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QUANTITATIVE EVALUATION TAXONOMY FOR TRANSPORT INFRASTRUCTURE PROJECTS

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Abstract
In most of the cases the decision to invest in a transport infrastructure is not simple, mainly, because the complications in planning process, the amount of capital need to invest before the business establishment and the high number of stakeholders involved in decision process. The decision process is more complicate in large transport infrastructures, where the project survivability strongly related to regional development prospects and the transport business targets in medium-long time horizon. Also, different expectations from authorities and stakeholders lead to significant conflict between authorities and local communities about the advantages and disadvantages to develop large transport infrastructure projects. This paper deal with the methodology approach to support strategic decisions about develop a new large transport infrastructure project. According a systematic approach, the analysis framework where the decision key issues are evaluated and the key messages to decision makers are presented. Conventional wisdom is to present a systematic approach appropriate to apply is relevant projects, providing the essential tool to support decisions at level of strategic planning. This paper attempts to fill gaps faced by stakeholders and decisions makers in the evaluation and decision making process of developing large transport infrastructure projects.

Introduction
Investing in transport infrastructures is a key driver in strengthening the national economy and enhancing nation's productivity, as it creates economic benefits and additional income. In national level, the assets portfolio is helping to enhance productivity and competitiveness through the funding of significant infrastructure projects and a comprehensive regulatory reform agenda. However, such a decision often must be made in environments that are much more fraught with uncertainty. The key question in such decisions is if new large sustainable transport infrastructures could be able to boost economic development.

In research society, it's well recognised that investments in infrastructure projects lead to economic development [1, 2, 3]. Government agencies and stakeholders need derivate estimations for the impact on regional economy caused by the development of new infrastructure projects. However, the details of the estimations may differ for each case, and it's essential the need to carrying out a pre-evaluation of the project feasibility to define the terms of which certain issues are expanded quantitatively and improved during the life cycle of the project. This assessment framework is an essential challenge, because the outputs have to provide information for the decision key factors highlighting trade-offs, risks, uncertainties and limitations

Usually, the transport infrastructure projects are different from ordinary infrastructure projects regarding the investment scale, function and funding schemes. A large scale project involves politics, economics, regulates and, almost, every side of society [4].

The preparation of infrastructure projects requires careful attention to the effective use of methodologies for forecasting, planning, appraising and costing. Such projects thrive in an atmosphere of certainty, involving ten-year, 20 or even 50 year commitments and billions of dollars. They are typically planned and constructed with a professional culture of 'closed systems' thinking which has a tendency to minimise the uncertainties and risks associated with the context(s) and working environments of the project.

The paradox, however, is that the reality of today in increasingly more uncertain times re-confirmed by recent developments associated with the increasingly inter-dependent multidimensional global economic crises unfolding before us, including: the longstanding crisis of world poverty the growing food production crisis the declining availability of global energy resources climate change induced global warming and the global finance liquidity crisis.

The purpose of efficient and productive large transport infrastructures is to strengthen the economic activities and development. The sustainable developed transport infrastructure facilitates sustainable economic growth and competitiveness by influencing goods and services markets and higher productivity.

Materials and Methods

Transport Infrastructure monitoring framework

At the project in strategic planning stage, a consistent framework is required that can be carried through to the later stages of project cycle. Such a framework provides causal links between inputs or activities and outputs, and between outputs and outcomes (short- and medium-term outcomes and long-term impact). The framework also provides a basis for project monitoring and evaluation at the implementation and operation stages. For example, benefits to be monitored associated with transport infrastructure project benefits can be related to the following categories of effects:

- Market gains such as domestic market extension and economies of scale (e.g., power), connectivity and access to markets (e.g., transport);
- Efficiency gains (cost saving) such as reduction in time, reduction in physical barriers to trade (e.g., better roads, railways); reduction in non-physical barriers to trade (e.g., reduced transaction costs due to trade facilitation); and
- Wider effects such as contribution to trade creation, benefits to all participating countries and sub regional community, and increased regional and global integration.

Quantification of equilibrium parameter analysis on transport infrastructure sustainable development

Transport has become a major contributor to economic growth that requires operational productive and efficient infrastructures and services [5,6]. The purpose of the demand side equilibrium parameter analysis is to identify key parameters from the literature and provide a qualitative assessment of impacts on transport demand. These forecasting approaches are based on quantitative methodologies using causal econometric models [7]. The operation of demand variables is intuitive; however, their precise values in the models vary significantly. In general, income and stability are positively correlated with freight transport demand, while prices, exchange rates and transportation costs are negatively correlated. [8].

The following Fig. 1 divides the parameters between classical (those which are used in existing transport demand models) and the new large transport infrastructure related variables which need to be included in the models. Values will have significant overall effects on transport freight demand, because not only are new parameters that should be internalized in existing causal models, but they will impact the classical variables in such a way that is likely to reduce overall demand. These parameters are interrelated [9].

A country's comparative advantage in market prices is a function of the costs associated with distance, infrastructure and transaction costs associated with industry and institutional structures. These accumulated comparative advantages are more complex than simply transport infrastructure, they take time to develop and therefore the comparative advantages also take time to erode.

Transport Infrastructure Decision making framework steps

Based on the distinguishing constitutes as multiple objectives, a System framework is proposed as a methodological structure for assessment of evaluation in large transport infrastructure projects [10, 11]. Decision process to invest in large transport infrastructure projects is conceptualized as a system framework with sub-systems consisting of different constituents. By capturing the dynamic behaviors, uncertainties and interdependencies of these constituents, the evaluation of transport infrastructure projects can be evaluated as described analytically in Fig. 2 [12]. Assessing concrete steps across a project's investment decision making process can be a powerful way of making it more resilient and ultimately more profitable for all of the stakeholders and agents across the value chain. Fig. 2 provides an example of a generalized System framework.

First step: Strategic Planning: Governments are responsible for the strategic planning in order to develop projects with correct forecasts and assumptions (for example, on demographics, demand, prices, revenues, capital expenditure, or operating expenditure), and a high understanding of market dynamics. They have also to plan for volatility and adverse scenarios.

Other challenges of the government and authorities include planning and management of future interface risks, caused by early-stage decisions regarding project structures and design. In addition, the risk of contractors, and private investors, who are essential, has to be taken into account in the phase of strategic planning.

A system of system approach involves making decisions using a risk-based perspective. Specifically, in the earliest design and planning phases of a rail project, this may require a conscious effort to identify, assess, and, quantify all the risks the project will be exposed to across its life cycle. This includes reflection on potential adverse circumstances and scenarios that has to be made by governments and authorities. The objective is to create a decision-making process to select the most suitable investment that will achieve the national targets and ensure the project is developed in a way that promotes regional economic development.

Second Step: The construction of a reference solution and the identification of promising alternatives are two aspects that will influence all the results of the following evaluations. Typical examples of options are: different routes, or different construction timing or different technologies considered for large transport infrastructure projects.

The feasibility analysis aims to identify the potential constraints and related solutions with respect to technical, economic, regulatory and managerial aspects. A project is considered feasible if its design conforms to technical, legal, financial and other constraints relevant to the geographic area.

Third step: The main purpose of the Financial Analysis is to use the project cash flow forecasts to calculate suitable net return indicators; special emphasis will be places on the Financial Net Present Value (FNPV) and the Financial Internal Rate of Return (FRR).

The Financial Analysis contrasts the financial inflows with the financial outflows.

Financial inflows can be:

- any possible revenues for the sale of goods and services (Tolls, fares and charges)
- the net cash from the management of financial resources (Government Transfers)

Financial Outflows are:

- investment Costs
- operation costs
- reimbursement of loans and interest paid,
- taxes
- other disbursements (e.g. dividends).

The first step in a Financial Analysis is to estimate the total cost of investment and the time horizon for the investment, which is the number of years for which forecasts are provided. The reference time horizon for example for railway projects are 30 years and for roads, ports and airports 25 years.

The calculation of total operating costs and revenues is the second step of a Financial Analysis. These costs do not take the form of an investment and are consumed within each accounting period; the operating costs comprise all the data on the disbursements foreseen for the purchase of goods and services.

A project is financially sustainable if it does not incur the risk of running out of cash in the future. The crucial issue here is the timing of cash proceeds and payments. Project promoters should show how sources of financing (including revenues and any kind of cash transfers) will consistently match disbursements year-by-year over the project time horizon. Financial sustainability is ensured if net flow of cumulated generated cash flow is positive for all the years considered.

The last step in the Financial Analysis is the appraisal of the financial return on capital, which aims to look at the project performance from the perspective of the assisted public and possibly private entities.

Fourth step: The Economic Impact Analysis appraises the project's contribution to the economic welfare of the region or country. It is made on behalf of the whole of society instead of just the owners of the infrastructure, as in the Financial Analysis. In the case of an economic evaluation based on a cost-benefit analysis, which takes the perspective of society as a whole, the market pricing of a good is not a good indicator of its true value to society as so-called external effects also play a significant role. Yet the valuation of these effects is crucial for Economic Analysis and may be important for the appraisal of the project. In order to internalise these externalities, the external effects have to be identified, quantified and have a realistic monetary value assigned to them. The economic impact footprint analysis includes additional indirect effects (if relevant) and monetisation of non-market impacts.

Results and Conclusion

For the purpose of integrated evaluations assessment, the decision framework analyses transport infrastructure investments at three levels: base level (inputs), process level, and project level (output) as analytically described in Fig. 3. This three-level analysis facilitates a bottom-up approach for evaluation assessment from the base level to the outputs. The inputs are the operation characteristics and the transport infrastructure operator performance. The outcomes are obtained by aggregating the multi-object agents and interdependencies of constituents at the level of network planning, considering all the social values and economic conditions. As shown in Fig. 3, the interactions between stakeholders, at the base level are aggregated to give the outputs concerning business sustainability, network evaluation and economic productivity of a new large transport infrastructures.

Ex Ante Quantitative Analysis Framework

Large transport Infrastructures are pre-evaluated looking at project rationale and strategic issues, alternatives, costs and benefits, risks and uncertainties, financial sustainability and economic impact analysis [13]. While financial analysis of large transport infrastructure investment projects is concerned primarily with whether the overall net economic benefits are positive, the economic analysis of large transport infrastructure projects goes a step further to analyse how their benefits and costs are distributed and where is the equilibrium point between economic benefits and financial sustainable analysis, as depicted in figure 4.
As multiple stakeholders must agree on and coordinate the institutional and financing arrangements of large transport infrastructure projects to ensure all stakeholders can anticipate net gains from the project in question, analysis of benefit-cost distribution helps to alleviate coordination failure and ensure project financial sustainability[14]. In particular, it is important to identify possible net losers and build in necessary adjustments for socioeconomic and environmental externalities.

The application provides the methodology outputs presenting the proposed decision framework for a large transport infrastructure railway project in north Greece deals with the upgrade of the existing railway corridor connecting Greece and Bulgaria. Analytically is the renovation of infrastructure – trackwork in located stretches of a line, as well as the installation of electrification – signalling – ETCS Level 1 along the entire Alexandroupolis – Ormenio – Bulgarian borders line. The 180km single track rail line between Alexandroupoli and Ormenio/Bulgarian border has been recently renovated with modern superstructure materials (UIC54 rails – B70 monoblock sleepers and SKL 14 spring anchors). The superstructure differs in terms of materials (wooden or steel sleepers and rails of various types), along a total length of about 30 km. The line includes 70 bridges (span > 4 m) and 13 stations serving passenger transportation.

There is lack of electrification infrastructure and advanced signalling equipment and this affects the efficiency of the corridor and its interoperability. The electrification of this part of the railway network and the upgrading of the signalling systems can improve the interoperability of the corridor, its capacity and safety.

Thrace region due to Geopolitical position, offers significant advantages that allow country to play a key role in freight transports in the wider region and Europe and become a freight traffic hub.
Improvement of the level of service in terms of distance, comfort, and quality and increase of rail safety –reduction and rail accidents will:

- Promote Intermodality and Combined Transport Operations
- Provide connectivity with the EU Rail Network
- Provide connectivity with East freight market
- Attract more international transit traffic
- Support full exploitation of the strategic location of the country
- Transformation to an international freight hub for Central and Eastern Europe
- Strengthening interconnectivity and regional integration
- Increase rail connectivity with ports and industrial areas in the region and in Bulgaria (Burgas) and (Varna)

The great importance of the upgrade of the Alexandroupolis-Ormenio rail line is the potential to connect Alexandropoulis with the two ports in Bulgaria (Burgas and Varna), which could increase intermodal transport and enable the operation of the three ports as transit centers for the commercially fast-growing Black Sea area, bypassing the Bosporus which is saturated with shipping.
Demand and revenues scenarios were developed in order to quantify generated demand in the project area of influence and diverted traffic from other transport modes for both freight customers. The scenarios are based on the

The proposed rail upgrade line will be an important investment in Greece. Even with the most modest estimates the investment is estimated at €160 million. The economic viability of the project itself and then the corresponding direct and indirect macroeconomic will impact to the local and national economy.

By constructing 24 scenarios for the fundamental variables that greatly affect the project's development, the transport demand and the pillars of economic conditions, and other external factors that impact project development, the financial viability as well as the economic contribution of the project to the economic system were calculated.

According to these results and the calculation of the corresponding Internal Rate of Return (IRR) and Net Present Value (NPV) for each scenario the proposed project appears to be financial viable in the highest alternative scenarios with positive economic conditions and high growth rates of transport demand. The return back period analysis provides additional evidence in support of the viability of the project as low scenarios calculated were not enough to guarantee the profitability of the project in the range of transport demand growth and capacity expected in all scenarios.

On the other hand, examining the equilibrium point as the proposed investment project according to the financial analysis seems to be profitable only for high scenarios, the economic contribution to the local and national economies seems to be more crucial and guaranteed for all the scenarios. A significant direct and indirect increase of total demand for all the scenarios were respectively estimated that were translated into a sizeable total increase in national GDP for all the scenarios.

Concluding investing in such a large rail infrastructure project is a significant decision. One of the major drawbacks is its high capital cost. However, the decision makers should not only focus on the financial cost, and the financial viability but also the potential positive impacts on the economic system and the society.

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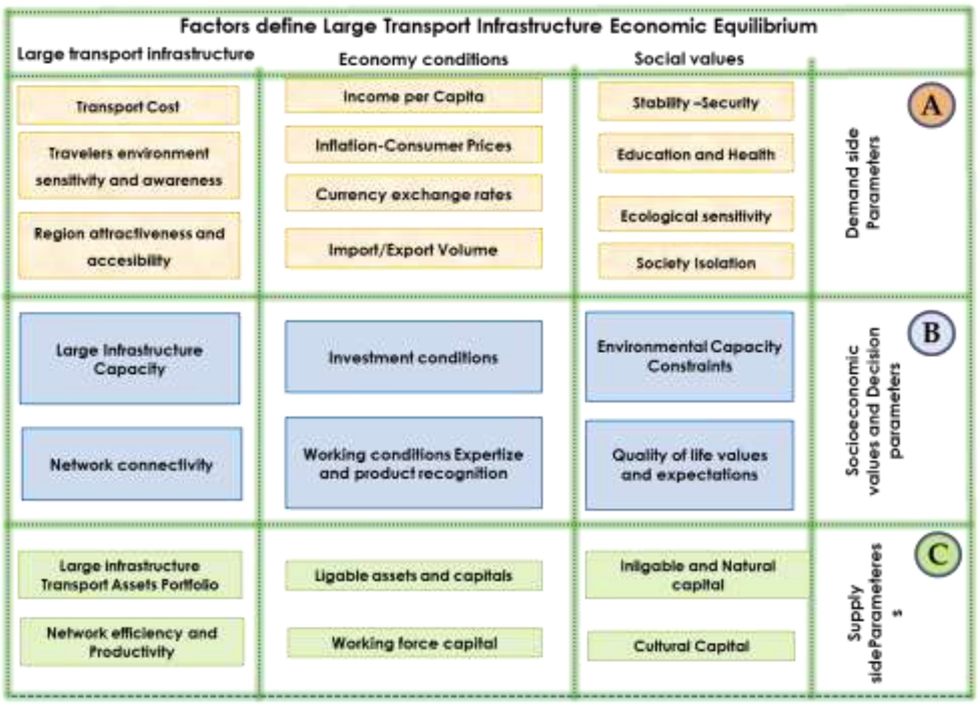

Fig. 1. Factors define transport infrastructure Economic Equilibrium [8]

Fig.2. Steps across a transport infrastructure project decision making process

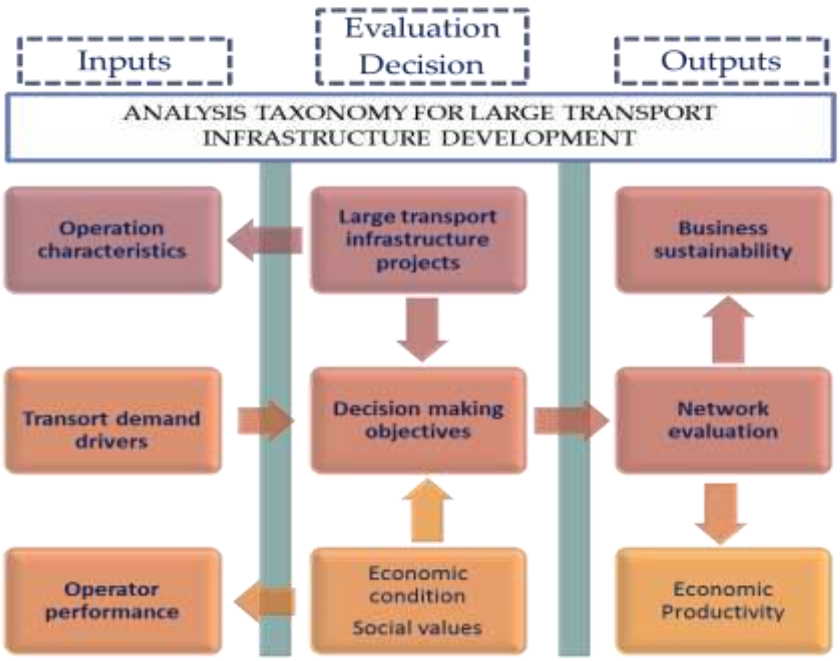

Fig. 3. Analysis Taxonomy for transport infrastructure development [9]

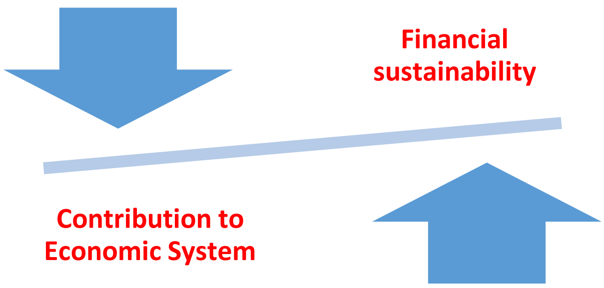

Fig. 4. Economic equilibrium of transport infrastructure between financial sustainability and economic contribution to economic system