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Assessing the wider economy impacts of transport infrastructure investment with an illustrative application to the North-West Rail Link project in Sydney, Australia

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ABSTRACT

This paper identifies the employment agglomeration impact of transport investments through a measure of change in effective employment density, using new empirical estimates of the elasticity of productivity with respect to effective density in order to calculate the uplift in benefits (or impact) from this key wider economy impact. The approach combines the behavioural richness of an integrated transport and location choice modelling system (TRESIS) and its outputs to a spatial computable general equilibrium model (SGEM), which uses data at a more aggregate level to compute the additional impacts of transport infrastructure change on the wider economy. This has allowed the development of an integrated transport–location–economy-wide model system known as TRESIS–SGEM. The model system is applied to the introduction of the North-West Rail Link project in Sydney, Australia to illustrate the capability of TRESIS–SGEM, identifying a 17.6% markup over the conventional transport user benefit.

1. Introduction

There is a growing interest in identifying the broader set of benefits and costs associated with investment in transport infrastructure that are not accounted for in the traditional set of benefits and costs captured by transport planning models and evaluation frameworks. These extended potential sources are referred to as the Wider Economy Benefits or Impacts (WEBs or WEIs) of transport projects (Joint Transport Research Centre, 2008). One of the sources of these benefits[1] is the so-called 'agglomeration' effect (Venables, 2007), often associated with improvements in the transport system. Agglomeration is generally understood to create some economies of scale external to the firm and industry, but internal to a particular urban area (see Graham (2007b)). These economies of scale arise, for example, from the use of an improved public transport network allowing the scale of the market to be increased, firms to share in a larger pool of intermediate inputs, labour inputs, knowledge ('technological spillovers') and other resources. This will result in increased specialisation and improvement in output and labour productivity (for existing as well as new activities); and these improvements can be said to be a source of the WEI of transport projects. The WEIs are not often considered in standard cost benefit analysis because of the usual assumption of constant returns to scale and perfect markets.

To measure the improvement in output and labour productivity following an improvement in the transport network, Venables (2007) used the concept of 'elasticity of output per worker with respect to employment' or 'employment density'[2] (i.e., 'agglomeration elasticity'[3] for short). Agglomeration elasticity measures the extent of the improvement in labour productivity following an increase in 'effective' employment density where the latter is defined, not only in terms of the actual physical employment numbers in various locations, but also in terms of their relative positions with respect to a particular reference point (for example, the CBD). Improvements in a transport system, therefore, can impact on the 'effective' employment density even before or without any of the physical employment numbers changing, provided travel times are used to indicate the relative positions of these employment numbers

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[1] Or costs, for example, if benefits (productivity gains) are supposed to be generated by an agglomeration effect, then the opposite of agglomeration (disagglomeration) will result in a disappearance of these benefits, i.e., a decline in productivity, and therefore an increase in production costs.

[2] The terms in the square bracket of the equation in the Appendix of Venables (2007) is in fact an aggregation of employment *densities* rather than of employments, using the inverse of the distance function between a location and the centre of the city CBD as weights.

[3] Although Venables (2007) did not use the term 'agglomeration elasticity', it is in fact the same concept as the 'agglomeration elasticity' used by others such as Graham (2007a,b), Mare and Graham (2009) except that in the case of Venables (2007), there is only 'aggregate' or 'effective density' (that of the CBD 'mass') to consider, whereas in the case of others, there are more than one 'effective densities' to consider associated with different 'masses' of different agglomerations in different regions.

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with respect to the reference point. In practice, however, since travel time is 'endogenous' (it can be affected by the measure of employment density itself through congestion, for example), actual physical distances are used to indicate the relative positions of the physical employment rather than travel time. This leads to the anomalous result that if a transport improvement cannot change physical employment directly (especially in the short run), then also it cannot change effective employment density and therefore cannot impact on productivity. The anomalous interpretation of this result is modified if it is recognised that in the short run and from the point of view of a static *partial* equilibrium analysis, a 'shock' to the transport system is analysed only in terms of its effects on travel behaviour whilst assuming other activities remain the same. However, in a dynamic or long run general equilibrium analysis, the impact of a transport improvement on the economy as a whole is to be considered not only in terms of its effects on travel behaviour (short run), but also on other interrelated decisions (medium and long run) such as housing and employment activities. Therefore, although the immediate or short run impact of a transport project is only on travel times this will bring about other 'adjustments' over time in other activities such as housing and employment redistribution and the associated physical housing and employment densities. It is through this latter effect that a transport improvement project can cause 'agglomeration' or dis-agglomeration in certain locations, and an impact on 'effective densities', and therefore impact on labour productivity. To model these effects, however, requires the use of a spatial general equilibrium model, integrated with a transport and land use model, and this is one of the objectives in our study.

The other major objective of our study is to estimate the actual extent of the agglomeration benefits (or dis-agglomeration costs), and therefore the magnitude of the WEIs that follow from a transport investment project for a particular geographical area, namely the Sydney Metropolitan Area (SMA). To do this, we need to estimate the values of the agglomeration elasticities for different employment occupations and different industries situated in this area. Due to data availability limitations for individual firm data, especially for a small geographical area such as the SMA, and the complexity of the estimation task, the estimation of agglomeration elasticities carried out in our study must be considered as preliminary. They are used mainly for the purpose of illustrating the usefulness of our approach rather than for the purpose of specific policy application and should be regarded as illustrative rather than definitive. Nevertheless, when the agglomeration elasticities estimated in this study are compared with other results coming from more exhaustive empirical investigations and based on more extensive spatially disaggregated data, it can be seen that our estimates are within the range of other studies, demonstrating very similar patterns between different industries. So, despite being illustrative, we believe they can be taken with a large degree of confidence, although future studies may want to improve on the accuracy or details of our estimates if improved spatial data in Australia becomes available.

The paper is structured as follows. The next section presents the methodology underlying the development of an integrated transport–location–economy-wide model system known as TRESIS–SGEM. This is followed by a section on agglomeration effects in which the model system is used to calculate agglomeration elasticities. The final section applies the model system to the proposed NWRL project in Sydney to identify the mark-up over the conventional transport user benefit to show the importance of including WEI in the economic evaluation of transport infrastructure.

2. Methodology

The challenge in establishing the nature and extent of WEI's is to recognise the need to embed methods which provide evidence on the full adjustment in the travel market as a consequence of the most meaningful coping or response strategies to new transport investments. This requires a modelling setting incorporating a sufficiently behaviourally rich suite of travel demand and location models, integrated with appropriate feedback and equilibrating mechanisms. Alongside this is the additional need to link the outputs of this to a modelling system that has a framework to identify the wider economy impacts of the specific transport investment under consideration. This latter framework is more commonly known as a spatial computable general equilibrium model (SCGE). In summary, the challenge requires the connecting of modelling at a microlevel which must be driven by individual behaviour change to SCGE modelling at a more aggregate (intersectoral and macroeconomic) level to compute the additional impacts of transport infrastructure change on the wider economy.

Although SCGE models have existed for many years, it is only in recent years that serious efforts have been made to connect SCGE models with more micro and behaviourally based transport models. The methodological difficulty arises from linking the two types of models which are based on different theoretical foundations, as well as data availability which are required not only at the micro-transport and land-use level but also at the sectoral and economy-wide level with a spatial sub-division which maps to the main areas of focus of transport models.

This theoretical framework underlying paper is based on Truong and Hensher (2012) which demonstrates a formal theoretical link between a series of discrete choice logit models, as used in disaggregated transportation and location models, and aggregate computable general equilibrium models, to ensure theoretical and empirical consistency between the inputs and outputs associated with both modelling capabilities.

2.1. TRESIS–SGEM

When there are improvements in some parts of a transport network, first there will be some short run behavioural responses in the form of changes in mode and time of day of travel. In the medium to longer term, changes in the transport network also implies changes in accessibility (in relative and absolute terms) to housing and employment opportunities in different parts of an urban area. This will then lead to other medium term behavioural responses in the form of changes in employment and residential locations; changes in dwelling type choice – stand alone house, town house, apartment, and tenures – rent vs. own; changes in working hours, in the number and composition of cars owned and in their usage, etc. To capture the extent of these behavioural changes accurately, often, we need a suite of disaggregate behavioural models to follow each of the above types of changes in an accurate and consistent manner. Such a suite of models has been constructed for the Sydney Metropolitan area (SMA) in the 'transport environmental strategy impact simulator' (TRESIS) developed at the Institute of Transport and Logistics Studies (ITLSs) (Hensher, 2002; Hensher and Ton, 2002).

Next, to ensure these disaggregate behavioural responses interact consistently with the supply and demand conditions in the rest of the local and regional economy, we need a computable general equilibrium model framework to embed these disaggregate behavioural responses within the structure of the local economy, and to allow for forward and backward linkages between transport, land-use sectors, and the rest of the economy, as well as between different locations of the geographical area under study. Such a model has also been constructed for the SMA, called Sydney General Economic Model (SGEM) and linked to the TRESIS model in the form of an integrated transport–land use–economic model (Truong and Hensher, 2012). This integrated transport–land use–economy model (TRESIS–SGEM) is then used in this study for the analysis