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# Attribute of the Effects Diversification to Eco-System from Large Investments in Supply Chain

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*Abstract-* In most of the cases the decision to invest in a new large transport infrastructure project t is not simple, mainly, because the complications in planning process, the amount of capital need to invest before the business establishment and the high number of stakeholders involved in decision process. The decision process is more complicated in restricted economic conditions and financing assumptions, where the project business plan performance is strongly related to regional development prospects and business sectors enlargement. This paper provides an attribute methodology approach to support decisions in large transport infrastructure projects based on the effects diversification to ecosystem affected by the new projects. The proposed methodology provides an evaluation framework based on a combination of an ex-ante assessment analysis taking into consideration the large transport infrastructure projects economic impact and its contribution to enlargement of the sectors of the ecosystem.

*Keywords: transport infrastructure investment, effects diversification, economic impact, ecosystem.*

*GJMBR-B Classification: JEL Code: E22*

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*Keywords: transport infrastructure investment, effects diversification, economic impact, ecosystem.*

## I. Introduction

The development of transport infrastructure to meet future demand needs is on the top of the agenda for governments, and regional development stakeholders. This is due to the recognition that transport infrastructure development has a vital role in contributing to wider socioeconomic development principles and is a key driver for new income generation and business growth (Dimitriou and Sartzetaki, 2019a).Consequently, there is a risk that a significant share of the predicted growth in transport demand will be left unaddressed if existing transport infrastructures are not expanded and/or new infrastructures are not built to meet this demand (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 are made within a complicated, and high risk economic framework in terms of project financing conditions and regional economy risks (Dimitriou et al., 2015).

Decision makers have recognized the contribution of large transport infrastructure investment to the economy (Elliasson et al., 2012). Governments and authorities therefore rightly acknowledge the benefit of investments in transport infrastructure projects in order to achieve socioeconomic goals. In principal, 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, making authorities and different stakeholders defense to accommodate additional demand.

This paper focuses on an evaluation framework that provides a step up and down methodology, which in two stages makes use of a combination of assessment and evaluation methodologies. The proposed methodology provides an evaluation framework based on a combination of an ex ante assessment analysis taking into consideration the large transport infrastructure's economic impact and the effects diversification to regional ecosystem. This approach is essential to provide key messages to national governments, decision makers and stakeholders regarding the contribution of new large transport infrastructure investment towards regional development. The case study adopted to illustrate the application of this methodology is two new large transport infrastructure projects in two different regions in the nation of Greece in south-east Mediterranean.

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 considered in the next section with the application of the framework. This results in a comprehensive assessment through the incorporation of the methodology framework. The paper finally outlines the conclusions and references.

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## II. Transport Infrastructure and Economic Development

It is widely recognized that transport infrastructure projects play an important role in regional economic development and are a crucial generator of socioeconomic prosperity for countries. The supply of these infrastructure projects as well as a service on health, education, justice, security, communications, the environment and the functioning of the public sector is a priority and concern of the governments. Although regional development is essentially a multidimensional concept, it is very often limited to employment, production or income indicators. A major aim of many regional policies is to reduce disparities, so that the overall picture of the economy is more in agreement with socio-economic objectives regarding equity.

According to Mackie et al., 2014, the implementation of an effective and efficient strategy requires an integrated approach which while considering the external socioeconomic environment interaction with the transport infrastructure project, which is defined by two basic parameters - economic development and political aiming. In order to investigate further the relationship between the external environment and the transportation system, the external environment has to be categorized into several dimensions, such as, territorial, institutional, economic and social.

Adequate infrastructure is a fundamental precondition for transport systems. Decision-makers in governments and international organizations face difficult challenges. These include the existence of physical barriers or hindrances, such as insufficient or inadequate transport infrastructures, bottlenecks and missing links, as well as lack of funds to remove them. Transportation agencies face municipal, state and federal; budget constraints, so awareness of funding priorities based on the physical condition of transportation system is key. The decisions to rehabilitate, expand, and construct new systems depend on the conditions of existing systems and competing modes. Furthermore, the scarcity of traditional transportation funding is contributing to a growing gap between the funds required for improvements and the funds available to do so. A well functioning and efficient transportation system depend on both its capacity and infrastructure condition.

Infrastructure investment covers spending on new transport construction and the improvement of the existing network. Infrastructure investment is a key determinant of performance in the transport sector. Inland infrastructure includes road, rail, inland waterways, maritime ports and airports and takes account of all sources of financing. Efficient transport infrastructure provides economic and social benefits to both advanced and emerging economies by: improving market accessibility and productivity, ensuring balanced regional economic development, creating employment, promoting labour mobility and connecting communities. Decision makers have long been concerned with the question of whether transport and large transportation infrastructure investment leads to economic development (Dimitriou, et al., 2017; Macharis et al., 2015; Van et al., 2014; Bismark et al., 2014). Decision making implies making choices, specifically in the case of large transportation infrastructures related to policy making for budget allocations and choices between alternatives for a new road or a new railway or another large transportation infrastructure project (Kelly et al., 2015).

Governments and decision makers promote public investment in large transportation infrastructure projects in order to achieve socioeconomic goals. Arguments for significantly boosting investment, especially in large infrastructures, in order to achieve sustained growth rest on high returns on investment in capital-scarce environments and the pressing deficiencies in these areas. One of the most critical issues for decision makers is to select which public investment projects will be funded.

There are many empirical analyses and ex-post assessments in literature that analyse the economic impact of large transportation infrastructure projects (Reisa et al., 2009; Correa et al., 2001; Mackie et al., 2014; Elliasson et al., 2012; Nelson et al., 2010). Crescenzi et al. (2012) emphasise the fact that transport infrastructure has represented one of the cornerstones of development and cohesion strategies in the European Union (EU) and examine to what extent transport infrastructure endowment – proxied by regional motorways – has contributed to regional growth in the EU between 1990 and 2004. The results of the panel data regressions indicate meagre returns for infrastructure endowment on economic growth, raising interesting questions about the opportunity costs of further infrastructure investment across most of Western Europe.

In order to better understand the impact of transportation infrastructure expenditures on national economies, Bismark et al. (2014) undertook an aggregate study of the relationship between transportation infrastructure expenditure and gross domestic product from the economies of 40 countries using three econometric frameworks (ordinary least squares, random-effects and random-parameters models) and data from 1992 to 2010. The estimated results show considerable variability across countries, with the impact of transportation infrastructure expenditure varying as a function of the country's existing transportation infrastructure and the reliance of specific economic sectors on transportation in each nation.

In addition there has been an extended interest in analyzing the economic effects of transportation of specific transportation networks, such as the impact on highways on regional regional economic development and urban regional development (Baum-Snow, 2007; Duranton et al., 2012; Datta, 2012).

Investment decisions are made in the face of uncertainty over future impacts. Ex-ante appraisals of the effectiveness of transportation infrastructure projects minimise this uncertainty and play a large part in the decision making and selecting projects for funding. Kelly et al. (2015) analysed the project level outcomes of ten large transport projects spread over eight countries that had benefited from EU Cohesion and ISPA funding and found that there is a clear need to improve the quality and consistency of ex-ante analysis, particularly in the areas of capital cost estimation, travel demand modelling and risk analysis. They also identified the limited role that formal decision-making analytical methods such as cost-benefit analysis and multi-criteria analysis play in the decision-making process of the countries surveyed.

Limitations in large project ex-ante evaluations stem from issues where such projects are capital intensive and require long project preparation periods and even longer project pay-back periods where both intentional or unintentional risks from the evaluation may arise and/or market trends may alter. Salling et al. presented a decision support system that enables decision makers to assess various project appraisal uncertainties in a systematic and explicit manner and concluded that the appraisal of large infrastructure projects can be effectively supported by addressing uncertainty issues. Mohamed et al. 2013 proposed a method capable of modelling the effects of both monetary and non-monetary aspects of an investment option, using interval mathematics to assess the inherent uncertainty associated with such aspects

## III. Economic Impact Analysis of Transport Infrastructure Projects

Economic impact analysis (EIA) unveils how transportation facilities and systems affect businesses, governments and households. Many researchers claim that transportation infrastructure and investments are vital for the economy and serve as engines that fuel economic growth.

Concerning the role of transport infrastructure investments to economic development, many researchers review the relationship of transport infrastructure projects and economic development. Investments in transport infrastructure, the development of management expertise and cultural exchange benefits affect various sectors of the regional economy (Dimitriou et al., 2017; Dywer et al., 2014).

Especially the transport infrastructures projects that affect tourism industry, their contribution is more essential to regional economic development (Lee et al., 2008). There many researchers that have analyzed the main methodology framework to estimate the impact on the economic system especially for the regions heavily depended on tourism (Dimitriou and Sartzetaki, 2018; Dimitriou et al., 2017; Dimitriou and Sartzetaki 2017b; Dimitriou et al., 2015). Institutions, associations and governmental bodies widely recognize the need for monitoring transport demand and adopting strategies to exploit the economic benefits for local society (Dimitriou and Sartzetaki, 2016).

Economic impact analysis traces the effects of expenditures of the transport sector through the economy. An initial expenditure circulates through the economy and creates and chain reaction of additional expenditures (Dimitriou and Sartzetaki, 2019a). The quantification of benefits is calculated through economic impact analysis. Economic impact analyses usually are based on two different methods for analyzing economic impact. The methods employed are the input-output analysis (IO analysis) and General Equilibrium Models (CGE).

## IV. Economic Impact Categories

There are four distinguished categories of transport infrastructure economic impact.

*Direct impact:* Direct impact is the impact with local firms providing support services to the t. These jobs are dependent upon this activity and would suffer immediate dislocation if the seaport activity were to cease. For the case of ports, direct jobs include jobs with railroads and trucking companies moving cargo to and from Port marine terminals and private terminals, freight forwarders, terminal operators, etc (Dimitriou et al., 2017). For the case of air transport direct impact is generated by air carriers, operations, aircraft maintenance, air traffic control and activities directly serving air passengers, such as check-in, baggage-handling, on-site retail and parking. (Dimitriou and Sartzetaki, 2018).

*Indirect impact:* Indirect impact generated in the local or regional economy is the income as the result of local purchases by the firms directly dependent upon the transport infrastructure activity. These indirect jobs generated include jobs in supply firms, equipment and parts suppliers, maintenance etc. For the case of air transport, the indirect contribution of air transport 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 centres, IT, etc.) (Dimitriou and Sartzetaki, 2018).

*Induced impact:* Induced impact is the income created throughout the regional economy due to purchases of goods and services by those directly and indirectly employed (Cervero et al., 2003). 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 (Dimitriou and Sartzetaki, 2018).

*Catalytic impact:* Catalytic impact identifies the drivers of national economic development interacted with transport sector. For the case of ports, the catalytic is throughout the state with manufacturing and wholesale and retail distribution firms using the seaport terminals for the shipment and receipt of cargo (Dimitriou et al., 2017). For the case of air transport catalytic there are many and different sources of catalytic economic impact, covering most of the business activities and tourism. Therefore, the catalytic effects represent the income generated by the air transport international tourist arrivals are the spillovers effects due to tourism spending. (Dimitriou and Sartzetaki, 2018)

### a) *Economic Impact Models*

In literature there are many researchers used IO analysis to estimate the economic impact of transport infrastructure in economy. Setol et al. (2009) used an input output inoperability model as a mechanism for analyzing the induced effects caused by critical infrastructure dependencies and interdependencies. Developed by Wassily Leontief in the 1930s, Input-Output analysis analyzes the interdependence of industries within a given economy.

Dimitriou et al. (2011) presented an instructive defensible picture of the economic and employment impacts that can arise from the development of the new airport in a Greek island. As was calculated in the input output analysis approximately 4000 direct, 1500 indirect jobs are estimated to be supported inside the airport. The circulation of direct and indirect impacts through the regional economy will generate additional multiplier impacts associated with suppliers and additional earnings and wages. The application of the method suggested that these impacts will result in an additional 10.200 regional jobs and output of 970 million Euros in the region. The total value added of the airport on the Region of Crete will be 970 million Euros.

Dimitriou and Sartzetaki (2018) analyzed the air transport sector contribution in Greece in last eight years. The results indicated that thorough the last year's economic downturn there is a high dependence of air transport sector to economy. The results indicated that in terms of generated income, while the total income in Greek economy is reduced about 25% between 2008 and 2016, the income caused by air transport is reduced less than 7% in the same time, providing evidence of the aviation business resilience. The results highlighted key messages to decision makers and stakeholders regarding the air connectivity and economy linkage and provide an essential tool to estimate the impact of alternative policies and investments in industries related to air connectivity, aviation and tourism.

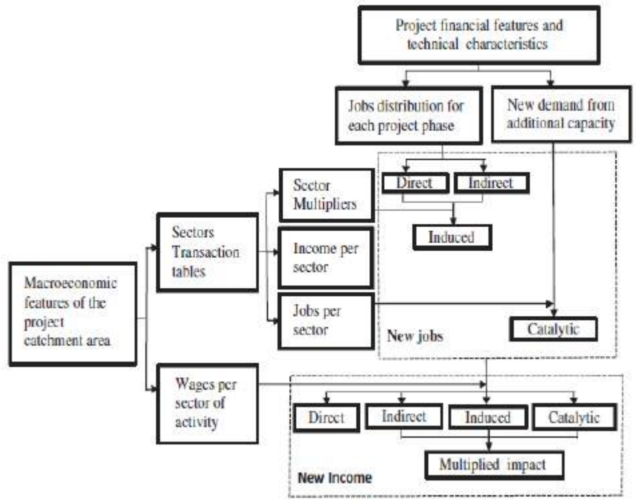
Dimitriou et al. (2017) estimated the macroeconomic impact arising from the major seaport assets using an Input–Output Analysis model. The results indicated in terms of employment, the port-related and shipping related jobs represent the 10% of total employment and represents 9.2% of Greece total income nationwide in 2014. The findings highlight the high contribution and especially of the manufacturing sector across the State, who export products and materials through the main ports of Greece, to economic growth.

Dimitriou et al. (2017) estimated the contribution of air transport sector in 2014 and investigated the forward linkage sectors of the average annual estimated macro-economic effects associated with the air transport sector highlighting those key economic sectors that will mainly benefit from air transport industry. The key sectors were highlighted to be wholesale trade, transportation, accommodation an food service activities. The estimated results provide a strong evidence of the existence of long run cointegrating relationship among economic growth, air transport and unemployment reduction investigating the high level of coverage of national socioeconomic targets caused by air transport industry.

### b) *Foundation of the IO Model*

The Input-Output analysis has been developed by the economist Wassily Leontief and shows how the parts of a system are affected by a change in one part of that system (Leontief, 1986). The basic structure of input output model and the collection of data to describe and quantify that structure, provide decision makers with a more thorough understanding of the internal processes of the institution being studied. Input-Output analysis is based on a system of linear equations that describe the distribution of an industry's product throughout an economy.

IO analysis based on the concept of multipliers is an appropriate approach to evaluate how an economy may react to specific policies or external shocks or changes such an investment in a new transportation infrastructure project. More specific, IO tables provide a complete picture of the flows of products and services in an economic system for a given year, illustrating the relationship between producers and consumers and the exchange of goods and services among economic sectors (Dimitriou et al., 2015; Zeng 2010). In other words, they illustrate all monetary market transactions between various businesses and between businesses and final demand sectors (i.e. consumers, government, investment, exports, etc.). Thus, they can be used to construct disaggregated multipliers in order to estimate apart from the direct impacts of a particular investment also its indirect and induced impacts. (Dimitriou et al., 2017).




*Graph 1:* IO model depiction (Dimitriou et al., 2015 ).

According to Miller and Blair (2009), it is assumed that the economy can be categorized into n sectors. If the total output is denoted by xi and by fi the total final demand for sector i's product, then the simple equation accounting for the way in which sector i distributes the simple equation accounting for the way in which sector i distributes its product through sales to other sectors and to final demand is:

$$X_i = a_{i1} + .. + a_{ij} + \cdots + a_{in} + \mathrm{b} = \sum_{j=1}^{n} a_{ij} + b_i \qquad (1)$$

In IO analysis, the fundamental assumption is that the flows of sector i to j depend on the total output of sector j. The aij terms represent inter industry sales by sector i (also known as intermediate sales) to all sectors j (including itself, when j = i).

An economic system is expressed by a monetary input output table. This table the sum of every sectoral final output value equals the sum of every sectoral value-added, which is called the gross national product (Zeng, 2010).

*c) Technological coefficients derivation*

The fundamental step after the assumptions and definitions is to convert the inter-industry transaction table into the Direct purchase coefficients table (McCann, 1998; Zeng, 2010). Based on the fundamental assumption of the IO model that the flows of sector i to j depend on the total output of sector j, the technical coefficient can be derived by dividing the inter-sectoral flows from i to j(aij) with total output of j (Xj). This will be the output by dividing each inter-industry transaction in the IO table by each industry's total Input. The Equation that derivates the Technical Coefficient Table is

$$f_{ij} = \frac{a_{ij}}{X_J} \qquad (2)$$

where, aij is also often termed as IO coefficient and (direct) input coefficient. The aij is regarded as determining fixed relationships between a sector's output and its inputs so can be expressed as follows:

$$a_{ij} = \frac{f_{ij}}{X_J} \qquad (3)$$

IO model describes an economic system in which n industries (each producing a single commodity) interact with each other using, as inputs, the outputs of the n industries. In its basic formulation the equilibrium equation of this model can be written in matrix form as Miller and Blair, 2009 define:

$$(I - A)^{-1} X = F \qquad (4)$$

Where

I = n × n unit matrix

X= nonnegative vector of gross output of each production sector

F = nonnegative vector of final demand

A= n × n nonnegative matrix of technological coefficients or the input- output matrix

n= number of production sectors in which (I−A)−1 is referred to as the multiplier, or Leontief inverse matrix (Miller and Blair, 2009).

The matrix (I-A)-1 which is the inverse of (I-A) in the case of n sectors is the Leontief matrix and is the key ingredient of the model. It is a representation of the nation's (or the region's) economy and helps to predict the effect of changes in one industry on others and shows all the connections between the different sectors of the economy.

## V. Attribute of Transport Infrastructure Effects Diversification to Ecosystem (EDES)

The Economic Impact Diversification to Ecosystem Indicator (EDI) is used as a measure of the ecosystem sectors entropy. The entropy measure compares the existing employment or income distribution among different sectors in a region to an equiproportional distribution. Higher entropy performance indicator values indicate greater relative diversification, while lower values indicate relatively more specialization. The maximum value of the measure would result with the 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.

*Table 1:* Sectors of A10 classification according to Nace Rev. 2

| | | |
|---|---|---|
| A | Agriculture, forestry and fishing | A1 |
| B_C_D_E | Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities | A2 |
| F | Construction | A3 |
| G_H_I | Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities | A4 |
| J | Information and communication | A5 |
| K | Financial and insurance activities | A6 |
| L | Real estate activities | A7 |
| M_N | Professional, scientific and technical activities, administrative and support service activities | A8 |
| O_P_Q | Public administration and defense, compulsory social security, education, human health and social work activities | A9 |
| R_S_T_U | Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies | A10 |

The framework is based on employment data for 38 sectors (classification ISIC Rev. 4/ NACE Rev. 2), grouped in 10 categories(A10)according to ISIC 4 Rev. 4/ NACE Rev. 2, as analytically given in table 1.

The equation is based on the following formula:

$$EI_t = \sum_{i=1}^{N} S_i \ln\left(\frac{1}{S_i}\right) \quad (5)$$

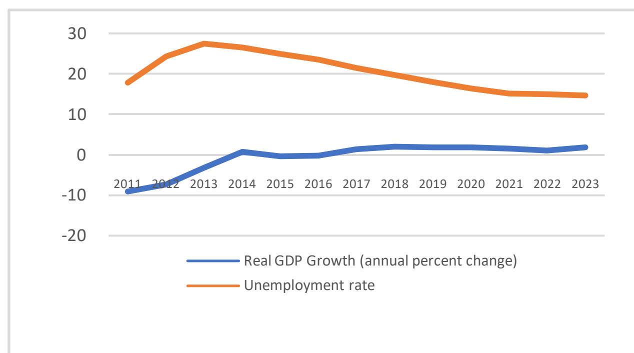
where N= is the number of grouped sectors, Si =share of economic activity in ith sector and *ln* is natural logarithm.

EDES evaluates the diversification of the regional ecosystem sectors of the case study area economic system prior and after the large transport infrastructure development.

## VI. Numerical Application

### a) *Case study area economic features*

Greece's after a depression since 2011 until 2016 (Graph 2), in 2017 economic recovery is gaining traction. GDP has started to recover after having fallen by a quarter from 2011 (Graph 2). In the last two years, the pace of reforms has accelerated and broadened (IMF, 2018). Despite these positive developments, challenges abound GDP per capita is still 25% below its pre-crisis level (IMF, 2018).



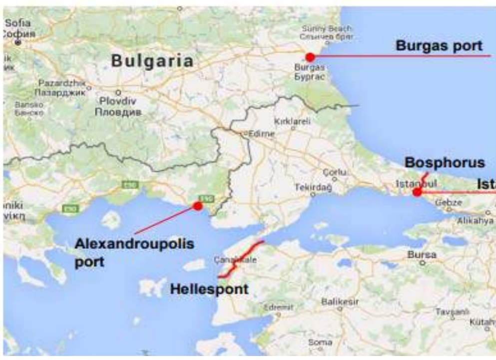

*Graph 2:* Real GDP growth and unemployment rate (2011-2017) and projections for 2018-2023 for Greece (IMF, 2018).

*Case study 1: Logistic centre development in North Greece*

The framework is applied in a strategic logistics hub in North Greece. The new large transport infrastructure investment project aims to optimize the transportation system, to enhance the performance of logistics and multimodal transport chains, advances the continuous integration of transport infrastructure and transport development (Sartzetaki and Dimitriou, 2019a).The investment will satisfy the overall need for developing a logistics hub in North Greece to support multimodal transportation between Greece and Bulgaria.

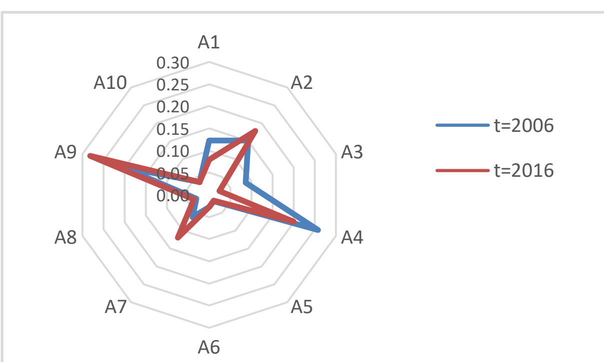
The development of transit hub includes infrastructure development of integrated management through multimodal land (road and rail) with the network of international ports in the region. The project also involves the renovation of 180km single rail track between the Alexandroupolis city and Ormenio/ Bulgarian border. This project is expected to attract more international transit traffic to fully exploit the strategic location of the country.

From a geostrategic point of view, this project will further strengthen the country's role, as it will be connected with the port of Burgas, enabling this way Greece to become an international freight hub for Central and Eastern Europe.




*Graph 3:* Strategic location of the project area (source: Dimitriou and Sartzetaki, 2019)

The regional ecosystem of the new project catchment area is driven mainly by the A4 thus wholesale and retail trade, transportation and storage, accommodation and food service activities and A9 thus public administration social security, education, human health and social work activities. The regional ecosystem sectors diversification change in last ten years is analytically depicted in following graph.




*Graph 4:* Sectors diversification (A10) in regional ecosystem for case study 1 project catchment area

*Case study 2: Airport development in South Greece (Crete island)*

Crete island in Greece is a faraway European destination (over 3.000 miles) from the countries that represent the main sources of tourist market, and is highly depended on air transport. Heraklion airport (IATA: HER) is the biggest airport in Crete and the second busiest airport in Greece, with very fast growing traffic volumes, handling above seven million tourists a year (7.97 million passengers in 2018), (25) with 83% International passengers share. The 80% of total passenger traffic concerns the tourism season (May – October) and around 50% concerns the peak season extend from July to September each year (HCAA, 2019).

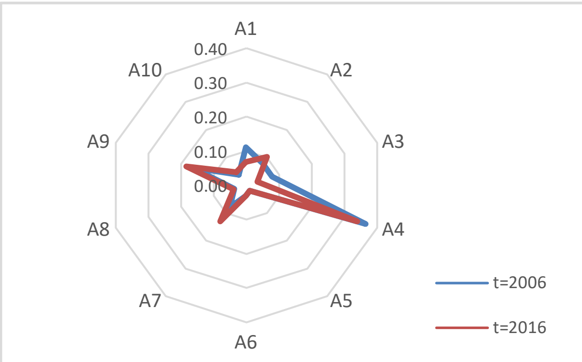
As the airport has constraints imposed by its limited runway length, terminal facilities and safety standards, operational constraints, the airport capacity needs to increase as failure to increase the capacity will have a negative impact on regional and national economic growth and international competitiveness. In response to this situation, a new airport will be developed under an international tender, located in Kastelli, a new site 20 km north of the city of Heraklion. The Government acknowledges that this new gateway will help the still struggling economy to recover. In 2018 there was bidder in the international tender for the project development.


*Graph 5:* Case study airport location (source: google maps; accessed July 2019)

b) *Project key features*

The Project concerns the design, construction and commissioning of a new international airport in the area of Kasteli of 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 runways, terminal, roads, parking lots and control tower and is expected to start operation after 5 years construction period. The project financing and management scheme will follow Public-Private Partnerships (PPP) Guidelines. The new airport will be developed on a design, build, finance, operation and maintenance (DBFOM) basis for a period of 35 years. The key technical features for the new airport in comparison with the existing one depicted in the Table 2.

The regional ecosystem of the new project catchment area is driven mainly by the A4 thus wholesale and retail trade, transportation and storage, accommodation and food service activities especially based on tourism. The regional ecosystem sectors diversification change in last ten years is analytically depicted in following graph.




*Graph 6:* Sectors diversification in regional ecosystem for case study 2

## VII. Results - Effects Diversification to Regional Ecosystems

*Case study 1*

*a) Economic effects based on IO modeling results*

Considering the uncertainties in future estimates of the financial parameters and the characteristics of the investment involving a payback period for the project over 30 years and based on the most likely demand scenarios the IO modelling framework is applied to derive the direct, indirect and induced total impact created by the project on the annual output (in million €). The large transport infrastructure project results in an annual increase of the total income ranging from €1.5 m to €0.6m for direct income generation, from €1.8m to €0.75m for indirect income creation, from €3.02m to €1.2m for induced income generation, for the 5 year of operation as depicted in following table.

*Table 2:* Effects in terms of income generated due to logistic center development

| Income (€ million) | Direct | Indirect | Induced | Total |
|---|---|---|---|---|
| 1st year | 1.500 | 1.800 | 3.028 | 6.328 |
| 2nd year | 0.900 | 1.080 | 1.817 | 3.797 |
| 3rd year | 0.600 | 0.720 | 1.211 | 2.531 |
| 4rth year | 0.612 | 0.734 | 1.235 | 2.582 |
| 5th year | 0.624 | 0.749 | 1.260 | 2.633 |
| 5-year Average | 0.8472 | 1.0166 | 1.7102 | 3.5742 |

*b) Effects Diversification to regional ecosystem*

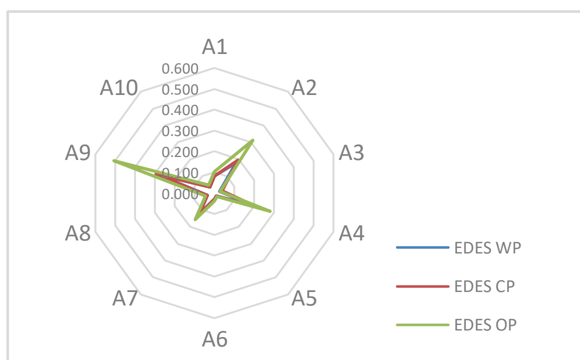
Analyzing the diversification index and investigating the forward linkage sectors of the average annual estimated macro-economic effects associated with the two different case study transport infrastructure projects, those key economic sectors that will mainly benefit from the projects are highlighted.

During construction period, the key sector that moves from the value 0.17 to value 0.30 will be the construction sector. This indicates that a unit change in final demand in this sector will create an above average increase in activity in the economy, and unit change in all sectors of the final demand will create an above average increase of output in this sector. During Operational period the key sector that are enlarged are the trade, transportation and accommodation, therefore the group of sectors corresponding to Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities move form value 0.20 to 0.28.

*Table 3:* Effects diversification to ecosystem results

| | CASE STUDY I | | |
|---|---|---|---|
| | WP | CP | OP |
| A1 | 0.079 | 0.080 | 0.103 |
| A2 | 0.178 | 0.195 | 0.313 |
| A3 | 0.025 | 0.040 | 0.027 |
| A4 | 0.200 | 0.220 | 0.280 |
| A5 | 0.017 | 0.018 | 0.022 |
| A6 | 0.029 | 0.030 | 0.037 |
| A7 | 0.120 | 0.126 | 0.156 |
| A8 | 0.036 | 0.037 | 0.046 |
| A9 | 0.281 | 0.295 | 0.506 |
| A10 | 0.035 | 0.037 | 0.046 |

This EDES evaluated the diversification of the different sectors of the case study area ecosystem without the projects (WP) prior and after the project implementation and thus the contribution of the project to the differentiation of the economic system and therefore towards economic and business development.




*Graph 7:* Effects Diversification from logistic center development to regional ecosystem

*Case study 2*

*a) Economic effects based on IO modeling results*

Based on an assumed peak on-site construction workforce of 1000 employees (ACI, 2015), direct employment supported by implementation of the proposed airport development is estimated to average 1100 FTE positions a year for four years, giving a total of

4000 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 1620 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 2855 annual FTE positions over the five-year construction period.

Table 4 presents analytically the calculated annual impacts in terms of employment and income for the five years of the new airport construction period.

*Table 4:* Effects in terms of income generated due to airport development

| Income (€ million) | Direct | Indirect | Induced | Total |
|---|---|---|---|---|
| CP- Construction Period | | | | |
| 1st year | 16 | 5.0 | 64 | 85 |
| 2nd year | 24 | 7.5 | 96 | 127.5 |
| 3rd year | 24 | 7.5 | 96 | 127.5 |
| 4th year | 20 | 6.0 | 80 | 106 |
| 5th year | 10 | 3.0 | 38 | 51 |
| 5 years average | 18.8 | 5.8 | 74.8 | 99.4 |
| CO- Operation Period | | | | |
| | | Low scenario | Basic scenario | High scenario |
| Annual direct income | | 78 | 109 | 150 |
| Annual indirect income | | 24 | 33 | 45 |
| Annual induced income | | 55 | 100 | 138 |
| Annual Catalytic income | | 330 | 450 | 600 |
| Total annual income | | 409 | 691 | 933 |

In terms of income it is estimated that due to airport project in the construction period will be generated EUR18.8 mio direct, EUR 5.8mio indirect, EUR 74.8mio induced and EUR 99.4mio total on average annually for the 5years 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 10-12 million passengers in the initial stage of operation (first year of operation).

According to 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 0.954 direct jobs (26), highlighting that economies of scale are significant in the airport environment even though different airline business models and operations require different number of workers on and around the airport campus. Based on this analysis and other evidence that connecting passengers create 3% less direct jobs than Origin/Destination passengers and Low Cost Carriers (LCC) passengers generate 20% less direct jobs than non LCC passengers; an analysis of the data traffic at Heraklion 2012-2017 and information regarding the use of the airport by LCCs indicates estimation of 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 demand (12 months) for the high scenario) and of 400 employees for the non-high demand months.

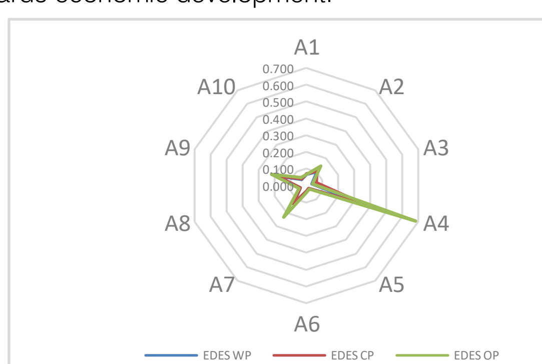
*b) Effects Diversification to regional ecosystem*

During construction period, the key sector that moves from the value 0.034 to value 0.062is the construction sector. This indicates that a unit change in final demand in this sector will create an above average increase in activity in the economy, and unit change in all sectors of the final demand will create an above average increase of output in this sector. During Operational period the key sector that are enlarged are the trade, transportation and accommodation, therefore the group of sectors corresponding to Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities move form value 0.341 to 0.682.

*Table 5:* Effects diversification to ecosystem results

| | CASE STUDY 2 | | |
|---|---|---|---|
| | WP | CP | OP |
| A1 | 0.069 | 0.071 | 0.069 |
| A2 | 0.104 | 0.107 | 0.146 |
| A3 | 0.034 | 0.062 | 0.038 |
| A4 | 0.341 | 0.375 | 0.682 |
| A5 | 0.019 | 0.020 | 0.025 |
| A6 | 0.031 | 0.032 | 0.037 |
| A7 | 0.130 | 0.136 | 0.233 |
| A8 | 0.039 | 0.041 | 0.047 |
| A9 | 0.183 | 0.193 | 0.220 |
| A10 | 0.049 | 0.052 | 0.059 |

This EDES 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.




*Graph 8:* Effects Diversification to regional ecosystem from the airport development

## VIII. Conclusions

The paper provided the evaluation methodology approach into a context to support decisions towards new large transport infrastructure projects. The proposed methodology provided an evaluation framework based on a combination of an ex ante assessment analysis taking into consideration the transport infrastructure economic effects and their diversification to regional ecosystems. The Input Output analysis framework was used to determine the economic footprint of the two case study projects development and an entropy-based index was introduced to review the projects effects diversification in a given regional ecosystem.

The results for the construction period 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 for both projects. 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.

In contrast in operation period the results suggest that investment in an airport infrastructure in restricted economic conditions and financing assumptions, where the project business plan performance is strongly related to regional development prospects and future airport business affect significantly the sector diversification to the regional ecosystem in the operation period in comparison with the logistic center 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 and achieve the enlargement of business sector diversification to regional and national ecosystem.

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