3. Catalytic impact assessment

Catalytic impact captures the way in which the airport facilitates the business of other sectors of the economy through several mechanisms such as tourism and trade increase and productivity (Dimitriou et al., 2017).

For the assessment of the catalytic impact, it is assumed that catalytic impact represents the income generated by the air transport international tourist arrivals. The estimation of the catalytic effects of aviation in tourism based on average international tourist spending, according to the following equation:

\[
CE = (ITA \times AS) \times ITAR
\]

Where: \(CE = \) Catalytic effects in terms of income generated by the air transport; \(ITA = \) International Tourist Arrivals to the region; \(AS = \) Average spending of ITA in the destination; \(ITAR = \) Percentage of air travellers ITA to the region.

### 3.2. 3rd level: Achievement of the economic goals and targets to enforce economic recovery

#### 3.2.1. Impact concentration to business ecosystem ratios development

For the evaluation of the contribution of an airport project’s development towards economic development, two ratios defining the concentration of airport employment and income generation in relation to total regional employment and income were adopted.

The Employment Concentration Ratio (ECR) is defined as the measure of the size of employment generated by the airport in relation to the total employment in the region. It ranges from 0 to 1.0, moving from 0 (which indicates a very low concentration of the airport’s generated employment in relation to the regional economy) to 1.0, which indicates a single monopsonistic producer if all the employment in the region was created by the airport. The Income Concentration Ratio (ICR) is the measure of the size of income generated by the airport in relation to the total income in the region over time. It ranges from 0 to 1.0, moving from 0 (which indicates a very low concentration of the airport in relation to the regional economy) to 1.0, which indicates a single monopsonistic producer if all the income in the region was created by the airport.

\[
ECR = \left( \frac{c_{e}}{e_{r}} \right),
\]

\[
ICR = \left( \frac{i_{e}}{i_{r}} \right),
\]

Where: \(t = \) the year of the construction and operation period respectively; \(c_{e} = \) new jobs created from the airport construction and operation for year \(t\); \(e_{r} = \) total employment in region; \(i_{e} = \) new income generated from the airport construction and operation for year \(t\); \(i_{r} = \) total income in region.

If ECR and ICR above 0.50 indicate high concentration of the employment and income generated due to the airport in relation to the total employment of the region. The above KPIs support the decision-making process in investing in transport infrastructures and especially in a new airport. The highest values correspond to high level of implication towards regional and economic development and governmental authorities should focus on the implementation of the project.

#### 3.2.2. Business ecosystem development target cover indicators

The Employment Target Cover Indicator (ECI) represents the annual coverage of the employment target set by the region, linked with the airport investment for the year \(t\). ECI provides indications to decision makers regarding the expected coverage of the employment target for the year \(t\) for the construction and operation period respectively. The Income Growth Target Cover indicator (ICI) represents the annual coverage of the national income growth target by the airport for the year \(t\). ITCI provides indications to decision makers regarding the expected coverage of the income growth target for the year \(t\), for the construction and operation period respectively.

\[
ECI_{t} = \left( \frac{e_{a}}{e_{r}} \right),
\]

\[
ICI_{t} = \left( \frac{i_{a}}{i_{r}} \right),
\]

Where: \(t = \) the year of the construction and operation period respectively; \(e_{a} = \) new jobs created from the airport construction and operation for year \(t\); \(e_{r} = \) employment growth regional target according to government projections for year \(t\); \(i_{a} = \) new income generated from the airport construction and operation for year \(t\); \(i_{r} = \) new income generated as national target according to government projections for year \(t\).

The ECI and ICI ranges between 0 and 1. If ICSI and ECSI are above 0.5 indicates a very large coverage of the target of the national income growth in year \(t\). The above KPI supports the decision-making process in investing a new airport. The highest value corresponds to high coverage of the regional target towards regional economic development in terms of increased income and decision makers and stakeholders should focus on the implementation of the project.
3.2.3. Impact diversification to business ecosystem

The entropy measure compares the existing employment or income distribution among different sectors in a region to an equiproportional distribution. Maximum entropy distributions use information in the form of constraints. A constraint is anything that restricts the set of possible probability distributions. In an economic context, examples of information we use to impose constraints are really no different than the typical model closures necessary to make a theory well-determined. They include, for example, a budget constraint, market clearing conditions, the non-negativity of prices, stock-flow consistency, savings equal to investment, behavioural constraints such as utility maximization, conservation of value in exchange, full employment, functional distribution of income, equalization of the rate of profit (Stutzer 2000).

Higher entropy performance indicator values indicate greater relative diversification, while lower values indicate relatively more specialization. The maximum value of the measure would result in an equal distribution of employment among all sectors. The minimum value of zero (maximum specialization) would occur if employment were concentrated in one sector. On the other hand, if employment were distributed equally among the N sectors, the entropy index would reach its maximum value, indicating perfect diversity. The Diversification Economic Impact Performance Indicator (EI) equalization measure of economic diversity. The entropy index is calculated based on employment data for 38 sectors (classification International Standard Industrial Classification of All Economic (ISIC) Rev. 4/ European Classification of Economic Activities (NACE Rev. 2), grouped into 10 categories under ISIC 4 (Dimitriou et al., 2017).

\[
EI = - \sum_{i=1}^{N} S_i \ln \left( \frac{S_i}{S} \right) \quad (6)
\]

where \( N \) = the number of grouped sectors, \( S_i \) = share of economic activity in \( i \)th sector and \( \ln \) is natural logarithm.

This KPI evaluates the diversification of the different sectors of the case study area economic system prior and after the airport project implementation and thus the contribution of the project to the differentiation of the economic system.

4. Numerical application

4.1. Case study economic key features and project key features

Greece’s after a depression since 2011 (GDP change, −9.1%) until 2016 (GDP change, −0.2%), in 2017 GDP has started to recover (GDP change, +1.5%). In 2020, the COVID-19 shock has interrupted Greece’s modest economic recovery. GDP contracted by 7.9% in the first half of 2020, a steep drop from 1.9% growth in 2019, as the lockdown weighed heavily on domestic demand and tourism. The unemployment rate has increased noticeably since March, despite significant employment support measures as analytically depicted in Table 1 (International Monetary Fund (IMF), 2020).

Crete is the largest island in Greece, the fifth largest in the Mediterranean. Due to the island’s location and landscape formation, Crete enjoys significantly more sunny days and high temperatures throughout the year than other destinations in the Mediterranean. Because of its microclimate, most of the urban areas are spatially located on the north coastline of the island. The GDP of Crete accounts for over 5% of national GDP. Tourism is the major industry in the economy of the island and accounts for over 30% of local GDP (ELSTAT, 2020).

Traditionally, Crete attracts a high number of tourists because of the climate, the coast along the Mediterranean, the spatial allocation of islands as well as the high number of archaeological places. Crete is a faraway European destination (over 3,000 miles) from the countries that represent the main sources of the market. Thus, transport participation in the total holiday package is high and depends on the time window between the origin and the destination. Heraklion airport (HER) is the biggest airport in Crete and the second busiest airport in Greece, with fast growing volumes, handling above seven million tourists a year (7.4 million in 2017), (Hellenic Civil Aviation Authority-HCAA, 2020). The Heraklion airport serves both business and leisure traffic, providing accessibility to most big cities in Greece, and airports accommodate charter airlines in Europe. Analyzing Crete tourist market volumes, the higher share is from European regions, which represent ~90% of total international tourist arrivals. The main tourist markets are depicted in Fig. 2, as well as the average expenditure per visit in the Crete region for the main countries of origin.

80% of total passenger traffic concerns the tourism season (May to October) and around 50% concerns the peak season, which extends from July to September each year. The nature of the tourism and aviation business, along with the seasonal nature of demand, leads to the growth of charter and seasonal flights to and from Heraklion airport. The demand for air travel in Greece is predicted to grow from its current levels by the year 2040. 2020 is estimated that ~30 million fewer passengers will fly to and from Greece in 2020, according to ICAO. It is estimated that ~60 million fewer passengers will fly in 2019 as well. This fall will negatively impact the Greek economy by 10 billion euros and put ~273,000 jobs at risk. Greece in the summer performed well versus

| Year | Population | Unemployment rate (%) | Real GDP growth (%) | GDP* | Net national income** | Net national income in Crete *** | Net national income in Crete **** FTEs in Crete***** |
|------|------------|-----------------------|---------------------|------|----------------------|----------------------------------|-----------------------------------------------|
| 2019 | 10.725     | 17.3                  | 1.9                 | 209.8 | 144.2                | 9.72                             | 7.21                                      | 191,500                                      |
| 2020 | 10.711     | 19.9                  | 1.9                 | 209.8 | 144.2                | 10.95                            | 6.45                                      | 186,521                                      |
| 2021 | 10.668     | 18.3                  | 4.1                 | 219.0 | 146.0                | 11.78                            | 7.3                                       | 189,505                                      |
| 2022 | 10.625     | 16.6                  | 5.6                 | 235.7 | 157.1                | 12.48                            | 7.9                                       | 192,726                                      |
| 2023 | 10.582     | 14.8                  | 3.7                 | 249.7 | 166.5                | 13.03                            | 8.3                                       | 196,196                                      |
| 2024 | 10.539     | 13.5                  | 2.4                 | 260.6 | 173.7                | 13.416                           | 8.7                                       | 198,746                                      |
| 2025 | 10.497     | 12.7                  | 1.5                 | 268.3 | 178.9                | 9.72                             | 8.9                                       | 200,336                                      |

*aCurrent prices (Billion of U.S. dollars).*
**Market prices (Billion of Euro).***
***Current prices (Billion of U.S. dollars). It is estimated as the 5% of GDP in nation.
****Market prices (Billion of Euro). It is estimated as the 5% of national income
*****It is estimated as the population in Greece (Aged 15-64), multiplied by unemployment rate.
its European competitors in terms of international air travel, due to its targeted testing policy for arriving passengers and removing quarantine. The country saw a lower percentage fall in ticket sales (58 percent) in July and August compared to similar tourist markets such as France (-81%), Italy (-81%), Spain (-85%), Portugal (-81%) and Cyprus (-82%). For the purpose of this paper, it is assumed that air transport will turn back to the development expected before 2020 after some years. Therefore, airport capacity around the country needs to increase as failure to increase the capacity will have a negative impact on regional and national economic growth and international competitiveness.

The existing airport in Heraklion has constraints imposed by its limited runway length, terminal facilities and safety standards, operational constraints. These issues, coupled with the need to increase capacity, mean that there is a need for a re-allocation of funds for the airport. In response to this situation, the Government of Greece intends to build a new international airport under an international tender, located in Kastelli, a new site 35 km north of the city of Heraklion. The Government acknowledges that this new gateway will help the still struggling economy to recover. In 2017, there was one bidder in the international tender for the project’s development. The airport is expected to be completed in 5 years.

The project concerns the design, construction, and commissioning of a new international airport in the area of Kasteli, Crete, with a capacity of fifteen (15) million passengers per year. The construction cost of the new airport is estimated at EUR800 million, comprised mainly of the construction costs of the runways, terminal, roads, parking lots, and control tower. The project’s financing and management scheme will follow Public-Private Partnership (PPP) Guidelines. The new airport will be developed on a design, build, finance, operation and maintenance (DBFOM) basis for a period of 35 years.

4.2. Level 1: Targets determination

Based on economic growth and unemployment rate data presented in Table 1 according to (IMF, 2020), the regional employment and income targets are estimated and depicted in Table 3, in terms of income and Full Time Equivalent jobs (FTEs).

4.3. Level 2: Economic impact assessment

4.3.1. IO modeling inputs

Based on an assumed peak on-site construction workforce of 1,000 employees (Federal Aviation Authority (FAA), 2013), direct employment supported by implementation of the proposed airport development is estimated to average 1,100 FTE positions a year for four years, giving a total of 4,000 annual FTE positions over the five years of construction period. Flow-on employment is estimated to average 324 FTE positions a year for five years, giving a total of 1,620 annual FTE positions over the five years construction period. Total employment supported by implementation of the proposed development is estimated to average 570 FTE positions a year for five years, giving a total of 2,855 annual FTE positions over the five-year construction period. Table 3 presents analytically the calculated annual impacts in terms of employment and income for the five years of the new airport construction period.

The operating life of the airport is set at 35 years. Assumption scenarios for the direct impact of the airport have been constructed for the first year of operation of the new airport. The relocation and expansion of the airport is expected to enable an increase of air passengers and reach 8–12 million passengers in the initial stage of operation (first year of operation). Based on World Airport Traffic Forecasts 2019–2040, with a predicted long-term Compound Annual Growth Rate (CAGR) of domestic passenger traffic of 3.4%, the Environmental Impact Analysis was approved through the award of an Environmental Terms Approval (ETA) by the Competent Authority through a Joint Ministerial Decision. Based on data traffic 2012–2019 (HCAA, 2020) and the above considerations, the new facility could meet an increased seasonal demand of 8 to 12 million passengers annually, as analytically depicted in scenario development in Table 4. It would become Greece’s second-busiest airport after Athens (capital of Greece) in terms of International Tourist Arrivals (ITAs), accommodating the majority of the seasonal international tourist arrivals on a national scale.

According to Airport Council International (ACI, 2015), analysis on the social and economic impact of European airports suggested that every 1000 passengers travelling through European airports is associated with an average of 0.954 direct jobs (ACI, 2015), highlighting those economies of scale are significant in the airport environment even though different airline business models and operations require a different number of workers on and around the airport campus. Based on this analysis and other evidence that connecting passengers create 3% fewer direct jobs than origin/destination passengers and Low Cost Carriers (LCC) passengers generate 20% fewer direct jobs than non-LCC passengers, an analysis of the data traffic at Heraklion 2012–2019 (HCAA, 2020) and information regarding the use of the airport by LCCs indicates an estimation of an average of 700 employees for the months of high demand (7 months of high demand for the low scenario, 9 months of high demand for the basic and full season (12 months) for the high-

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**Table 3**

| CP# | t | ir | Er | it | Et |
|-----|---|----|----|----|----|
| 2019 | 7.21 | 191,500 | 0.76 | 4,979 |
| t – 1 | 6.45 | 186,521 | 0.85 | 2,984 |
| t – 2 | 7.3 | 189,505 | 0.56 | 3,221 |
| t – 3 | 7.9 | 192,726 | 0.47 | 3,470 |
| t – 4 | 8.3 | 196,196 | 0.36 | 2,550 |
| t – 5 | 8.7 | 198,746 | 0.26 | 1,590 |

**CP Construction Period.

**OP Operational Period.

*Net income at market prices in Crete.

**FTEs in Crete.

***target in terms of income in year t.

****target in terms of FTEs in year t.

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**Fig. 2.** Expenditure per visit in Crete region main for main countries of origin (Bank of Greece, 2020).
season (12 months of the low-seasonal and 12 months of the airport by LCC) and amidst-seasonal and amidst-seasonal and based on the airport by LCC—months, based on the airport by LCC—2012–2019 based on the data, 2012–2019.

4.3.2. IO modeling assessment results

In terms of employment, it is estimated that due to airport project in the construction period will be generated 940 direct, 294 indirect, 671 induced and 1905 total FTE jobs on average annually for the 5 years period. The analytical employment values are depicted in Table 5.

In terms of income, it is estimated that due to airport project in the construction period will be generated 18.8 € millions direct, 34.2 € millions indirect, 62.9 € millions induced and 115.7 € millions on average annually for the 5 years period.

4.4. Level 3: Impact concentration and diversification ratios results

Applying the performance indicators towards regional development adopted in the methodology framework to evaluate the contribution of the airport to cover the regional targets for economic development, the results show that ECI for employment growth will be 0.326 in the first year of construction, 0.816 in the second year, 0.756 in the third year of construction, 0.584 in the fourth year, and 0.394 in the fifth year. The concentration ECR for the 1st year of operation will be 0.495 for the low scenario, 0.629 for the medium scenario and 0.770 for the high scenario. The target will be over 1.0, highlighting that the development of the new airport not only fulfills the target of economic recovery in the 1st year of operation but will generate additional income and employment.

The ICI for income growth in the first year of construction will be 0.132, 0.125 in the second year, 0.184 in the third year, 0.182 in the fourth year, and 0.112 in the fifth year. The achievement of the target in terms of income coverage in the first year of operation will be over 1.0, highlighting that the development of the new airport not only fulfills the target of economic recovery in the 1st year of operation but will generate additional income and employment (Table 6).

The ECI and ICI indicators in construction period are above 0.25 and in many years above 0.5 thus correspond to high coverage of the regional target towards regional economic development in terms of increased employment informing decision makers and stakeholders on the boost of employment during construction and operation period.

Many sectors of the economy will enjoy increased activity in comparison with others. Considering the existing business development model and the regional spending transactions in I-O analysis, as estimated in terms of income it is estimated that due to airport project in the construction period will be generated totally 1,005 (million Euro) for the 5th year of construction period and 126,096 (million Euro) for the medium scenario for operational period. If the economic system and the sectors were equally distributed economic activity for each sector would be equal with 100 (million Euro) for the 5th year of construction period and 12,609 (million Euro) for the medium scenario for operational period. Applying the shares of economic activity results for each ith industry, the equation (5) results in EI indicators as depicted in Table 7.

These indicators evaluated the diversification of the different sectors of the case study area economic system prior and after the airport project implementation and thus the contribution of the project to the differentiation of the economic system and therefore towards economic development. Analyzing the diversification index and investigating the forward linkage sectors of the average annual estimated macro-economic effects associated with the project, those vital economic sectors that will mainly benefit from the project, are highlighted. Considering that equally distributed economic activity is considered more diverse, the higher entropy index values (2.01) in construction period indicate greater relative diversification, while the lower values in operational period (1.32) indicate greater relative specialization.

5. Conclusions

The paper provided the evaluation methodology approach into a context to support decisions towards airport development projects. The proposed methodology provided an evaluation framework based on a combination of an ex-ante assessment analysis taking into considering the airport’s economic impact and its contribution to the regional economy. The Input Output analysis framework was used to determine the economic footprint of the airport development and a series of key performance indicators was introduced to review the project performance in a given economic system. The case study focused on the new

Table 4

| Input data for IO Modeling. | t – 1 | t – 2 | t – 3 | t – 4 | t – 5 | t – 6 |
|---------------------------|------|------|------|------|------|------|
| Direct impact in terms of employees | 800  | 1,200| 1,200| 1,000| 500  | 4,600|
| Number of passengers (million pax) | 8.0  | 10.0 | 12.0 | 10.0 | 12.0 | 18.0 |
| Additional ITAs in new airport | 50,000 | 1,050,000 | 2,050,000 | 1,500 | 3,050 | 5,050 |
| Total ITAs in new airport | 4,000,000 | 5,000,000 | 6,000,000 | 1,000 | 3,000 | 5,000 |

Table 5

| Employment and income generated due to airport development in t. | Construction period | Operation period (1st year) |
|---------------------------------------------------------------|---------------------|-----------------------------|
|                                                              | t = 1 | t = 2 | t = 3 | t = 4 | t = 5 | t = 6 | t = 1 | t = 2 | t = 3 | t = 4 | t = 5 | t = 6 |
| (FTE jobs)                                                    | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | Low  | Medium | High | Low  | Medium | High |
| Direct                                                       | 800  | 1,200| 1,200| 1,000| 500  | 2,600 | 4,250| 6,400  |      |      |      |      |
| Indirect                                                     | 250  | 855  | 855  | 715  | 355  | 2,385 | 3,899| 5,872  |      |      |      |      |
| Catalytic                                                    | 30   | 30   | 30   | 30   | 30   | 93,333| 116,667| 140,000|      |      |      |      |
| Total - ea (€ millions)                                      | 1,625| 2,435| 2,435| 2,025| 1,005| 99,098| 126,096| 154,222|      |      |      |      |
| Direct                                                       | 16   | 24   | 24   | 20   | 10   | 78    | 109 | 150    |      |      |      |      |
| Indirect                                                     | 5    | 7.5  | 7.5  | 6    | 3    | 24    | 33  | 45      |      |      |      |      |
| Induced                                                      | 64   | 96   | 96   | 80   | 38   | 55    | 100 | 138     |      |      |      |      |
| Catalytic                                                    | 85   | 127.5| 127.5| 106  | 51   | 2,957 | 3,742| 4,533  |      |      |      |      |
airport in Heraklion, Crete (in the Kasteli valley), which is one of the most attractive tourist destinations in the south-east Mediterranean. The key performance indicators estimate provide strong evidence of the existence of a long-term co-integrating relationship between economic growth, infrastructure investment, and unemployment reduction, resulting in the achievement of regional economic targets, especially in difficult economic circumstances under stress. Increasing and sustaining the level of air transport investment can make a positive contribution to the achievement of the objectives of accelerated and regional economic growth, contribute to achieve and cover the targets for socioeconomic development. It is imperative, therefore, to encourage decision makers to invest in such infrastructures as part of a decision-making process to bring about a sustained recovery in economies suffering from stress and reduce the high levels of poverty and unemployment within a country. The results suggest that during and after the current COVID-19 crisis, investment in transport infrastructure offers a strong employment enforcement and keeps businesses afloat and maintains the productive capacity of the economy. Especially with cash flow restrictions, infrastructure investment projects should all continue at the fastest pace possible as it provides the base load for the sector and can shield the economy from further job losses in accordance with health issues related to COVID-19. The application addressed in this paper is a tool to support governments in considering some of the regulatory impediments that will inhibit or slow growth, developing new megaproject-strategies, and focusing on their existing asset base while improving efficiency, resilience, and broader cross-sector economic impacts. The key message is that investing in sustainable infrastructure projects such as new airports in such constrained economic conditions and financing assumptions, where the project’s business plan performance is strongly related to regional development prospects, and future airport business can contribute to meeting regional economic development targets, is a wise move.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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KPIs towards Post COVID-19 economic recovery over time.

| Construction period | Operation period (1st year) |
|---------------------|----------------------------|
| t = 1               | t = 6                      |
| 2020                | 2025                       |
| ICR 0.009           | 0.005                      |
| ICI 0.011           | 0.266                      |
| ECI 0.326           | 0.336                      |
| ICI 0.132           | 1.000                      |

Table 6

| Prior to airport development | Construction period (5 years average) | Operation period (1st year) |
|-----------------------------|--------------------------------------|-----------------------------|
| EI 1.74                     | 2.01                                 | 1.32                        |
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