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Evaluating benefits of transportation in models of new economic geography

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A R T I C L E I N F O

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A B S T R A C T

In the presence of price distortions, cost-benefit analysis must include changes in the deadweight loss in addition to the direct benefits and costs to transportation users and nonusers. Advances in new economic geography (NEG) have highlighted the importance of price distortions associated with imperfect competition. This paper reviews recent contributions to cost-benefit analysis in NEG models, and explores which elements of the models have contributed to the differences in the results obtained.

1. Introduction

The usual practice in transportation project evaluation is to estimate the direct benefits and costs to transportation users (such as travel time savings, operating costs, and accident reduction) and to nonusers (such as reductions in greenhouse gas emissions), and to ignore the indirect impacts caused by general equilibrium repercussions (such as higher property values and regional production). It is widely known that such an approach cannot be justified if price distortions exist (Venables and Gasiorek, 1999; Kanemoto, 2011; Jara-Diaz, 2007). The sources of price distortions are diverse: taxes and subsidies, imperfect competition, and unpriced congestion. Recent advances in new economic geography (NEG) show that urban agglomeration economies reflect price distortions of various forms. In an excellent review article, Duranton and Puga (2004) classified the sources of agglomeration into three types: sharing, matching, and learning. Virtually all of them—for example, sharing of gains from variety and specialization, matching between employers and employees, and knowledge generation and diffusion—are associated with non-negligible price distortions.

Past empirical work indicates that urban agglomeration economies are substantial. For instance, according to a review by Rosenthal and Strange (2004, p. 2133), "In sum, doubling city size seems to increase productivity by an amount that ranges from roughly 3–8%."[1] Agglomeration economies on the consumer side are also substantial, as argued by Glaeser et al. (2001), with estimates by Tabuchi and Yoshida (2000) and Asahi et al. (2008) suggesting economies of around 10%.

The importance of agglomeration benefits has been recognized by practitioners, especially in the United Kingdom where the Standing Advisory Committee on Trunk Road Assessment (SACTRA) has studied what they call the wider impacts that arise when markets are imperfect. In their guidance on wider impacts, the Department for Transport (2012a, 2012b) identified agglomeration benefits as one of the three wider impacts[2] that have to be examined.

The earliest and most influential contribution is Venables and Gasiorek (1999), which was written for SACTRA. They started with a simple framework in which there are two regions in the economy, one of which (region 1) has an imperfectly competitive industry producing differentiated products. A transportation investment project reduces the cost of transporting the products from region 1 to region 2. They assumed a constant elasticity of substitution (CES) (Dixit–Stiglitz) utility function for the differentiated products, and computed the ratio between the true welfare change and the naive cost-benefit analysis (CBA) calculation, which they called the multiplier. In the partial equilibrium model, the multiplier is 1.40 for the short-run case where the number of producers is fixed, and it is slightly larger at 1.41 or 1.42 depending on the size of the change in transportation costs.

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[1] Recently, Combes et al. (2010) showed that accounting for the endogeneity of the quality and quantity of labor makes the estimates smaller, yielding a density elasticity of around 2%. They, however, estimated the market potential effect separately, and including this in the agglomeration effects makes the sum exceed 5%.

[2] The three impacts are agglomeration, increased or decreased output in imperfectly competitive markets, and labor market impacts.

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They also examined a variety of extensions, for example, to full general equilibrium and three region models. The multiplier is smaller in general equilibrium, for example, at 1.31 or lower in the case of symmetric regions.

In response to the report for SACTRA later published in Venables and Gasiorek (1999), Newbery (1998) analyzed the welfare impacts of transportation cost reductions for imperfectly competitive homogeneous good sectors. He showed that the resulting impacts can be small, or even negative with lower transportation costs reducing production efficiency.

Rouwendal (2012), examining the same issue, showed that the additional benefits in general exist and may be substantial, but that their sign and size depend crucially on the specifications of the model. In a logit model with free entry, he found that the additional benefits are negative, implying that a conventional CBA would overestimate the welfare effects of the policy measure. More specifically, the negative effect occurs when the transportation project reduces the fixed cost; if it reduces only the marginal cost, the additional benefits are zero.

Venables (2007) examined transportation cost reductions for commuting and, using simulations with a reduced-form aggregate production function, showed that the additional benefits are substantial. Kanemoto (2012a, 2012b) introduced the microfoundations of urban agglomeration and confirmed the result that the additional benefits in general exist. The sources of the benefits are identified in the context of the Harberger formula for excess burden. The extra benefits of transportation investment involve variety distortion in addition to price distortion. The Harberger measure of excess burden can also be expressed by using a wage distortion that captures both variety and price distortions.

Another finding in Kanemoto (2012a, 2012b) is that an improvement in urban transportation in one city increases the population in that city but reduces the populations in other cities. If the population of the rural area (or equivalently, the total population of the urban areas) is fixed, then the changes in the excess burden cancel each other out and only the direct benefit remains. Positive additional benefits require migration from the rural area to cities.

This paper reviews these contributions to cost-benefit analysis, and explores which elements of the models have contributed to the differences in the results obtained. Because all the works in this area use models of imperfect competition, we choose as our platform a monopolistic competition model of urban agglomeration, which represents the sharing of gains from variety in the classification of Duranton and Puga (2004). Our basic methodology can be applied to other sources of agglomeration, such as matching and learning, if the origins of price distortions are clearly specified.

Departing from the tradition of the NEG literature, we adopt a methodology that allows us to obtain general results, some of which are new, without resorting to specific functional forms. For example, in the short-run case where the variety of differentiated products is fixed, the results are clean-cut and general. For an improvement in commuting transportation, the additional benefit consists only of the agglomeration benefits that equal the price markup times the increase in the total wage bill in the entire urban sector, and for a transport cost reduction of differentiated products, we have to add the price markup times the direct benefit to the agglomeration benefits. These general results appear to have escaped notice because of reliance on specific functional forms. In the long-run case with endogenous variety, the agglomeration benefits are more complicated, including the effects of a change in variety in addition to a change in the output level of each product. Although the benefits are positive with functional forms that have been used in NEG models, we cannot rule out the possibility that they become negative when variety is anticompetitive.

Holvad and Preston (2005) and Vickerman (2008) offered excellent reviews of the recent literature on the wider benefits of transportation investment. The present article has a narrower focus on NEG-type differentiated good models, and explores which elements of the models contributed to the differences in the results obtained by Venables and Gasiorek (1999), Newbery (1998), Rouwendal (2012), Venables (2007), and Kanemoto (2012a, 2012b).[3]

The remainder of this paper proceeds as follows. Section 2 presents a model of urban agglomeration economies based on monopolistic competition in differentiated intermediate products. Section 3 derives a general Harberger-type formula for welfare change. Assuming the number of differentiated products is fixed, Section 4 derives second-best benefit measures for a transportation investment that affects one of the three types of costs: marginal costs, fixed costs of supplying differentiated goods, and commuting costs. Section 5 examines the endogenous variety case where free entry determines the variety. In Section 6, we compare the results in a general equilibrium setting with those in the partial equilibrium models analyzed by Newbery (1998) and Davies (1999). Section 7 contains conclusions and implications for the practice of cost-benefit analysis.

2. A model of differentiated intermediate goods as a source of urban agglomeration

2.1. The basic structure of the model

In NEG-type models based on differentiated products, the welfare impacts of transportation improvements depend on whether they affect the products' CIF prices directly. A reduction in transportation costs for the products has this direct effect, but a reduction in commuting costs does not have a direct impact on the prices. Furthermore, a transportation improvement might reduce the fixed cost of the differentiated goods, for example, by lowering the transportation costs of materials used to build a factory. In our model, where intermediate products cannot be transported outside a city, more natural examples are business-to-business services, including those provided by law and accounting offices and consulting firms. Improvements in intra-city transportation reduce the costs of delivering these services by reducing the time costs of intra-city business trips. There is no reason to suppose that these cost reductions are limited to marginal costs. We therefore examine three types of transportation projects: those leading to decreases in the marginal costs of supplying the differentiated goods, those leading to decreases in the fixed costs, and those leading to improvements in commuting transportation.

To make our exposition as simple as possible, we adopt a framework of differentiated intermediate goods used by Abdel-Rahman and Fujita (1990), Duranton and Puga (2004), and Kanemoto (2012a, 2012b). As discussed below, the results are similar to a model of differentiated consumer goods, although minor differences exist.

The basic assumptions are as follows. The economy contains n cities and a rural area, where all cities are monocentric, i.e., all workers commute to the central business district (CBD). All cities have the same topographical and technological conditions. The differentiated goods produced in the cities are not transportable to outside the city. Workers/consumers are mobile and free to choose

[3] Lafourcade and Thisse (2011) and Tabuchi (2011) offered excellent reviews of the role of transportation in NEG models.