A review of computable general equilibrium models for transport and their applications in appraisal

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A B S T R A C T

In the transport planning process, decision makers require reliable and informative appraisals to facilitate comparisons and determine if a proposal is worthwhile to society. The cost–benefit analysis is the most common form of appraisal, where benefits are primarily measured from the change in consumer surplus in the transport market. However, these benefits will only reflect maximum social welfare if markets operate perfectly competitively and without any market failures. There may be significant uncaptured impacts, known as wider economic impacts, which agencies are beginning to incorporate in appraisals using ad-hoc methods. Computable general equilibrium (CGE) models are an increasingly popular method for assessing the economic impact of transport, including both direct and wider economic impacts, as they can determine the distribution of impacts among every market and agent in the economy by simulating the behaviour of households, firms and others from microeconomic first principles. Aside from their traditional role estimating changes in macroeconomic variables, CGE models can provide a measure of welfare that guarantees no double counting and accounts for nth order effects. This paper reviews the full range of CGE models that have been applied to transport issues and discusses their role in transport appraisal. CGE models for transport have been developed in urban, regional and environmental economics as well as other fields, and each field has applied its own theory, assumptions and practices to represent the relationships between transport and the economy relevant to the field. This paper also discusses the general role of CGE modelling in transport appraisal, as well as theoretical and practical concerns regarding CGE modelling practice.

1. Introduction

Planners and engineers worldwide strive to improve transport networks as cities grow and technology advances. Given ever-present constraints on funding, the appraisal of proposed projects is vital to provide a rational basis for decision making. Cost–benefit analysis (CBA), in which the economic impacts as well as some of the social and environmental impacts of projects are monetised, remains one of the most popular methods to assess and rank projects. In a CBA, each impact is assessed separately, taking care to reduce the risk of double-counting.

A key issue is that there are many interactions in the economy that are not captured in this process. For example, new infrastructure can stimulate economic growth, which in turn generates additional transport demand that may alter the benefits of the project and complicate its evaluation. These concerns have been recognised since the genesis of the CBA approach:

If investment decisions are so large relatively to a given economy… that they are likely to alter the constellation of relative outputs and prices over the whole economy, the standard technique [of CBA] is likely to fail us, for nothing less than some sort of general equilibrium approach would suffice in such cases.

Prest and Turvey (1965)

In other words, significant transport projects can impact demand and supply in other markets, and therefore the transport market should not be treated as independent from the rest of the economy. The effects of this treatment have been assumed to be inconsequential in CBAs until recent years, possibly resulting in incomplete and misleading analyses.

Agencies have begun to incorporate these uncaptured impacts, known as 'wider economic impacts' (WEIs), in CBAs over the past two decades to strengthen the justification for transport projects. In some cases, WEIs can rival traditional (direct) impacts in scale. Most WEIs are estimated with a number of ad-hoc models, which has led to differing assessment practices between jurisdictions and the risk of double-counting impacts.

One particular type of model that has the potential to unify the estimation of WEIs is the computable general equilibrium (CGE) model. A CGE model simulates an entire economy by representing the supply and demand of every market. The central mechanism is that both supply and demand in each market are functions of all prices across other markets in the economy, not just their own price, meaning changes in one market affect all others. Solving a CGE model involves searching for a set of prices that results in equilibrium in all markets simultaneously, i.e. 'general equilibrium'.

Furthermore, CGE models applied to transport can provide a framework to assess both direct impacts and WEIs within a single model. GDP, prices and other economic measures can be extracted as the models are built from fundamental microeconomic behaviour. This enables agencies to prioritise across transport projects and facilitates comparisons with proposals for government expenditure in other sectors. Planners can also identify the distribution of impacts when agents and markets are spatially disaggregated, and can measure welfare directly from utility functions, rather than using the transport market as a proxy. However, there are questions about what role CGE models should play in appraisal. Data and computational requirements can be prohibitive, especially when spatial detail is necessary. The operation of CGE models also tends to be a 'black box' where model mechanics are hidden or difficult to understand. Thus far, only the Netherlands has guidelines detailing the use of CGE models in WEI appraisal (Wangsness et al., 2016).

This paper has two aims: (1) to review the full range of CGE models applied to transport issues in the literature, and (2) to synthesise the case for applying CGE models in transport appraisal. Section 2 summarises existing transport appraisal methods and issues, including conventional CBA practices, their limitations and the valuation of WEIs within CBAs. Section 3 introduces the concepts underlying CGE modelling and Section 4 provides a comprehensive review of existing CGE models applied to transport. Section 5 explores how CGE models can be incorporated in appraisals, identifies theoretical and practical concerns regarding their application and outlines directions for future research. Section 6 concludes the paper. In contrast with previous reviews of CGE models in transport, this paper examines CGE modelling within the context of transport planning and covers all strands of economics that have developed CGE models for transport.

2. Current practice in transport appraisal

Transport appraisal involves the comprehensive and consistent quantification of the impacts of a proposed transport project or policy. It is critical as a decision tool within the broader context of transport development (shown in Fig. 1) as it enables planners and engineers to refine solutions, compare proposals and assess the worthiness of a project. However, Mackie et al. (2014) explain that in practice, human judgement and its shortcomings are often a confounding factor in appraising proposals, and projects are often influenced by the political environment. It is therefore vital to have an efficient and robust appraisal methodology that is both useful to decision makers to select projects, and that can be relied upon by the community to provide a fair assessment of the outcomes of government spending. State-of-the-art practice concerning transport appraisal is discussed by Mackie et al. and Thomopoulos and Grant-Muller (2012).
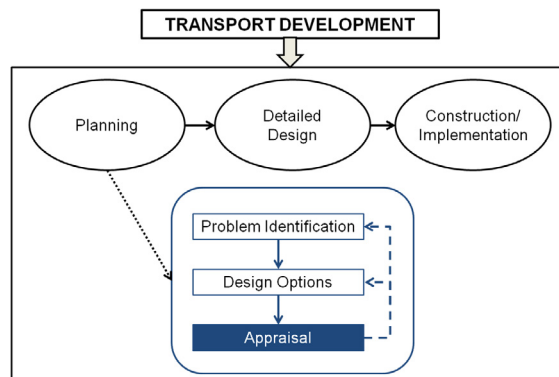

Fig. 1. Conceptual framework for transport development.