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Conference Paper

A Post-Opening Transport Infrastructure's Socio-Economic Evaluation: The Case of "Attiki Odos Motorway"

53rd Congress of the European Regional Science Association: "Regional Integration: Europe, the Mediterranean and the World Economy", 27-31 August 2013, Palermo, Italy

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Belegri-Roboli, A.; Marinos, Th.; Markaki, M. (2013) : A Post-Opening Transport Infrastructure's Socio-Economic Evaluation: The Case of "Attiki Odos Motorway", 53rd Congress of the European Regional Science Association: "Regional Integration: Europe, the Mediterranean and the World Economy", 27-31 August 2013, Palermo, Italy, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/124135>

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53rd ERSAs Congress
Regional Integration: Europe, the Mediterranean and the World Economy
Palermo, August 27-31, 2013

A Post-Opening Transport Infrastructure's Socio-Economic Evaluation: The Case of "Attiki Odos Motorway"

Abstract: The purpose of this research is the post-opening evaluation of "Attiki Odos Motorway" (AOM) socio-economic impacts, during the period of its operation. The AOM is the peripheral ring-road of the metropolitan Athens-Attica area. To this end, the study estimates an ex post project's "Overall Returns Index" (ORI) based on Multi-Criteria Analysis (MCA). Within this framework, selected factors-criteria specified by the interaction mechanism between the motorway's operation and its socio-economic environment are assessed. Then, at each criterion a number of sub-criteria that characterize it are assigned. These are evaluated not on the basis of subjective judgments – as in the case of the traditional MCA – but on the basis of performance indexes, supported by factual dataset. With regard to the empirical results, the socio-economic returns of the studied motorway, as they occurred from the formula, are high. This means that, on average, the selected sub-criteria and thus the criteria of the formula appear high compliance in our case study. However, the estimates are subject to the limitation of the methodology employed as well as other factors. Clearly, future research on the subject would be of great interest.

Keywords: "Attiki Odos Motorway", socio-economic impacts, Multi-Criteria Analysis, Overall Returns Index.

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1. Introduction

The aim of this paper is twofold: first, to propose a post-opening transport infrastructure's socio-economic impacts' indicator (Overall Return Index – ORI), based on multi-criteria analysis (MCA); and second to estimate this indicator for a case study.

The case study is the “Attiki Odos Motorway” (AOM). The AOM is the peripheral ring-road of the metropolitan area of Athens-Attica¹. It is a cutting-edge European motorway, meeting the highest design standards for high-speed motorways. It constitutes a priority project, since its operation incorporates significant linkages with: i) regional, ii) national, and iii) international² factors. It forms a backbone for the region's transport network, assisting the strategic layout of Attica's communication network, contributing to the regional integrated urban planning³. The motorway's construction started in 1996 and cost approximately \$1.3 bn. It was partly opened to traffic in March 2001 to serve the new Athens International Airport “Eleftherios Venizelos”, while its full operation started in 2004⁴. The total length of the AOM is 65 kilometers with 20 junctions, serving on average about 265,000 vehicles per day over the period of its operation. In this context, the ex post socio-economic evaluation of AOM is a particular interest venture, due to the above features of the project.

In general, transport infrastructures have traditionally been regarded as an important instrument in public policies' effort to boost national and regional economic development and decrease inter/intra-regional inequalities. Transport infrastructures facilities reduce the factors of “distance” and “time” and hence reduce transport cost by increasing regions' accessibility. A well developed and efficient transport network increases productivity, stimulates employment and generates additional investments. In other words, provides economic and social opportunities and benefits which, in turn, result positive multiplier effects: improved accessibility increases the mobility of goods and labor and reduces firms' cost of production. On the other hand, a deficient transport sector has important economic and social cost, such as reduced or missed opportunities, congestion and environmental pollution (Rodrigue *et al.*, 2009).

European Union (EU) early⁵ accepted the significance of transport infrastructures as a fundamental factor to an efficient European economy. The aim of the EU was to promote transport projects as a key element for the reinforcement of the economic and social cohesion. Hence, a large number of projects of common interest benefited from financial support of the Community budgets⁶. The European Investment Bank (EIB) has also greatly contributed to the financing of these projects through loans⁷. Hence, a significant share of its funds was directed to investments in transport projects⁸, in

¹ Athens metropolitan area citizens' are 3.813.000, which means about 40% of country's population (ELSTAT, 2011).

² The AO-94 is incorporated to the Transport European Network (TENs-T).

³ http://www.roadtraffic-Technology.com/projects/attiki_odos/

⁴ The motorway was financed and constructed under a DBFOT arrangement with a consortium of companies under the name Atiki Odos SA.

⁵ The idea of Trans-European Networks (TEN) emerged by the end of the 1980s in conjunction with the proposed Single Market. The construction of TENs is an important element for economic growth and the creation of employment, http://ec.europa.eu/ten/index_en.html.

⁶ TEN-budget, Structural Funds and Cohesion Fund.

⁷ http://ec.europa.eu/ten/index_en.html.

⁸ http://ec.europa.eu/transport/themes/infrastructure/index_en.html

order to create an integrated and efficient European Transport Network (TENs-T). This choice besides, was also supported by the observed increased volumes in traffic demand; domestic and international trade⁹.

However, the last years' ominous economic situation and the pressures that the EU Governments face to reduce their fiscal expenditures, led them to reduce their investments in transport projects. Additionally, the dispute –in the empirical research era at least– about the transport infrastructures' contribution to economic development advocated to this direction. Besides, private sector's participation is still restrained due to the high risk that transport projects encapsulate. Hence, the limitation of public and private funds for transport projects makes the direction of the investments a particular difficult task, since they must be provided carefully to projects with high economic and social returns.

In this context, the EU's new transport policy focuses on financing a smaller number of projects, where EU value added can be realized. Member States also face more rigorous requirements in terms of cross-border specifications and legal obligations about their completion¹⁰. Therefore, the ex post evaluation of a project with a set of socio-economic criteria, which can give an “overall” measure of its performance is the main question in the current economic situation and it can constitute a significant policy tool for the future.

The structure of this paper is as follows: Section 2 presents a literature review. Section 3 describes the methodological approach proposed in this paper. Section 4 contains the case study. In Section 5, the empirical results are analysed. Finally, section 6 summarizes the main findings and the conclusions of the study.

2. Literature Review

The role of transport infrastructures in the spatial distribution of the economic activity has become of increased interest to researchers in macro and micro level for more than three decades now (i.e. for a review see Straub, 2008; Banister and Berechman, 2000). Moreover, the theoretical predictions on the net effects of infrastructures improvements on firms and local economic outcomes are ambiguous. Given this theoretical position the effect of projects improvements on the firm level and aggregate level outcomes remains an empirical question (Gibbons *et al.*, 2012).

Macro framework constitutes an axiomatic approach, which scopes to elaborate the structural relation of the public investments with economic measures such as employment and growth. The onset was the Aschauer's paper (1989), which argued that public investments stimulate private ones, since public investments in infrastructures increase the rate of return of private capital. The basic principle underlying this argument was that public capital is an intermediate input in the private production technology. Hence, the availability of a low cost intermediate input increases the production of final goods and stimulates economic activity (for a review see Banister and Berechman, 2000).

⁹ Freight transport is expected to grow by 80% and passenger transport by more than 50%, by 2050.

¹⁰ http://europa.eu/rapid/press-release_MEMO-11-706_en.html

Micro studies, on the other hand, are mainly focused on the appraisal of the socio-economic impacts of specific transport schemes on their contiguous areas. They belong to the operational research area, carried out either *ex ante* – when funds are to be invested to alternative projects – or *ex post*, for the project's operation assessment. The *ex ante* studies are based on the forecasted values of variables related with the project's operation, using the experience of other projects' operation with same characteristics (utilization rate, traffic volumes, average speed of traffic, cost and time of construction etc.). The *ex post* evaluation are usually carried out a period after the project's opening, either to confirm or to disprove the expectations of the planning phase.

For example, Kjerkreitef *et al.* (2008), applying cost-benefit analysis (CBA), carried out a post-opening evaluation of eight (8) Norwegian trunk-road schemes for the years 2006-2007. The selected trunk-roads should have been opened to traffic for approximately five (5) years and their construction cost was above 200 mill Norwegian Kroner. The main goal was to find out whether the predicting impacts, in the planning phase, were actually achieved. The results indicated that the Net Present Value (NPV) of the 7 out of 8 projects was greater than forecasted, implying that these projects have led to larger net gains¹¹.

“Frontier Economics”, “Atkins” and the “Institute of Transport Studies”¹² (2011) carried out an *ex post* CBA for ten (10) European transport projects¹³. The results, compared with the available *ex ante* evaluations, have shown that 9 out of 10 projects yielded positive NPV; however at the seven (7) of these, this was lower than the *ex ante* expected ones. The main causes for this deviation were the differences between the *ex ante* estimated and *ex post* realized travel demands and the cost overruns.

In a different spirit, Gibbons *et al.* (2012), estimated the effect in productivity, employment and wages caused from road transport improvements in UK. The goal was to construct a measure of accessibility to employment through road network, over the period 1998-2003. Using firm's data estimated the changes in employment due to the changes in the road accessibility in these years. Then, applying 2 steps OLS, tested the impact of changes in accessibility on firm' outcomes. The regression results did not detect significant changes in Total Factor Productivity (TFP), labor productivity or wages, associated with improvements in the employment accessibility. There was some evidence of an increase in the plants' number in the postcode sector but weaker evidence of employment growth. According to the authors, a possible explanation for this could be the fact that, the induced changes to employment accessibility were too small and geographically localized to generate detectable changes in productivity.

Finally, in the Greek territory, the Observatory of the “Egnatia Odos Motorway” (2006) published a report about the effects of its operation, over the period 1995-2005. As a case study Vatero was selected; an area with significant business

¹¹ In the case of the only project that yielded smaller *ex post* NPV this was due to the underestimation of its construction cost. The higher post-opening NPVs were explained by the fact that the rate of traffic growth had been higher than forecasted and, additionally, by divergences in accident costs, investment costs and changes in projects' design.

¹² University of Leeds.

¹³ Those projects had been funded from the EU Cohesion Fund and the Instrument for Structural Policies for Pre-Accession (ISPA), the period 2000-2006

concentration for the last few years. The data analysis¹⁴ indicated that the motorway's operation brought reduction in travel times and, hence, cost of transport to the contiguous to Vatro areas and especially to Thessaloniki. This had as a result the attraction of a significant number of new businesses, mainly of the logistics' sector. However, the motorway's operation was not the only factor, which led to business location in Vatro. The availability of free space was another notable reason, mainly for the firms of the secondary sector. The new firms located in Vatro after the motorway's opening, resulted in turn, the significant increase of the area's labor power, both of the secondary and tertiary sectors.

Concluding the above studies, “[the] understanding [of] the relationship between transport improvements and economic outcomes is essential to the design of transport policy, and given the importance of road transportation for the movements of people and goods, the evaluation of the impact of road investments is also important for economic policy as a whole” (Gibbons *et al.*, 2012).

3. Methodological Framework

The formula applied for the appraisal of the social and economic impacts of the AOM's operation, is developed on the basis of the multi-criteria analysis (MCA) framework. The MCA constitutes an important tool in the decision-making era, in complex situation fields as infrastructure projects' evaluation. It is based on the *ex ante* model initially proposed by Joynt (2004), properly adjusted to estimate a post-opening “overall return index” (*ORI*) for our case study.

“Multi-criteria analysis is undertaken to make a comparative assessment between projects or heterogeneous measures. In the evaluation field, multi-criteria analysis is usually an *ex ante* evaluation tool, and is particularly used for the examination of the intervention's strategic choices. In *ex post* evaluations, multi-criteria analysis can contribute to the evaluation of a program or a policy through the appraisal of its impacts with regards to several criteria”.¹⁵ According to Anon (1996) it constitutes an easy, valid and cost-effective project evaluation technique, with regard to the project's objectives that have been defined in the planning phase (cited in Joynt 2004).

Compared with the traditional techniques, commonly used in the literature¹⁶, MCA allows to be analyzed both quantitative and qualitative factors (criteria), related with the socio-economic aspects of the project in question¹⁷ (Lake and Ferreira, 2002; Taylor and Aldian, 2005).

The method's main drawback is that the appraisal of the criteria which determine the final evaluation output usually emerges from the subjective judgments of the decision makers. Hence, in many cases, there is a conflict among the different groups involved

¹⁴ The analysis used qualitative and quantitative data, before and after road's opening to traffic and a semi-open questionnaire. The study period was the decade 1995-2005.

¹⁵ http://ec.europa.eu/europeaid/evaluation/methodology/tools/too_cri_res_en.htm

¹⁶ Three (3) methods are usually met in bibliography on transport projects' evaluation: a. the Multi-Criteria Analysis (MCA), b. Cost-Effectiveness Analysis (CEA) and c. Cost-Benefit Analysis (CBA) (Van de Walle, 2002).

¹⁷ The factors in MCA are not necessary to be transformed in monetary terms, a fact which is not always feasible.

to this, with regard to its impacts or the expected results will occur from the realization of different alternatives scenarios (Taylor and Aldian, 2005). In ex-post project evaluation - as our case study - the traditional method is properly adjusted: the subjective appraisal of the criteria in question is now been done with the support of factual quantitative data.

The objective of the next section is to be described the ex-post evaluation formula developed in order to be estimated the socio-economic impacts of the AOM in the MCA framework. The proposed formula is also applicable for the evaluation of the socio-economic impacts of individual transport projects.

3.1. The MCA Evaluation Formula

According to MCA, the problem of the evaluation of the AOM is first inducted to the detection of the key factors both affect and been affected by the motorway's operation. Namely, to the selection of those factors that are considered to determine the causal relationship between motorway's operation and the social activity and economic performance in the geographical areas of its influence. These factors form the basis of our model and constitute the criteria of the proposed evaluation formula. The number of the selected criteria should be limited; otherwise the effectiveness of the MCA technique is reduced.

At each criterion is assigned a weight. In order to avoid the subjectivity of differential weighs, at all the criteria is assigned the same weigh (Anon, 1996), with their sum to be equal to unity (3.1):

$$\sum_{i=1}^N w_i = 1, i = 1 \dots N \quad (3.1)$$

where w_i is the weight of the criterion i , and N the number of the selected criteria.

After the criteria's selection, the analysis goes further to the specification of each one's important characteristics, with regard to the project's socio-economic effects. In this way, at each criterion a number of sub-criteria are assigned, which interpret its causal relationship with the project in question.

At this point is important to be mentioned, that both the selected criteria and sub-criteria of the formula are not unique. There are a large number of factors and characteristics, which explain the causal relationship between the project's operation and the socio-economic activity of its contiguous areas. The selection of the criteria and sub-criteria of the formula on the one hand is supported by the theoretical enquiry of the project's objectives and on the other hand describe the research group's perception about the key-factors that fulfill these objectives. Moreover, there is always the theoretical constraint of the limited number of the criteria and sub-criteria of the evaluation formula. More precisely, the selected sub-criteria should not ideally exceed sixteen (16), otherwise the effectiveness of the MCA is limited (Joynt, 2004).

Following Joynt (2004), the evaluation of the sub-criteria is accomplished using individual performance indexes, by the support of factual data. Their fulfillment is indicated by an evaluation scale, which takes prices (scores) from 1 to 5; 1 denotes the

lowest price and 5 the highest one¹⁸. These scores are used to estimate the degree of fulfillment of each sub-criterion. The degree arises as the ratio of its score to the highest potential one (5). For example, if from the analysis occurs that the score of a sub-criterion is 3, then, its fulfillment degree is 3/5.

Thus, in total the evaluation degree of each criterion is the weighed sum of its sub-criteria's degree. Again, in order to avoid subjectivity issues in the determination of the final degree of each criterion, we assume that the weights of its sub-criteria's degrees are equal, with their sum to be equal with one (1) (3.2):

$$\sum_{j=1}^M q_{ij} = 1, j=1...M \quad (3.2)$$

where q_{ij} is the weight of the sub-criterion j of the criterion i , and M is the total number of the sub-criteria of the criterion i .

The ORI has the general form:

$$ORI = \sum_{i=1}^N w_i C_i, i=1...N \quad (3.3)$$

$$C_i = \sum_{j=1}^M q_{ij} S_{ij} = \sum_{j=1}^M q_{ij} (G_{ij}/5), j=1...M \quad (3.4)$$

where

Analytically from 3.3 and 3.4 we have w_i and C_i are the weight and the degree of the criterion i , respectively. C_i is the weighed sum of the degree of the sub-criteria j (S_{ij}) of the criterion i ($S_{ij} = G_{ij}/5$, where G_{ij} , is the score of the sub-criterion j).

Equations (3.3) and (3.4) indicate that ORI takes values from 1/5 (in the case where all the sub-criteria take degree equal to 1) to 1 (in the case where all the sub-criteria take score equal to 5). In other words, the more ORI approximates the unity, the project's operation is considered more efficient. According Joynt (2004), a project with $ORI < 0.5$ is considered to have pure returns, from 0.5-0.7 average to good, while prices of $ORI > 0.7$ indicate high economic and social returns.

Concluding, the ORI is estimated as the weighted sum of criteria's degree in the MCA formula. This indicator expresses the direct, indirect, induced and prospective impacts arise from the motorway's operation.

4. Case Study: Attiki Odos Motorway

4.1 Interaction Mechanism

The specification of the appraisal formula, as it was mentioned in the previous section, first requires the illustration of the interaction mechanism underlies the project's operation and the social and economic activity to its neighboring regions. The analysis does not differ from the traditional analysis, has widely developed in the

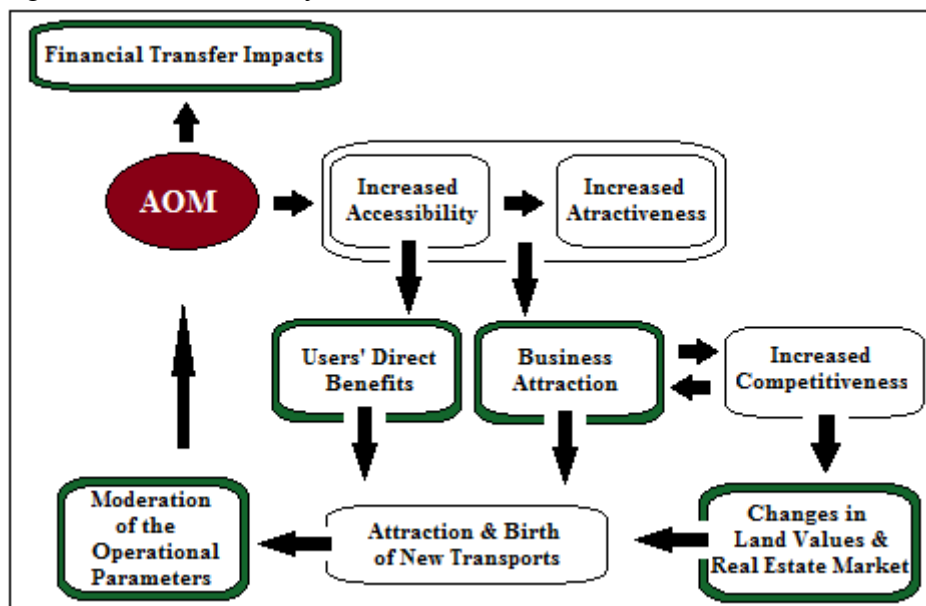
¹⁸ If a sub-criterion takes a value of 5, this means that it is significantly evident in the area study, while a value of 1 declares exactly the opposite. The prices 2, 3 and 4 indicate increasing evidence of the sub-criterion in question.

literature¹⁹ dealing with the relationship between transport projects and the socio-economic activity of their influenced areas.

However, the essential role of the AOM must be taken into account: it is a project with significant regional, national and international – as part of TENs-T – role, planned to serve local, long-distance and interregional transports of great commercial and economic importance. Besides, motorway’s direct connection with the new Athens International Airport “Eleftherios Venizelos” and the two main country’s axles (the NS Athens-Thessaloniki and the EW Athens-Patras) attaches additional characteristics to its operation. Furthermore, it is tightly related with the wider urban planning of Attica (Master Plan of Attica-Athens/ 2021, 2011), with priorities: a) the relief of the Athens’ urban transport network and b) the balanced and sustainable development of the suburban areas.

More extensively, the AOM is expected to improve the accessibility of its contiguous areas, giving them a comparative advantage, mainly toward the areas of the traditional urban center of Athens, which suffers from congestion and scarcity of untapped space, due to the over-buildup socio-economic activity and transport infrastructures’ deficiency. Hence, the motorway’s nearby areas are expected to attract a significant number of firms and the creation of new ones, in order to exploit the benefits of a modern motorway. This, in turn, will have increased direct impact in land prices and in real estate market. As a consequence, the motorway will attract a share of Attica’s transport volume and will create new. However, there is a twofold relationship between the AOM’s effected areas’ socio-economic development and the operation of the motorway. The social and industrial development of its neighboring areas and the actual levels of transport demand may require the moderation of the motorway’s operational parameters; in order to be revised possible erroneous estimates in project’s planning phase.

Figure 1: The motorway’s social and economic interaction mechanism



¹⁹ Transit Cooperative Research Program Report 35, 1998

Figure 1 shows the mechanism proposed from the international bibliography, adjusted to the research's purposes and, as we will see next, constitutes a useful guide for the specification of the factors that will form the criteria of the evaluation formula.

4.2. Specification of Criteria and Sub-criteria Analysis

From Figure 1 emerges that the first criterion (I) of the AOM's evaluation is the "*financial transfer impacts*" (FTI). These impacts are referring to the direct economic effects related to the operating and maintenance cost of the motorway. The chosen factors (sub-criteria) for the estimation of this criterion are: "*the number of employees*" in the motorway's operating company²⁰ (toll collectors, engineers, traffic controllers, workers etc.), the firm's "*intermediate inputs*" and also the return of "*indirect taxes*" associated with the toll collection. The magnitude of these impacts in the national economy is a first factor that interprets the economic effect of the AOM's operation.

Furthermore, the motorway operation has "*direct benefits to its users*" (DBU). These benefits (sub-criteria) are: "*the reduction of travel time*", "*the reduction of transport cost*" and "*the improvement of transport safety*". These benefits have wider economic importance concerning the affect -direct cost savings (operational and productive) for the firms located in the motorway's area. Hence, DBU constitutes the second criterion (II) of the evaluation formula.

The third (III) criterion is related with the "*induced economic impacts*" (IEI) from AOM's operation. The factors (sub-criteria) using to analyze the IEI's criterion are the "*motorway's attraction for the location and the creation of new business*", fact which leads to production factors transfer and the creation of new jobs to the area in question. In this way, the "*agglomeration of the economic activity*" is a key factor of the scale economies creation and the improvement of productivity level of the firms located in motorway area. Also, a factor that determines the intensity of the induced benefits is related with the "*social and economic maturity*" of these areas. For example, if the areas in question are composed exclusively by vacant farmlands and there is no business and social activity, they don't favor the attraction of new business and the creation of a dynamic economic environment. On one hand, a fully developed area already is mature with no significant opportunities for further development. On the other hand, areas with an existing and structured economic and social environment, but with the necessary available land space, are considered ideal for the creation of a strong urban economy (Joynt, 2004). Hence, the existence of such areas declares the potential for further development induced by the operation of the AOM.

The fourth criterion (IV) is the "*real estate market impact*" (REMI). This criterion expresses the changes occurred in the land value and the real estate market in the motorway areas. More precisely, its factors (sub-criteria) are the shifts in the "*market land prices*" and the "*changes in land uses*". Moreover, the "*new buildings constructed*" during the operation period of the motorway, characterize the situation of real estate market and, thus, will be introduced into the formula.

The last criterion (V) of the formula is related with "*the operational environment*" (OEN) of the AOM. More specifically, the "*intermodality and interoperability*" are two characteristics-factors that a modern motorway as AOM must fulfill. Moreover,

²⁰ "Attikes Diadromes SA"

the “*level of service*” (LoS) is the second factor of operational environment that interprets its capacity to serve additional transport loads, arising from the further socio-economic development. Finally, the existence of basic “*auxiliary infrastructures*” in the areas in question is a necessary condition of further development.

Concluding the analysis above is summarized in Table 1.

Table 1: MCA Formula’s Criteria and Sub-criteria

CRITERIA	SUB-CRITERIA
I. Financial Transfer Impacts (FTI)	<ol style="list-style-type: none"> 1. <i>New Jobs’ Creation</i> 2. <i>Intermediate Inputs</i> 3. <i>Tax Payments</i>
II. Direct Users’ Benefits (DUB)	<ol style="list-style-type: none"> 1. <i>Reduction in Travel Time</i> 2. <i>Reduction of Transport Cost</i> 3. <i>Increase of Transport Safety</i>
III. Induced Economic Impacts (IEI)	<ol style="list-style-type: none"> 1. <i>Attraction for Business</i> 2. <i>Agglomeration Economies</i> 3. <i>Socio-economic Maturity</i>
IV. Real Estate Market Impacts (REMI)	<ol style="list-style-type: none"> 1. <i>Changes in Land Values</i> 2. <i>Changes in Land Uses</i> 3. <i>New Buildings’ Construction</i>
V. Operational Environment (OEN)	<ol style="list-style-type: none"> 1. <i>Intermodality- Interoperability</i> 2. <i>Level of Service</i> 3. <i>Auxiliary Infrastructures</i>

4.3. Specification of Sub-criteria’s Performance Indexes

In the previous section we came up to the selection of the criteria and sub-criteria that form the appraisal formula of the AOM. In this section we try to specify the evaluation score for each one of the selected sub-criteria. The purpose is, where is possible, to avoid the subjective assessments of premises; in order the evaluation outcome to constitute a reliable indicator of the motorway’s returns. However, the complete simulation of the reality is a tricky task and, hence, there is always the risk of subjective estimations in the analysis.

The performance indexes and evaluation score of the criteria’s sub-criteria are described next.

I) Financial Transfer Impacts (FTI)

As it is illustrated in Table 1, the FTI is related with the 1) the creation of new jobs (I_1), the demand for intermediates inputs (I_2), and the tax payments (I_3). The FTI - sub-criteria analysis and their scores are summarized in Table A.1, Appendix A. Finally, in this case, the examined period is the years of the motorway’s operation (2005-2011).

I₁) New Jobs' Creation

This sub-criterion's evaluates the ratio of the AOM's employees to the capital invested to the motorway (L_{AOM}/K_{AOM}), with the ratio of the employment created per unit of net capital stock of the Greek economy (L_{GR}/K_{GR}). More precisely, it is assumed that the created employment per unit of net capital stock for the Greek economy, expresses the average national level (and thus the average of the Attica's region) and, hence, corresponds to the score of three (3), (Table A.1, Appendix A). The specific sub-criterion [$I_1 = (L_{AOM}/K_{AOM}) / (L_{GR}/K_{GR})$] examines the AOMs' contribution in jobs creation.

I₂) Intermediate Inputs

The sub-criterion quantifies the intermediate inputs demand created by the operation and the maintenance of the AOM. It estimates the AOM's intersectoral linkages with the rest of the economy; since it expresses the backwards effects (direct and indirect) of AOM's demand to a range of economic activities. Similarly with above, the evaluation of this sub-criterion is based on the comparison of the ratio of the intermediate demand to the capital invested to the motorway (Z_{AOM}/K_{AOM}), with its corresponding ratio for the Greek economy (Z_{GR}/K_{GR}), (Table A.1, Appendix A); thus we have [$I_2 = (Z_{AOM}/K_{AOM}) / (Z_{GR}/K_{GR})$]. Again, a value equal with this for the Greek economy corresponds to the score of three (3).

I₃) Tax Payment

The last sub-criterion of the financial transfer impacts examines the economic benefits occurred for the public sector, from the operating company's indirect taxes (VAT) payment on toll revenues. For its evaluation it is estimated the ratio of the taxes in question to the invested motorway capital (T_{AOM}/K_{AOM}) with its respective ratio of the Greek economy (T_{GR}/K_{GR}). [$I_3 = (T_{AOM}/K_{AOM}) / (T_{GR}/K_{GR})$]. Same with I_1 and I_2 , we assume that the national average corresponds to three (3).

II) Direct Users' Benefits (DUB)

The direct users' benefits are: 1) the reduction of travel time (II_1), 2) the reduction of transport cost (II_2), and 3) the increase of transport safety (II_3). The DUB sub-criteria analysis and their scores summarized in Table A.2, Appendix A.

II₁) Reduction of Travel Time

The sub-criterion expresses the time saved by the use of the AOM, due to its modern operational characteristics, shorter routes and the improved motorway's traffic conditions. Specifically, the sub-criterion is evaluated by the ratio of the mean travel time necessary to cover characteristic routes²¹ via the Athens urban network (T_{AUN}) to its respective time via AOM (T_{AOM}). The sub-criterion's score is provided from the ratio above [$II_1 = T_{AOM}/T_{AUN}$], (Table A.2, Appendix A).

II₂) Reduction of Travel Cost

The sub-criterion II_2 examines the travel fuel saving that occurs from the use of the AOM, compared to the use of the urban road network, in characteristics routes. Its

²¹ These routes express the majority of travels of the AOM's users

score is provided by the ratio of the mean fuel consumption (lt/100 km) by the urban road network (C_{AUN}) to its respective consumption by the AOM (C_{AOM}), [C_{AOM}/C_{AUN}], (Table A.2, Appendix A).

II₃) Increase of Transport Safety

The last sub-criterion of the direct users' benefits examines the increased road safety, first due to its modern geometric and operational characteristics and, second, due the effective incident management methods. The score of the sub-criterion arises from the AOM's fatal accidents rate (per 100 million vehicle-kilometers) compared with its respective rates of characteristic Attica's roads²². Analytically, the evaluation scale is shown in Table A.2, Appendix A.

III) Induced Economic Impacts

It is assumed that the induced economic impacts are characterized by: the attractiveness of the neighboring to the AOM areas (III₁), the agglomeration of the economic activity (III₂), and the socio-economic maturity of these areas (III₃).

III₁) Attractiveness of the Neighboring Areas

This specific sub-criterion examines the attractiveness of the motorway's contiguous areas, with regard to the number and the size of the firms located in this. Its importance is that signifies the potential of these areas for further economic development. More precisely, while in the short-run, the location of large-size business in a region, affects its economic measures (production, employment, income), in the long-run is leading up to significant multiplier effects (Straub, 2008). For its evaluation, the number of firms located to the motorway's contiguous areas, with regard to the number of their employees is used (Table A.3, Appendix A).

III₂) Agglomeration of Economic Activity

The sub-criterion examines the potential increase in firms' productivity that will occur, due to large-scale economic activity in the AOM's axle, such as economic centers and industrial plants (agglomeration economies). According to Joynt (2004), enlarged diffusion of knowledge, technology, labor and productive resources, met in such economies, have also as a result the attraction of other related or nonrelated activities. The sub-criterion is evaluated by the spatial expansion of agglomeration economies across the motorway's axle. The regions of interest are economic centers of regional importance²³ (Table A.3, Appendix A).

III₃) Maturity of Socio-economic Activity

The last sub-criterion of the induced economic effects examines the combination of already developed urban and rested agricultural lands in the neighboring to the AOM areas. A region, composed by both developed and free surfaces constitutes an ideal receptor of socio-economic activity and, hence, a future development area (Joynt, 2004). In this principle is based the sub-criterion's evaluation since it estimated the percentage of the agricultural surfaces to the already developed ones. As optimal case

²² With equivalent with AOM operational characteristics.

²³ Areas with surface at least 30,000 m², according to Van der Merwe, 1987 (cited in Joynt, 2004).

is considered an area that constituted by approximately equal surfaces of developed and free lands (Table A.3, Appendix A).

IV) Real Estate Market Impacts

The characteristic measures of the real estate market impacts are: the changes in land values (IV₁), the changes in land uses (IV₂) and the new buildings construction (IV₃), Table A.4, Appendix A.

IV₁) Changes in Land Values

The sub-criterion examines the resulted shift in the land values of the areas that the AOM is passing through and expresses the demand changes occurred to these areas. The evaluation of the IV₁ is based on the land market prices' change of the areas in question, during the period of the motorway's operation (Table A.4, Appendix A). As a yardstick, the total percentage change recorded in land prices in the region of Attica the specific period is chosen.

IV₂) Changes in Land Uses

The specific sub-criterion finds out the post-opening changes instituted or planned to be instituted, on the land uses of the contiguous to the motorway areas. The areas of interest are the development poles and the receptors of productive activities, both of the secondary and tertiary sectors. The sub-criterion's score arises from the proportion of these areas' surface constituted after 2002²⁴ and those planned by MPA/2021²⁵ (2011) as so, to the total Attica's non-urban receptors' surface (Table A.4, Appendix A).

IV₃) Construction of New Buildings

The specific sub-criterion refers to the construction activity that has been developed to the motorway neighboring areas. Its evaluation is based on the comparison of this activity with its respective activity of Attica. More specifically, the sub-criterion's score occurs from the average annual rate of construction activity changes in the areas in question, to its respective rate in Attica, over the period of the motorway's operation, (Table A.4. Appendix A).

V) Operational environment

The characteristics that describe the AOM's operational environment are: the motorway's intermodality-interoperability (V₁), its level of service (V₂), and finally, the existence of basic auxiliary infrastructures in the areas that AOM is passing through (V₃).

V₁) Intermodality-interoperability

The sub-criterion examines the AOM's interconnection with alternative modes of transport such as: i) road, ii) railway, iii) marine, iv)air and v) public transport network. For the sub-criterion's evaluation, it is assumed that the motorway's connection with the above five (5) types of transport contributes equally to the sub-criterion's final score. This connection can be characterized as: direct, indirect or

²⁴ The year that the motorway started to operate.

²⁵ Master Plan of Attica-Athens

defective. In the case of direct connection the score is 1, of indirect is 0.5 and of defective is 0. As it is illustrated in Table A.5 (Appendix), the sub-criterion's final score is the sum of the five (5) AOM's connection partly scores.

V₂) Level of Service

The specific sub-criterion refers to the prevailed AOM's traffic conditions and, as mentioned in section 4.2, interprets its capacity to serve additional transport loads. The sub-criterion's evaluation is based on the motorway's annual mean daily Level of Service of a typical working day (Table A. 5, Appendix A).

V₃) Auxiliary Infrastructures

The last sub-criterion examines the existence of the necessary public infrastructures²⁶ in the motorway's neighboring regions. Its evaluation is based on the inventory of these infrastructures: electricity, water, sewerage, stormwater system and transport network (Joynt, 2004). The provision of each one of the above infrastructures can be characterized as: sufficient, deficient or absent. If the provision of one of the above types of public infrastructures is sufficient in the areas of the analysis, then is assigned a score equal to 1, if it is deficient a score equal to 0.5, while when is absent a score equal to 0. The final score of the sub-criterion is the sum of the above partly scores (Table A.5, Appendix A).

After the definition of the performance indexes and the evaluation scale for each one of the selected sub-criteria, the formula (3.4) is applied to assess the socio-economic impacts of the AOM.

5. Empirical Analysis

5.1 Sources and Data

The different nature and the large number of the selected sub-criteria established the selection of the necessary for their evaluation dataset, a particular difficult task. In certain sub-criteria, the availability of the appropriate data restricts the adopted period of analysis. With regard to the area of analysis, (for the sub-criteria with spatial notions), the focus is mainly on the contiguous to the motorway municipalities. The dataset comes from different sources, both primary and secondary. Primary data sources are: "Attikes Diadromes S.A.", "Attica's Motorway Police Administration Department", the Bank of Greece and the Hellenic Labor Inspectorate and secondary sources are: HelStat, Eurostat and the related literature.

The data used for the evaluation of the three (3) sub-criteria of the FTI, are both primary and secondary. Primary data comes from "Attikes Diadromes S.A." and refer to: a) the annual number of the company's employees, b) the annual intermediate inputs, c) The annual VAT, the company pays to the Greek Government and d) the invested to the motorway capital. The respective measures for the Greek economy are secondary and comes from the Eurostat's database²⁷. The capital stock of the Greek

²⁶ Maritz (1993)

²⁷ http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

economy is estimated using the Perpetual Inventory Method (Derbyshire J., *et al.* 2009).

The data for the evaluation of the sub-criteria of the DUB, comes from “Attikes Diadromes S.A.” and “Attica’s Motorway Police Administration Department”. The data from the “Attikes Diadromes S.A.”, consists on the travel times and fuel consumption spent for the coverage of twenty two (22) characteristic routes via the AOM and the Attica’s urban road network, respectively. Both the travel times and fuel consumption are estimated by trial runs done by the same car, mainly the morning and afternoon peak hours, during the period 29/02/12-22/03/12. Additionally, from the same source comes the traffic loads necessary for the estimation of the fatal accidents rate (per 100 million vehicle-kilometers). The data from the Attica’s Motorway Police Administration Department refer to the number of the deadly accidents happened in the Attica’s urban road network, the years 2010 and 2011.

The data used for the evaluation of the sub-criteria of the IEI comes from: i) the Hellenic Labor Inspectorate and refer to the number of the located business and their number of employees to the regions of the East and West Attica, the year of 2008, ii) from Zifou²⁸ (2011), and iii) qualitative information was collected from the space inspection and aerial photographs’ observation of the area in question.

The data used for the evaluation of the three (3) sub-criteria of the REMI, comes from the Bank of Greece, Zifou (2011) and the Hellenic Statistical Authority’s (HelStat) records²⁹. Bank of Greece’s data contain sale prices for a sample of 3,796 plots in the contiguous to the motorway municipalities, the period 2002-2010. From Zifou’s paper we used her estimates for the surfaces of the areas instituted or are planned to be instituted as development poles and receptors of productive activities. Finally, HelStat’s records provided us the number and the surfaces of the new buildings constructed at municipality level in Attica, over the period 2002-2010.

The evaluation of the sub-criteria of OEN is based on data coming from: i) “Attikes Diadromes S.A.”, ii) “Athens’ Master Plan/2021”, iii) “Greek Ministry of Environment, Energy and Climate Change”, iv) “Athens’ Operational Program, 2007-2013”, and v) the available operational programs of the municipalities that the AOM is passing through. “Attikes Diadromes S.A.” provided us the annual mean percentage rate of the AOM’s vehicles that travel at each level of service, every hour of a typical working day, the period 2009-2012.

5.2. Criteria and Sub-criteria Results Analysis

The criteria and sub-criteria evaluation is summarized in tables B.1-B5 (Appendix B) and table B.6 (Appendix B) contains the criteria and sub-criteria scores.

Analytically the results of the FTI criterion (Table B.1, Appendix B) indicated that the AOM’s impact on employment is limited. On the other hand, motorway’s intermediate demand is significant. The AOM’s taxes’ contribution to the public revenues is also important. According to the above analysis, the findings (Table B.1,

²⁸ “Work execution for the technical support and the production of auxiliary data to be used for the Athens’s Master Plan maps and the texts with regard to the productive activities” (Zifou, 2011, in Greek).

²⁹ <http://www.statistics.gr/portal/page/portal/ESYE/PAGE-database>

Appendix B) I_2 corresponds to perfect (5) and I_3 to four (4); this means that these two sub-criteria fulfilled at a very high degree, while the first I_1 , as was expected due to the nature of the project (capital intensive) at a low one.

The DUB and its sub-criteria evaluation indicates that the AOM's users save on average, more than the half of the time needed for the coverage of the characteristic routes via the urban road network. Additionally, in AOM the average consumption of fuel is about 5.8 lit/100km; 20% lower than its respective consumption in the urban network. Finally, the AOM is by far the Attica's safest road (Table B.2, Appendix). The findings show that this criterion is satisfied to a very high degree (0.93), highlighting its remarkable importance in the regional economic and social life.

The results of the IEI criterion and its sub-criteria are presented in table B.3 (Appendix B). The findings show that the neighboring to the motorway areas appear increased business attractiveness. Specifically, from the 1678 business with more than 10 employees located to the West and East Attica, 821 are near the AOM's axle (48.9%). Additionally, a significant number (22.17%) of these are large-sized business, a particular interesting finding, especially for the Greek economy, where the average employment is only 4.8 employees per firm. Moreover, the agglomeration of the economic activity is observed to a significant part (60%) of the motorway's axle³⁰. Namely, we observe that there are specific areas of industrial concentration associated with the AOM operation. But still remains the necessary unbuilt land neighboring to the axle of the motorway areas, to installed future socio-economic activity. Except the North Attica, where the central part of the AOM is located, which is fully occupied, there are about 12600 arcs on the West and 5000 arcs on East Attica of free space (Zifou, 2011), near the motorway's axle, which are ideal receptors of future activity. Therefore, it appears that the road contribution to meeting this criterion is very important (0.73). Particularly, sub-criteria III_1 and III_2 reveal the most important contribution, when III_1 exhibits less one.

Table B.4 (Appendix) summarizes the estimated measures that determine the scores of the REMI criterion (IV) and its sub-criteria (IV_1 , IV_2 and IV_3). In this context, the empirical results indicate that land values have a general upward shift in the motorway's contiguous municipalities, over the period analyzed. However, this shift does not differ significantly from the increase estimated for the region of Attica and hence, it cannot be claimed with confidence that this is due to the AOM's operation. This fact is more intensive to the areas of the West Attica – the most degraded of the areas that the motorway is passing through – where is noted an insignificant increase on the plots' recorded market prices. Besides, the same result arises from the realized construction activity of the areas in question, where it follows the generalized Attica's decreasing trend. Finally, according to Zifou (2011) the AOM's neighboring areas concentrate a significant part of the Attica's non-urban development poles and receptors of productive activities. Even this situation had been established – at its greatest part – before AOM's construction, however, motorway's operation expanding the urban construction along its axle. The previous analysis shows that the evaluation of this criterion and its sub-criteria are unclarified. Thus, the AOM's contribution to the fulfillment of this criterion was limited.

³⁰ Regarding the more intensive areas we have the West Attica area (Thriassio Field), the North Attica (Kifissias Av.- Pentelis Av.), and the East Attica (Gerakas and Pallini to Peania-Gantza municipalities and along the Laurio Av.).

The last criterion (ONE) and its sub-criteria scores contained in table B.5 (Appendix B). The AOM is connected at a very satisfactory level with Attica's transport means and hubs, of national and international importance. The only deficient of the motorway, with regard to its intermodality, is that it is not connected with the port of Piraeus neither with the commercial port of Perama, while it is connected indirectly with the ports of Rafina and Laurio. In this way the first sub-criterion's (V₁) satisfaction level is very important and stands at 0.87. With regard to the second sub-criterion, the evidences show that the great majority of the AOM's users travel under conditions of A and some under B level of service. Levels of C and more are temporarily, recorded only at the motorway's central part, the pick hours of the years with the highest annual traffic loads. Finally, the auxiliary infrastructures of the neighboring to the motorway areas are considered satisfactory for their further development. The only serious problems that these areas face is the absence of a sewer system in most of the areas of East Attica (Mesogia) and the deficient stormwater systems of East and West Attica.

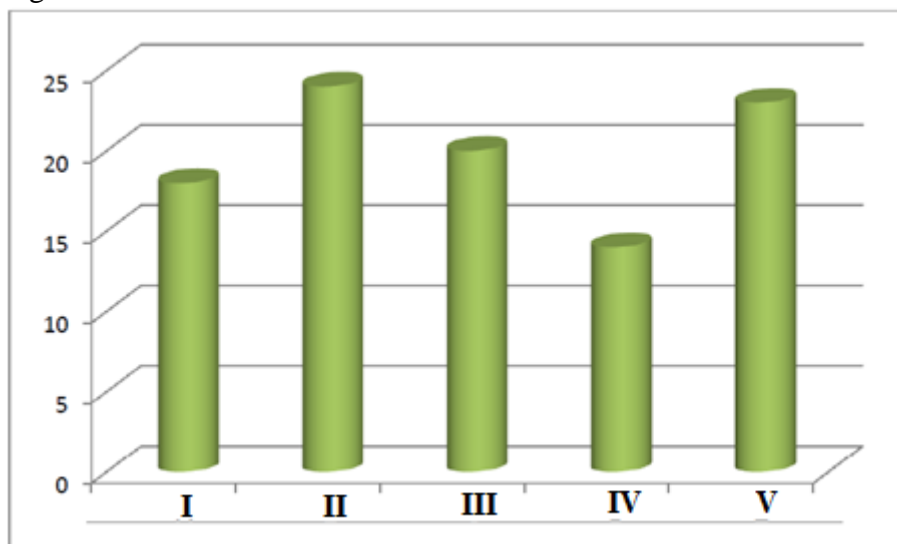
5.3. Overall Returns' Estimation

The estimation of the criteria and sub-criteria's scores (Table B.6, Appendix B) allows us now to apply the equation 3.4 and 3.5, and to calculate the motorway's ORI:

$$ORI = 1/5 * (0.67 + 0.93 + 0.73 + 0.6 + 0.87) = 0.76$$

According to the theoretical thresholds of section 3.1 the motorway's socio-economic returns are considered as high. This means that, on average, the selected sub-criteria appear high compliance in our case study. In other words, the motorway's operation is involved in the satisfaction of these criteria at a very high level. But, the contribution of each criterion in the ORI differs (Figure 2). Figure 2, indicates that, the users' direct benefits (criterion II), is the factor that contributes the most to the ORI's level. This is more or less expected, since this factor constitutes the AOM's main advantage.

Figure 2: Criteria's Contribution to the AOM's ORI



Also, high is the contribution of the criterion that expresses the operational characteristics and environment of the motorway (criterion V). This means that, the expected socio-economic returns, coming from the operation of the AOM, was also increased. Another interesting finding is that, the AOM's financial transfer impacts

(criterion I) contribute significantly in the motorway's socio-economic returns, which is not something common in the transport projects' evaluation. This means that the operation of the motorway contributes at a significant level to: intermediate demand and public revenues. Finally, the AOM's impact in the neighboring areas' real estate market was limited. This does not mean that the motorway operation did not cause changes on the contiguous areas' land values and uses or the construction activity; however, a number of other factors, such as the residential maturity of areas in question, the prevailed land uses and of course the economic crisis, have restricted the expected results.

As we have already mentioned, the criteria analysis may include subjective appraisals to some degree. At first, we assume that the weighs of the criteria are equal to each other. In order to investigate the sensitivity of the evaluation outcome to the specification of the criteria's weighs, three (3) alternative scenarios (S1, S2 and S3) are exploited. At each one of the three scenarios it is assumed that a different criterion is more important to the configuration of the AOM's socio-economic returns. The Table 2 shows the four (4) alternative scenarios (including the basic one) and their respective ORI estimates.

Table 2: Sensitivity Analysis Scenarios

Scenarios		ORI
Basic (S)	Equal importance of all criteria	0.76
S1	Increased importance of the "Financial Transfer Impacts"	0.77
S2	Increased importance of the "Direct Users' Benefits"	0.79
S3	Increased importance of the "Induced Economic Effects"	0.76

According to Table 2 there are not observed great differences of ORI's alternative scenarios. This means that the evaluation output is not particularly sensitive to the criteria's assigned weighs. At every case, the AOM's returns are ranging at high levels, a fact which attaches robustness to the estimated ORI of the basic scenario. From the foregoing it is evident that the operation of the AOM has contributed at both criteria and sub-criteria to a high degree and thus in strengthening economic and social factors of areas linked.

6. Conclusion

The purpose of this study is the ex post evaluation of the economic and social impacts of the AOM's operation. To this end, a multi-criteria analysis (MCA) formula is developed. Within the MCA framework, the Overall Returns Index (ORI) is estimated.

With regard to the empirical results, the ORI, as they occurred from the formula, are high. This means that, on average, the selected sub-criteria and thus the criteria of the formula appear high compliance in our case study. Moreover, the sensitivity analysis

did not indicate significant differences on the alternative ORIs. This means that the outcome of the evaluation is not particularly sensitive to the criteria's assigned weighs.

Looking at the ORI score, is clear that AOM's operation contributed in Attica's integration to the TEN'S and, hence, to the European single market. This element is an important tool for the regional policy's cohesion and the investment distribution. It is interesting to compare the results of this study to a similar work. However, the estimates are subject to the limitation of the methodology employed as well as other factors. Clearly, future research on the subject would be of great interest.

Acknowledgement

Financial support from the Labour Institute of the General Confederation of Greek Labour Union (INE/GSEE) is greatly appreciated.

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Links

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- http://europa.eu/rapid/press-release_MEMO-11-706_en.html
- <http://www.statistics.gr/portal/page/portal/ESYE/PAGE-database>

APPENDIX A

Table A.1: Evaluation Sub-Criterion Scale: Financial Transfer Impacts (FTI)

SCORE	PERFORMANCE
	TFI₁
5	Number of employees per unit of invested capital in AOM: > 150% of its corresponding ratio for the national economy
4	Number of employees per unit of invested capital in AOM: 110-150% of its corresponding ratio for the national economy
3	Number of employees per unit of invested capital in AOM: ±10% of its corresponding ratio for the national economy
2	Number of employees per unit of invested capital in AOM: 90-50% of its corresponding ratio for the national economy
1	Number of employees per unit of invested capital in AOM: < 50% of its corresponding ratio for the national economy
	TFI₂
5	Intermediate demand per unit of invested capital in AOM: > 150% of its corresponding ratio for the national economy
4	Intermediate demand per unit of invested capital in AOM: 110-150% of its corresponding ratio for the national economy
3	Intermediate demand per unit of invested capital in AOM: ±10% of its corresponding ratio for the national economy
2	Intermediate demand per unit of invested capital in AOM: 90-50% of its corresponding ratio for the national economy
1	Intermediate demand per unit of invested capital in AOM: < 50% of its corresponding ratio for the national economy
	TFI₃
5	Tax on revenues paid per unit of invested capital in AOM: > 150% of its corresponding ratio for the national economy
4	Tax on revenues paid per unit of invested capital in AOM: 110-150% of its corresponding ratio for the national economy
3	Tax on revenues paid per unit of invested capital in AOM: ±10% of its corresponding ratio for the national economy
2	Tax on revenues paid per unit of invested capital in AOM: 90-50% of its corresponding ratio for the national economy
1	Tax on revenues paid per unit of invested capital in AOM: < 50% of its corresponding ratio for the national economy

Table A.2: Evaluation Sub-Criterion Scale: Direct Users' Benefits (DUB)

SCORE	PERFORMANCE
	DUB₁
5	Mean travel time in the characteristic routes via the urban road network: > 200% mean travel time via AOM
4	Mean travel time in the characteristic routes via the urban road network: 150-200% mean travel time via AOM
3	Mean travel time in the characteristic routes via the urban road network: 100-150% mean travel time via AOM
2	Mean travel time in the characteristic routes via the urban road network: 50-100% mean travel time via AOM
1	Mean travel time in the characteristic routes via the urban road network: < 50% mean travel time via AOM
	DUB₂
5	Fuel consumption in the characteristic routes in the urban road network: 150-200% fuel consumption in AOM
4	Fuel consumption in the characteristic routes in the urban road network: 125-150% fuel consumption in AOM
3	Fuel consumption in the characteristic routes in the urban road network: 100-125% fuel consumption in AOM
2	Fuel consumption in the characteristic routes in the urban road network: 50-100% fuel consumption in AOM
1	Fuel consumption in the characteristic routes in the urban road network: >50% fuel consumption in AOM
	DUB₃
5	Fatal accident rate per 100 million vehicle-kilometers of Attica's characteristic roads: >200% of the fatal accident rate per 100 million vehicle-kilometers of the AOM
4	Fatal accident rate per 100 million vehicle-kilometers of Attica's characteristic roads: 150-200% of the fatal accident rate per 100 million vehicle-kilometers of the AOM
3	Fatal accident rate per 100 million vehicle-kilometers of Attica's characteristic roads: 100-150% of the fatal accident rate per 100 million vehicle-kilometers of the AOM
2	Fatal accident rate per 100 million vehicle-kilometers of Attica's characteristic roads: 50-100% of the fatal accident rate per 100 million vehicle-kilometers of the AOM
1	Fatal accident rate per 100 million vehicle-kilometers of Attica's characteristic roads: <50% of the fatal accident rate per 100 million vehicle-kilometers of the AOM

Table A.3: Evaluation Sub-Criterion Scale: Induced Economic Impacts (IEI)

SCORE	PERFORMANCE
	IEI₁
5	High business attraction where the large-sized-business: > 50% of the located ones, in the neighboring areas
4	High or average business attraction where the large-sized-business: > 20% of the located ones, in the neighboring areas
3	Average business attraction where the large-sized-business: > 50% of the located ones, in the neighboring areas
2	Average or limited business attraction where the large-sized-business: > 20% of the located ones, in the neighboring areas
1	Limited business attraction without large-sized-business, in the neighboring areas
	IEI₂
5	Occurrence of economic centers of regional importance at the 80-100% of the length of the axle of the AOM
4	Occurrence of economic centers of regional importance at the 60-80% of the length of the axle of the AOM
3	Occurrence of economic centers of regional importance at the 40-60% of the length of the axle of the AOM
2	Occurrence of economic centers of regional importance at the 20-40% of the length of the axle of the AOM
1	Occurrence of economic centers of regional importance at the 0-20% of the length of the axle of the AOM
	IEI₃
5	Percentage of free to total surfaces: 45-55% along the axle of the AOM
4	Percentage of free to total surfaces: 40-45% and 55-60% along the axle of the AOM
3	Percentage of free to total surfaces: 30-40% and 60-70% along the axle of the AOM
2	Percentage of free to total surfaces: 10-30% and 70-90% along the axle of the AOM
1	Percentage of free to total surfaces: <10% and >90% along the axle of the AOM

Table A.4: Evaluation Sub-Criterion Scale: Real Estate Market Impacts (REMI)

SCORE	PERFORMANCE
	REMI₁
5	Total percentage increase of the market land values the period of the operation of the AOM: > 150%
4	Total percentage increase of the market land values the period of the operation of the AOM: 100-150%
3	Total percentage increase of the market land values the period of the operation of the AOM: 50-100%
2	Total percentage increase of the market land values the period of the operation of the AOM: 0-50%
1	Decrease of the market land values the period of the operation of the AOM
	REMI₂
5	The after 2002 instituted, or planned to be instituted receptors in the neighboring to the AOM areas: 80-100% of the total surface of the already instituted or planned to be instituted non-urban receptors of Attica
4	The after 2002 instituted, or planned to be instituted receptors in the neighboring to the AOM areas: 60-80% of the total surface of the already instituted or planned to be instituted non-urban receptors of Attica
3	The after 2002 instituted, or planned to be instituted receptors in the neighboring to the AOM areas: 40-60% of the total surface of the already instituted or planned to be instituted non-urban receptors of Attica
2	The after 2002 instituted, or planned to be instituted receptors in the neighboring to the AOM areas: 20-40% of the total surface of the already instituted or planned to be instituted non-urban receptors of Attica
1	The after 2002 instituted, or planned to be instituted receptors in the neighboring to the AOM areas: 0-20% of the total surface of the already instituted or planned to be instituted non-urban receptors of Attica
	REMI₃
5	Mean annual percentage change rate of the neighboring to the AOM areas' construction activity: > 150% of Attica's respective rate
4	Mean annual percentage change rate of the neighboring to the AOM areas' construction activity: 110-150% of Attica's respective rate
3	Mean annual percentage change rate of the neighboring to the AOM areas' construction activity: ±10% of Attica's respective rate
2	Mean annual percentage change rate of the neighboring to the AOM areas' construction activity: 50-90% of Attica's respective rate
1	Mean annual percentage change rate of the neighboring to the AOM areas' construction activity: < 50% of Attica's respective rate

Table A.5: Evaluation Sub-Criterion Scale: Operational Environment (OEN)

OEN₁	
Types of Transport	CONNECTION
	Direct / Indirect / Defective
Road	1 / 0.5 / 0
Railway	1 / 0.5 / 0
Sea	1 / 0.5 / 0
Air	1 / 0.5 / 0
Public	1 / 0.5 / 0
SCORE	Sum
OEN₂	
SCORE	PERFORMANCE
5	Annual mean daily Level of Service of a typical working day: A
4	Annual mean daily Level of Service of a typical working day: B
3	Annual mean daily Level of Service of a typical working day: C
2	Annual mean daily Level of Service of a typical working day: D
1	Annual mean daily Level of Service of a typical working day: E, F
OEN₃	
Infrastructures	PERFORMANCE
	Sufficient /Deficient/ Absent
Electricity	1 / 0.5 / 0
Water	1 / 0.5 / 0
Sewerage	1 / 0.5 / 0
Stormwater system	1 / 0.5 / 0
Transport network	1 / 0.5 / 0
SCORE	Sum

APPENDIX B

Table B.1: Scores of FTI sub-criteria

		2005	2006	2007	2008	2009	2010	2011	Mean	SCORE
I₁	L _{AOM} /K _{AOM}	0.83	0.77	0.83	0.93	0.91	0.93	1.00	0.89	1
	L _{GR} /K _{GE}	6.44	6.34	6.21	6.11	5.96	5.78	5.42	6.04	
I₂	Z _{AOM} /K _{AOM}	0.06	0.06	0.07	0.08	0.07	0.08	0.07	0.07	5
	Z _{GR} /K _{GE}	0.03	0.03	0.04	0.04	0.03	0.04	0.03	0.03	
I₃	T _{AOM} /K _{AOM}	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	4
	T _{GR} /K _{GR}	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
I										0.67

Table B.2: Scores of DUB sub-criteria

					SCORE
II₁	Mean Coverage Time (min)	Urban Network (T1)	47.71	T1/T2 (%)	5
		AOM (T2)	22.29	225	
II₂	Mean Fuel Consumption (lt/100klm)	Urban Network (C1)	7.3	C1/C2 (%)	4
		AOM (C2)	5.8	126	
II₃	Mean Rate of Fatal Accidents (100 mil. vech-klms)	Urban Network (FA1)	2.04	FA1/FA2 (%)	5
		AOM (FA2)	0.65	314	
II					0.93

Table B.3: Scores of IEI sub-criteria

						SCORE
III₁	Num. of business	Num. of business that employee >10 persons	Num. of business that employee >10 persons located in contiguous to the AOM area (1)	Num. of business that employee >50 persons located in contiguous to the AOM area (2)	Ratio (2)/(1) (%)	4
III₂	AOM's Length (1) (klm)	Length of the economic agglomeration (2) (klm)		Ratio (2)/(1) (%)	4	
		54	32.3			60
III₃	AOM's Length (klm)	Length of the occupied areas along AOM's axle (1) (klm)	Length of the free areas along the AOM's axle (2) (klm)	Ratio (2)/(1) (%)	3	
						54
III						0.73

Table B.4: Scores of REMI sub-criteria

							SCORE	
IV₁	Mean percentage change of the land prices the period 2002-2010						Mean	3
	West Attica	33.37	North Attica	128.86	East Attica	134.52	98.92	
IV₂	Surface of the non-urban already instituted or planned to be instituted receptors (arcs)						Ratio (2)/(1) (%)	2
	Attica (1)			Areas near AOM (2)				
	71500			22677			31.72	
IV₃	Mean annual percentage increase of the construction activity (2002-2010)						Ratio (2)/(1) (%)	3
	Attica (1)			AOM's contiguous municipalities (2)				
	-17.53			-19.37			1.10	
IV								0.60

Table B.5. Scores of OEN sub-criteria

V₁	Alternative types of transport						4
	Road	Railway	Sea	Air	Public		
	Direct	Direct	Defective	Direct	Direct		
V₂		2009	2010	2011	2012	Mean	5
	LoS (24 hours)	4.74	4.77	4.83	4.88	4.8	
	LoS (12 hours)	4.51	4.56	4.68	4.77	4.63	
V₃	Infrastructures						4
	Electricity	Water	Sewerage	Storm - water	Transp. network		
	Sufficient	Sufficient	Deficient	Deficient	Sufficient		
V		1	1	0.5	0.5	1	0.87

Table B.6: Evaluation formula's criteria and sub-criteria

Criteria	Sub-Criteria		
I	I₁	I₂	I₃
0.67	0.066	0.333	0.266
II	II₁	II₂	II₃
0.93	0.333	0.266	0.333
III	III₁	III₂	III₃
0.73	0.266	0.266	0.200
IV	IV₁	IV₂	IV₃
0.60	0.200	0.133	0.200
V	V₁	V₂	V₃
0.87	0.266	0.333	0.266
ORI= 0.76			