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Wider economic impacts of transport infrastructure investments: Relevant or negligible?

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A B S T R A C T

Wider economic impacts (WEI) comprise all effects that are not assessed appropriately in conventional cost-benefit analysis (CBA). These effects are generated by market imperfections, in the view of neo-classical equilibrium theory. In real economies such imperfections are not exemptions but frequent phenomena, e.g. stemming from increasing returns to scale or scope, or structural changes of products and industrial processes. Although the existence of WEI is not in question, they are usually not considered in practical assessments of transport infrastructure investments because they can only be estimated with high uncertainty and – in industrialised countries in particular – they are assumed to be of negligible magnitude. This paper presents approaches to WEI measurement based on GDP and on welfare, analyses the feasibility for combining WEI with conventional CBA, and discusses issues related to decision-making in situations where consideration of WEI appears to be relevant.

1. Introduction

Transport economists widely agree on the measurement and evaluation of direct impacts of transport infrastructure investments, which are "mandatory" for cost-benefit analysis (CBA). These impacts include changes of generalised user costs as well as of external costs (accidents, environmental damage) caused by users. This micro-economic neo-classical approach allows for a partial project-oriented assessment as long as the transportation investment project is relatively small and all economic impacts can be captured by the surplus measurement (consumer's and producer's surpluses) in an equilibrium environment.

As soon as we abandon the unrealistic assumption that all markets are perfectly organised and clear if the state only removes some exceptional market failures the surplus measurement fails to appropriately take into account all the relevant economic impacts stemming from transport infrastructure investment, i.e. the wider economic impacts (WEI). However, the identification and measurement of WEI is dependent on the assumed type of market imperfection and on the applied economic approach.

In the following we gradually relax the neo-classical assumption of perfectly organised markets and describe the associated modelling approaches. We start with the assumption that at least one sector of the economy shows increasing returns to scale while all others work perfectly. This leads to (spatial) computable equilibrium models (CGE, SCGE), which integrate the basic features of Krugman's (1991) economic geography. Venables (2007) or Bröcker et al. (2010), Bröcker and Mercenier, (2011) use this approach. Graham (2006) has simplified the sophisticated SCGE model using an elasticity approach, which is easy to implement in practical assessments.

In contrast to welfare-based quantification approaches, a number of methods have been developed which use central indicators of national accounts for the identification and measurement of WEI. Comparable to welfare modelling, the neo-classical economic theory has developed a fundamental didactic approach based on perfectly organised markets. Solow (1956) and Swan (1956) were the founders of the macro-economic growth model, which assumes that labour and capital are the relevant inputs for production while the rate of technical progress increases the efficiency of inputs over time. Ultimately, the growth rates of labour and productivity (technical progress) are the (exogenous) drivers of economic dynamics and determine the equilibrium growth rate of the economy.

Romer (1990) has extended the basic model of growth dynamics by explaining the technical progress endogenously. High-level educated human capital, employed in research and development, generates blueprints for new technology (innovations), which are purchased by companies and lead to a higher productivity of capital. This is associated with increasing returns to scale and causes substantial deviations from the neo-classical world of perfect competition. State activity becomes a key instrument for providing long-term growth through investments in education, research and innovation.

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Several macro- and regional economic models for measuring WEI based on GDP use the Romer idea explicitly or implicitly as a point of departure. Infrastructure is introduced as an additional driver of growth, which works in a way comparable to education. It can be integrated into the supply side of macro-econometric models, which may be based on Keynesian theory on the demand side and assume fundamental departures from neo-classical equilibrium theory. In Keynesian models, prices are fixed temporarily while quantities (labour, income) adjust flexibly such that equilibria are not identical to welfare optima, i.e. they can include temporary underemployment. Consequently, reactions to investments such as the multiplier/accelerator effects can occur and these have short-term income/employment effects but can also change the long-term growth potential by increasing capacity (capital stock) and productivity (introducing the Romer-type mechanism into the production function).

Regional economic models aim to transfer such macro-impacts to the spatial dimension, i.e. by taking land-use changes into consideration. In this context, regional potential factor modelling introduces a further deviation from the neo-classical equilibrium world by assuming that specific regional endowments beyond labour and capital are influencing the effects of transport investments on regional GDP. The synergy between transport infrastructure and other potential regional factors can explain why the economic impacts of transport investments can vary by region.

System dynamics modelling (SDM) allows for a construction of dynamic models completely independent of neo-classical principles and only bound to empirical evidence and plausible hypotheses. These models consist of enforcing and dampening feedback loops, which can lead to equilibria if the latter dominate but can also model fluctuations or other processes without approaching an equilibrium growth path. SDM generates time profiles and not only point-to-point comparisons. Modelling changes of trends is possible because the dominating feedback loops may change over time. This means that, in principle, it is possible to model many types of market imperfections as they are observed in the real world. An SDM can therefore integrate various kinds of dynamic relationships between transport and the economy, including the Romer mechanism. But this requires intense empirical research in order to avoid subjective judgements of modellers dominating the outcome (as was the case with the first large application of SDM in economics by Meadows et al., 1972).

Integrated assessment models (IAM) have been applied for evaluating complex interaction mechanisms of climate change and the impacts of climate change policy. IAM consist of a host of modules which model single impact areas with a (desired) high level of accuracy. As projects of transport investment programmes show a strong internal and external interdependency, such models can be used for assessing very large projects, transport policy action plans or integrated transportation/regional development/technology/climate protection plans. The EU Commission has launched several projects with this orientation such as HIGH-TOOL (finalised) or TRIMODE (in progress).

In the context of the recent discussion on integrating WEI into a more holistic assessment package, we can observe two main streams:

(1) *Neglect of WEI.* For instance, the new German assessment scheme for federal transport infrastructure investments is based on the hypothesis that there are only marginal impacts of such investments on economic structures (see Intraplan et al., 2014). The approach presumes that a general and spatial economic equilibrium with full employment will exist in the year 2030 and after such that the conventional CBA surplus measurement captures all relevant economic impacts.

(2) *Consider WEI as an additional component of final assessment.* A number of studies suggest calculating WEI for large projects and infrastructure investment programmes. In particular the European Commission is interested in quantifying the "European Value" of projects co-sponsored by the EU, which presupposes the application of a wider scope of analysis compared with the national CBA studies. The French Rapport Quinet (2013) and the British DfT recommend carrying out WEI in addition to CBA for important transportation projects.

Departing from this baseline, the following questions will be treated in this paper:

- What are WEI and how can they be identified using models which relax the unrealistic assumptions underlying conventional CBA?
- Which approaches of measurement and evaluation exist?
- Can the results of conventional CBA be combined with the results of WEI?
- Are WEI still relevant for industrialised countries with well-developed transportation networks?

2. History, definition and typology of WEI

2.1. History[1]

Jules Dupuit (1844) is recognised as the founder of utility measurement for transportation infrastructure. He is regarded in some of the literature as the predecessor of Marshall's consumer's and producer's surplus measurement, which was published about 40 years later (Marshall, 1890). While Dupuit's measure of "relative utility" appears similar to Marshall's consumer's surplus, there is a fundamental difference which has been underlined by Ekelund and Hébert (1999, pp 83): Dupuit does not consider the transport market with its prices and quantities but rather markets of goods that are carried on the transport infrastructures between locations. This is illustrated by the prominent example of the transport of stone from a quarry to a destination location (Fig. 1). In the initial situation, stone is broken at quarry I and carried by animal-pulled carts to the destination. While the transport is relatively cheap, the stone is expensive because of the high costs of production. If a canal, which creates a new link between quarry II and the destination, is constructed, the transport costs can go up (because of the high fixed costs of the canal, which lead to amortisation and interest cost) but the costs of production are reduced drastically such that the cost of stone at the destination goes down. The relevant measure for Dupuit's relative utility is based on the price and quantity of stone at the destination, i.e. the location of trade. His example served as a dedicated argument against Navier's measurement concept (quoted in Ekelund and Hébert, 1999, p 83), which was based on the difference of transportation costs with and without investment. From today's viewpoint it also raises doubts over the partial economic approach to measuring the economic impact of transport investments only on the basis of the Marshallian consumer's and producer's surpluses on the transport market.

It is easy to extend Dupuit's example and to assume that there is a location close to quarry II with some demand for consumer goods that are produced near the destination for the stone and can be carried by the barges on their return trip to the quarry. Or one can assume that workers can commute between the locations by ferryboats such that specialisation and density impacts on labour productivity occur. Last but not least the canal can also be used for leisure and tourism. Such extensions result in a spectrum of "wider economic impacts", which are outside the Marshallian framework of surpluses measured partially on the transport market. Although these extensions are not mentioned explicitly by Dupuit, one can argue that he prepared the "secret origins"[2] of WEI measurement.

[1] The following paragraph is largely identical to W. Rothengatter's paper on „Mr. Dupuit and the Marginalists" (2016) to be published in a special issue of Transport Policy on J. Dupuit.

[2] This wording is taken from the title of the book of Ekelund and Hébert (1999).