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***Recent Evolution of Research
into the Wider Economic
Benefits of Transport
Infrastructure Investments***

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1. INTRODUCTION

The debate on whether there are wider economic benefits from transport infrastructure investments continues to cause debate and controversy. This debate occurs both between analysts seeking to find a robust method for identifying and measuring the size of such benefits and between policy makers seeking to justify or refute the need for a particular investment. It is timely to review progress on arriving at a consensus view of the contribution of infrastructure to the wider economy which is consistent with best practice in appraisal. This paper will review progress and try to bring out some common themes for discussion.

The main aim of this paper is to bring together the various alternative methodological approaches to this problem which differs not just in the detail of the analysis, but more significantly in the scale at which the analysis is undertaken. It is argued that it is of particular importance to understand the way in which changes in the provision of transport affect microeconomic decisions, including those within firms and households, and to understand the operation of markets as well as to model the resultant flows and their macroeconomic consequences.

By wider economic benefits we mean all economic benefits which are not captured in the direct user benefits of the type which are normally analysed in a well constructed transport cost-benefit analysis after allowing for environmental and other directly imposed external costs. Such benefits are typically thought of as being positive, but logically they can also be negative implying that the direct user net benefits could over-estimate the value of a project. The traditional transport appraisal approach assumes that a well-specified cost-benefit analysis will capture all the economic impact of a transport infrastructure investment since users will be willing to pay exactly the economic value of the transport to them. Any attempt to add on wider economic benefits would thus represent double-counting. On the other hand macroeconomic studies have shown strong positive links between the aggregate level of infrastructure investment and economic performance as measured by GDP or productivity growth or employment. If it is the case that increased investment leads to faster growth then this needs to be identified and included in demand forecasts. Are these positions consistent, and if not can they be reconciled?

There are two main avenues of debate to effect such a reconciliation. One relates to the assumptions made about the nature of competition and returns to scale. This argues that when the traditional assumption of constant returns to scale in perfectly competitive markets is relaxed there will be agglomeration effects which generate wider benefits not captured in the user benefits. The second argues that the non-marginal nature of many large scale investments results in traditional forecasting approaches failing to capture the changes in behaviour of transport users.

The intention of this paper is to explore the linkages between these different approaches to identify the relationship between the different levels of analysis in order to develop a way towards a more synthetic approach which can capture best practice. However, it will be stressed that the purpose of any analysis always needs to be made clear in order to avoid inconsistencies between the appraisal of individual projects and overall evaluation of policy towards networks.

There will be a brief review of the objectives of infrastructure studies followed by a summary of the key issues which emerge from the various types of study in order to identify common themes and differences. This will lead to an attempt to synthesise the key issues and identify priorities for further work.

2. THE PURPOSE OF INFRASTRUCTURE STUDIES

One of the major areas of confusion between the different types of study into the wider economic impacts of infrastructure is that different studies have clearly different objectives. These need to be understood before any attempt is made to reconcile the results or to apply the results of one type of study to a different case. At the lowest level comes the investment appraisal of an individual link in a network. At the highest level comes the attempt to relate overall macroeconomic performance to aggregate investment in infrastructure and hence to the stock of infrastructure. The difficulty is knowing whether an elasticity obtained from the macro-study is in any way applicable to a single investment decision.

Investment appraisal is where the critical decisions are taken about transport infrastructure. The majority of individual decisions are about link improvements. These have historically been determined by methods which rely almost exclusively on the identification of user benefits, heavily dominated by user time savings, relief of congestion and reduction in accidents, but also allowing for environmental impacts. But investment decisions based on cost-benefit type procedures depend critically on the accurate measurement of future demands which in turn require correct modelling of the responses of users to the new investment (see Vickerman, 2007a, b for recent discussions of this issue). This is the problem related to a move from the traditional assumption of fixed trip matrices in which new transport investments would simply lead to a reassignment of traffic in a network rather than a revision of travel patterns.

Allowing for generated or induced traffic is a two-edged sword: failing to allow for it can lead to the sort of underinvestment which produces more congestion rather than less and hence overall benefits less than the estimated user benefits (see Venables, 1999, for a discussion of the theoretical basis of the problem); grasping it can lead to the optimism bias often used as a basis for justifying projects which might otherwise not appear to generate sufficient user benefits (as shown by Flyvbjerg *et al.*, 2003).

One of the major problems with the traditional investment appraisal exercise is that it is seen as a purely transport exercise which ignores the interactions between transport and all the activities which use transport. It ignores in other words the market situation in which transport is located and how it interacts with the locations of economic activity, residences, workplaces, sources of inputs, markets for outputs etc. This is why a market based approach is essential to understand the way in which a particular transport investment serves particular markets. The traditional theoretical approach to appraisal relied on the well-known results of Dodgson (1973) and Jara-Diaz (1986) that, assuming that all other markets were in perfect competition such that price equalled marginal cost, the user benefits would exactly equal the total benefits because the full value of transport to all users would be exactly

measured. Jara-Diaz demonstrated how these results might differ if the state of competition differed in the regions linked by the transport improvement, but the simplest solution was always to ignore the problems of imperfect competition.

This may not be unreasonable for the typical appraisal of a link in a network which makes only minor changes to overall accessibility, but where there is a need to appraise a fundamental change in a network, or indeed a network in its totality the dimension of the problem changes and the market situation cannot be ignored. The temptation has been to look for simple adjustments to the user benefit result – a wider economic benefits multiplier – which would enable the aggregation of a set of unspecified wider benefits. This multiplier may be thought to be related to the price-cost mark-up associated with imperfect competition, the greater the imperfection in competition the more pro-competitive would be a transport improvement and hence the greater the uncaptured benefits from a simple user benefits appraisal. Such an approach needs to consider that the degrees of imperfection will differ between sectors of the economy and that in some cases poor transport may serve as a useful trade barrier protecting a region from the more aggressive competition gained by a larger region enjoying greater scale economies in its production. Improved transport in such situations may be globally beneficial but to individual regions could cost both output and employment. This emphasises clearly the need for a careful definition of the geographical scale of the region of interest from a transport improvement, bringing it again closer to an integration with the various spatial markets relying on that transport.

Scale economies are closely related to the existence of imperfect competition. The existence of scale economies implies the greater concentration of economic activity and this has clear implications for the most efficient transport network. As scale economies increase the barrier to trade posed by transport costs can more readily be overcome and hence there is a tendency towards concentration. If transport costs fall beyond a certain level then the advantages of concentration for the individual activity may become less and dispersion may arise. However, this ignores the interaction between the activities and it is these agglomeration forces which will tend to dominate and preserve the concentration. In this case improved transport is no longer unambiguously pro-competitive. The role of transport in agglomeration has been explored thoroughly in the new economic geography approaches to the spatial economy (see for example Fujita *et al.*, 1999; Fujita and Thisse, 2002) and the implications for transport appraisal considered in Venables and Gasiorek (1999). This has implications at two levels. One is the way inter-regional transport can accelerate the agglomeration of one region at the expense of another, the second is the way intra-regional transport can reinforce that process. The clearest example of the latter is the way improved commuter transport can help keep down the real unit cost of labour to firms whilst maintaining the real wage differential to workers encouraging them to remain in the agglomeration.

Market-based approaches only go so far in helping our understanding of the impact of transport on the economy since like the macro studies they work on the basis of average propensities and elasticities. But in order to understand the real impact of new investments in transport we need evidence of how these changes actually affect activities at the micro-level, that of the individual firm and household. This is not just about these agents' market behaviour, where they buy and sell, where they live and work, but how their activities are organised internally. Hence we need to examine how firms will reorganise their operations to reflect reduced transport costs, will they concentrate all activities into a single location or will they use existing locations, but functionally specialise between these locations? Similarly for households, not only will individuals be able to use improved transport to enlarge their own labour market search, but different members of the household may be able to match a wider range of potential job offers thus enabling the household to reallocate activities between household members or its optimal location.

How does this relate to the overall contribution of transport to an economy's macroeconomic performance? Is this a simple aggregation of the impact of the individual links, or is it a problem of a different dimension? There are two aspects to this which again take us back to the basic question of what it is we want to measure. The first is geographical scale. Whilst it is not suggested that all transport improvements are likely to be a zero-sum game as far as individual regions are concerned, most will have some redistributive effects between regions, either relatively in that they benefit some regions more than others or absolutely in that there are gainers and losers (but the former could compensate the latter and still leave an overall gain). The second is the need to consider the mechanism by which it is believed that the transport improvement works through the economy. One approach would be to treat it simply as an adjustment to the price of a key input which leads to changes in the relative prices of activities according to their transport content, and the impact on competition – this takes transport simply as a derived demand. The other views transport as a substitutable input to activities such that it has an impact on total factor productivity. The simple aggregate production function approaches to transport infrastructure fail to make the relevant mechanism clear leading to some of the problems of interpretation of the results from such studies.

3. MACRO-LEVEL EVALUATION OF INFRASTRUCTURE²

Much has been written on the macro- evaluation of infrastructure in terms of its impact on productivity and growth, typically using some form of production function approach. There has been a considerable output of empirical studies which aim to test the impact of infrastructure at both national and regional level. The main issues to emerge from this are the problems of measurement and the difficulty of making firm statements about the impact.

3.1. Measurement

The first problem with most macro studies is that they rely on a very aggregate view of transport infrastructure, typically just using the volume of investment or stock of infrastructure capital as the variable which impacts on output. The problem with measuring infrastructure by its capital value is that this is likely to be a much less accurate measure of the services provided by that infrastructure than is the equivalent value of private capital. This is for two reasons: infrastructure has high asset specificity (zero opportunity cost); and is much less likely to be provided under conditions representing a free market in which the price paid is indicative of the marginal productivity of the asset. For this reason many studies prefer to use physical measures of infrastructure such as lane kilometres or track kilometres (usually expressed as a density per square kilometre to standardise for differences in region or country size). This is closer to incorporating a clearer measure of the level of service provided by the infrastructure.

The second issue is the what is being measured, output, productivity or employment. To some extent this depends on the purpose of the study. Studies concerned about the role of infrastructure in growth or convergence will use output measures such as GDP or GDP/capita. Technically, to ensure consistency with the normal Solow growth model premise, convergence studies should be based on a productivity measure of GDP/worker to allow for less than full employment. For political reasons

there has obviously been a lot of interest in the employment impacts of infrastructure since this is a way of selling expensive publicly funded projects to an electorate on the promise of more jobs. Each of these approaches implies a very different underlying process of infrastructure impacts.

3.2. Output

Output-based models imply infrastructure working essentially as any other factor of production; regional economies with more infrastructure will have more output, the logic of this argument actually tends to derive from the opposite – that the lack of infrastructure would act as a constraint on output. Regions with denser infrastructure are presumed to have a more efficient transport system which will enhance the productivity of other factors of production, especially private capital, and this will generate the growth bonus which formed the basis of Aschauer's (1989) argument in the work which sparked the current round of interest in the role of infrastructure.³

The problem with such an approach is that it takes no account of the way on which infrastructure is used by the activities within the economy in question. A given volume of infrastructure can be either adequate or inadequate for the needs of the economy depending on, for example, the sectoral structure of the economy or the physical configuration of the infrastructure. It is clear that in a purely aggregate demand view of the production function, the scale of infrastructure spending will affect output and growth simply because of its scale. Since construction expenditure has a particularly rapid pass-through and usually generates a relatively large employment multiplier, infrastructure investment is a good means of providing a short-run boost to the economy as long as it does not crowd out other more productive investments. This was the motivation of the Aschauer work, to deny the argument that public infrastructure would be a less good use of available investment funds than expenditure on private capital. But this is not helpful evidence for use in planning or appraising infrastructure and, as many subsequent studies have argued, may confuse the direction of causality. This was the essence of Gramlich's (1994) review article which focused on the importance of identifying the specificity of particular infrastructures.

3.3. Productivity

The spillovers in productivity have become the focus of more recent work, not only between sectors but also spatially, following the work of Holtz-Eakin (1994) and Holtz-Eakin and Schwartz (1995). This is not always overtly spatial, except in the limited sense of inter-state comparisons (see Pereira and Andraz, 2004, for an example) although a more detailed study using county data does come closer to examining the more local complementarities in network developments (Boarnet, 1998).⁴ The issue of the endogeneity of infrastructure and overall output leads to a consideration of the appropriate leads and lags. It is clear that there may be a lags in both directions; the time taken for output growth to generate the demands which can justify new infrastructure and the time for activities to adjust to a new level of transport provision. However, there is also the possibility of a leading response in which the promise of major new infrastructure stimulates investment as firms try and obtain a first-mover advantage to exploit new opportunities. All of this adds to the potential econometric confusion which even the most sophisticated techniques find it difficult to unravel.

3.4. Employment

The alternative use of employment data addresses a slightly different problem. The underlying assumption is essentially one of fixed input coefficients so that the impact on employment is directly related to that on output. As Jiwattanakulpaisarn (2007) shows, the impact of infrastructure on jobs is not universally positive (especially when taking into account different types of road) and this, along with other evidence, may cast some doubt on the wisdom of policy makers pushing for infrastructure expansion. The problem here is that effective infrastructure which reduces transport costs will induce the substitution of cheaper transport for more expensive, less mobile inputs. Land is one obvious substitute – the justification for just-in-time production techniques saving on inventories – but labour, especially less skilled labour, may also be a casualty as it too may be less mobile. Furthermore, the improved infrastructure increases the competition from more mobile labour from outside the region which may take up any increase in jobs resulting from the higher level of activity. Hence the improved infrastructure is good for the local economy in terms of growth but may be bad for the employment prospects of (some) local residents. This reinforces the need to look at more disaggregated models which allow for the differences between both infrastructure type, sectors and employment structure.

3.5. Alternative models

Fully aggregate econometric models have not been found to be appropriate for this and most work has been done using advanced land use-transport interaction (LUTI) models or more recently spatial computable general equilibrium (SCGE) models. These can capture more specific spatial impacts of infrastructure, but tend to be limited by their data requirements and/or their need to make highly simplifying assumptions about the operation of the various markets or the spatial coverage of the impacts. A number of studies have carried out ex ante evaluations both of network developments as a whole and of specific infrastructure improvements. Many of these have been as part of European Union funded projects to look at the potential impact of the development of the Trans-European Networks (TENs).

3.6. Land Use Transport Interaction Models

LUTI models have been used by urban planners for some time as extended travel demand models which allow for the interaction of transport and land use (Simmonds, 1999). More recently LUTI models have been extended to deal with regional and inter-regional impacts of transport development (Wegener and Böckmann, 1998; Bröcker *et al.*, 2004). These models vary in the precise way they operate but essentially comprise a series of linked detailed models covering travel/transport, production and GDP, labour markets and population and land use. At the heart of the model is the transport sector. Changes in accessibility which change the cost of transport, impact on both production and the labour market. The production sector is typically modelled through a set of input-output relationships which define the need for transport to move goods into and out of a defined spatial area. This includes the need for labour inputs which interacts with the available labour force (and hence local population) to determine commuting and migration patterns. Land use acts as a constraint on the development of the economy since production and the resident labour force have minimum requirements for land.

The main problem with LUTI models arises from the assumptions implicit in each of these constituent models. Hence input-output models are often static in nature, dependent on existing patterns of behaviour and are solved by ensuring that equilibrium is reached in each relevant market. Similarly the links between population, labour force and labour demand also depend on assuming that existing patterns of behaviour do not change, when the evidence from major changes in the transport network is that behaviour can actually change quite significantly. Furthermore, the models make assumptions about the land-use requirements which do not allow for changing capital and labour intensities and tend to treat different sectors equally. LUTI models assume perfectly competitive markets in which the market outcome is a valid measure of the welfare change.

3.7. Computable General Equilibrium Models

CGE models, by their nature, also assume equilibrium and are based on the fundamental input-output relationships in the economy, but in this case they allow for more interaction between constituent markets in order to achieve a general equilibrium of all sectors through a process of numerical iteration. The key difference is that CGE models have at their core the possibility of assuming that consumers display preferences over differentiated goods which are produced by imperfectly competitive firms (Bröcker, 2000, 2004; Bröcker *et al.*, 2004). Because of this use of a utility function CGE models can make a direct estimate of the welfare effects resulting from a change.

Bröcker's CG-Europe model generates three important results. First, despite significant changes in transport costs and accessibility occasioned by the development of the TENs, the impact on welfare is relatively modest (equivalent typically to less than 2 per cent of regional GDP). Secondly, the network as a whole has positive impacts on some regions and negative impacts on others. Thirdly, specific investments have differential impacts both on the specific regions they serve and in the added value they bring to the European economy as a whole.

More specific project applications include an evaluation of the regional impacts of highway developments in Japan (Miyagi, 1998, 2001) and to evaluate the impact of a high-speed rail link between the Randstad and the Northern Netherlands (Oosterhaven and Elhorst, 2003; Elhorst *et al.*, 2004). The Dutch RAEM model focuses not just on the output and welfare implications, but also very specifically on the labour market since the improvement to transport will not just affect the location of employment but also the residential location decision. This introduces further difficulties because it requires not just a balance of production and consumption in the goods markets, with a potential response through migration to long-term imbalances, but a period by period balancing of labour markets demands and supplies, zone by zone. Furthermore, once the key beneficiaries are passengers rather than goods some of the simplifying assumptions used in the typical CGE structure become less plausible. For example, the use of 'iceberg' transport costs, in which the cost of transport of a good is subsumed into the value of the goods moved such that they are worth less at the destination than at the origin by the amount of the cost of transport, is inappropriate for passengers. Similarly the assumption of constant costs of transport per unit of distance is even less appropriate for passenger transport.

Nevertheless the application of a CGE model to this project has produced an interesting set of results. The wider benefits are shown to vary significantly as a result of the precise nature of the project and the region studied (especially core-periphery differences), and constitute a higher proportion of direct benefits than earlier studies suggested, of the order of 30-40 per cent. These wider benefits are higher than theoretical simulation models have suggested; SACTRA (1999) suggested that a figure of 10 to 20 per cent was a likely range, following the conclusion by Venables and Gasiorek (1999) that 30 per cent was a likely to be exceeded in only a few cases. (It is worth noting however

that in the earlier version Oosterhaven and Elhorst had produced a figure of 83 per cent). What is clear from Elhorst *et al.* (2004) is that the degree of detail in the modelling of labour market responses may be crucial here.

But CGE models do still have major drawbacks: assumptions about equilibrium, the need for large data inputs from existing sources and the ‘black box’ nature of large models all limit their usefulness and ease of application. Thus far CGE models have tended to be used for cases where there are thought to be significant non-transport impacts; their use as part of the regular appraisal of minor transport projects might be difficult to justify. SACTRA (1999) strongly recommended that the UK Government should invest further in this approach. Following an assessment by RAND Europe (Gunn, 2004), the Department for Transport (2005) has issued a discussion document suggesting how this could be achieved.

3.8. Ex-post Studies

Most of the empirical evidence quoted above relates to ex ante studies of potential future projects. There have been relatively few in depth ex post studies of the revealed impacts of completed projects. One of the difficulties is that of identifying the specific impacts of a project over the timescale necessary to allow for these to be revealed. However, one of the relatively few ex post studies indicates a much lower level of impact than ex ante studies. Hay *et al.* (2004) have shown how a very significant project, the Channel Tunnel, has not produced significant wider benefits over its first ten years of operation, at least on the regional economies close to the tunnel. In fact it is suggested that any wider benefits are so dispersed and so long term as not to be easily detectable.

4. MARKET LEVEL EVALUATION OF INFRASTRUCTURE

The previous section has identified in several places the importance of disaggregation in order to identify the particular needs of individual sectors and activities. We have already noted the extent to which the labour market is likely to play a major role in this process. Disaggregation by space is also an essential element of a fuller understanding of the impact which infrastructure investment will have. This emphasis on markets becomes important once we move out of the comfort zone of the perfect competition assumption. In a world of increasing returns and imperfect competition we need a more subtle evaluation of the role of infrastructure.

The theoretical justification for this approach is provided by the new economic geography or new spatial economics. The principal result of this approach is to demonstrate that agglomeration can take place and continue without a process of self-balance setting in. Transport costs play a key role in this process. However, the nature of this approach is that the impact of any particular reduction of transport costs cannot be determined a priori. It will depend on the initial level of transport costs, the degree of agglomeration already present, the size of each market, the extent of scale economies and of the backward and forward linkages within that market (Fujita *et al.*, 1999; Fujita and Thisse, 2002).

What becomes relevant here is the extent of the mark-up over marginal cost in the transport-using industries. In perfectly competitive sectors there is no mark-up and hence any changes in transport costs will have to be passed on directly to the final activity, so the extent of the impact on the wider economy is dependent on the elasticity of demand for that final activity. Since the amount of transport demanded depends directly on the demand for the final activity the direct user benefits capture all the economic benefits. As mark-ups increase there is in effect a wedge driven between the market for the transport-using activity and the transport associated with it. Any reduction in transport costs from new infrastructure does not need to be passed directly on to the customers of the final activity, but firms can use the opportunity to increase or reduce the mark-up. Reducing the mark-up by passing on more than the reduction in transport costs could be a way of increasing a firm's market area and gaining market advantage over firms in a more competitive market. On the other hand firms may use the fall in transport costs to increase the mark-up, for example to invest so as to reduce other costs and gain from potential scale economies. It is also possible that the net impact can be negative. If the mark-up is negative, for example where there are industries with significant subsidies, such as in economically lagging regions, then the direct user benefits may over-estimate the total economic benefit. Hence the ultimate impact from any infrastructure project is likely to be unpredictable, both in terms of magnitude and sign.

There are three main elements to the total economic impact. First is the impact on competition in the affected regions, secondly there is the impact on the ability to gain benefits from the change in market power through agglomeration, and thirdly is the impact on the linkages and in particular on backward linkages such as the labour market. Once these have been assessed we have to identify how to include them in a full cost-benefit framework.

4.1. Competition Effects

The impact on competition is ambiguous. In perfectly competitive markets, as we have seen, the impact of increased competition is essentially neutral and should be adequately captured by the direct user benefits. In imperfectly competitive markets, the direct effect of any increased competition resulting directly from lower transport costs is also likely to be essentially neutral in its impact. It is traditionally argued that monopoly power is derived from the effective barriers to competition provided by higher transport costs so that reductions in such barriers are pro-competitive, reducing monopoly mark-ups and hence there is a wider benefit resulting from the reduction of prices. On the other hand such competitive pressures if they do exist may also drive firms out of the market and the effect of lower transport costs is to reduce the number of firms able to compete in the market in the long run. It is likely that such effects cancel each other out in most cases and thus there is little in the way of wider economic benefits which can be added.

There may be some exceptions to this where new links are created which have such a significant impact on transport costs (which are already very high) that significant market restructuring takes place introducing competition to previously protected local monopolies. This is the 'unlocking' argument advanced by SACTRA (1999) and reaffirmed in its latest guidance by the UK Department for Transport (2005). These are likely to be rare in most developed market economies.

4.2. Agglomeration Effects

Much more significant than the market competition effects are the agglomeration benefits which may result from the change in transport costs. The argument here is that the rise in output which follows from the lower transport costs has cumulative effects through the way in which firms interact in a market. This involves both localisation economies, in which firms within the same industry benefit from proximity to each other through such factors as specialised labour pools or shared R&D, and urbanisation economies, in which firms obtain a form of public goods benefit from the existence of an urban infrastructure including knowledge, research and culture as well as the physical infrastructure. The larger the market the greater the likely net additional impact which arises because there is an additional impact on productivity.

There has been a long debate over the extent to which urban size and productivity are related, and the direction of causality, but there is an increasing consensus that there is a strong positive relationship which can have a significant additional impact on the benefits from transport improvements (Fujita and Thisse, 2002; Venables, 2007; Graham, 2005). This argues that although the lower transport costs may cause firms to increase the size of their market, that increased size provides an incentive for the firm to enjoy scale economies and to benefit from proximity to other more efficient firms. Typical productivity elasticities are in the range 0.01 to 0.1. Ciccone (2002), using data for EU regions, finds an elasticity with respect to employment density of 0.05. Graham (2005) finds for UK industries a weighted average elasticity of 0.04 for manufacturing, but significant variations between industries with some as high as 0.2, and an average of 0.12 for service industries. Graham also identifies some important variations between regions reflecting different degrees of localisation of industry groups.⁵

A further element of this output benefit under imperfect competition is that because productivity is increasing, the direct user benefits will also be greater than would be the case under an assumption of perfect competition. The largest direct user benefits from most projects are time savings, valued relative to the wage level assuming that wages reflect productivity. The increase in productivity implies that a higher value of time savings should be applied. But the increased productivity enables firms to increase output (or produce the same output with fewer workers) which implies an uplift needs to be applied to the time savings.

4.3. Labour Market Effects

The basic advantage which some regions obtain in an imperfectly competitive world derives from a larger market size which enables firms to increase both output (scale) and productivity. However, it is useful to break that larger market size effect up into a pure market size effect and the backward and forward linkages which are associated with agglomeration. One of the key backward linkages relates to the labour market. As transport costs are reduced labour markets become larger as commuting times are reduced and firms have access to a larger labour supply. This enables firms to benefit both from wage levels which might be lower than they might be as result of more competition in the larger market, but access to more skilled labour which will be more productive for the reasons discussed above.

Normally it would be expected that there would be a wage premium at the market centre reflecting its greater accessibility, scale and productivity effects, but also to reflect the wage necessary to attract labour to commute in from across the wider region. As transport is improved more workers find it attractive to work in the market centre, both in terms of there being a larger catchment area for

which commuting is feasible and more people at each location find it worthwhile to seek work in the centre rather than elsewhere (or not at all), or if they are working in the centre to be prepared to work longer hours. Hence there is an output effect which arises because of the increased size of the labour market. Where there is also a productivity effect due to agglomeration effects at the market centre the output effect from the expansion of employment is added to by the increased output of all existing workers (see Venables, 2007).

4.4. Implications for Appraisal

Whilst this provides an interesting academic debate on the existence of agglomeration economies and the way they can be manifested in terms of wider economic benefits from transport investment, do these approaches provide us with an effective means of enhancing appraisal techniques of new infrastructure? Most applications to date have been in the context of major investment projects. We have noted above the application of LUTI and SCGE models to such projects as the TENs, Dutch high-speed links and Japanese highways; similar exercises have been carried out for a variety of other major projects across the world. The most detailed application of agglomeration-based modelling has been in the context of the Crossrail project for a major cross-London underground rail link (Department for Transport, 2005). Such exercises remain difficult and costly in terms of both data and modelling and frequently can only be justified where the scale of a project is large enough to cover the cost of such modelling. The goal is to have a simple and easily applicable appraisal model which can capture the same effects for any project, not least because much network development is actually the result of a series of independently taken link decisions.

Note that it is not the size of an infrastructure project which determines the scale of the wider economic benefits. Large projects are likely to have a wider impact in terms of greater direct user benefits, but the wider benefits are not simply proportional to the direct user benefits. Some relatively minor projects, the ‘unlocking’ projects, can have disproportionately large wider benefits, whereas some very large projects may have relatively little impact on the key scale, productivity and linkage effects. This is why there is no a priori reason for applying a simple wider benefits multiplier. It also demonstrates that seeking a simple output elasticity as in the macro analyses can be misleading. However, even at this level the empirical evidence (such as that presented by Graham) demonstrates the variability between sectors and regions of the likely impacts of given level of infrastructure investment. It is this which argues strongly for the addition of more micro level evidence of the impacts within firms and households.

In the UK the official guidance following the 1999 SACTRA Report was to consider wider economic benefits through an Economic Impact Report where there was a confirmed regeneration benefit or where the capital value of the project was greater than £5 million. The Eddington Report (2006) identified the importance of all these processes and particularly importantly wanted these to be identified at an early stage of project development – there is a clear problem that if the wider benefits are only ever considered for a fully developed project proposal many more effective options may have been rejected.

5. MICRO-LEVEL EVALUATION OF INFRASTRUCTURE

At the micro level there has been much less systematic work showing how infrastructure changes the behaviour of firms and individuals. Some work on the impact of high speed rail has shown that the impacts on the internal organisation of firms may be more significant than the overall redistribution of activity. The increasing interest on the impact on labour markets also demonstrates the need to make more of a connection between the different levels of analysis as the micro-behavioural decisions can be linked to overall labour market operation and to productivity and agglomeration effects. To explore this further requires in-depth studies of changes which have occurred as the result of the introduction of new infrastructure.

5.1. Labour Market Effects

Gibbons and Machin (2005) provide some evidence of the impact of new infrastructure on individual behaviour by estimating the impact on house prices of the provision of a new Underground line in London. This looked at the effect of new stations on values at different distances from the station assuming that the new station increased accessibility to workplaces in Central London. The results showed that there was a clear positive link, average values rose by 9.3% more in areas affected by the new stations and values rose by about 1.5% for a 1 km reduction in access to the station. Such results are based on assumptions about where people might work and ignore job creation in the areas affected by the new stations, but do seem remarkably robust econometrically. Moreover they imply rather higher values of accessibility (as measured in house values) than do cross-section results comparing areas of different accessibility. This suggests that there is a strong positive response to the addition of new infrastructure which traditional model approaches based on assumptions of market equilibrium may fail to identify.

5.2. Business Organisation Effects

Turning to the impact on business, most studies have been carried out into the impact of the French TGV lines, particularly to examine the relative impacts on Paris and the provincial cities. Although such services led to a substantial growth of traffic the impact on the local economies of the cities served was much less certain. Generally such services cannot be shown to have had a major impact on the net redistribution of economic activity between Paris and the provincial cities, or on the overall rate of growth of these cities.

The evidence includes studies of the TGV Sud-Est, Paris-Lyon, opened in 1981 (Plassard and Cointet-Pinell, 1986), the TGV Atlantique, including a study of Nantes, opened in 1989 (Klein and Claisse, 1997; Dornbusch, 1997), and early studies of TGV Nord, including studies of Lille and Valenciennes, opened in 1993 (SES, 1998; Burmeister and Colletis-Wahl, 1996). All of these studies demonstrate a considerable growth in traffic between Paris and each of the provincial cities since the opening of TGV. The impact on business traffic is more mixed. In the case of TGV Sud-Est there was

a substantial growth, in the case of TGV Atlantique as a whole there was a marginal reduction in business traffic, but the period immediately after opening coincided with a serious recession.

The Paris-Lyon study showed a major impact on the pattern of mobility, but with changes in both directions. Essentially many businesses in both locations modified their pattern of working leading to increases in travel in both directions. There was no overall net impact on the economies of either of the major cities, but a general tendency towards the concentration of economic activity towards these major cities from the regional hinterland, especially in the Bourgogne and Rhône-Alpes regions. This centralising effect of high speed rail is now a well established impact.

In the case of TGV Atlantique, the development of business traffic showed interesting contrasts. Tours, at 240km (1h 10m) from Paris showed a significant reduction in business traffic of 24 % in total and 40% by rail between 1989 and 1993. Nantes, 380km (2h 05m) from Paris showed a total increase in business traffic between the two cities of 66% with a tripling of rail traffic. In 1989 some 73% of the traffic originated in Nantes, but there was a much larger increase in Paris originating traffic (+99%) compared with that originating in Nantes (+55%) with the coming of TGV. In Nantes there was considerable anticipation of the coming of the TGV in the light of some of the experiences of Lyon, but this was mainly felt in property development and relatively little impact on, for example inward movement of enterprises was identified. As in the case of Paris-Lyon there was evidence of a degree of internal reorganisation within firms to take advantage of changing transport costs for business travel. For Toulouse, 700km from Paris (5h 06m), the increase in total business traffic after the TGV was introduced was 21%. In this case however, more of the increase in traffic was locally based (+35%) and Paris originating traffic actually fell by 5%. However, much of the driving force behind these changes was seen to be the business cycle rather than changes in the supply price of transport. The key factor here is seen to be the differential impacts on the cities around 2 hours from Paris, those closer and further away did not benefit to the same extent. This is consistent with other evidence that high speed rail has its major impact in the 2-3 hour journey time band.

For TGV Nord the distances are shorter than would be likely to make a major impact – Lille is just 1 hour from Paris. Nevertheless total traffic grew substantially over the first three years of operation, 5% in the first year, 6% in the second year and 11% in the third year. Except in year two the growth was stronger for traffic originating in Nord-Pas-de-Calais region. What is of interest is that rail showed much stronger growth in the latter market than for traffic originating in the Paris region.

The Lille study suggested that about one-third of all business travel was changed as a result of the introduction of TGV (both outward from regional based enterprises and inward by clients of such enterprises). However, 90% of enterprises identified no impact of TGV on their overall activity. As in the earlier studies there was evidence of some internal reorganisation, described in this study as a form of “spatial dualisation”. Some considerable differences were noted between Lille and Valenciennes, just as in the Paris-Lyon study there was some evidence of centralisation of activity towards Lille, the major regional centre, at the expense of the weaker one, Valenciennes.

The French studies demonstrate the critical importance of time thresholds in the impact which TGV services will have on the relationships between major centres. Thus the headline time of two hours between Paris and Lyon was very significant. This is particularly true of the diversion of trips from air to rail, but it has also affected the potential for generation of new journeys reflecting new activity possibilities. A further issue is that although much of the success of the TGV in generating new traffic has been by providing through services from locations off the new infrastructure the economic spin-off for these centres has not been as great as the for the locations on the main lines.

Thus there does seem to be clear potential for further work on the direct impact of new infrastructure on the behaviour of individual, households and firms which may produce rather different implications than the traditional market-based or macro-based models.

6. CONCLUSIONS AND IMPLICATIONS

The main theme of this paper is that it is necessary to be clear as to the objective of any study of the impact of transport infrastructure on economic activity as the nature of the answer required will affect the appropriateness of different methodologies and different methodologies may give very different answers. These differences do not necessarily reflect inconsistency in results but rather incompatibility in method.

Much more development has been carried out of macro studies of the overall impact of transport on the economy. These have their place as part of our understanding of the basic relationship, but are not necessarily compatible with methods for the planning or appraisal of new infrastructure. The endogeneity question remains central to the problems which such methods pose, though recent work has been able to produce more stable results, especially where the infrastructure itself is disaggregated and made more homogeneous.

The recent (renewed) growth of interest in measuring agglomeration effects is central to our understanding of the more market based approaches. These allow for specific variations in the degree of imperfection of competition, both in product markets and in labour markets. This makes them more suitable as inputs to the appraisal process, although there is a question as to how far the data requirements of such procedures can be met in the case of other than abnormally large projects. What is clear is that there is little evidence of there being standard transferable multipliers region to region or project to project.

Where there is still a considerable need for further work is in genuinely micro studies of the response to specific changes in order to understand something of the process of decision making in response to changed transport provision by both individuals and households, and firms. The evidence from both labour market studies and firm studies of the impact of new rail links is that these responses may be more significant than otherwise assumed.

But full appraisal will continue to require inputs from all three types of study to be able to understand the overall economic impact of new transport infrastructure. Each has its role to play according to the policy priority and the initial situation, such that where the lack of transport infrastructure is a constraint on economic growth the best understanding will still arise from traditional macro studies. Where questions of regional competitiveness are paramount, market based studies of agglomeration will be central to any appraisal. Where it is about improving efficiency and maximising social benefit then more detailed micro studies will be essential. There remains much still to do.

NOTES

1. This paper draws on a number of recent papers by the author, especially Vickerman (2007a, b).
2. It is not intended to provide a complete review of the development of this literature as several comprehensive reviews exist already, see for example Gramlich (1994); SACTRA (1999) and Vickerman (2000, 2002).
3. This is not to ignore a huge volume of previous work which had sought to identify the 'social' value of transport, that above its direct value to users, which can be found in the works of such diverse authors as Dupuit (1844); Pigou (1920); Knight (1924); Fogel (1964) and Fishlow(1965).
4. For a valuable discussion of this literature see Jiwattanakulpaisarn (2007).
5. See also further discussion in Graham (2006, 2007).

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