EVALUATION OF A SUSTAINABLE URBAN TRANSPORT SYSTEM THROUGH THE USE OF THE TRANSECON METHODOLOGY

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ABSTRACT

The concept of 'sustainable development' is an achievement of policy as it introduces a new philosophy on matters regarding environmental protection and natural resource management. This paper begins by investigating the origin of the term 'sustainability' and the deeper social and economic causes of its emergence, through its historical evolution. The necessity for achieving sustainable development in the transport sector is pointed out and the policies which will lead to this objective are set forth. To the degree, however, that this concept alters our perceptions and introduces a new reasoning, this can result in a qualitative alteration of our analytic and synthetic planning tools. For instance, revision of the assessment criteria and the addition of new social and environmental parameters led to the creation of new methods and techniques of evaluation, capable of incorporating the new data. However, the process through which the assessment and the calculation of parameters is realised is evaluation; therefore, this change in the way of assessment essentially lies in the differentiation in the approaches and the evaluation criteria. The traditional evaluation with purely economic (quantitative) criteria has been replaced (or at least supplemented) by more integrated evaluation techniques (multicriteria and socio-economic analyses) that take into account both quantitative and qualitative criteria. The multicriteria evaluation methodology, which resulted from the TRANSECON (Urban *Tran*sport and *Socio-Econ*omic Development) Project, is used in this paper, in order to evaluate an investment of the Public Transport Operator of Thessaloniki concerning its network expansion. The paper aims at the examination of two things; firstly the possibility of adapting and applying the TRANSECON methodology to this specific investment pointing out the essential assumptions and secondly to examine how a non-viable investment in economic terms can contribute to the achievement of sustainable development.
Keywords: multicriteria analysis, socio-economic evaluation, sustainable development, sustainable transport system.

1 INTRODUCTION

The concept of 'sustainable development' reveals the need for the change of content in the concept of 'development'. Up to some decades ago, before the appearance of intense social and environmental problems, development was related exclusively to the size of a society's productive process. Nowadays such an approach is considered insufficient. No longer can a process that contributes to the increase of production but simultaneously degrades the environment and intensifies social problems be considered as a developmental process. It is precisely this need of completion of the development concept, with wider social and environmental criteria, that is served by the concept of sustainable development.

Sustainable development concerns all basic sectors of economic activity, such as industry, energy, transport, agriculture and tourism, with different objectives and orientation for each sector. The concept of sustainable development has a significant application in the transport sector, which, besides the fact that it is an important part of the total economic activity, has very important social and environmental repercussions as well. The need to include a number of non-monetary criteria in the evaluation process leads to the modification of the evaluation methods themselves. Towards the achievement of this objective, multicriteria techniques demonstrate remarkable advantages in comparison to cost–benefit analysis (CBA) since they are able to take into account all the qualitative aspects of an investment.

Certain basic policies that are promoted for the achievement of sustainable development in the transport sector [1] are the improvement of competitiveness in the means of transport, the technological improvement of vehicles and fuels, the application of measures for the promotion of public transport, the imposition of direct and indirect taxes aiming at the incorporation of the real cost of infrastructure and environment etc. Over the last 15 years, there has been an abundance of research programmes conducted by the European Union (EU), aiming at the promotion of these measures. One of them was the TRANSECON (Urban *Tran*sport and *S*ocio-*Econ*omic Development) project [2], which aimed at performing a thorough evaluation of the socio-economic impacts, based on a multicriteria technique, stemming from urban transport policies and investments. This was possible because of the available evidence from implemented schemes and systems in 13 appropriate case studies of urban transport policies and infrastructure investments. In this paper, the possibility of utilising the TRANSECON methodology for an ex-post evaluation of the investment concerning the expansion of the transport network of the Public Transport Operator of Thessaloniki (OASTH) is examined. The expansion concerns 13 adjacent municipalities in the region of Thessaloniki. It must be reported that the investment does not have economic efficiency (EE) but serves broader social objectives. The application of the TRANSECON methodology aims at expressing and assessing the qualitative benefits of the investment of OASTH in terms of the sustainable development objective.

2 THEORETICAL ASPECTS CONCERNING SUSTAINABLE DEVELOPMENT AND THE LINK TO TRANSPORTATION ISSUES

The concept sustainable development expresses a change in principles and values in the ways of thought and reflection with regard to the meaning of development. Until recently the use of the term 'development' conveyed, almost exclusively, the meaning of economic development, which is assessed with purely economic criteria. Over the last decades, however, it was considered necessary to also include other criteria such as environmental, social etc. within the meaning of development. This is also correlated to the meaning of the term 'sustainable development', that is to say it differentiates the parameters upon which development is evaluated, adding broader social and environmental dimensions to the evaluation process.

There exists no precise definition of the term and that is explained because it is not mathematically specifiable since it does not constitute a specific indicator. Whereas the meaning of economic development (or growth) has definitely been defined since it constitutes a specific indicator, that of the annual percentage increment of the GDP, sustainable development is essentially a pursued policy, a setting of objectives, not any numerical indicator. This contributes as much to the difficulty of explicitly determining its significance as to the describing of any criteria for its achievement. Notwithstanding this, what is important is not the strict definition of its significance, as much as the understanding of its importance and its objectives. Below are given some definitions that have been proposed for sustainable development.

- Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (Brundtland Commission, 1987) [3, 4].
- Development that ensures that the use of resources and the environment today does not damage prospects for use by future generations [5].
- The concept refers to achieving economic and social development in ways that do not exhaust a country's natural resources [6].

The concept sustainable development does not constitute an innovation; similar speculations have occupied the scientific community long before its official definition in 1987 by the Brundtland

Commission. However, what is important is that it was then that this manner of development, based on sustainability, was officially defined for the first time; it signalled the need for a change in the ways of regard and evaluation, which emerged after a long series of previous individual and fragmentary policies. Hereafter are reported [1, 7–9] certain critical periods and characteristic dates of the historical development of the term, from its first appearance, the course of its configuration and composition, up to its final establishment on a global level as the foremost political priority.

- End of the 18th century: The term sustainability appears for the first time in the management of the German forests in the concept of sustainable production, which stood for the production of lumber in way that would not subvert the biological continuity of the forests.
- End of the Second World War: The end of the Second World War signalled the establishment of a series of international organisations (WHO, FAO, UNESCO, etc.), which intended to safeguard the prosperity of the people in order to avoid future conflicts. The concept of sustainability appears to form during this period [1], at the point where the effort for rational use of natural resources, which is undertaken by the organisations, intersects the effort for acquisition of the largest possible advantages from natural reserves under the logic of serving the system of material values of the post-war era.
- 1960: For the first time, the concept of sustainability is linked to that of development in the foundation pact of Organisation for Economic Co-operation and Development (OECD).
- 1972: 'Limits to Growth', published by the Club of Rome (an organisation of European economists), suggested that current economic patterns would lead to ecological disaster [10].
- 1979: The OECD article 'Are there physical limits to Growth' is published, issuing the debate concerning the limits of global development combined with the population growth.
- 1980: The idea of sustainability will be presented as linked to that of development in a series of works such as 'World Conservation Strategy' by the International Union for the Conservation of Nature [7].
- February 1983: EU announces the third action plan for the protection of the environment, where the concept of environmental protection is connected to all other matters of policy concerning the OECD.
- Brundtland Commission, 1987: The World Commission on the Environment and Development (or Brundtland Commission) of the UN constructs the 1983 report 'Our Common Future', which adopts the view of a change in a policy level through sustainable development. It was then that the concept of sustainable development became broadly known [11, 12].
- 1990 until today: In 1992, the United Nations held a conference known as the Earth Summit. One of the Earth Summit decisions, Agenda 21, called for action at national level, but also called on each local authority to produce a Local Agenda 21 in consultation with their community [13]. The EU has declared that the term will be included in the Maastricht Treaty and in 1993 the 5th action plan for the environment under the title 'Towards sustainability' is described the strategy towards sustainable development. Almost 10 years later, in 2002, the World Summit on Sustainable Development in Johannesburg (South Africa) was attended by 22,000 delegates (100 political leaders, representatives of non-government organisations and thousands of journalists). Sustainable development is now common policy and a strategy of all international organisations and institutional organs.

The concept of sustainable development unavoidably affected the transport sector as well, by transforming its general objectives and therefore its overall approach. This stands to reason as the transport sector affects all the elements constituting the concept of sustainable development, the

environment, natural resources and society. The objective was therefore to ensure that all these new parameters were incorporated into the evaluation procedure and that the appropriate tools for implementation of the methodology were developed or at least adapted. Before embarking onto this endeavour, however, the first step was to define the concept of a sustainable transportation system.

During the 1990s, several attempts have been made to define what is meant by sustainable transport. Most of them have been based on the general definition of sustainable development introduced by the Brundtland Commission in the late 1980s. Generally speaking, a sustainable transport system must contribute to economic and social welfare without depleting natural resources, destroying the environment or harming human health. There is still, however, no strict definition of sustainable transport. In 1999, the joint expert group on transport and environment defined a sustainable transport system [14–16] as a system that:

- allows the basic access needs and development of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health and promotes equity within and between generations;
- is affordable, operates efficiently, offers choice of transport mode and supports a vibrant economy and regional development;
- limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation and uses non-renewable resources at or below the rates of development of renewable substitutes and minimises the use of land and the generation of noise.

The definition proposed by the expert group is an extension of the definition of environmentally sustainable transport that has been carried out by the OECD project on environmentally sustainable transport. According to the OECD project, an environmentally sustainable transport could be defined [17] as a transport system that does not endanger public health or ecosystems and meets needs for access consistent with:

- the use of renewable resources at or below their rates of regeneration and
- the use of non-renewable resources at or below the rates of development of renewable substitutes.

The qualitative definitions referred to here give a general picture of what is meant by sustainable transport. However, in order to guide the transport sector in its endeavour for achieving sustainable transport planning objectives, a more quantitative definition is needed. Therefore, it is important to seek the ways and find the methodological tools that will help to develop a more operational definition of a sustainable transport system.

3 PREREQUISITES AND WAYS FOR ACHIEVING SUSTAINABLE TRANSPORTATION PLANNING

3.1 From conventional planning to comprehensive planning [18, 19]

Sustainability is a planning perspective that accounts for economic, social and environmental goals, including impacts that are indirect, difficult to measure and distant in time and space. Sustainable transportation requires more comprehensive planning than what is commonly practiced. Sustainable planning can provide an opportunity to identify strategies that can help achieve multiple goals.

Concern about sustainability may be seen as a reaction to the tendency of decision makers to focus on easily measured goals and impacts while ignoring those that are indirect or harder to measure. Conventional planning often reflects a 'reductionist' approach in which a particular organisation or individual is responsible for dealing with a particular problem. This may be appropriate in some

situations, but it often results in solutions to one problem that exacerbate other problems or failure to implement solutions that provide modest but multiple benefits. Sustainable decision making can therefore be described as comprehensive planning that focuses on a variety of goals and impacts regardless of how difficult they are to measure. Sustainable planning and economics often refer to the triple bottom line, which focuses on the economic, social and environmental impacts. These challenges for transport planning also mean that a new way of thinking is required in terms of methods and approaches to analysis. The question that arises is what methods and evaluation tools should be used in order to achieve comprehensive planning and sustainable development.

3.2 Evaluation tools – comparison of methods

Multicriteria analyses and multiobjective decision models are beginning to receive much attention and seem to present a new opportunity to arrive at a balanced analysis of all facets of modern planning problems, particularly because they take into account many intangible aspects like social effects and environmental repercussions.

There are two rough categories of evaluation methods [20]: the first category includes methods that attempt to compute monetary values for the different project outcomes indirectly (e.g. CBA, cost-effectiveness analysis and planning balance sheets). The second category of evaluation methods stems from a different point of view. Instead of a monetary transformation of all different project outcomes, non-monetary evaluation methods attempt to take into consideration the multiple dimensions of a decision problem. When project outcomes are analysed on the basis of their own dimensions, the obvious problem that arises is how to weigh the various project outcomes in relation to each other. Clearly, such a weighing procedure depends on the relative priorities attached to the various decision criteria for the plan in question. These methods are therefore also called multicriteria methods (MCA). Table 1 demonstrates the basic advantages and disadvantages of these categories of methods. The multicriteria analysis (MCA) outperforms the CBA approach when examined insofar as its ability to include qualitative aspects. In these cases, MCA not only offers the freedom to determine the criteria but also presents greater risks insofar as their assessment because it contains the subjectivity of the decision makers. On the other hand, the CBA approach is incapable of assessing all the indirect effects of a project, except for those that can be translated into monetary terms.

Here it is important to emphasise that [21] MCA does constitute an important evaluation tool which is capable of resolving societal conflicts by providing satisfactory responses to the needs of various stakeholder groups. It would be incorrect to argue that CBA is necessarily superior to MCA because of CBA's alleged capability to determine the societal desirability of projects. The reality is that complex decision-making problems associated with a high number of non-monetary effects, multiple stakeholders and substantial ambiguity, as regards the value of parameters such as the

Table 1: Comparison of the CBA and MCA approaches.

Approaches	Evaluation criteria	Value of the criteria parameters
CBA approach	Restriction on the determination of the criteria – deficiency on counting in the indirect effects	Better accuracy of the criteria values that are used in the evaluation process
MCA approach	Unlimited selection of the criteria – better description of the evaluation case	Greater risk in the assessment of the criteria values

consumer's willingness to pay, can greatly benefit from MCA. Such a case is the transport investment of OASTH for Thessaloniki's network which requires a multicriteria approach for correct evaluation.

4 THE TRANSECON CASE FOR THESSALONIKI'S NETWORK: ACHIEVING SUSTAINABLE GOALS

4.1 The EU TRANSECON Project

TRANSECON is a project funded by the EU and addresses the socio-economic impacts of transport investments, policies and networks in the EU Key Action on 'Sustainable Mobility and Intermodality' and in particular the subtask 'Urban transport and local socio-economic development'. The project was started in July 2001 and was completed in December 2003.

TRANSECON seeks [22] to understand how the wider socio-economic impacts of transport policy and investment interact in a quantitative and qualitative way and how this interaction can be used to the best effect. The methodology is driven by a multidisciplinary perspective that requires expertise in related fields such as urban and regional land use planning and sustainable development planning, urban regeneration and renewal design, implementation and management, sociology, macro-economics, development economics, labour economics, political science, decision-making process and organisation science.

The project work-plan relies on 13 appropriate case studies of urban transport policies and systems that will be evaluated as part of the project in terms of their socio-economic impacts. The selected case studies cover a sufficient range of city and intervention types (in terms of geographical distribution, city size, transport policies and investments) and have been selected on the basis of having adequate before and after data ('mobility' data from specific surveys, but also data related to employment, land use changes, socio-economic characteristics, land values, commercial activities, etc). Most of the needed data sets are available as an input from other studies. The case studies cities and themes are as follows:

- Athens: Traffic Restriction Measures, New Metro Lines
- Vienna: Metro and Tram
- Madrid: Orbital Metro Line
- Helsinki: Metro/Intermodality
- Brussels: Tram/Metro Integration, Ring Roads
- Lyon: New Metro and Urban Toll Road
- Newcastle: Light Metro (Tyne & Wear Metro)
- Stuttgart: Light Rail Transit/S-Bahn
- Valencia: New Tram Line
- Manchester: Light Rail Transit (Metrolink)
- Delft: Cycle Routes Network
- Zurich: Tram System Extensions, Airport Rail Link
- Bratislava: Tram System Modernisation

These specific cities were selected as case studies because they cover a wide range of city types and public transport (PT) systems as well. This wide spectrum also serves another objective, that of the development of an adaptable methodology, which can be applied to other projects as well. The TRANSECON project partnership involved 16 organisations (five universities, two research centres, seven consultancies) in 11 EU member states. Ultimately, the main technical achievements expected of

TRANSECON were to provide definitive evidence regarding the social, economic and environmental impacts of urban transport investments and policies. The main objectives of the project were the following [2, 22–25]:

- To design a specific methodology from a multicriteria approach to evaluate a number of infrastructure impacts: changes in mobility patterns, changes in location of activities, environmental improvements, urban regeneration and economic development, based on the analysis of the selected case studies.
- To review and analyse available evidence and experiences on socio-economic impacts of urban transport policies and investments, in Europe and the USA.
- To employ several case studies covering a range of European cities that have implemented relevant urban transport policies and investments, with adequate before and after data and stakeholder interviews while using a consistent framework for harmonisation and comparability of the results.
- To assess infrastructure and policy impacts, based on the selected case studies.
- To disseminate the results to city authorities related to the case studies, city and transport associations and to exploit the results in future relevant initiatives and actions at local, national and EU levels.

4.2 Description of the investment of OASTH in Thessaloniki [26–28]

In the urban Precinct of Thessaloniki and the suburban area, more than 1,600,000 trips are made daily using all means of transport (data from 1998). Of these, 40.6% of the trips are made either as passenger or as the driver by private vehicles, 27.5% of the travellers choose PT, while the remaining percentage travels on foot, using two-wheeled vehicles, taxis, etc. The PT comprises buses exclusively, which constitute the sole means of PT in the city to date. The organisation which is in charge of the implementation and the exploitation of PT in the region of Thessaloniki is called OASTH.

OASTH is a private entity governed by the Ministry of Transport and Communication. As from 1.1.2001, there has been a financial arrangement between the Greek State and OASTH which extends the execution of urban commuting in the area of Thessaloniki up to 31.12.2009. OASTH employs 2400 employees who drive 505 out of the organisation's 536 buses each day.

As from 4.8.2003, there has been an additional financial arrangement which extends OASTH's jurisdiction to cover 15 new municipalities (Kallithea, Agios Athanasios, Xalastras, Aksiou, Halkidona, Koufalia, Migdonias, Assirou, Laxana, Lagkada, Koroneias, Thermis, Vasilikon, Mikras and Epanomis) (Fig. 1). Twelve new lines have been established and 48 new buses are in circulation. The transport investment that was evaluated with the TRANSECON methodology concerns exactly this expansion of the PT network of OASTH.

Despite the fact that OASTH is a private entity, its particularities on issues that concern proprietary issues insofar as its legal frame of operation, the social role of the services it offers and the state-induced policy insofar as transport charges, create an environment of operation which is significantly different than the one under which private businesses function, namely that of private economy. This is also the reason why the investment was carried out to completion, i.e. even though the investment was judged as not viable under purely economic criteria, nevertheless social factors were taken into account that rendered the investment advantageous.

Finally a clearer picture of the OASTH investment is given by the data that follow, which pertain to the network expansion needs.

- Capital cost: € 7,691,269.44
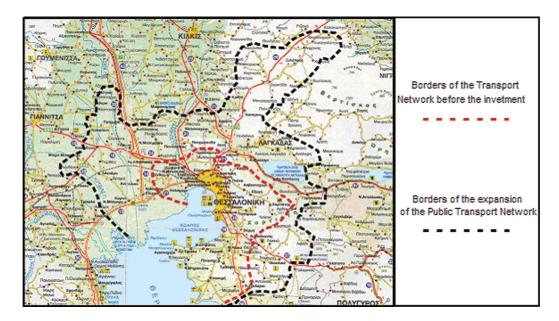- Nine principal bus lines

Figure 1: The borders of Thessaloniki's transport network before and after the investment. Source: [28].

- Three local bus lines
- 319 km of transport network
- 48 buses with capacity of 85 passengers
- 4080 passenger seats
- 377 routes on a daily basis
- 22,639 vehicle/km covered daily
- 146 drivers
- 24 technicians
- 13 employees as administrative personnel
- 17 employees as remaining personnel (supervisors, stationmasters, controllers)

4.3 Application of the TRANSECON methodology to the OASTH transport investment

4.3.1 Description of the methodology [22]

The evaluation method will follow an MCA approach, in order to simultaneously evaluate a specific number of objectives – economic benefits, social benefits and environmental improvements – that need to be aggregated. Each objective is measured using one or more specific criteria, which is given a value through one corresponding targeted indicator. Some of the criteria are quantitative but in other cases they are qualitative by nature. The latter must be measured by choosing an appropriate indicator. At the end, the level of achievement of each objective must be expressed as a numeric value. Therefore, a procedure to convert the qualitative results into a final score must be defined for each topic under evaluation.

Once each individual impact is measured, all these values must be aggregated into a final single value. To this end, it is necessary to carry out two tasks; firstly to convert the range of variation in each indicator to a homogeneous one, typically from −1 to 1. This conversion could be linear or

non-linear; therefore, transformation curves or value functions have to be designed for each indicator. The value function will convert the indicator variation among scenarios into a homogeneous value scaled from −1 (maximum negative impact) to 1 (maximum positive impact). Impacts can be positive or negative, and the correct sign must be applied. These homogeneous values will be the individual social utility for each criterion. The second step in the aggregation procedure is to assign the homogenised indicators to each criterion to represent its relative importance to the overall objective of sustainability and social welfare. The final impact will be the weighted sum of all indicators multiplied by the weight assigned to their corresponding criterion. The final formulation of the process will be the following:

$$\text{MCA infrastructure impact} = \sum_{i=1}^{n} (W_i x a_i),$$

where index i is the type of impact from a set of n indicators, W_i are the normalised weights and a_i the individual social utilities of each of the n indicators.

4.3.2 Application of the methodology

As has already been reported, the investment of OASTH is not an economically advantageous investment. Its implementation served greater social objectives such as social cohesion, improvement of the provision of PT and support of the economic activity in the wider region of Thessaloniki, which have a mainly qualitative character. With the application of TRANSECON methodology, all the qualitative objectives of the investment are included in the process of evaluation to examine whether sustainable development is achieved with the implementation of the project.

The adaptation of the data of the investment of OASTH for application of the TRANSECON methodology requires certain assumptions. Firstly, the application of TRANSECON methodology used certain indicators, the economic development effect (EDE), the social equity indicator and the urban regeneration indicator, which were calculated by researching the questionnaire results and correlating the data from the TRANSECON case studies. For the OASTH investment, these indicators are calculated taking into account the average of the corresponding indicators of the same category of investments in other case studies as listed below. The characteristics of the OASTH investment classify it in the category of case study cities that share the investment in the PT system between the suburbs and the city centre, which are referred to as 'City and Suburbs projects'. As we will see, these adaptations are considered to be satisfactory since the values of indicators for the projects of the same category do not diverge significantly. Another differentiation is that the capital cost of the investment is one of the criteria in the evaluation. The transformation of this pecuniary cost into 'social utility' units is realised with the value function that is fixed by the capital costs of the investments of the TRANSECON project, following the same logic as for the remaining criteria applied in the methodology. Capital cost is included as one of the criteria because it is considered that this renders the evaluation more complete.

Finally, it is underlined that the evaluation of the OASTH investment is retroactive which means that the investment had already been realised and therefore the only investment scenarios examined are the scenario of no investment (do nothing) and the investment scenario that was finally implemented. More specifically, the application of the TRANSECON MCA to the investment of OASTH includes the following steps.

Step 1: Determination of the criteria based on which the evaluation will be implemented. TRANSECON methodology has led to concrete criteria which describe the entire range of non-measurable effects such as the social and the environmental repercussions of a transport project. From these criteria, only those that fit the case study of the OASTH investment will be selected. For example,

environmental criteria will not be taken into account because the environmental repercussions of the investment are considered to be negligible. Therefore, the first step was to set up Table 2 containing the criteria of the investment, which constitutes a subtable of the complete table of criteria that resulted from the TRANSECON methodology. For the case of OASTH, the general objective of sustainable development is pursued by the achievement of the economic and social criteria which are shown in Table 2.

At this point, a more detailed description of the criteria of the investment is needed.

- Capital cost: It constitutes the cost of the investment that concerns the market of new buses and their equipment.
- EE: It is defined as the difference of annual income that results from the extension with its functional expenses.
- Social equity: This term indicates the social benefits that result from the investment and concern the improvement of balanced growth and regional development of the wider region of Thessaloniki (in the examined area).
- Improvement of use of PT: The term 'improvement' indicates not only the qualitative upgrade of services with the replacement of old buses and the increase of itineraries but also the guarantee of accessibility–mobility of all social groups and particularly the economically worse-off, old men, students, etc.
- Economic growth: It assesses the development of the economic activities in the wider region, the creation of new working places, the reinforcement of existing activities and the attraction of new ones.
- Urban regeneration: It indicates the improvement of the traffic and environmental conditions of the city centre as a result of providing motives for decentralisation regarding accommodation, recreation and other activities.

Step 2: The values of the criteria selected for the different investment scenarios were calculated. For the OASTH investment, two scenarios were considered; the first one is the 'do nothing' scenario in which the investment is not implemented and the region being studied remains under the jurisdiction of 'Common Fund of Buses' (KTEL) organisation as it was before 2003. KTEL is a private entity that served the interurban passenger traffic in the prefecture of Thessaloniki.

The second scenario concerns the OASTH investment that was implemented. The values of the economic criteria were taken directly from the two organisations (OASTH and KTEL), while the values of the social criteria were calculated based on assumptions, the aim of which is to adjust the available data of the investment to the methodological framework of TRANSECON.

Table 2: Investment criteria used in the study.

Objective	Subobjectives	Criteria
Sustainable development	Economic benefits	Capital cost
		Economic efficiency
	Social benefits	Social equity
		Improvements in the use of public transport
		Economic growth
		Urban regeneration

The analysis and calculation of the values for each criterion is set forth below:

- Capital cost: For the first scenario, the capital cost will be null (because the investment did not take place), while for second one that concerns the OASTH investment, the capital cost consists of the cost of purchasing 48 new buses and the instruments with which they will be equipped and amounts to € 7,691,269.44.
- EE: The EE is the difference between income and operational costs for each scenario and consequently for the first scenario it consists of the EE of KTEL (before the investment) and that of OASTH based on the data of the demand for transport along the lines of the expansion for the second scenario.

Thus, we have:

$$EE = (FR - OC)_{scen.2} - (FR - OC)_{scen.1},$$

where FR is the annual fare revenue of the PT network of OASTH = € 4,040,872; OC is the annual operation costs of OASTH = € 8,607,605; FR is the annual fare revenue of the PT network of KTEL = € 2,759,970; OC is the annual operation costs of KTEL = € 4,665,057; and $(FR - OC)_{scen.2}$ refers to the OASTH scenario (investment scenario) and $(FR - OC)_{scen.1}$ refers to the KTEL scenario (do nothing scenario)

The difference in the EE between the two scenarios is negative and equals EE = −4,566,733 − (−1,905,087) = € −2,661,646. Therefore, the investment will result in annual losses of € −2,661,646 (2004).

- Economic growth: For the calculation of the economic growth that the investment offers to the wider region, the TRANSECON methodology defines the EDE indicator. The economic growth of the investment is equal to the EDE indicator multiplied by the number of residents that the investment covers and influences.

    The investment for the OASTH expansion of concerns 1,500,000 people (which includes the residents of Thessaloniki and surrounding municipalities). Furthermore, the EDE indicator is calculated by the average of the indicators of the corresponding projects which are Helsinki with EDE = 7, Manchester with EDE = 6, Stuttgart with EDE = 10, Newcastle with EDE = 6 and Zurich with EDE = 10. At this point, a clarification is needed; the corresponding projects are the City and Suburbs projects which belong to the same category with the OASTH investment based on the function of the investment within the whole PT network (expansions of existing infrastructure) and their location characteristics (connection between city centre and suburbs). The average of the indicators constitutes the best approach for the EDE of Thessaloniki and is equal to 7.8.

    As a result, the economic growth for the OASTH investment is

$$Economic\ growth = 7.8 \times 1,500,000 = 11,700,000.$$

- Urban regeneration: The calculation of this criterion also depends on the population that the project covers, and for the case of Thessaloniki this is 1,500,000 people. The value of urban regeneration is also calculated for the investment (and not independently for the scenarios). This indicator of urban regeneration for the Thessaloniki project is estimated by the average of the indicators of the City and Suburbs projects.

    The values of the urban regeneration indicator for these cases of investments are the following: Zurich 4; Stuttgart 3.5; Helsinki 4; Newcastle 4; Manchester 2.

Their average is 3.3 and therefore the final urban regeneration indicator for the region of Thessaloniki is equal to:

Urban regeneration = 3.3 × 1,500,000 = 4,950,000.

- Social equity: The social equity is given by the product of the social equity indicator and the population that is influenced by the investment. The social equity indicator for the OASTH investment is also estimated by the average of the indicators of the City and Suburbs projects. These values are Helsinki 3.57, Manchester 3.36, Stuttgart 3, Newcastle 4.43 and Zurich 3.86.

  Their average is 3.644 and therefore:

Social equity = 3.644 × 1,500,000 = 5,466,000.

- Improvement in the use of PT: This criterion examines that the increased use of PT by the residents are influenced by the investment. The value is the difference between the forecasted demand for the transport service after the investment and the demand for the KTEL transport service before implementation of the investment. The difference between these two values depicts the improvement of the use of PT.

  The estimated annual demand for OASTH is equal to 8,128,440 passengers, while for KTEL the annual demand is 3,027,024 passengers. The difference of the two values 8.128.440 − 3,027,024 = 5,101,416 passengers, which represents the value of the criterion.

Step 3: At this point, the calculated values of the criteria are converted into homogenised indicators, all expressed in absolute social utility units. This process is carried out using value functions for each indicator of the evaluation process [22].

The definition of the value functions constitutes the most important and critical point for every multicriteria technique. The main achievement of the TRANSECON methodology is that value functions are developed for each indicator which correlates the results of the different investments. This allows the value functions to be adjusted and applied to other investments, so as to correlate their results with the TRANSECON results, thereby covering the general objective of the methodology which is its ability for expansion.

The range of the value functions is selected to be [−1.1] where −1 expresses the minimum (negative) social utility and 1 expresses the maximum (positive) social utility. This range is selected (and not the [0.1]) because the negative repercussions of economic criteria must be included in the evaluation. The range differs depending on the criterion so as to reflect its quantitative significance. Specifically the range [22] for capital cost is [−1.1], for EE it is [−1.1], for economic growth it is [−0.33, 0.33], for urban regeneration it is [0.67, 0.67], for economic growth it is [−0.33, 0.33] and for the improvement in the use of PT it is [−1.1]. The maximum rate of the range for each criterion is used as a coefficient in its value function. At this point, the social utility of each criterion using the value functions that define the TRANSECON methodology is calculated.

- Capital cost: The value function of capital cost is $y = x/2{,}487$, where x is the capital cost of the investment in Million Euros and y is the cost reflected in social utility units. The denominator of the ratio represents each time the highest criteria value among the investments (in this case 2,487 is the capital cost of the Vienna project in Million Euros which is the highest). If x is replaced by the capital cost of the OASTH investment, the capital cost of the OASTH project in social utility units will be:

$y = -7.691/2{,}487 = -0.0031$ (homogenised capital cost of OASTH investment).

- EE: The value function of EE is $y = x/562$. The denominator of the ratio represents the highest indicator value among the investments (in this case 562 is the economic efficiency of the Brussels project in Million Euros per year). By replacing the value of the OASTH investment:

$$y = -2.662/562 = -0.0047 \text{ (homogenised EE of the OASTH investment).}$$

- Economic growth: The value function of economic growth is $y = 0.33 \times x/26,027,040$. The denominator represents the indicator value of the Madrid project (26,027,040 persons affected per year) which is the highest and by replacing the value of the OASTH investment:

$$y = 11,700,000/78,869,818 = 0.148 \text{ (homogenised economic growth of the OASTH investment).}$$

- Urban regeneration: The value function of urban regeneration is $y = 0.67 \times x/3,986,264$. The denominator represents the indicator value of the Athens project (3,986,264 persons affected per year) which is the highest and by replacing the value of the OASTH investment:

$$y = 4,950,000/5,949,648 = 0.832 \text{ (homogenised urban regeneration of the OASTH investment).}$$

- Social equity: The value function of social equity is $y = 0.33 \times x/3,843,897$. The denominator represents the indicator value of the Athens project (3,843,897 persons affected per year) which is the highest and by replacing the value of the OASTH investment:

$$y = 5,466,000 / 11,648,174 = 0.469 \text{ (homogenised social equity of the OASTH investment).}$$

- Improvement in the use of PT: The value function is $y = x/74,176$, where the denominator of the ratio represents the highest indicator value (in this case 74,176 is the PT improvement of the Athens project in PT trips per day). By replacing the value of the OASTH investment:

$$y = 14,171/74,176 = 0.191 \text{ (homogenised improvement of the use of PT).}$$

Step 4: This step of the multicriteria evaluation involves assigning to each criterion a weight to represent its relative importance insofar as the overall objective of sustainable development. For the OASTH investment, the weights were determined through a consultation process based on question-naire research, with the participation of a group of nine experts. The six criteria of the OASTH investment have scores ranging from 1 to 10, where 10 is the maximum importance with respect to sustainable development. The results of the weights for the various criteria after their normalisation $[W_i = (w_i/\Sigma w) \times 100]$ are presented in Table 3.

Step 5: Calculation of the product of social utility and normalised weight for each criterion and recording thereof in the column 'social utility with weights' of Table 3. The aggregation of all products defines the overall socio-economic utility of the investment in absolute homogenised value units (project impact). All results are presented in Table 3.

5 RESULTS

In order to verify and check the final results and conclusions that emerged from the evaluation procedure, a sensitivity analysis is conducted. The most important parameters for the final result of the method are considered to be the indicator values (EDE, urban regeneration and social equity indicators) and the normalised weights of the criteria. With the sensitivity analysis, the most extreme values of the aforementioned parameters in different scenarios are examined.

The outcomes of the research are divided to quantity and quality results according to the model calculations and general conclusions of the study, respectively.

Table 3: Results of the TRANSECON evaluation process.

Objectives	Criteria	Value of the criteria		Absolute difference	Social utility (a_i)	Normalised weights (W_i)	Social utility with weights $(a_i \times W_i)$
		Scenario 1 (do nothing)	Scenario 2 (investment)				
Economic benefits	Capital cost	0	7,691,269	7,691,269	−0.0031	11.1	−0.03441
	Economic efficiency	−1,905,087	−4,566,733	−2,661,646	−0.0047	14	−0.0658
Social benefits	Social equity	–	–	5,466,000	0.469	19.56	9.17364
	Improvement in the use of PT	8,408	22,579	14,171	0.191	18.34	3.50294
	Economic growth	–	–	11,700,000	0.832	18.83	15.66656
	Urban regeneration	–	–	4,950,000	0.148	18.1	2.6788
Aggregation							30.92173

More specific, the analysis of the scenarios described above provided the following results:

- The final indicator value of the TRANSECON method for the investment of OASTH is 30.92, when the values that resulted from the application of TRANSECON for the other case studies are as follows: Athens 46.70, Vienna 8.99, Madrid 16.35, Helsinki 10.85, Brussels 11.54, Lyon 6.12, Newcastle 17.09, Stuttgart 9.30, Valencia 5.56, Manchester 5.93, Delft 2.87, Zurich 9.84 and Bratislava 0.46.
- Choosing the lower values of the indicators, which are 6 for EDE indicator (Manchester case study), 2 for urban regeneration indicator (Delft case study) and 3 for social equity indicator (Stuttgart case study), along with a simultaneous increase of the capital cost (30%) and a 30% decrease of the EE and the improvement in the use of PT values, the sensitivity analysis results 21.35 for the final indicator value of the OASTH investment.
- A radical alteration of the normalised weight values for the criteria of the investment of OASTH and more specific an almost 40% decrease of the weights of the social criteria and an almost 100% increase of the weights of economic criteria lead to a 45% decrease of the final indicator value (16.98).
- The combination of the two previous scenarios, namely the alteration of the normalised weights along with the before mentioned values of the indicators, results 12.52 for the final indicator value of the OASTH investment.

6 CONCLUSIONS

Transport is a special field of the overall economic activity. Its participation in the economic circuit differs in relation to other fields. This is due to the fact that transport is not an end in itself, but usually constitutes the means for the completion of other needs. This particular characteristic, combined also with the important social and environmental extensions of the field, makes the achievement of sustainable development a particularly difficult mission for transport engineers. The difficulty derives from the need to develop adequate evaluation methods that include the overall effects of the transport sector and have as a goal the promotion of sustainable solutions.

In the case of the OASTH investment, it would have been difficult to evaluate the qualitative parameters on monetary terms, even if there was an availability of data. With the expansion of the TRANSECON methodology for the case study of Thessaloniki, the correlation of those qualitative figures was achieved without the demand of data availability for the OASTH. This is particularly important as it is proved that a complete evaluation based on the principles of comprehensive planning can be applied through the adjustment of the examined investment in the TRANSECON methodology and its correlation with similar investments, without the need of data collection.

The evaluation of the TRANSECON investment concerns a case of insufficient data, but the correlation with other projects overcomes this obstacle. A difficulty on measuring or acquiring data of the qualitative parameters is common in many investments. A useful conclusion from the above statements is that the development of a common methodological framework helps to evaluate the current investments by examining the characteristics of previous implemented investments. In this sense, a correlation of the characteristics based on benchmarking could be used to overcome the data non-existence, resulting in the achievement of comprehensive planning that leads to sustainable development.

Comparing the final score that resulted from the application of the TRANSECON methodology to the OASTH investment with other implemented transport investments, it is obvious that it accomplishes the overall objective of achieving sustainable development. The final result for Thessaloniki (30.92) is only lagging behind that of the investment made in Athens (46.70), while it

is greater than all the rest (Vienna 8.99, Madrid 16.35, Helsinki 10.85, Brussels 11.54, Lyon 6.12, Newcastle 17.09, Stuttgart 9.30, Valencia 5.56, Manchester 5.93, Delft 2.87, Zurich 9.84 and Bratislava 0.46). The final result is high due to the high parameter values that ensued from the qualitative (social) criteria in contrast to the economic ones. In the sensitivity analysis, the values of the qualitative parameters and their weights are decreased, while the economic ones are increased in order to examine the sensitivity of the final result in relation to the alterations of these parameters. The results of the sensitivity analysis showed clearly that the project promotes the general objective of sustainable development because even in the worst off evaluation scenario, the final indicator value (12.52) remains among the highest compared with the other projects. It is important to note at this point that the capital cost is included in the evaluation process for the OASTH investment, while it was not included for the other investments. In case the capital cost was not included in the evaluation, the final score would have been even higher as this specific indicator has a negative function.

Additionally, the final high result of the evaluation of the OASTH investment points out that the achievement of sustainable development is not necessarily accompanied by economic efficiency. Even though the OASTH investment is not deemed viable under strictly economic criteria, it is nevertheless considered to be expedient where social benefits are concerned. As a result, we must seek the indicators and methods that take into account the qualitative criteria of such projects, to ensure efficient evaluation concurrently with the objective of the investment (sustainable development or purely economic goals). MCA constitutes a very useful tool towards this direction.

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