DATA ANALYSIS BASED ON CBA CONCEPT

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Content

1. Introduction

The main objective of this document is to illustrate common principles and rules for application of the CBA (Cost Benefit Analysis) approach into the practice in public transport projects. It targets a wide range of users, including civil servants, staff of financial and transport departments at self-government administrative bodies, public transport operators, or consultants involved in the preparation or evaluation of investment projects. Chapter one presents the CBA guiding principles, working rules and analytical steps that shall be considered for investment appraisal. The proposed methodological framework is structured as a suggested agenda, both for the investment proposer, and the project examiner involved in project appraisal. To facilitate the understanding of some specific aspects of CBA, discussion and several case studies from RUMOBIL project are introduced. Document was prepared respecting *the Guide to Cost-Benefit Analysis of Investment Projects - Economic appraisal tool for Cohesion Policy 2014-2020* which is reflecting a specific requirement for the European Commission to offer practical guidance on major project appraisals, as embodied in the cohesion policy legislation for 2014-2020.[1] We plan to continue our work with the new app collecting information from transport service users. So we found this document to be the draft version of D.T1.1.3.

2. CBA – methodological framework

2.1. General principles

A cost benefit analysis is a process by which organizations can analyse their decisions, systems or projects. The model is built by identifying the benefits of an action as well as the associated costs. When completed, a CBA will yield concrete results that can be used to develop reasonable conclusions around the feasibility of a decision. It is the foundation of the decision-making process across a wide variety of disciplines including transport. Organizations rely on CBA to support decision making because it provides an evidence-based view of the issue being evaluated, without the influences of opinion, politics, or bias. In government, cost benefit analysis offers unique and valuable insight when:

- Developing benchmarks for comparing projects.
- Weighing investment opportunities.
- Measuring social benefits.
- Appraising the desirability of suggested policies.
- Quantifying effects on stakeholders.

There is no standard format for performing a cost benefit analysis, however there are certain core elements that should be present there, including five basic steps as follows:

- Establish a framework to outline the parameters of the analysis.
- Identify costs and benefits so they can be categorized by type, and intent.
- Calculate costs and benefits across the assumed life of a project or initiative.
- Compare cost and benefits using aggregate information.
- Analyse results and make an informed, final recommendation.[2]

[1] https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdfPilots preparation
[2] https://www.smartsheet.com/expert-guide-cost-benefit-analysis

The analytical framework of CBA refers to a list of underlying concepts which is as follows:

- **Opportunity cost.** The opportunity cost is defined as the potential gain from the best alternative forgone, when a choice needs to be made between several mutually exclusive alternatives.
- **Long-term perspective.** Along-term outlook is adopted, ranging from a minimum of 10 to a maximum of 30 years or more, depending on the intervention. Hence the need to: set a proper time horizon; forecast future costs and benefits; and take into account uncertainty by assessing the project's risks.
- **Calculation of economic performance indicators** expressed in monetary terms. CBA is based on a set of predetermined project objectives, giving a monetary value to all the positive (benefits) and negative (costs) of the intervention.
- **Microeconomic approach.** CBA is typically a microeconomic approach enabling the assessment of the project's impact on society as a whole via the calculation of economic performance indicators, thereby providing an assessment of expected welfare changes.
- **Incremental approach.** CBA compares a scenario with-the-project with a counterfactual baseline scenario without-the-project. In case where a project consists of a completely new asset, e.g. there is no pre-existing mobility service, the without-the-project scenario is one with no operations. In case of investments aimed at improving an already existing service, it should include the costs and the revenues/benefits to operate and maintain the service at a level that it is still operable (Business as Usual (BAU)) or even small adaptation investments that were programmed to take place anyway (do-minimum). In particular, it is recommended to carry out an analysis of the promoter's historical cash-flows (at least previous three years) as a basis for projections, where relevant. The choice between Business as Usual or do-minimum as counterfactual should be made case by case, on the basis of the evidence about the most feasible, and likely, situation. This takes into account all the investment, financial and economic costs and benefits resulting from the project.

2.2. Project appraisal steps

Standard CBA is structured in several steps. The following section illustrates, in detail, the scope of each step shown in Fig. 1.

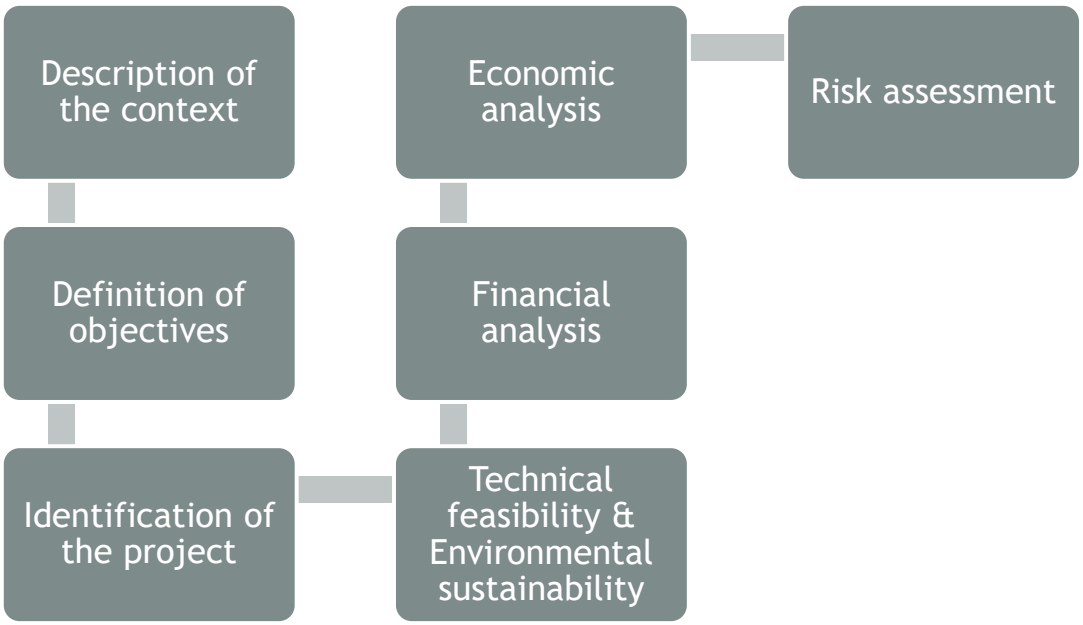


Fig. 1 The steps of appraisal

2.2.1. Description of the context

In establishing the framework of a cost benefit analysis, first it is necessary to outline the proposed program or policy change in detail and prepare situation overview to examine the existing state of art including background, current performance, any opportunities it has brought, and its projected performance in the future. First step aims to describe the social, economic, political and institutional context in which the project will be implemented. The key features to be described relate to:

- the socio-economic conditions of the region that are relevant for the project, including e.g. demographic dynamics, labour market conditions, unemployment trend, etc.;
- the policy and institutional aspects, including existing economic policies and development plans, organisation and management of services to be provided by the project, as well as capacity and quality of the institutions involved;
- the current infrastructure endowment and service provision, including indicators/data on coverage and quality of services provided, current operating costs and tariffs/fees/charges paid by users, etc.;
- other information and statistics that are relevant to better qualify the context, for instance, existence of environmental issues, etc.;
- the perception and expectations of the population with relation to the service to be provided.

The presentation of the context is instrumental to forecast future trends, especially for demand analysis, and for verifying that the project is appropriate to the context in which it will take place. Investments to provide services to citizens can achieve their goals through the integration of either new or renewed services into already existing. Partnership with the various stakeholders intervening in the system is thus a necessity.

2.2.2. Definition of objectives

The second step of the project appraisal is to define the objectives of the project. From the analysis of all the contextual elements, the regional and/or sectorial needs that can be addressed by the project must be assessed. The project objectives should then be defined in explicit relation to needs. As far as possible, objectives should be quantified through indicators and targeted in line with the result orientation of regional or sectorial policies. They may relate, for example, to improvement of the output quality, to better accessibility to the service, or to the increase of existing capacity, etc. A clear definition of the project objectives is necessary to:

- identify the effects of the project to be further evaluated in the CBA,
- verify the project's relevance.

2.2.3. Identification of the project

A project is clearly identified when:

• the physical elements and the activities that will be implemented to provide a given service, and to achieve a well-defined set of objectives, consist of a self-sufficient unit of analysis;

• the body responsible for implementation (often referred to as 'project promoter' or 'beneficiary') is identified and its technical, financial and institutional capacities analysed; and

• the impact area, the final beneficiaries and all relevant stakeholders are duly identified.

Physical elements and activities

A project is defined as activities or services. These activities or services should be instrumental in the achievement of the previously defined objectives. A description of the type of infrastructure (e.g. railway

line), type of intervention (new construction, upgrade, etc.), service provided (public transport) and location should be provided in order to define the project activities.

Body responsible for implementation

The project owner, i.e. the body responsible for project implementation, should be identified and described in terms of its technical, financial and institutional capacity. The technical capacity refers to the relevant staff resources and staff expertise available within the organisation of the project promoter and allocated to the project to manage its implementation and subsequent operation. In the case of the need to recruit additional staff, evidence should be provided that no constraints exist to find the necessary skills on the local labour market.

The impact area

After having described the project activities and the body responsible for project implementation, the boundaries of the analysis should be defined. The territorial area affected by the project effects is defined as the impact area. This can be of local, regional or national (or even EU) interest, depending on the size and scope of the investment, and the capacity of the effects to unfold. For example, transport investments such as a new roadway, even if implemented within a regional framework, should be analysed from a broader perspective. A good description of the impact area requires the identification of the project's final beneficiaries, i.e. the population that benefits directly from the project. It is recommended to explain what type of benefits will be enjoyed and to quantify them as much as possible. In addition, all bodies, public and private, that are affected by the project need to be described. Stakeholders – parties (organisations, individuals) that had an interest in a project, and could either affect or be affected by the project should be addressed to participate.

The stakeholder identification process is one of the most important processes in each project management, because projects are undertaken to fulfil the requirements of stakeholders who would benefit from it. To satisfy and fulfil the requirements of stakeholders, it is necessary to identify all relevant stakeholders. In RUMOBIL project the tool developed by the 7th FP research project – Changing Behaviour was used for identification of stakeholders (Fig. 2). In RUMOBIL project potential stakeholders were divided into three categories:

Primary stakeholders: Who were ultimately be affected by new transport measures (e.g. different social groups – certain municipalities or village communities, elderly people, young people, employed and unemployed people, business branches, organisations, etc.).

Key actors: Who had political responsibility (mayors, other authority levels); financial resources (public and private funds); the authority (by domain or territory); the skills and expertise (public administrations, universities, private sector) in transport and related domains (land use, environment, education, health, tourism, etc.).

Intermediaries: Who implemented transport policy (PT and infrastructure operators, public administrations, police, etc.). Who carried out major transport activities (PT operators). Who represented pertinent interest groups (associations, chambers, cooperatives, networks, NGOs). Who informed and reported on transport (authorities, operators, local media).

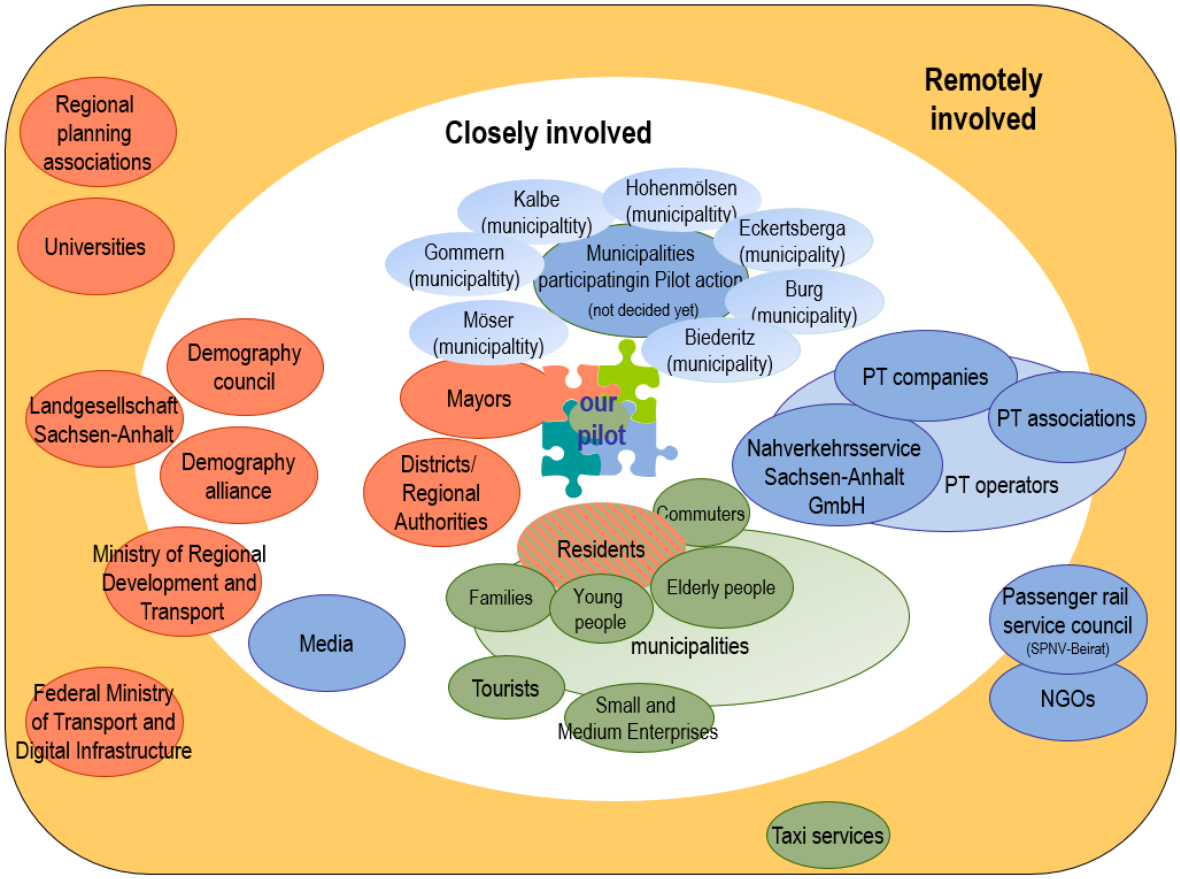


Fig 2 – Example of stakeholder map from Saxony-Anhalt region, Source RUMOBIL project documents

Each potential stakeholder occupies a color-coded bubble (colours stand for the different kinds of stakeholders: green – primary stakeholder, orange – key actor, blue – intermediary). Stakeholders are moved around the pilot project, putting them closer or further away (the proximity indicates the strength of relationship need to be built with them, and their importance) (Fig. 2).

2.2.4. Technical feasibility and environmental sustainability

Technical feasibility and environmental sustainability are among the elements of information to be provided in the funding request for major projects. Although both analyses are not formally part of the CBA, their results must be concisely reported and used as a main data source within the CBA. Detailed information should be provided on:

- demand analysis;
- options analysis;
- environment and climate change considerations;
- technical design, cost estimates and implementation schedule.

Demand analysis

Demand analysis identifies the need for an investment by assessing:

- current demand (based on statistics provided by different organisations);
- future demand (based on reliable demand forecasting models that take into consideration macro- and socio-economic forecasts, alternative sources of supply, elasticity of demand to relevant prices and income, etc.) in both the scenarios with- and without-the-project.

Both quantifications are essential to formulate demand projections, including generated/induced demand where relevant and to design a project with the appropriate productive capacity. For example, it is necessary to investigate which share of the demand for public transport services can be expected to be satisfied by the project. Different techniques (e.g. multiple regression models, trend extrapolations, interviewing experts, etc.) can be used for demand forecasting, depending on the data available. In case of transport projects, sophisticated forecast models are required.

Options analysis

In order to assess the technical, economic and environmental convenience of a project, an adequate range of options should be considered for comparison. A strategic options analysis, typically carried out at pre-feasibility stage may require multiple criteria analysis. The approach for option selection should be as follows:

- establish a list of alternative strategies to achieve the intended objectives;
- screen the identified list against some qualitative criteria, e.g. multi-criteria analysis based on a set of scores, and identify the most suitable strategy

Once the strategic option is identified, a comparison of the specific technological solutions is typically carried out at feasibility stage. Once all potential technological solutions are identified, also in the context of the Environmental Impact Assessment (EIA) or the Strategic Environmental assessment (SEA) procedures, they need to be assessed and the optimal solution selected as the subject of the financial and economic appraisal. The following criteria can be applied:

- if different alternatives have the same, unique, objective and similar externalities, the selection can be based on the least cost solution per unit of output produced;
- if outputs and/or externalities, especially environmental impacts, are different in different options, it is recommended to undertake a simplified CBA for all main options in order to select the best alternative. The calculation of the financial and economic performance indicators in the simplified CBA must be made, as usual, with the incremental technique. The criteria considered in selecting the best solution shall always be presented by the project promoter as a justification for the option chosen.

Environment and climate change considerations

Some requirements on the project's environmental sustainability should be fulfilled in parallel with the technical considerations and contribute to the selection of the best project option. When appropriate, an EIA must be carried out to identify, describe and assess the direct and indirect effects of the project on human beings and the environment. Its outcomes need to be integrated in the CBA and be in the balance when choosing the final project option. The costs of any environmental integration measures resulting from the EIA procedure are treated as input in the assessment of the financial and economic viability of the project. On the other hand, the benefits resulting from such measures are estimated valuing the non-market impacts generated by the project. Impacts of the project on climate, in terms of reduction of GHG emissions, are referred to as climate change mitigation and must be included in the EIA. On the other hand, the impacts of climate change on the project, referred to as climate change adaptation or resilience to climate change, must also to be addressed during the project design process, when necessary. Costs and benefits resulting from the integration of both mitigation and adaptation measures in the project design are used in the appraisal of the project's financial and economic performance.

Technical design, cost estimates and implementation schedule

- Location: description of the location of the project including a graphical illustration. Availability of land is a key aspect: evidence should be provided that the land is owned (or can be accessed) by the beneficiary. In the latter case, the conditions of acquisition should be described.

- Technical design: description of the main works components, technology adopted, design standards and specifications with defined key output indicators.
- Production plan: description of the infrastructure or service capacity and the expected utilisation rate. Project scope and size should be justified in the context of the forecasted demand.
- Costs estimates: estimation of the financial needs for project realisation and operations.
- Implementation timing: a realistic project timetable together with the implementation schedule should be provided including, for example, a Gantt chart.

2.2.5. Financial analysis

Financial analysis is carried out in order to:

- assess the consolidated project profitability;
- assess the project profitability for the project owner and some key stakeholders;
- verify the project financial sustainability, a key feasibility condition for any typology of project;
- outline the cash flows which underpin the calculation of the socio-economic costs and benefits.

A cost-benefit analysis should begin with compiling a comprehensive list of all the costs and benefits associated with the project. The costs involved in a CBA might include the following:

- Direct costs include the capital costs of all the fixed assets (e.g. land, constructions, buildings, equipment, etc.) and non-fixed assets (e.g. start up and technical costs such as design/planning, project management and technical assistance, construction supervision, publicity, etc.);
- Indirect costs might include electricity, overhead costs from management, rent, utilities;
- Intangible costs of a decision, such as the impact on customers, employees, or delivery times.
- Opportunity costs such as alternative investments.
- Cost of potential risks such as regulatory risks, competition, and environmental impacts.

Benefits might include the following:

- Revenue and sales increases from service.
- Intangible benefits, such as improved safety or customer satisfaction due to enhanced service.
- competitive advantage on market, and many others.

There are different types or methods of analysis to determine the economic efficiency of a project as Benefit Cost Ratio, Incremental Cost Benefit Ratio, Net Present Value, The Payback Period, etc. An analyst or project manager should apply a monetary measurement to all of the items on the cost-benefit list, taking special care not to underestimate costs or overestimate benefits. A conservative approach with a conscious effort to avoid any subjective tendencies when calculating estimates is best suited when assigning a value to both costs and benefits for a cost-benefit analysis. Finally, the results of the aggregate costs and benefits should be compared quantitatively to determine if the benefits outweigh the costs.

The project is financially sustainable when the risk of running out of cash in the future, both during the investment and the operational stages, is expected to be nil. Project promoters should show how the sources of financing available (both internal and external) will consistently match disbursements year-by-year. In the case of non-revenue generating projects, or whenever negative-cash-flows are projected in the future a clear long-term commitment to cover these negative cash flows must be provided.

The financial analysis is carried out by a set of accounting tables, as illustrated in Figure 3. Determination of investment costs, operating costs, revenues and sources of financing enables the assessment of the

project profitability. The next step is the identification of the different sources of financing that cover the investment costs.

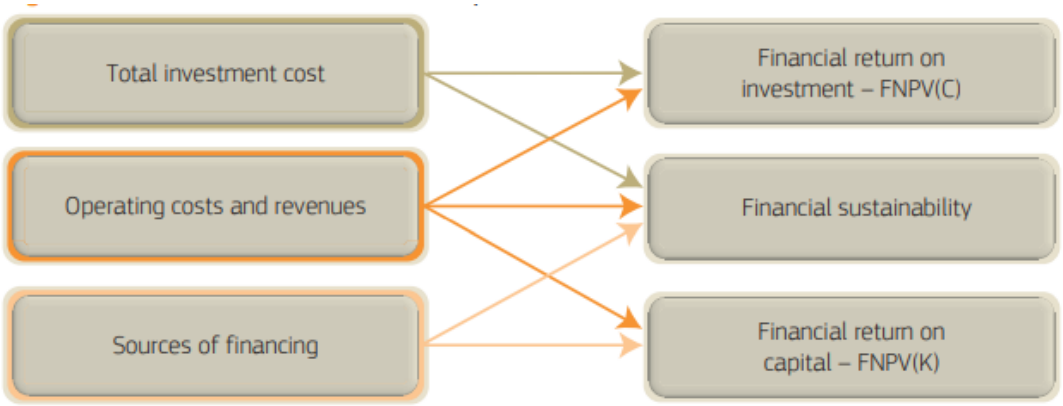


Fig 3 – Financial analysis, Source: EC CBA Guide 2008[3]

2.2.6. Economic analysis

An economic analysis must be carried out to appraise the project's contribution to welfare. The key concept is the use of shadow prices to reflect the social opportunity cost of services, instead of prices observed in the market, which may be distorted. Starting from the account for the return on investment calculation, the following adjustments should be:

- fiscal corrections;
- conversion from market to shadow prices;
- evaluation of non-market impacts and correction for externalities.

After market prices adjustment and non-market impacts estimation, costs and benefits occurring at different times must be discounted. The discount rate in the economic analysis of investment projects, the Social Discount Rate (SDR), reflects the social view on how future benefits and costs should be valued against present ones.

Evaluation of direct benefits

The concept of marginal Willingness-to-pay (WTP) is commonly used to estimate the shadow price of the project output. In other words, to evaluate the project direct benefits, related to the use of the services rendered. The WTP measures the maximum amount of people who would be willing to pay for a given outcome that they view as desirable. Different techniques, including revealed preference, stated preference and benefit transfer methods, exist to empirically estimate the WTP. The adoption of one or another method depends on both the nature of the effect considered and the availability of data.

Evaluation of non-market impacts and correction for externalities

Impacts generated on project users due to the use of a new or improved service, which is relevant for society, but for which a market value is not available, should be included as project direct benefits in the economic analysis of project appraisal. In principle, the WTP estimated for the use of the service should capture these effects and facilitate its integration in the analysis. Examples of (positive) non-market impacts are: savings in travel time; increased life expectancy or quality of life; prevention of fatalities; injuries or accidents; improvement of landscape; noise reduction; increased resilience to current and future climate change and reduced vulnerability, etc. Environmental effects are typical externalities in the context of CBA. Valuing externalities can sometimes be difficult even though they may be easily identified. Whenever money

[3] https://ec.europa.eu/regional_policy/en/information/publications/evaluations-guidance-documents/2008/guide-to-cost-benefit-analysis-of-investment-projects

quantification is not possible, environmental impacts should at least be identified in physical terms for a qualitative appraisal in order to give to decision-makers more elements to make a considered decision.

Economic performance

Once all project cost and benefits have been quantified and valued in money terms, it is possible to measure the economic performance of the project by calculating the following indicators:

- Economic Net Present Value (ENPV): the difference between the discounted total social benefits and costs;
- Economic Rate of Return (ERR): the rate that produces a zero value for the ENPV;
- B/C ratio, i.e. the ratio between discounted economic benefits and costs.

2.2.7. Risk assessment

A risk assessment must be included in the CBA. This is required to deal with the uncertainty that always permeates investment projects, including the risk that the adverse impacts of climate change may have on the project. The recommended steps for assessing the project risks are as follows:

- sensitivity analysis, which enables the identification of the 'critical' variables of the project. Such variables are those whose variations, be they positive or negative, have the largest impact on the project's financial and/or economic performance;
- qualitative risk analysis involves the identification of adverse events that the project may face. Building a list of potential adverse events is a good exercise to understand the complexities of the project;
- probabilistic risk analysis is required where the residual risk exposure is still significant. In other cases, it may be carried out where appropriate, depending on project size and data availability;
- risk prevention and mitigation should be the basis for risk management, which is the identification of strategies to reduce risks, including how to allocate them to the parties involved.

3. CBA application for transport projects

The funding of transport infrastructure requires the basic evaluation of the potential effects of the investments in the targeted area. New transport infrastructure and services are planned to enhance the transport or mobility conditions. The most used methodology for transport project appraisal is CBA, which has the long-term tradition, and deals especially with the evaluation of new transport infrastructure. Most of the official CBAs implemented in nationwide or European funding context take into consideration different parameters before and after implementation with expectation to minimize the negative and maximize positive project impacts. But there are also new approaches which consider the other aspects, as the personal evaluation from the side of users.

There are some guides for CBA implementation in investments projects, e.g. Guide to Cost-Benefit Analysis of Investment Projects Economic appraisal tool for Cohesion Policy 2014-2020, which was presented in chapter 2[4]. But there is also demand for new approach and next generation of CBA[5]. This part of the document brings some new insights on some aspects of traditional CBA analysis for transport projects.

[4] https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

[5] https://consultations.entsoe.eu/system-development/cba-2-0/

3.1. Baseline elements of CBA

3.1.1. Context and objectives

Description of context should include information on socio-economic trend in targeted region, reference to the political, institutional and regulatory policies, and existing service conditions. The next step is to clearly state the main objectives of the transport project. These are generally related to the improvement in travel conditions for goods and passengers both inside the impact area and to and from the impact area (accessibility), as well as improvements in both the quality of the environment and the wellbeing of the population served. Projects typically deal with the following objectives:

- improvement of the capacity or performance of a network;
- reduction of congestion by resolving capacity constraints;
- improvement of the safety of a network;
- minimisation of GHG emissions, pollution and limitation of the environmental impact;
- completion of missing links or poorly linked networks;
- improvement of accessibility in peripheral areas or regions.

Project identification state its functions, which should be coherent with the investment objectives. This should be followed by a description of the project typology. Finally, a detailed list of the physical realisations must be included.

3.1.2. Forecasting traffic volume

When developing a demand analysis for transport projects, particular attention should be paid to the sensitivity of traffic to some critical variables such as: demographic changes, socio-economic changes, economic structure of regions, industrial and logistics structure, elasticity with respect to quality, time and price, capacity constraints on competing modes and strategies in place, spatial changes, change of traffic management policies, technological changes. It is generally recommended to develop, as a minimum, three traffic scenarios (high, most likely and low), which should further feed into risk analysis. Traffic modelling is usually required for demand analysis. Different models exist, ranging from relatively simple to complex network models. The choice of the appropriate model depends on a large number of factors. Complex transport modelling is considered compulsory in large projects. The output from the transport model is used to design adequate sizing and features of the investment. It also provides quantitative information that informs the scheme design, the CBA and the EIA.

3.1.3. Option analysis

Option analysis includes possible design options in transport including mode; location/route; alignment, technical solutions; interchanges, etc. Different options may have different demand, costs and impacts. For option selection, the suggested approach is generally to use Multi-Criteria Analysis for shortlisting the alternatives, then CBA to compare the results of the shortlisted options and consequently select the most promising one.

3.1.4. Financial analysis

Financial analysis obviously includes:

- *Investment costs* (total cost of the project and the unit value (e.g. cost per km, cost per unit of rolling stock, etc.); costly engineering structures (tunnels, bridges, overpasses, etc.); the works required for its functioning; cost of land and costs for environmental protection.
- *Operation and maintenance costs* – routine and periodic maintenance.

- *Revenue projections.*

3.1.5. Economic analysis

In transport projects the main direct benefits are measured by the change of the following measurable:

The consumer surplus, defined as the excess of users' willingness-to-pay over the prevailing generalised cost of transport for a specific trip. The main items to be considered for the estimation of the consumer surplus are: fares paid by users; travel time; road users vehicle operating costs.

The producer surplus, defined as the revenues accrued by the producer minus the costs borne. The change in the producer surplus is calculated as the difference between the change in the producer revenue less the change in the producer costs. The main items to be considered for the estimation of the consumer surplus are: fares paid by users, and producer operating costs.

Relevant non-market impacts on safety and the environment need to be evaluated too.

Travel time saving is one of the most significant benefits that can arise from transport projects. In carrying out CBA, different methods are possible to value time for passengers and freight traffic. To value time for passengers, a distinction is usually made between the estimation of work and non-work travel time.

Vehicle Operating Costs are defined as the costs borne by owners of road vehicles to operate them (fuel, and lubricants consumption, tires deterioration, repair and maintenance costs, insurance, etc.

Operating costs for service carriers – in some investments there are the users of the infrastructure - companies (carriers) that, in turn, operate the service for final users.

Accidents - all transport activities imply a risk for the users of suffering an accident. Economic cost of accidents includes direct and indirect costs (e.g. medical rehabilitation costs, administrative costs for police, the emergency service, costs of insurances, etc.)

Noise pollution can be defined as the 'unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport. There are several methods to evaluate the effects generated by transport projects on noise.

Air pollution - CBA should integrate the economic cost of air pollution, which consists health effects, building and material damages, crop losses, and impacts on ecosystems and biodiversity. To calculate the external costs caused by air pollution, the bottom-up approach is regarded as the most elaborated and best practice methodology.

Climate change - CBA should integrate the economic cost of climate change resulting from positive or negative variations of GHG emissions.

3.1.6. Risk assessment

Following the sensitivity analysis, a risk assessment must be carried out. It is recommended to test at least the following variables:

- value of time;
- accident costs;
- assumptions on GDP and other economic variables trend;
- rate of increase of traffic over time;
- number of years necessary for the realisation of the infrastructure;
- investment and maintenance costs (as disaggregated as possible);
- fare/tariff/toll.

3.2. Discussion

The scientific literature frequently discusses questions if cost-benefit analysis (CBA) or multi-criteria decision-making (MCDM) is the appropriate appraisal tool in transport policy-making, or a combination of both. There is not a united opinion about the CBA as a helping tool (Annema et. al, 2015) and the results differ among the politicians. Hardly any literature exists on the opinions of real transport policy decision-makers about appraisal tools such as CBA or MCDM (or both) which are actually supposed to help them. In their study Annema et. al, interviewed twenty-one Dutch transport politicians on their views on CBA. The results showed that politicians use CBA but in a non-decisive manner and they find the aggregate outcome (the composite result) of CBAs pretentious. They seem especially interested in appraisal tools which show clearly to them the political important trade-offs of a transport policy.

The costs and benefits of a transport project or policy are evaluated over a long time period. For example, the initial capital expenditure of a transport investment may occur in the first couple of years but ongoing maintenance costs and impacts on factors like travel time or greenhouse gas emissions will last much longer. Therefore, to compare the costs and benefits of a scheme, the appraisal period, the period over which streams of costs and benefits are estimated, should 'cover the period of usefulness of the assets encompassed by the options under consideration'.

CBA concept has evolved constantly. The study of Meuniere et. al presents, analyses and compares the evolution of reference values used in national guidelines issued for cost-benefit analysis of transport infrastructure projects, over the last fifty years, in France, UK and Germany. The nature of unit values used in transport CBA has evolved step by step, starting from classical items such as value of time and safety and evolving towards a more and more precise assessment of environmental externalities (noise, air pollution) and even more global externalities (greenhouse gases). Within each nature of value, an increasing degree of differentiation of the values has also been observed. One of the more recent differentiation drivers is linked to the generalization of the geo-referencing capabilities of the traffic models and to their ability to estimate refined impacts such as pollution level at a very detailed scale, depending on traffic level and composition, population density or other local characteristics or variables. These refinements also induce an increased complexity which in turn, besides making benchmark comparisons highly difficult or impossible, makes also models and CBA results less easily explainable and understandable (Meuniere et. al., 2015).

Traditional CBA approach considers the future expected changes in transport demand or supply within various scenarios. The base scenario description the current situation. The forecasted scenario with no change -Do nothing. BAU scenario - business as usually. The main advantage of traditional CBA is that it enables to calculate the aggregate forecasted values in the transport infrastructure. The con is the fact, that there are no subjective considerations of users. Because there is also discussion regarding the potential changes in the CBA.

3.2.1. Users perspective

Travellers perceive both money costs and time costs associated with the trips they make. When someone makes a trip these costs will be outweighed by the opportunities and potential benefits at the destination. This potentially exaggerates freedom of choice in the short term since, having made decisions about where to live, work or locate a business, individuals and businesses may have limited options about the trips they have to make. However, in the longer term, and for the purposes of appraisal, use of the transport system is assumed to be the result of a balanced consideration of pros and cons by each individual decision-maker, subject to all the various constraints which exist. The calculation of transport user benefits is based on the conventional consumer surplus theory where consumer surplus is defined as the benefit which a consumer enjoys, in excess of the costs which he or she perceives.

For example, if a journey would be undertaken provided it takes no more than 32 minutes, but not if it takes more than 32 minutes, then the benefit of the journey to the traveller is equivalent to a cost of 32 minutes of travel time. If actual travel time for the journey is only 12 minutes, then the traveller enjoys a surplus of 5 minutes. The user impacts of a transport scheme which changes the perceived costs of travel should be assessed based on the change in this surplus. For example, if a scheme reduced the travel time in the example above to 12 minutes, it would increase the traveller's surplus by 3 minutes. The assessment of consumer surplus should incorporate changes to the following components of perceived cost:

- changes in travel time;
- changes in user charges, including fares, tariffs and tolls;
- and changes in vehicle operating costs met by the user (i.e. for private transport).

Of course there can be also benefits to Public transport operators in the amount of revenue. The higher number of passengers should also affect revenue. Most of the traditional national CBAs are comparing projects in variants without or with changes. This type of approach estimates the future benefits in the form of travel time or environmental pollution reduction.

3.2.2. Considering the Value of time

As was explained earlier, the traditional CBA calculations work the value of travel time, which is expected to be reduced if the new transport infrastructure or service would be built or introduced. The value of travel time is one of the important parameters in CBA calculations. For instance, the value of travel time saving (VVTS) is one of the main criterions considered in the CBA transport infrastructure calculation in Slovak republic. The results are calculated per year.

VVTS =(TTBAU-TTWS) x VO x VOD

Where:

TTBAU is travel time of scenario Bau as usually

TTWS is travel time of new scenario

VO is vehicle occupancy

VOT is value of travel time in Euro per minute.

There are also other approaches which considered the importance of travel time. Wardman and Lyons, (2016) explored savings in travel time. Savings in travel time and more specifically their monetary value typically constitute the main benefit to justify major investment in transport schemes. However, worthwhile use of travel time is an increasingly prominent phenomenon of the digital age. Accordingly, questions are increasingly being asked regarding whether values of time used by countries around the world based on their appraisal approaches are too high. Their paper highlights the challenges faced in both current and indeed potential alternative future appraisal approaches. Such challenges are rooted in the difficulty of measuring time use and productivity with sufficient accuracy and over time to credibly account for how travel time factors into the economic outcomes from social and working practices in the knowledge economy. They outlined that there is a need for further research to:

- establish how improvements in the opportunities for and the quality of worthwhile use of travel time impact on the valuation of travel time savings for non-business travel;
- improve our understanding of how productive use of time impacts on the valuation of time savings for business travellers;
- and estimate how these factors have impacted on the demand for different modes of travel.

For implementing the value of health, we can see various methods, for instance the assessment of health economic assessment tool HEAT, the benefit of travel time is not required to be reduced, but increased. The HEAT tool is designed to enable users without expertise in impact assessment to conduct economic assessments of the health impacts of walking or cycling. The tool is based on the best available evidence and transparent assumptions. It is intended to be simple to use by a wide variety of professionals at both national and local levels. These include primarily transport planners, traffic engineers and special interest groups working on transport, walking, cycling or the environment. That means if you walk, cycle a longer time, more benefits from building the cycling or pedestrian infrastructure you gain.

There is another approach, dealing with fact, that each person has a limited volume of time. The value of time savings in activity *i (VTSi)* is defined as:

VTSi = RVT − MVTi

Where *RVT* is the resource value of time, representing the benefit of an increase in the total time budget if such was possible, and *MVTi* is the marginal valuation of time spent in activity *i*. The marginal valuation of time spent travelling (MVTi) not only includes comfort related issues, but it also has the potential to be strongly influenced by being able to undertake worthwhile activities during travelling.

The alternative base work coming from various methods considering the individual needs. The Maslow pyramid of needs defines the hierarchy of news, where the lower needs in the hierarchy must be satisfied before individuals can attend to needs higher up. From the bottom of the hierarchy upwards, the needs are: physiological, safety, love and belonging, esteem, and self-actualization.

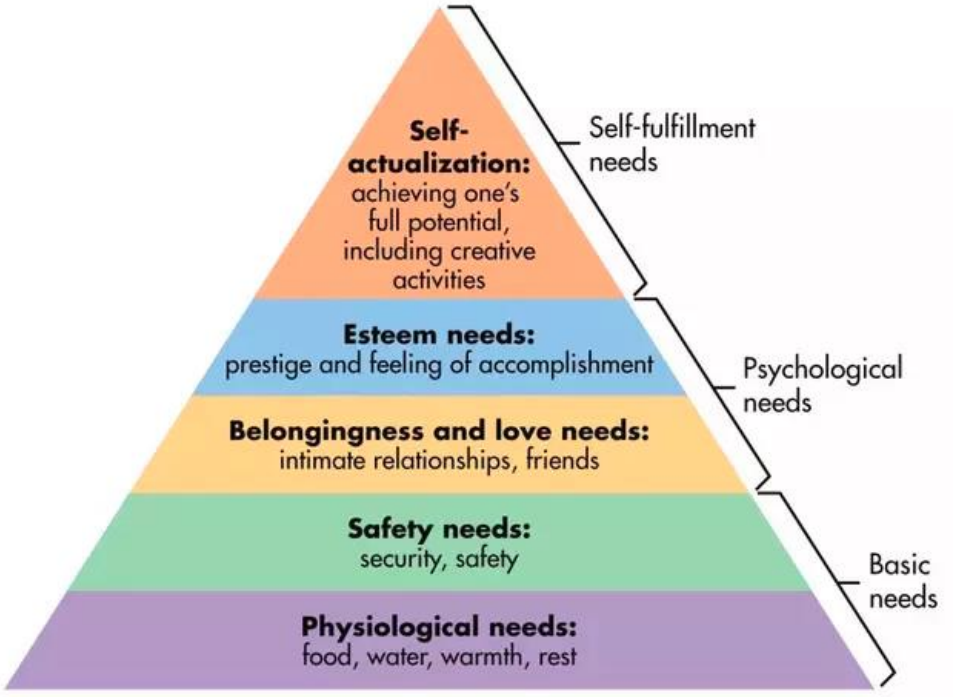


Fig. 3 - The principle of Maslow pyramids of needs, Source:[6]

Allen, Muñoz, and de Dios Ortúzar (2019) used Maslow's hierarchy of (transit) needs to understand public transport satisfaction. Public transport administrators require mechanisms to prioritise investments for improving their services, to maintain existing customers, and also to attract new users. Customer satisfaction surveys allowed detecting the level of global satisfaction with the PT system in addition to more specific satisfaction with its various attributes. Statistical analyses of these data allow determining which

[6] https://www.simplypsychology.org/maslow.html#gsc.tab=0

attributes impact more strongly on overall satisfaction. Authors postulated the existence of a Maslow's hierarchy of transit needs, with three types of attributes: functional (utilitarian), security (protection) and hedonic. To test their hypothesis, they estimated structural equation models (SEM), SEM-Multigroup, and SEMM (finite mixture) models, and assessed their differences in four different cities with Bus Rapid Transit (BRT)-type systems in Latin America. Their results confirmed the existence of a hierarchy in the different BRT-type system contexts, allowing to derive more generalizable conclusions. Finally, they provide direct policy recommendations by constructing a set of priorities for their case studies, concerning reliability, safety, customer services and comfort.

There are many areas where the value of time is deployed, for instance in the emerging area of autonomous vehicles (Zhong 2020). Engelson, and Fosgerau (2020) derived the value of a signal obtained by a traveller prior to the choice of departure time. The signal does not have to be a perfect prediction of the travel time. It is sufficient that it carries information about the travel time. The traveller may then consider the distribution of travel time conditional on the signal to increase her/his expected utility by making a better informed choice of departure time. They furthermore demonstrated that even perfect travel time information does not necessarily eliminate the cost of travel time variability and established necessary and sufficient conditions for when it does. They found that the predictable part of travel time variability may or may not be costly, depending on the shape of the traveller's scheduling utility at the origin of the trip. Using estimates of scheduling preferences from the literature, they showed that the cost of predictable travel time variability may constitute a substantial part of the total cost of travel time variability. In a particular case of scheduling preferences, travel time distribution and noise distribution, they establish an analytic relationship between the strength of the signal and the expected utility of the trip and evaluated the marginal cost of signal weakness. This knowledge may facilitate design and cost-benefit analysis of traveller information systems and policies decreasing travel time variability.

There is also study which proposed the reasonable travel time (RTT) (Banister 2008). It is defined as the door-to-door journey time that is acceptable to the individual traveller for reaching a particular destination, and its associated activities, given the conditions provided to turn 'lost time' into 'useful time' while travelling. Jara-Diaz (2020) focused on the decomposing the value of travel time savings into the value of liberated time and the value assigned to travel conditions requires a time use model.

3.3. MOTIV project - Considering the personal value of time

In the project MOTIV which focused on the personal valuation of travel time, the data collection campaign had been conducted in various countries. The main goal was to investigate which factors and how they contribute to the mode choice. The project defined various hypothesis that have been confirmed in the data collection campaign. The project introduced the worthwhileness index (WI). WI is the result of the various parameters (personal) and it differs among the population or travel mode. The research project tried to investigate how the travel time can contribute to the enhancement of physical activity (Fitness), Productivity (doing and worth work during the travel) or Leisure (just enjoying the travel time, listen to music etc.). It reflects the different aspects of various travel modes from the perspective of passenger.

The worthwhileness of travel time is recognised in CBA from a theoretical perspective as the productive time or time when the higher value does not mean the negative parameter, but on the contrary the benefit from the passenger perspective. For instance, time to relax, time to be productive (make work agenda, preparation work, different talks, etc.). The main results consider the different types of trip purpose which could be evaluated in different way, for instance the trip to work as the shortest travel time or leisure trip with enjoying the travel time. That means the different scope of travel time allows to have benefit either for shorter or extended travel time. This quite different approach to traditional CBA which see benefits only in the parameter savings.

3.4. Case studies

In this section we introduced some of the pilots implemented within RUMOBIL (Interreg Central Europe) project. We focus especially on impacts generated for which a market value is not available, but should be included as project direct benefits in the economic analysis of project appraisal. Examples of (positive) non-market impacts can be savings in travel time or increased resilience to future climate change. There is a lot of methodologies for quantification of the volume of emissions additionally emitted, or saved, in the atmosphere, as well as for calculation of other benefits. We try to provide simple comparison of individual pilot measures with car transport. For each calculation we considered one trip made by car and compared it with the trip done by public transport. Note: Calculation is based on https://www.eea.europa.eu/themes/transport/speed-limits-fuel-consumption-and

3.4.1. Case 1 - Introduction of the new bus line Jihlava - Havlíčkuv Brod - (Czech Republic)

This RUMOBIL pilot aimed at improving offer of public transport connections as a key condition for development of mobility of population, in terms of linking rural areas to major settlements as well as to transport networks of national and EU importance. The pilot strives to test and verify demand for new public bus transport connections in the context of a territory with fragmented settlement structure and in the context of preparation of the future regional integrated transport system "Public Transport of Vysočina".

In the preparation phase of the pilot, a thorough analysis of the current situation was carried out, including specification of the pilot locality, identification of concrete measures, list of public transport connections for the pilot and estimated costs of their operation.

The pilot implementation itself then started in March 2017 and involved 34 new bus connections on 4 existing lines, operated by 4 public bus transport operators. The pilot start and implementation were accompanied by a publicity campaign with a view to raise awareness about the new connections and attract new passengers to public transport. In the monitoring period (March 2018 – June 2018), the pilot buses covered a total distance of almost 52 000 kilometres and transported more than 25 000 passengers. The pilot implementation in this period costed 1,293 mils. CZK (ca. 50 048 EUR), financed by the RUMOBIL budget and the Vysočina Region own resources. In accordance with Czech legislation on public transport services, this amount is to be understood not as actual costs of the bus connections' operation, but as a payment by means of which the region compensates to the transport operators their provable loss – the balance between their real costs and revenues.

As foreseen by the Interreg CENTRAL EUROPE implementation rules, the Vysočina Region ensured full pre-financing of all activities, with the EU contribution to be refunded later after successful verification process. The share of the RUMOBIL budget allocated the amount of EUR 108 750 for pilot implementation. Total costs, meaning total compensation to the transport operators by the region (as explained above), reached more than 4 mils. CZK / approx. 159 000 EUR. The detailed breakdown for the pilot period (March 2017 – June 2018) is listed in the Table 1 below. Three of the four operators were running the pilot connections throughout the whole pilot period; the pilot line of the operator ARRIVA Východní Čechy has a seasonal character and was not operated in the winter months.

Within the pilot, the Jihlava - Havlíčku Brod line with a length of 18 km and an average occupancy of 33 passengers was selected for calculation. This was then compared in terms of impacts on different aspects with the car.

3.4.2. Case 2 - Introduction of citizens buses Osterburg (Germany)

Whereas Saxony-Anhalt provides a good main transport network (rail service and interregional bus services), a number of rural/ peripheral areas are not adequately connected to the main transport network. Most parts of these regions suffer from an ongoing population decline and dynamic aging as well as services of public interest retreat from these areas. This, however, brings enormous challenges for the provision of public

services, such as public transport (PT). One the one hand, population decrease and limited funds to finance PT result in reduced PT offers. On the other hand, mobility needs in regions where people are aging quicker than elsewhere are changed and even increased. Residents of those areas can overwhelmingly not benefit from Saxony-Anhalt's main transport network despite higher mobility demands. New approaches are therefore necessary to better connect peripheral areas affected by demographic change to transport network.

The MLV together with its in-house transport agency NASA aimed at introducing a new bus service operating according to the demand of residents. A "Citizen Bus", in German "Bürgerbus" operated by local communities and volunteers represents a highly innovative and cost-effective approach for connecting rural/ peripheral areas. The approach was tested in two municipalities with the buses running between remote villages and bigger towns/secondary or tertiary transport hubs.

Various costs were associated with the implementation of the two citizen bus projects in Saxony-Anhalt. The implementation period took time from December 2017 to May 2018. Planned and real cost of the different relevant budget sections were approx.:

Total stuff costs:

planned: 57.250, - €

real: 43.000, - €

Equipment:

Planned: 18.000, - €

Real: 11.843, - €

Infrastructure:

Planned: 20.000, -€

Real: 8.158, - €

For calculation we chose 6 km long line connecting marginal part of Osterburg with a train station. We supposed that this line can carry 16 passengers a day. We compared results of the same trip if those people use a car.

3.4.3. Case 3 - Introduction of park and ride scheme in Rajecké Teplice (Slovakia)

The main aim of the project was to restore the small rural intermodal connection hub in the town of Rajecké Teplice in order to better serve the local people and to promote intermodal travelling options in this rural territory. The improved station acts now as an interface between the various modes of transport and potentially it will also increase the ratio of people using public transport connections to central city Žilina and consolidate the entire public transport system in the pilot area. Another aim of the pilot project was to examine how will the higher level of multimodal hub services influence behaviour of commuting passengers. From the newly built multimodal transport Žilina self-governing region expected the stabilization of decline in the number of passengers despite the aging of the population. They expected better coordination of different types of transport and at the same time a gradual increase of the number of passengers in the period of two or three years.

The aim of the project was to upgrade the space of bus station, give there monitoring panels informing about departures and arrivals of public transport lines, ensure barrier-free access from bus to railway station and accommodate this connecting point with adequate number of safe bike kickstands. There were also new places for car parking established to support car users to change to other mode when travelling within the region. Improved station acts as the interface between the different modes and potentially increase the proportion of commuters who use public transport.

For the calculation, we chose a multimodal trip from a small village to Rajecké Telice (to the Park and Ride park) and from there to Žilina by train, 20 km away. We compared this route with passengers using a car.

3.4.4. Case 4 - Introduction of tourist train Zagreb - Ozalj (Croatia)

The implementation of pilot focused on the rail line linking peripheral areas of Karlovac County with Karlovac and Zagreb, hence an area most affected by depopulation and where the improvement of transport access to the national and therefore European passenger transport network is seen as a strategic mean to confront this challenge. The main objective of the pilot project was to raise awareness of public transport in Ozalj region and to attract more people to use rail transport. Other specific objectives included enhancement of local economy, especially tourist industry, support for local producers, shopkeepers and cultural organisations by attracting more people to visit Ozalj region.

To reach stated targets HŽ Passenger Transport Limited Liability Company prepared a series of thematic trains. The first train was dispatched on March 25th 2017. In total 37 trains were dispatched on the line Zagreb-Kralovac-Ozalj in period March 2017-March 2018. Each train was connected with special event, out-door activity, or visit of historical or natural places in Ozalj region. When organizing each special train and its content, HŽ PP cooperated with local stakeholders, like municipality of Ozalj, and other 20 stakeholders representing local organisations, and businesses. Stakeholders suggested what should be done for each train. In case that events were further then walking distance from the train station, bus operators were contracted to transfer passenger from the train to the event location. Cooperation with local government was essential. Combining multiple transportation services in one location required creation of local partnerships and agreements among different partners and stakeholders involved. External stakeholder that HŽ PP has hired (marketing agency) was responsible for advertisement in cooperation with marketing department of HŽ PP.

We compared the journey done by train from Zagreb to the town of Ozalj with a length of 65 km, for calculation we used 50 passengers. This is a very specific type of new service, which is intended mainly for tourists and is therefore not provided on a daily basis. From the CBA's point of view, this is an unconventional way of comparing, especially to services that are operated on a daily basis. Therefore, we evaluated it with the non-traditional approach used in the CBA.

3.4.5. Results

Each pilot was evaluated by the traditional CBA approach, which would happen if the service did not exist and passengers would have to use a car with only 1 passenger – driver. This means that the consumption of a passenger car, the pollution of CO2, or PM10 was converted to 1 kilometre of trip by a diesel passenger car. Traditional CBA perceived the reduction of travel time as improvement for all travel modes. We can see that the travel time has more savings considering the car. On the other hand, the speed of public transport vehicles is slower than individual cars. The presented CBA is aimed to evaluate the investments within RUMOBIL Interreg project from the perspective of traditional and alternative CBA calculation.

From the following Fig. 4 we can see that if passengers used cars, it would lead to higher consumption demands, especially for trips on a regional scale, while lower energy savings would be especially for local service (citizenbus) as well as occasional service. (new rail service).

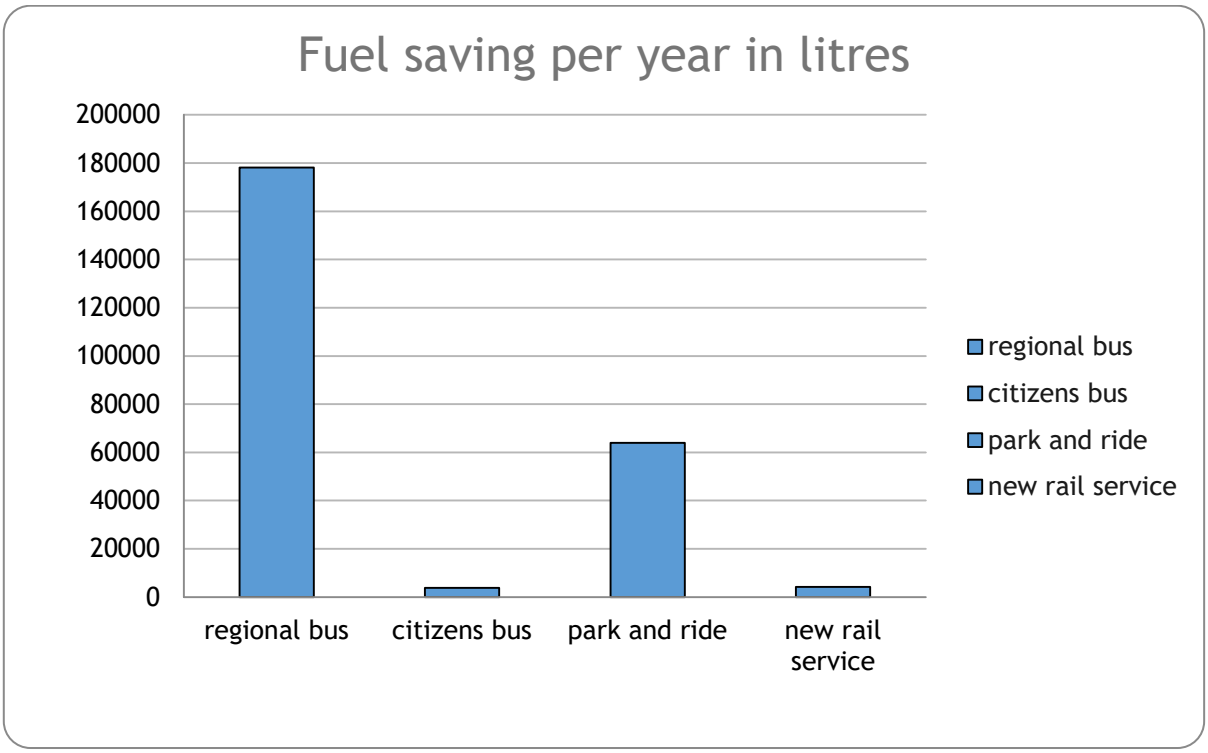


Fig. 4 - The fuel savings by various mobility services

The same method was applied in estimation of PM10 and CO2 savings, see Fig.5. Similarly, we can see that the greatest savings compared to individual car transport are mainly transport services based on regularity or high frequency. Saved emissions are expressed in tonnes per year.

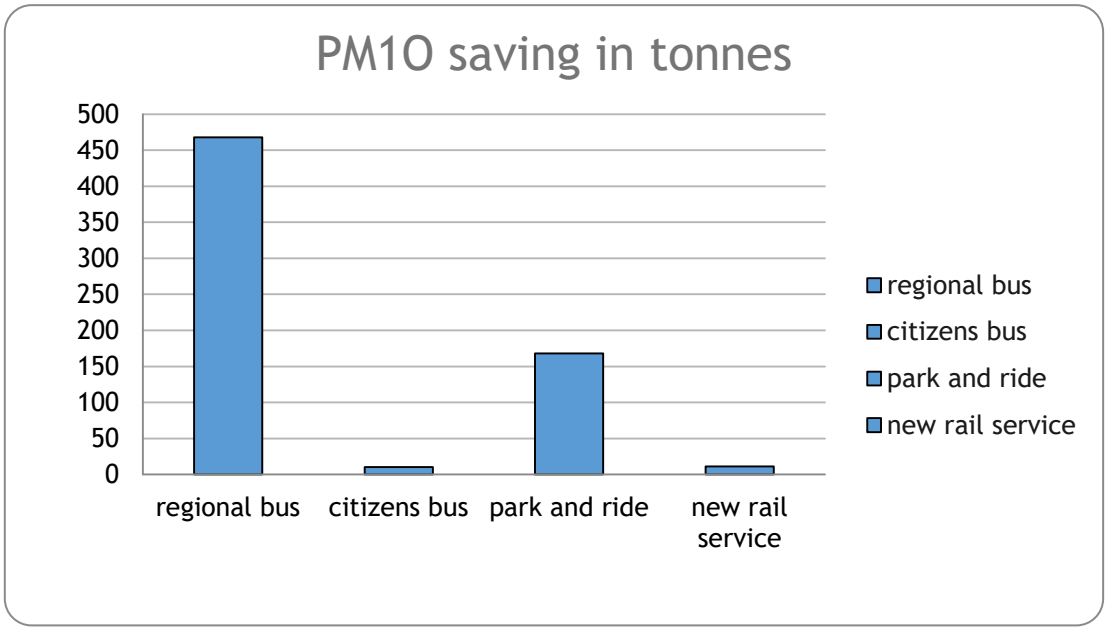


Fig. 5 - The PM10 savings by various mobility services

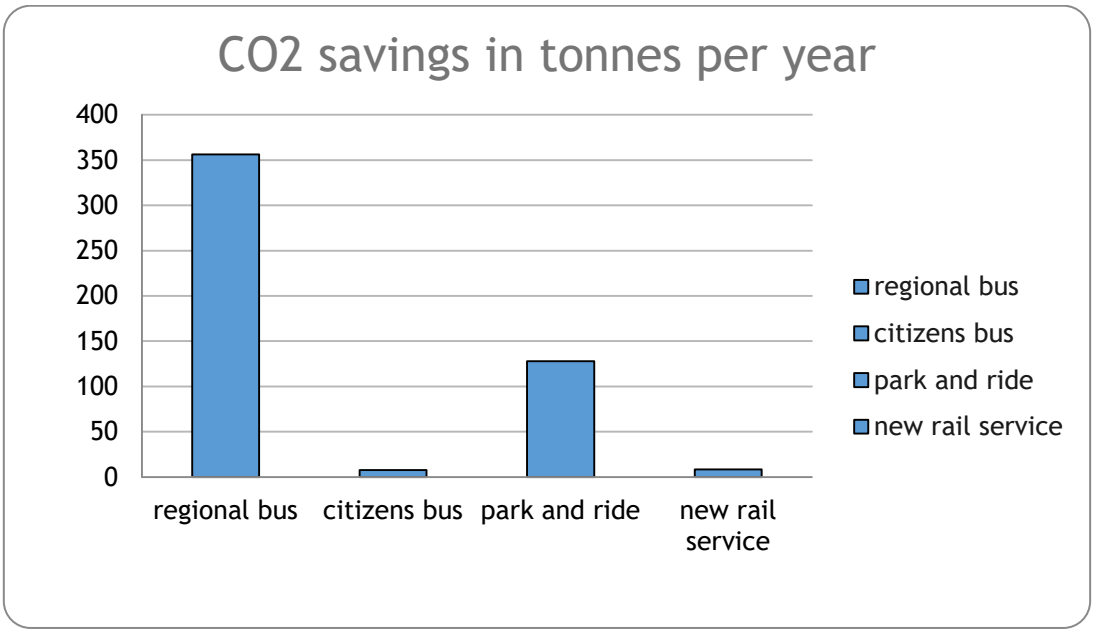


Fig. 6 - The CO2 savings by various mobility services

However, it does not always have to be just about saving. Individual pilots / new transport services can also contribute to increasing carriers' revenues. In this case, there may be different types of discounts for different groups of passengers, which may vary from country to country. Therefore, for simplification, a uniform tariff of 0.1 Euro per 1 kilometre per passenger was applied. The following Fig. 6 shows a model example of revenue estimates for carriers for each mobility service per year. If these mobility services were not implemented, carriers would have zero revenues.

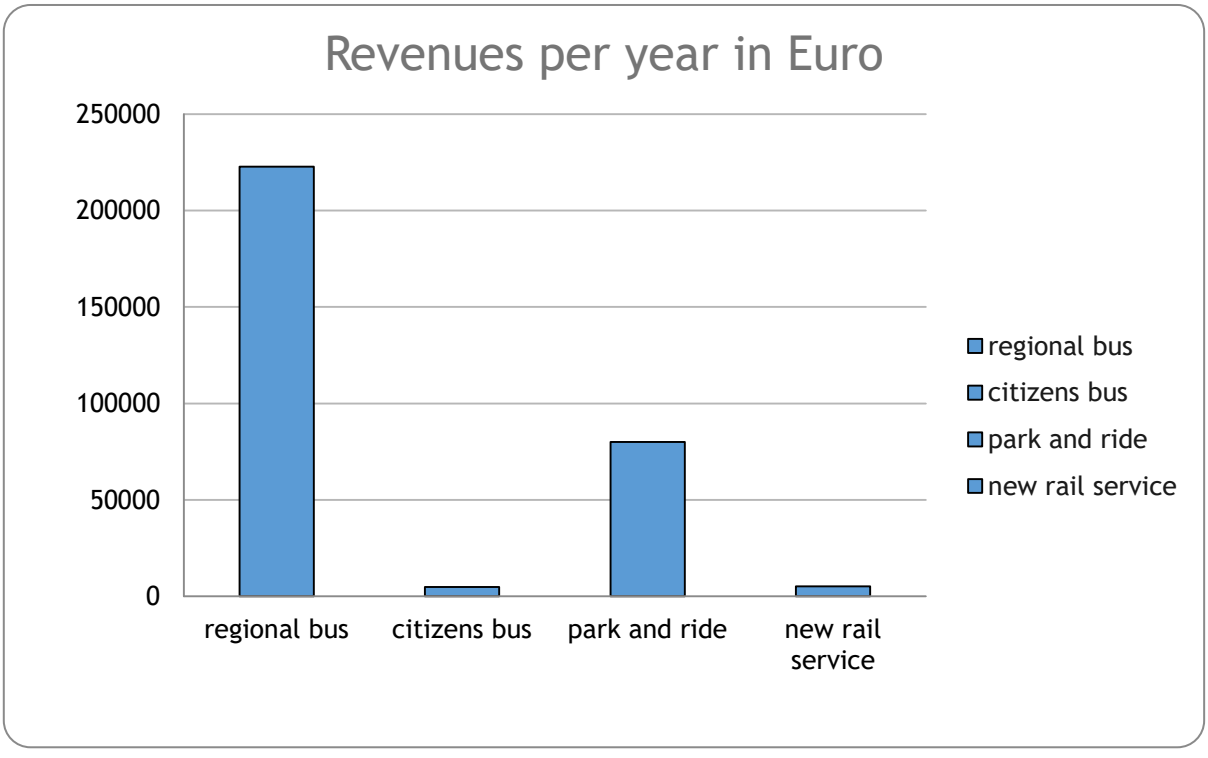


Fig. 7 – The simplified expected revenues in case studies

On the other hand, we have attributes that are against public transport. In this case, it is the travel time, which represents a comparison of driving by car and public transport. We can see that in neither case is the

travel time shorter than driving a car, but from the point of view of comparing the travel time of a car versus public transport, this is not an extreme difference. In addition, this initial disadvantage may also appear to be an advantage in the alternative assessment of the value of travel time.

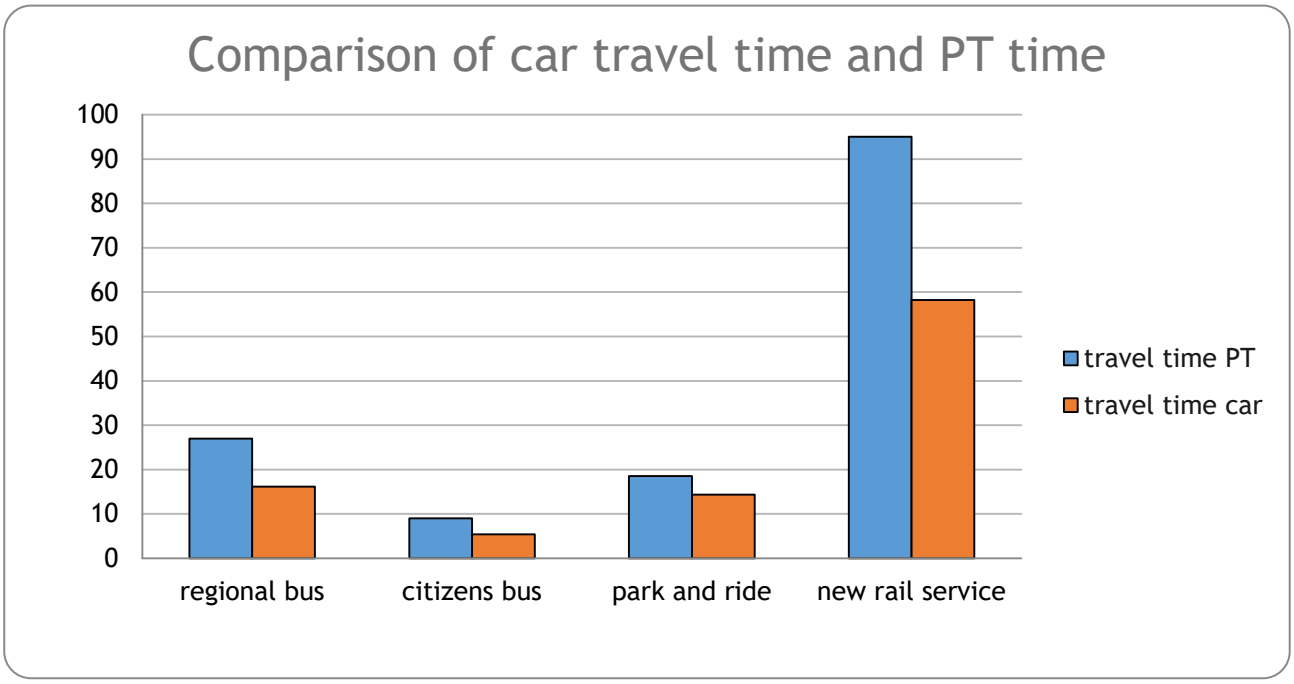


Fig. 8 – The comparison of travel time – car vs. public transport

Although, the public transport cannot compete with faster car travel, it allows to evaluate another aspect of personal travel time and benefits from MoTiV project. The approach from MoTiV project about the worthwhileness during travel time represents the following figure with sum of total passengers' time are in the contrast with car travel, where is no productive time.

The total time allocation is shown in the Fig.9. You can see that the highest productivity (worthwhileness) of time is generated in new touristic railway service. The low level is in the case of citizens' bus and park and ride. This is logical due to the small amount of travel time. The results points on the fact that the productivity or worthwhileness of time has sense if the travel time allows passengers to do other activities during the journey. For the short travel time it is not recommended to implement. You can also see the difference between day (Fig. 9) and year (Fig.10) comparison. The daily benefit is in favour of railway service, but in longer horizon (e.g. year), the new frequent bus services provides the total productive or worthwhileness time benefit for the travellers.

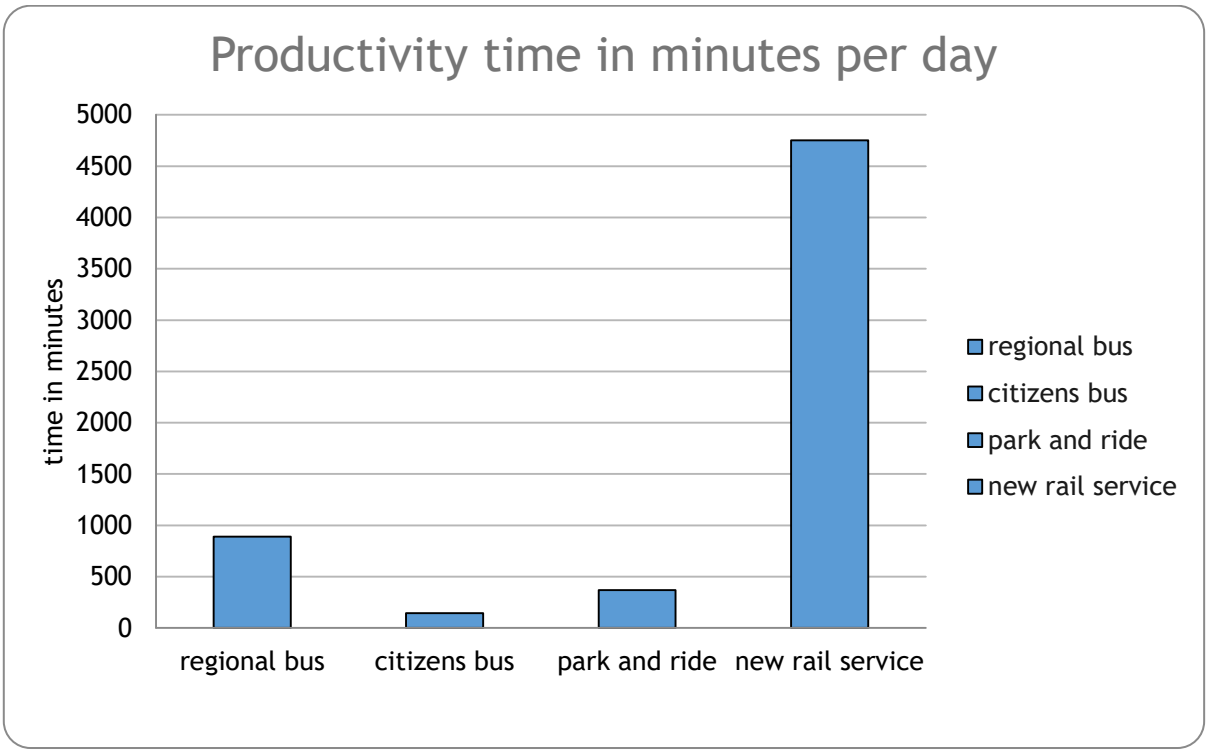


Fig. 9 – The productive or worthwhileness travel time allocation per day

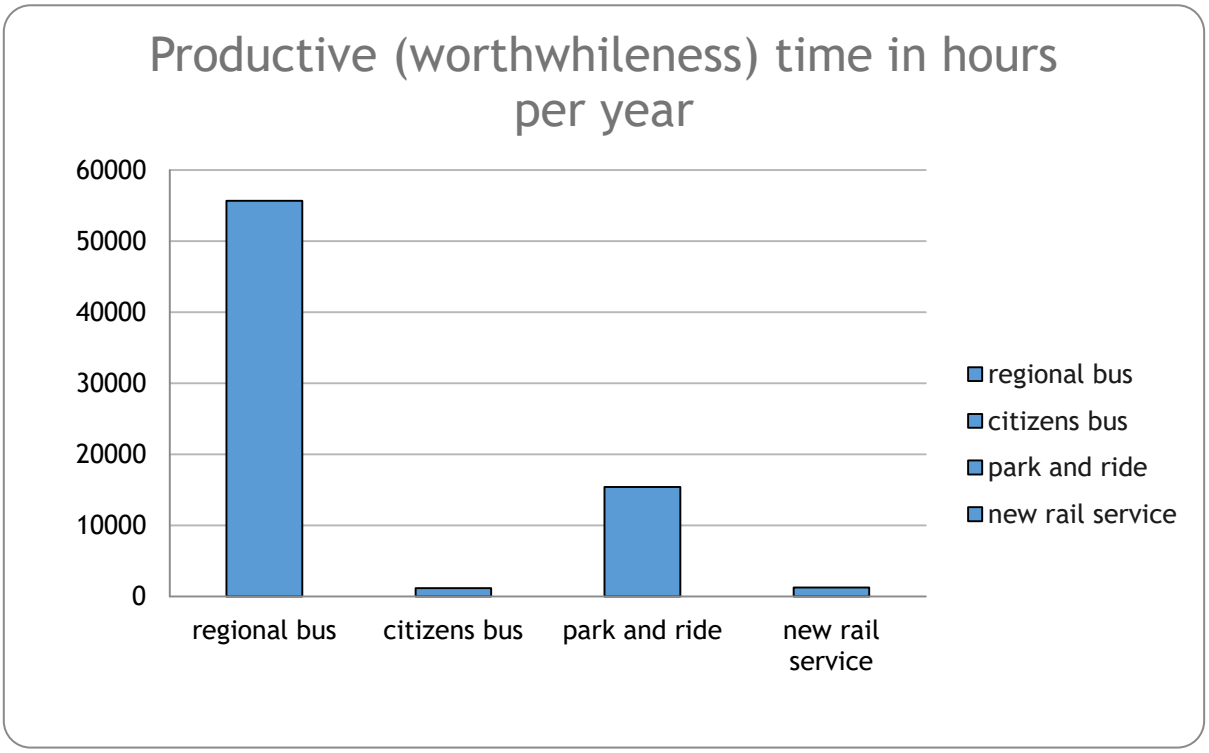


Fig. 10 – The productive or worthwhileness travel time allocation per year.

The problem when applying the value of worthwhileness is its economic quantification, which should be carried out on a certain sample of passengers, where part of them can use travel time productively, part

can just take a rest and part will not use this time in any way. For this reason, it is necessary to use several empirical and social approaches that should lead to consensus, how could be productive time or meaningfully spent travel time economically quantified. The final Cost Benefit ratio is presented in Fig. 11. The most effective measure is the launching the new bus line, followed by Park and Ride scheme, citizens bus and new railway services. It is important to mention that the Cost benefit ratio is affected by the number of service frequencies. That means, the services operated mainly during the weekends or holiday season have lower CBR than the services during the work days. This is very significant in comparison of regular bus lines operated on the daily basis with touristic rail service operated mainly during the summer weekends.

As a result, we obtained the Benefit Cost Ratio (see eqv.1). The individual parameters were converted into a monetary comparison (e.g. Price of 1 liter of diesel = 1 Euro, 1 ton of CO2 = 180 Euro, 1 ton of PM10 = 13.400 Euro).

Benefit Cost Ratio = Present value of Future Benefits /Present value of Future Cost **(1)**

Its value for each case study is shown in Fig. 11, with the regional bus service, and park and ride scheme being seen having the greatest value. The lowest is for citizens bus and touristic rail service, which means that it is not easy to compare different types of measures.

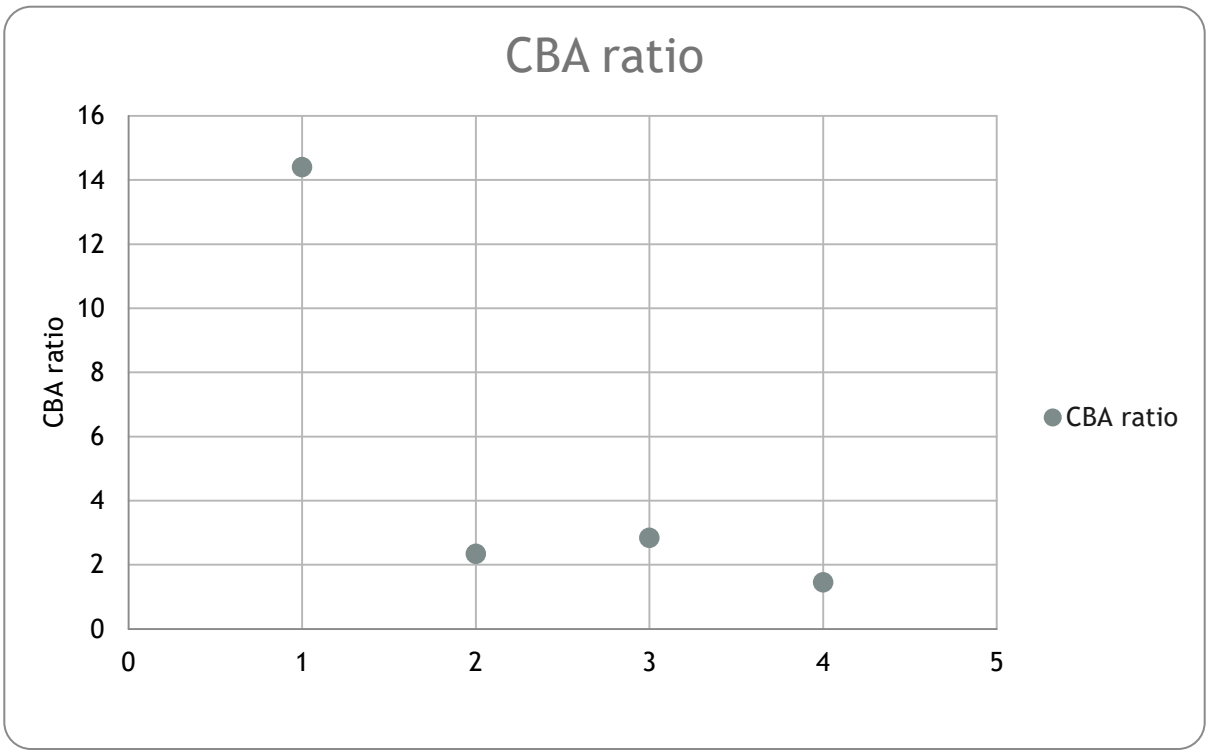
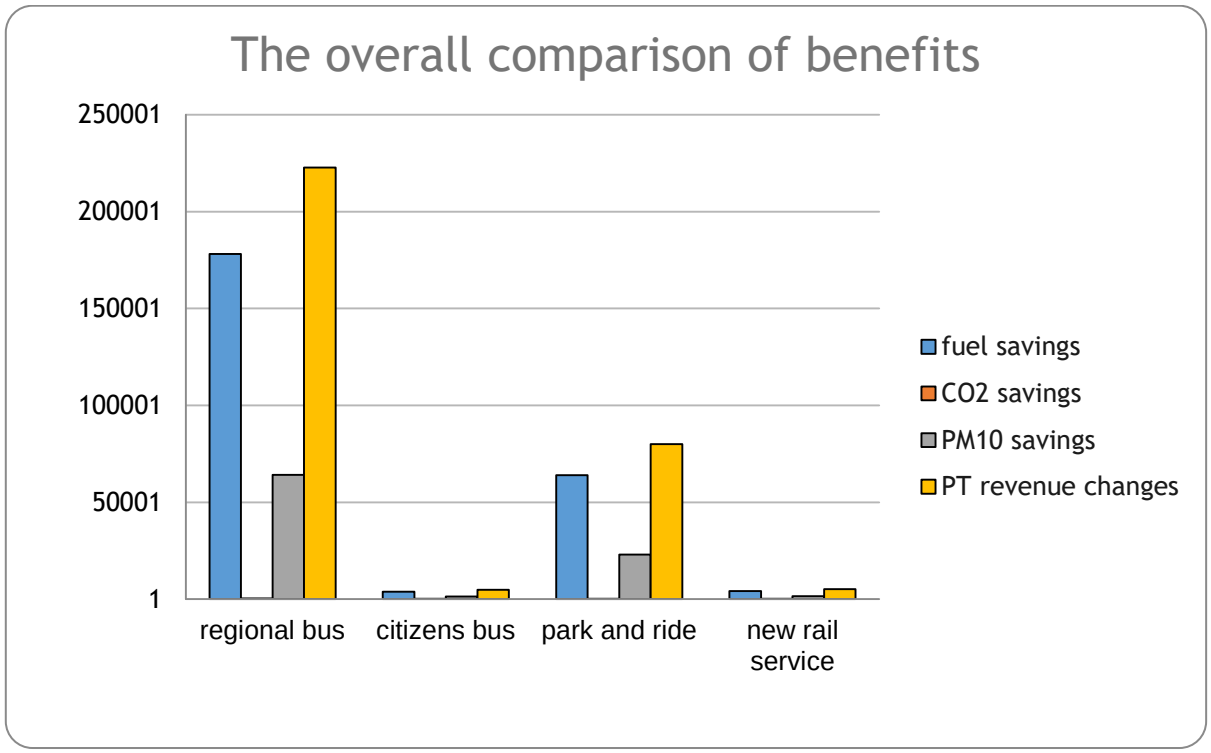


Fig. 11 – The overall comparison of CBA ratio

This is better illustrated in Fig. 12, which shows the individual benefits expressed in monetary terms. Again, the biggest success has services, which have a high frequency as well as potentially more passengers. The benefit of potential revenues is interesting, but we cannot determine it in the future due to differences in tariffs for individual providers of transport services. Similarly, for mobility services that are focused on the development of tourism (Ozalj), it would be appropriate to add other parameters that may have a positive impact on the area, e.g. support for the local economy, etc., but we did not have this data. It should also be mentioned here that not all types of measures can be consistently compared, as the CBA is based on a quantitative comparison and thus high-frequency services with more travellers will always have an advantage over other ones. The overall comparison of CBA ratio is represented in the Fig. 12.



The Fig.12 The overall CBA benefits comparison

Discussion.

We can see the different case studies and evaluation from the CBA perspective. Honestly we can say, that case studies are very different. Therefore, it is very hard to compare them. We have conducted also the non-traditional comparison (MoTiV approach), but there is also possibility to include other banefits for instance the health benefit (for example in the case of Park and Ride, Bike and Ride facilities), or social benefits (sharing the ride with someone) which is very difficult to measure, if there is a lack of data. Concluding the general approach, the most valuable case studies are such kind of services that are featured with high frequency, but also other types which enhance the micro accessibility within the targeted area (citizens bus, Park and Ride). The results also show that there is still lack of knowhow how to evaluate the public transport service which are related to the enhancement of the touristic accessibility. It is possible to combine them with other touristic economic impacts. Further, there is also possibility to evaluate the entire journey consisting of single legs for instance from home to origin bus stop, from bus stop to destination stop, from stop to destination, etc. Then we could also assess the health or physical benefits of walking to bus or train stop, but for purpose of the CBA there is lack of such information. We will continue our work in the next project period when we plan to implement new app. This will collect new information about other benefits from the transport service users.

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