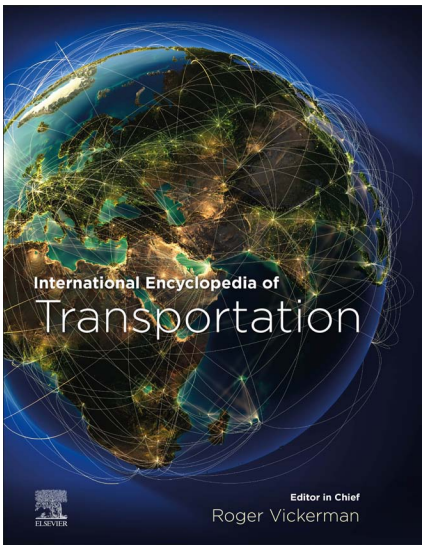

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Wider Economic Impacts of Transport Investments

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Introduction

The economic impacts of transport improvements can be classified into three types. First are the direct benefits of the improvement in terms of vehicle operating costs, timesavings, and other benefits to existing and new users, together with the costs of noise and pollution produced. Second are the economic benefits deriving from better connectivity, holding constant the spatial distribution of economic activity; for example, the flow of knowledge between places may improve with benefits for productivity. Third are the changes in the location of economic activity arising as transport improvements change the spatial pattern of private sector investment; new investments may be induced in some places, possibly at the expense of other places.

A standard cost–benefit analysis (CBA) focuses on the first of these. This is not because analysts are unaware of the other impacts, but because analysis of a project is generally set in the context of a wider economy with few or no externalities or other market failures.[a] In such an economy changes in quantities, such as new patterns of investment, are of zero social value; the marginal benefit of an activity is equal to its marginal cost. The terms "wider economic impacts" or "wider benefits" are used to describe the second and third types of effects and are the subject of this paper.

Analysis of the effect of transport investments has to contain two elements. One is to establish the quantity effects of the improvement; this means the changes in economic quantities—numbers of journeys made, new investments undertaken, and jobs created—arising because of the investment. This assessment may need to be quite broad because creation of a job in one place may be at the expense of a job lost somewhere else; establishing whether relocation and displacement effects of this type occur is crucially important. The other is to place a social value on these quantity changes; this is relatively straightforward if everything is traded at fixed prices in competitive markets, and more complicated otherwise.

To explore these issues this paper proceeds in three stages. The next section offers a brief review of some of the elements of spatial economics, fundamental to transport investments. Section "Wider Impacts I: Connectivity and Productivity" looks at wider impacts arising from changes in connectivity and productivity, given patterns of land-use and the spatial distribution of activity. Section "Wider Impacts II: Induced Private Investment and Land-Use Change" looks at ways in which transport improvement can induce changes in private investment and land-use, and at the value of any such changes. Throughout, the focus is on identifying and quantifying wider impacts for the purpose of ex ante appraisal of transport investments. The literature on ex-post evaluation of investments is reviewed in Redding and Turner (2015).

The Spatial Context

Economic activities are spatially "lumpy", tending to concentrate in space. This is partly due to the minimum efficient scale of some business activities (e.g., large factories that supply a wide geographical area) and partly due to agglomeration economies. These arise if there are complementarities and increasing returns to scale operating across a range of firms and workers who are in close proximity to each other. They are driven by a number of mechanisms. Large local labor markets enable better matching of workers to firms' skill requirements. Better communication between firms and their customers and suppliers enables knowledge spillovers, better product design, and timely production. A larger local market enables development of a larger network of more specialized suppliers. Fundamentally, larger and denser markets allow for both scale and specialization, thereby creating areas of relatively high productivity.

[a] There is an extensive literature on market failure and externalities within the direct context of the project itself. Imperfections in labor markets and in international trade policy were central to an older literature on shadow pricing in developing economies (Dreze and Stern, 1987).

Agglomeration economies typically involve externalities between firms, and between firms and workers. To take one example, the larger the market, the more likely it is to be worthwhile for an individual to specialize and hone skills in producing a particular good or service, thereby achieving high productivity. The specialist will be paid for the product or service supplied but, depending on market conditions, is unlikely to capture the full benefit created.[b] Since the benefit is split between the supplier and her customers, there is a positive externality. This creates a positive feedback—more customers will be attracted to the place to receive the benefit, growing the market, further increasing the returns to specialization, and so on. This is the classic process of cluster formation.

The spatial and sectoral range of agglomeration economies varies according to the context. They are important within particular sectors, particularly those prone to cluster (e.g., financial services and high tech) and are referred to as localization, or Marshal–Romer economies. They also operate at a wider urban level, referred to as urbanization or Jacobs economies.

Agglomeration economies are a benefit, but proximity also has costs, particularly in the urban context. Clustering of firms increases commuting costs for workers who may have to travel far to employment centers such as the central business district. These costs are exacerbated by congestion—a negative externality—and other costs of dense urban living. Land becomes the scarce factor and housing consumption (floor space per household) is reduced. However, it is important to note that high land rents and land prices are not a real cost; these are a transfer payment from occupants of land to its owners, so do not use up real resources (as does time in commuting).

The location of economic activity is determined by the interplay between the benefits and costs of proximity, together with location fundamentals (including "first-nature" physical geography). Since agglomeration effects are largely externalities, location outcomes are generally not efficient, and there may be situations in which a place is stuck in a low-level equilibrium. These facts create the potential for transport improvements to be "transformational," bringing large quantity changes and perhaps also large welfare gains. We will discuss these effects in section "Wider Impacts II: Induced Private Investment and Land-Use Change," but note that they are, in practice, extremely hard to predict. The practical literature applying wider benefits to the practice of CBA has largely taken a more conservative route, looking at improvements in connectivity given the location of activity and the pattern of land-use. It is to this that we now turn.

Wider Impacts I: Connectivity and Productivity

Transport investments make places closer together, in economic terms, potentially increasing productivity, thereby also creating a wider impact. To capture this, a quantitative measure of the importance of agglomeration economies is needed, and many studies have produced estimates.[c] A simple approach to this quantification involves two steps. First, compute a measure of the economic scale and density of a place, and, second, regress productivity on this measure. Scale and density are typically calculated by a measure such as "effective density" defined as $ED_i = \sum_j f(d_{ij}) employment_j$. This says that the effective density of place i is the sum of employment in other places, j, weighted by an inverse function of the distance between i and j, d_{ij}, with $f(.)$, a decreasing function. At the second stage, the elasticity of productivity with respect to effective density is estimated, typically by regressing productivity in each place on its measure of effective density and other factors.

Doing this across cities, the first finding is that the elasticity of productivity with respect to city size is of the order of 0.05–0.1. Thus, a city of 5 million inhabitants typically has productivity of 12%–26% higher than a city of ½ million. This raw number has been refined in many directions, the literature on which is surveyed by Rosenthal and Strange (2004) and Combes and Gobillon (2015). For example, measured productivity depends on the skill and occupational mix of the labor force in each place. Controlling for observed measures of skill (e.g., education) typically brings the elasticity down by about a quarter. This might only be part of the story, as there may be sorting, meaning that people with higher innate ability (regardless of education) are disproportionately drawn to cities. The only way to observe this is to track individuals as they move in to cities or to cities of different sizes. Recent empirical work doing this suggests that the pure agglomeration effect has elasticity of 0.02–0.04. This is still a substantial number.[d]

This framework has been applied to transport appraisal, notably in the WebTAG guidance of the UK Department for Transport. A transport investment that cuts journey times reduces effective economic distance between places, d_{ij}, and hence (given employment) increases the effective density of such places. This raises the productivity of *all* workers in these areas according to the estimated elasticity of productivity with respect to effective density. The productivity increment is a welfare gain that is added to the user-benefits derived from a standard transport CBA. These "wider benefits" can amount to around 15%–25% of the total net benefit of a large transport project.

The approach constitutes a well-grounded attempt to add some wider impacts in a rigorous and contained manner, although a number of further issues remain. Application of the method is sometimes mechanical, with little attention to context. There

[b] This example is a pecuniary rather than a technological externality, that is, an effect transmitted through an imperfect market. The supplier will capture the full benefit only if able to perfectly price discriminate. Otherwise, the customer will also receive some consumer/user surplus on the introduction of a new product. This observation is central to the wide-range of economic models in which the number and variety of goods and services offered is endogenous.

[c] Methods and data sources vary widely, and are surveyed in Gibbons and Graham (2018).

[d] In some contexts, it may not be appropriate to impose all these controls. Suppose that someone achieves high productivity by undertaking education to acquire a skill that is in demand only in large cities. Then both the city and the education are necessary for attaining the productivity, and it would be wrong to attribute it all to education (Combes and Gobillon, 2015).

are further measurement issues, as the strength of localization economies varies by sector, and the spatial range of effects is important (i.e., the form of the function $f(.)$, for example, see Gibbons and Graham (2018) or Rice et al. (2006)). Further problems arise if a transport investment only effects one mode of transport; for example, a rail improvement may only affect a small proportion of total journeys made between two places, so calculation of its impact on an overall measure of "economic distance" is controversial.

Wider Impacts II: Induced Private Investment and Land-Use Change

Large transport improvements generally change the spatial pattern of private investment and hence jobs—indeed, this is often the motivation for undertaking the improvement. Estimating these quantity changes, ex ante, generally requires modeling techniques such as computable spatial equilibrium models or land-use transport interaction (LUTI) models. These provide useful quantitative frameworks and can indicate a range of possible outcomes, although they are far from precise predictions. Studies of past transport improvements provide further information, but are fraught with statistical problems.[e] There are problems of endogeneity (is a region booming because a road was built, or was the road built because the region was expected to boom?), selection of appropriate control areas, and of distinguishing net aggregate growth from spatial relocation. Above all, there is the problem of context specificity; what we learn from previous transport investments may or may not be relevant to the context of a particular new investment.

Given estimates of quantity changes, the task is to ascribe them social values. The benchmark is "small" changes in a "perfect" economy, in which case the net value of quantity changes is zero. We move beyond this case in several steps, progressing from "small" changes, that is, those that leave prices in affected places broadly unchanged, to large ones.

Market Imperfections and "Small" Changes

Why is it socially valuable to create a job in a particular place, even if it may involve losing a job elsewhere? One answer is that there is involuntary unemployment, so creating a new job expands the total number of people in employment, rather than just relocating jobs. Another is that there are spatial income differentials, so social welfare increases if a job moves to a low-income area. A third is that there are factors that "distort" individuals' choices about labor-leisure decisions, or about choice of place of work.

An example of the last of these arguments, included in the UK Department of Transport appraisal procedures, is the move to more (or less) productive jobs. This can arise if there are productivity differences between places within a city (or between regions in the country) and a transport improvement causes an increase in employment in one area and a decline in another. Thus, in the intra-urban context, it may be the case that productivity is higher in the city center than at the city edge. This can be an equilibrium, as the combination of commuting costs and high city-center house prices means that individuals are indifferent between taking a high-wage and high-productivity job in the center and a lower wage job at the edge. An improvement in commuting transport infrastructure that leads to more people working in the center raises average productivity but does not necessarily create a net benefit; there is no such "wider benefit" if individuals' job and location choices are efficient.[f] The change only has nonzero value if there is some market failure or distortion that makes private choices inefficient. One such distortion is income tax. Individuals' choice of place of work depends on posttax income, not pretax (which reflects productivity). It turns out the net social gain from moving people to higher productivity jobs is exactly equal to the additional income tax revenue raised as a consequence of the move.

Price Change and Transfer of Surplus

Transport improvements may trigger "large" changes in investment and activity in an affected place, as with the development of new urban subcenters or attempts to rebalance regional economies. Large developments will change prices, and it then becomes important to understand the effect to which such changes are, or are not, internalized in developers' decisions. Land value appreciation in the immediate vicinity of the project can be internalized by ownership of the land, but the development might also change land prices over a wider area (perhaps reducing them elsewhere). The development might also reduce prices of goods and services if there is an increase in their supply, or bid up the wage rate if employment expands. If these changes impact on people and firms other than the project developer then there is a divergence between the private and social returns from the development; higher wages or lower prices caused by the development are a benefit to those who receive/pay them, but not to the developer. This divergence means that the development—the indirect quantity change induced by the transport improvement—has nonzero social value.

Implications are illustrated in **Fig. 1**. The horizontal axis is the cost, t, of accessing a potential new development site (e.g., transport costs borne by customers or employees). If this is very high the development is not undertaken—both private (developer) and social returns are negative, as measured on the vertical axis and indicated by the solid lines.[g] Improving access (reducing t) increases both private and social returns. Initial access costs are at point A, and they are reduced by amount Δt by a

[e] A good example of this work is Donaldson (2018), and see Redding and Turner (2015) for a review of modern approaches.
[f] For purposes of this argument, productivity levels are assumed to be exogenous and fixed. See Venables (2007) for a more general case.
[g] In **Fig. 1**, these are the social returns associated with the price and wage change not those in the standard CBA, which can be thought as being in *net* cost $C(\Delta t)$.

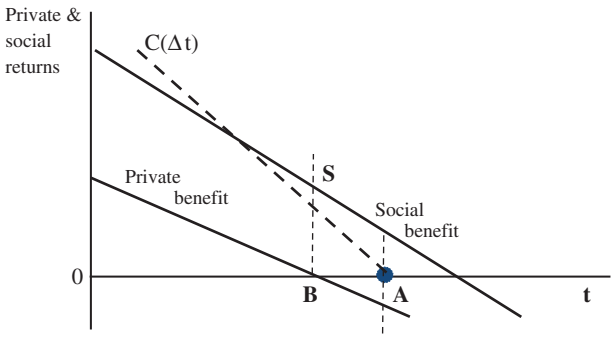

Figure 1 Transport improvement unlocking development.

publicly funded transport investment with net cost $C(\Delta t)$ (larger the greater the transport cost reduction). At initial point A the development is not undertaken; private returns are negative, although social returns are positive, the divergence between the two arising from the price or wage change effects is discussed earlier. A transport improvement reducing access costs to point B ($\Delta t = A - B$) would be just sufficient to trigger the development, yielding "wider benefit" $S - B$, an amount that should be added to a conventional narrow CBA.

In summary, the fact that the development is "large" means that the initial point A is inefficient. Transport improvement is a (second best) way of removing the inefficiency, and thereby creating social gain. This is a "wider impact" of a transport improvement that unlocks development potential.

Agglomeration and Coordination Failure

In section "Wider Impacts I: Connectivity and Productivity," we saw that transport improvement could raise productivity by increasing effective density; even if economic activity does not move, places become closer in terms of travel time and economic distance, d_{ij}. However, transport improvements generally induce changes in the location of activity that will lead to further productivity. Using the framework set out in section "Wider Impacts I: Connectivity and Productivity," effective density and hence productivity will change as the terms $employment_j$ in the expression for ED_i change.[h] Thus, if a transport improvement—for example, an increase in commuting capacity—enables employment in a cluster of activity to grow then, in the presence of agglomeration economies, the productivity of workers in the cluster (existing workers as well as new) will increase. This has been an important argument informing decisions to improve commuting into city centers, although it is subject to caution for the usual reasons of displacement. If workers are just moving from one cluster to another then the productivity gains in the growing cluster may be cancelled out by losses in the other.[i]

A more fundamental issue arises as transport improvement may have as its objective not just to move investment and employment into an area, but also to trigger the establishment of a new cluster of activity. There are important market failures associated with establishing new clusters, deriving from the fact that agglomeration economies are positive reciprocal externalities; firms and workers in a cluster create and receive benefits. This creates the first-mover problem; no one wants to be the first to move to a new place unless they are confident that others will follow. Expectations of future returns are critical (particularly since location decisions are generally long-lived and incur sunk costs), and these depend on who else is (or is expected to be) there. Success requires that expectations are coordinated—so each firm knows that each other firm will move. Absent this, there is "coordination failure." The private benefit of moving is less than the full social benefit so investment will not take place, similar to being stuck at point A on **Fig. 1**.

What is the contribution of transport to this? Many conditions have to be met for a place to become attractive for new investment, and it is hard to argue that reducing transport costs alone is sufficient to trigger development of a new cluster. However, a transport improvement can play an important role in coordinating expectations, over and above any transport cost reductions that it may bring. For example, consider a growing city in which it is clear that a new subcenter would be profitable, but there are many potential sites for such a center. If no one knows which site will develop, then no one will invest; the challenge is therefore to create a credible signal that will coordinate expectations. City plans are one instrument to achieve this, but their poor implementation record means that they are unlikely to be credible. Investment in infrastructure is an alternative, credible since such investments are sunk and irreversible.

[h] Changes in effective density holding employment constant are sometimes referred to as "static clustering," and those with employment changing are "dynamic clustering."

[i] If there is full employment, then displacement implies $\sum_j \text{employment}_j = 0$. In some circumstances, productivity effects will exactly cancel; see Kline and Moretti (2013). However, they will not cancel out if agglomeration is driven by sector-specific localisation economies and cluster growth enables a high-agglomeration sector to expand.

Conclusions

There is often a tension between the strategic case made for a major transport improvement, and the economic case. The former is likely to be based on assertions about wider impacts, and the latter on a narrow CBA that implicitly ignores all such effects. It is important to develop a rigorous understanding, based on theory and evidence, of the mechanisms, circumstances, and magnitudes of any such wider impacts. This is needed both to make the arguments for wider impacts and to challenge spurious arguments that are sometimes made.

Progress has been made on the conceptual side, laying out the mechanisms through which wider benefits can occur, and in empirical work quantifying some key relationships such as the productivity benefits of density. More needs to be done, building on a variety of techniques including modern quantitative spatial modeling, both to get a better understanding of possible quantity changes brought about by transport investments and to ensure that these are valued in a full general equilibrium setting, where displacement effects are taken into account and the risk of double counting are minimized.

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