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Transport and Economic Growth

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ABSTRACT: There is a perceived wisdom that transport provision (especially of roads) is an essential pre-requisite for economic growth which has tended to justify a “predict and provide“ approach to the provision of roads. The evidence is much more mixed, GDP growth has been a good predictor of both passenger and freight growth, at least until recently, leading to speculation that there might be an optimum “transport intensity” of the economy. This has become a potential objective for sustainable transport policies to try and reduce transport intensity, i.e. seek ways of reducing the amount of transport which is necessary to sustain a given level of GDP. There remain, however, many instances of where specific provision has not led to the economic growth which was confidently expected, despite traffic growth which exceeded forecast levels. How should governments and other providers respond to this situation, and in particular should they, and if so how, introduce better measurement of the wider economic effects of transport improvements into investment appraisal? How do these effects relate to other external effects of transport, for example, on the environment?

This paper will report on an approach to these issues based on a recent report on *Transport and the Economy* by the U.K. Standing Advisory Committee on Trunk Road Assessment (of which the author was a member). The key points which this Report brings out are the lack of any general solution to the issue, the importance of considering the extent of imperfect competition in the sectors using transport, the importance of distinguishing the redistributive effects from the net impacts and the incidence of the “two-way road” effect where transport improvements sought by a region may work against its best interests, and the need to demonstrate clearly the relationship between the wider economic and environmental impacts of any proposal.

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Background

The debate on the link between transport and economic growth has a long history. On the one hand there is the argument that there is such an obvious logical link (economic growth requires trade, trade requires transport) that it is not a subject of any great interest. This tends to go hand in hand with the argument that transport is simply a derived demand and therefore any empirical evidence on the correlation between transport growth and economic growth is largely meaningless as it is an identity.

Empirically we can observe a remarkable constancy in the relationship between transport growth (both passenger and freight kilometres) and economic growth over the long period in many countries. This is particularly remarkable given the technical changes which have occurred in transport by all modes over the years. It might be expected that if transport is only a means to an end, if it can be economised then we should expect to see a reduction in the amount of transport necessary to achieve a given level of welfare.

However, it appears that transport faces both a strong positive income elasticity of demand and an overall price elasticity not far from unity. There is a suggestion that in terms of both money and time budgets there is a given (proportional) allocation to transport. As transport has become cheaper and easier, people have travelled for the same time and spent the same proportion of their budget, but have therefore travelled further. Hence we see people living further from their place of work; even the telecommuter spends about the same time in the week travelling as the daily commuter, taking the benefits of the telecommuting freedom to live in a better area. Likewise they travel further for their main holiday, fifty years ago it was to the nearest coastal resort, now it is often half way round the world. Freight transport faces the same change as firms seek wider markets and wider sources of supply.

If this general pattern is true then we are faced with the problem that the increasing demand for transport to maintain and expand economic welfare will lead more rapidly to a conflict with the overall sustainability of the economy. Transport generates substantial externalities, both to other users in the form of congestion if they expansion of capacity cannot keep pace with demand, and to non-users through carbon emissions and local air and noise pollution. Transport is the major single generator of global warming emissions. Transport infrastructure is also one of the major items of public capital expenditure. Governments, increasingly concerned about budgetary balance as a control on inflation and dues to worries about the crowding out of private investment through higher taxes and higher interest rates, have looked to savings on such expenditure as a means of exercising budgetary restraint.

Thus we are faced with the situation that there is increasing pressure for a reduction in the rate of growth of transport. The question is whether this can be achieved without also placing serious restraint on the rate of growth of the economy overall. To understand this we need to go back and understand much more clearly the nature of the relationship between transport and the rest of the economy. In the remainder of this paper we look first, in section 2, at some evidence on transport and economic growth. In section 3 we address the theoretical issues. In section 4 we examine ways of assessing the wider economic significance of transport interventions, whether through investment or through systems of traffic restraint.

Some Evidence

That GDP and traffic growth have developed in parallel is not in much doubt over the long term. Passenger traffic (passenger-km) displays an income elasticity of a little more than unity, freight traffic (tonne-km) an elasticity close to unity. For passenger traffic this reflects a roughly constant propensity to make journeys, and a fairly constant time budget devoted to travel, but a very substantial growth in the average length of journeys. Although there is also a switch between journey purposes, the increase in journey length is associated with most journey purposes. In most developed countries we now travel further to work, to shop and to play.

Of course the even more remarkable change is the switch in the mode of transport used – the motorization of modern life. It is this observation of the growth in car traffic that makes us believe that we are making many more journeys than we actually are. The question thus is how far does this increase reflect a genuine desire for more mobility, how far is it a response to changing patterns of land use permitted by increased access to the car, how far is it yet another reflection of the presumed value placed by consumers on the existence of variety?

Figure 1 summarises the basic information for the UK over a 30 year period. Note particularly how closely the growth of heavy goods vehicle traffic tracks the GDP growth whilst cars and light goods vehicles are growing much more rapidly. Although the rate of growth relative to GDP growth is falling over the period to 1980 it increases again in the 1980s and 1990s with an excess of traffic growth over GDP growth of around 0.5 percentage points per annum. There is, however, more of a break in the pattern for freight in the 1985-95 period when after a long period of an average 0.2 percentage points slower growth in freight traffic, it suddenly increased to a growth of up to 0.4 percentage points faster. This occurred during a period of relatively slow economic growth and might suggest that changes in spatial patterns of economic activity made during the previous period could not easily be altered when economic conditions were less favourable.

If we explore the pattern for other European Union countries, there are some detailed differences, but with the exception of Italy, freight traffic growth is reasonably close to GDP growth whilst all countries show a much faster overall rate of car traffic growth than GDP growth.

Figures 2 and 3 show a basic international comparison of traffic intensity, measured as road traffic levels relative to GDP. There are some obvious differences which relate to geography and the spatial structure of the various economies. Compare for example the freight figures for the US and Belgium, one a large country where we would expect to find a high level of traffic necessary to support a given level of GDP, the other a small economy where we would expect a much lower level, but in fact observe an above average level due it is expected to the large amount of transit traffic caused by Belgium's central geographical situation in Europe. This shows that it is not just domestic GDP which is a critical determinant of traffic levels.

For the EU countries, Figures 4 to 6 show the relationship between traffic intensity and GDP/capita. There is a slight but significant negative relationship observable suggesting that there may be a saturation level of traffic, similar to the saturation levels found in predicting car ownership. However, this does not imply that traffic will not continue to grow at a rate close to that of GDP, just that any excess will become smaller over time. This, however, ignores the extent to which geographical and spatial structure differences between countries may be a more important influence than any general relationship between the level of economic activity and the transport necessary to sustain it. We need to explore these links more formally before drawing any conclusions from this evidence.

A Conceptual Model of Transport and Growth

In this section we set out some of the issues which need to be addressed in building a more formal model of transport and economic growth. We shall address this in three broad sections dealing with the aggregate macroeconomics issue, the microeconomic efficiency issues and the spatial issues. First, however, we need to address some questions of definition.

Some definitions

Our aim is to assess ways in which changes in the transport sector can affect economic growth. Principally our interest is twofold, are there selective interventions in transport which can promote both the level and rate of economic growth (the competitiveness question) and is it possible to act to constrain the rate of traffic growth without harming the overall economic performance of the economy (the sustainability question)? But what do we mean by the transport sector and what are the appropriate interventions which need to be considered?

It is clear that much of the literature does confuse the issue of what is meant by the transport sector. Some studies look exclusively at infrastructure investment, others look at all public expenditure on transport (including physical investment, subsidies to operators and the direct provision of transport services). Here we include all of these, but we also need to consider the conditions under which all transport services are provided, both "public" transport (whether provided by the public or private sectors) and private transport. Regulation, direct charging for the use of infrastructure and taxation (whether or not related directly to the externalities caused by transport) are all elements in this. Since overstretched infrastructure, being used at or above its nominal capacity, is seen as the typical transport problem, it is particularly important to examine the pricing regime at which this is provided before examining the impact of infrastructure investment. Since overstretched infrastructure typically does not work at its theoretical capacity due to degradation and maintenance problems it is important also to consider this element of transport provision.

Likewise there is a tendency to concentrate on the roads problem as the infrastructure capacity problems. The public transport sector is seen more as an organisational problem, how to reduce the cost to the public sector of maintaining the minimum level of accessibility to transport consistent with an acceptable minimum level of social exclusion (what might be termed "social sustainability")? We shall look less at this

issue, but nevertheless it is important to introduce the concept of efficiency right across the transport sector with all sectors treated on the same basis. Hence we need to be aware of the extent of competition within the transport sector since this will affect the relationship of price to cost in this sub-sector and the relative prices at which different, potentially competing, services will be offered.

We are using here the generic term "interventions" to include all possible types of public policy towards transport. The underlying assumption is that various types of market failure will lead to an unregulated free market producing sub-optimal levels of transport. That sub-optimality is with respect to both the competitiveness and the sustainability question. Whatever the competitive situation and conditions of supply within any one sub-sector (e.g urban public transport, inter-city rail transport, car etc.) there will be problems of competition between sub-sectors. Thus governments will need to intervene to avoid an excessive dead-weight cost from this market failure in the transport market as a whole. Such intervention could be direct supply, of either or both infrastructure and services on that infrastructure, it could be the application of various forms of taxation or direct pricing to ensure prices perceived by users reflect adequate marginal social costs, or it could be various forms of control or regulation designed to achieve the outcome of an optimal charging system without the (political) cost and technical complexity of introducing a workable system.

It is a premise of this paper that all interventions need to be treated in an identical way, the cost and benefits calculated and the impact on the system assessed. All too often one system of appraisal and evaluation is used for additions to a road infrastructure network and an entirely different method of assessment to the introduction of second-best attempts at an optimal charging system, for example, a parking charge, or the provision of subsidy to public transport. In addition to these examples, interventions could include the restriction of access to certain roads or traffic lanes (including toll lanes or high occupancy vehicle lanes), traffic management systems (including real-time intelligent transport information systems), various combinations of fuel taxes, zonal or cordon pricing systems or full marginal social cost (electronic road pricing) charging.

Transport and growth: the aggregate approach

The aggregate approach to transport and growth is to treat transport as a variable in the overall determination of economic growth. There are three basic ways in which transport can fit into a typical growth model: as investment and productivity enhancement, as a contributor to market integration and as an endogenous contribution to total factor productivity.

Investment and productivity: the Aschauer debate

The direct investment approach is the most familiar and has been the subject of much debate over the past decade following the contribution of Aschauer (see Aschauer, 1989, for an initial description and Munnell, 1992, Gramlich, 1994 and Transportation Research Board, 1997, for good reviews of the subsequent debate). Essentially this approach takes the main contribution of infrastructure as a direct injection into the economy, modelled as an additional factor in the aggregate production function, which has the effect both of increasing the level of economic activity and of enhancing the

productivity of private capital. This is achieved through public infrastructure acting as a public good; better roads mean more efficient firms.

The argument against public infrastructure, whether directly provided by the public sector or provided by the private sector but subsidised or guaranteed by the public sector, is that its initial impact would be to crowd out private investment by raising either or both the level of taxation and the interest rate. It was this belief which led to the downturn in public infrastructure investment in many countries in the late 1970s and early 1980s, a downturn which also caused the development of maintenance backlogs which are affecting the quality of service provided by existing infrastructure today.

What Aschauer attempted to show econometrically, using a Cobb-Douglas production function with infrastructure as an additional input to labour and private capital, was that the output elasticity of the infrastructure input was so large, values of 0.4 to 0.5 were estimated, that the social rate of return would be in excess of 100% on such investment. This implied that infrastructure investment must be an important source of economic growth, which would, in the long run, more than outweigh any short-run crowding out. The attempts by governments to control public sector budgets by restricting public investment in infrastructure were thus seen as counter-productive and made the situation more difficult. By increasing public investment they could have increased economic growth which would have enhanced private sector productivity and more than paid for itself in higher long run growth levels.

This approach is open to criticism, both on econometric and methodological grounds¹. The correlations could be spurious, and the equations mis-specified. More sophisticated approaches (e.g. Lau and Sin, 1997) suggest output elasticities of the order of 0.1. There is also the problem of measuring the true value of public infrastructure, given the difficulty of measuring the true cost of capital to the public sector; if the shadow price of public investment is underestimated then the output elasticity of that capital will appear to be much higher.

This debate and the search for more refined methods of trying to measure public infrastructure capital and to capture its overall impact will clearly continue. The best that can be said with any confidence is that infrastructure investment will have a modest positive contribution on economic growth, but that the more accurately are the opportunity costs measured, the less attractive return infrastructure investment offers than other types of public investment expenditure, especially education and training to enhance human capital.

It should be noted that we have been discussing here the aggregate contribution of infrastructure to overall economic growth in a closed economy. We shall deal later with the question of how far differential investment in infrastructure can lead to changes in the relative economic performance of different regions.

Transport and market integration

Secondly, we consider the impact of transport investment on market integration at the aggregate level. By this we mean that reduced transport costs enhance export

¹ For alternative models see, for example, Ford and Poret (1991), Lynde and Richmond (1993) and, at a regional level, Duffy-Deno and Eberts (1991), Holtz-Eakin (1993), Holtz-Eakin and Schwartz (1995), Holtz-Eakin and Lovely (1996), Hulten and Schwab (1991), Munnell (1990)

opportunities and hence lead to increased output, but also introduce the threat of import competition which leads to restructuring and increasing efficiency in industry to reduce production costs. The process is analogous to that which is argued to happen as a result of the removal or reduction of tariffs or non-tariff barriers. Often the argument stops at that point, or even earlier at the recognition of increased exports without even considering the two-way impact of transport cost reductions (an issue we shall return to later). Lower transport costs may also have the effect of widening labour market areas (and the markets for other factors) leading to a reduction in factor costs.

There are, however, some important feedback effects in this system. First, there is the impact of increased production on factor markets. If there are bottlenecks in factor markets such as full employment of labour or a shortage of developable land then the impact of the attempt to increase production will be increasing factor prices and a countervailing impact on costs and hence competitiveness. The upward pressure on wages may of course induce either or both inward migration to a region or increased inward commuting. Secondly, the increase economic activity resulting from the lower transport costs leads to an increased demand for transport which can lead to congestion on the network and hence to an increase in transport costs. This is part of the argument for needing to consider induced traffic when appraising transport investments. If it is assumed that the overall level of traffic is given independently of the changes in costs in the system this could lead to an over-estimate of the benefits of a given improvement (SACTRA, 1994).

Transport and endogenous growth

The arguments so far have related to impacts on the *level* of economic activity. The final set of arguments relates to possible impacts on the *rate* of economic growth. This involves the instruction of arguments from the endogenous growth literature which says that certain changes will lead to a continuing increase in the rate of growth in the economy, rather than a shock to the system which shifts the level upwards but ultimately leads to a return to an exogenously given underlying rate of growth. This requires us to argue that improving transport has an impact on the process of industrial restructuring through the entry and exit of firms and the seeking of wider markets, on the rate of innovation and technology transfer (e.g. through the parallel improvement in flows of information) and hence on the growth of total factor productivity.

Underlying this argument is a belief that the transport-using sectors are inherently imperfectly competitive, contrary to the usual (often implicit) assumption that transport is serving essentially perfectly competitive industries. In such a case, all users of transport will be prepared to pay exactly the value of the transport service to them, the price at which transport is provided is thus a good indication of the value of transport to the economy as a whole. We shall examine the implications of this argument in more detail in the following section of the paper.

Microeconomic efficiency

The conventional assumption in evaluating transport improvements has been that the sectors using transport are perfectly competitive. This has the effect that any change in transport costs will be immediately passed through into the prices charged by these firms and hence the true value to the economy of any transport improvement is

measured directly by the willingness to pay for use of the transport system.. Thus appraisal of any transport improvement has only to measure accurately the transport demand function and these transport user benefits will be a complete and accurate measure of the full economic value (Dodgson, 1973, Jara-Diaz, 1986).

Suppose that there are firms in the transport using sector which are in imperfectly competitive markets. The key feature of such firms will be that their prices do not directly reflect costs. Imperfectly competitive firms engaged in rent seeking behaviour will thus be able to benefit from transport cost reductions without passing these benefits on to their customers, as long as this does not induce increased competition from firms in the same sector located in other regions or new entrants into the sector locally. The problem is that this behaviour is not predictable analytically.

More importantly, however, such a situation shows how firms may well have a vested interest in not seeking transport improvements since poor transport access to a market can act as a very effective barrier to competition from outside (see Hotelling, 1929, for an early graphic exposition of this effect). As long as a firm can gain sufficient scale economies within the local market there is no incentive to seek transport cost reductions. In such circumstances the benefits of a transport cost reducing measure will not be measured accurately by the transport user benefits. Since the lowering of a transport cost barrier may have the effect of increasing competition, the impact on prices may be greater than the cost reduction and hence the total benefit to consumers larger than the conventionally measured transport-user benefits. Whether this will happen, and by how much, will depend on the availability of scale economies and the ability of the local firm to maintain entry barriers in the absence of transport cost barriers.

Under various different assumptions concerning the demand elasticity facing the transport-using firm, the extent of market power, the extent of linkages and agglomeration effects, Venables and Gasiorek (1999) have shown that these benefits could be anything up to 40% of the conventionally measured benefits². Interestingly they also demonstrate that there can be circumstances, where firms in a sector are charging a price below marginal social costs, in which the conventional user benefits would overestimate the wider benefits. In such cases the transport improvement would go to support, for example, an existing subsidy, which may have been given to compensate for poor access to markets and which should clearly be removed if that access is improved.

Spatial implications

In the discussion above we have mainly considered the impact of a transport improvement on an individual region taken largely in isolation, except for its competitive position with the rest of the world in terms of export and imports. We now need to examine the possible impacts of a given change in transport provision on two or more different regions, especially in cases where there exist different conditions of supply.

² This figure is highly dependent on the assumptions made concerning demand elasticities and market power (price/cost margins), in comments on the Venables and Gasiorek work, Newbery (1999) and Davies (1999) have produced figures for the additional benefits of 2.5% and 12% respectively. Bröcker (1998c) finds a figure of 5-10% for a plausible range of values of price/cost margins.

There are three main stages in examining the spatial implications. First, we look at the competition between firms within the transport-using sector, secondly we look at the implications for the local labour markets and thirdly at the land and property markets.

Spatial competition

The spatial competition effects are best dealt with in the framework of the "new economic geography" (Krugman, 1991, 1998b). As shown above this stresses the importance of the interaction between on the one hand market size and scale economies and on the other the costs of transport. We need to add to this the conventional explanation for the concentration of economic activity, the existence of agglomeration and urbanisation externalities. Once the existence of scale economies leads to market dominance by a firm in a particular location with a growing market area, there will be forces leading to the concentration of other firms in that same location.³ The forces external to the firm but internal to the industry will include the specialisation of labour and of suppliers, training providers, providers of finance etc. - the industrial district originally identified long ago by Marshall (1920). In addition external to the industry are all the factors relating to the process of urbanisation, acting as public goods to firms, efficient local public transport, generic education and training (Glaeser, 1998).

All of these forces are essentially non-linear and non-monotonic. Thus increasing concentrations of industries lead to diseconomies or urbanisation, not just the exhaustion of economies and the increasing marginal costs of providing additional services, but also other disbenefits which arise with larger urban areas, such as crime, environmental degradation etc. These lead to ambiguities in the impact of a transport improvement on the relative performance of different regions (see Venables and Gasiorek, 1999). Where scale economies dominate, any reduction in transport costs may lead to a concentration of economic activity in larger core regions up to the point where diseconomies from agglomeration set in. If one region has lower input costs (e.g. wages or rents), which compensate for a lack of scale economies, then deconcentration rather than concentration may occur.

However, large changes in transport costs may produce indeterminate effects and this is the real insight of this approach. The existence of U-shaped relationships from the interaction of the various factors can mean that a given reduction in transport costs at one level of such costs or with one level of scale economies can produce completely different overall impacts on the distribution of economic activity from the same reduction at different initial parameter values. Thus we can observe simultaneously increasing agglomeration of industries but a decrease in concentration and regional specialisation in some economies and the reverse in others (Krugman, 1998a, Brühlhart, 1998).

The most important insight is, however, to examine the general equilibrium effects on a region, allowing for the linkages both between and within sectors, sectors which have differing needs for transport, differing degrees of competitive power and differing spatial markets. If regions are symmetrical (identical) then generally the benefits will be seen to be larger in both regions than in a simple model because of the allowance for

³ See Fujita *et al* (1999) for a full description

the linkages, although most of these increased benefits should be picked up in a standard cost-benefit model which allows for induced traffic. If the linkages between sectors are weak, however, then there is a stronger probability of agglomeration within individual sectors within one or the other region. This can lead to asymmetric effects with one region gaining at the expense of the other.

Regional impacts

Venables and Gasiorok (1999) use a simple stylised model of geography with two or three regions. Each region has two transport-using sectors, one of which typically displays imperfect competition, the other is perfectly competitive. The labour markets in each region are assumed to be perfectly competitive and to clear. The transport sector benefits from an improvement which reduces the costs of transport between the regions. We consider four cases which summarise the main types of differential regional effects of interest: the centre-periphery case; the production diversion case; the three region centre-periphery case; and the three region network case.

The centre-periphery case considers the consequences of an improvement between a large central region and a smaller more peripheral region. Such a case typically starts with a concentration of activity in the central region because of the scale economies. Except in the case of very high initial transport costs, improvements tend to reduce the output and wage differentials between the regions. There is a theoretical case for an inverse U-shaped relationship between transport costs and regional inequalities such that from a situation of very high transport costs, a reduction can initially lead to increases in inequalities as the scale economies in the central region overcome the initially prohibitive transport costs, but further reductions beyond a certain level would lead to the expected reduction in inequality. Very large reductions in transport costs from a high initial level could lead to either increases or reductions in inequality.

The production diversion case considers the case of three initially identical regions in which there is an improvement of transport between any two, but not with the third. Starting from a position where the three regions have identical levels of output and wages, the improvement between the two regions gradually concentrates more activity in these at the expense of the third with substantial wage differentials opening up. The welfare gains in the benefiting regions more than outweigh the much smaller reductions in the third region.

The three region centre-periphery case considers the case of three regions lying along a single corridor, where an improvement takes place between two of the regions, one central and the other peripheral, but not between the centre and the third region. In such a case the locational advantage of the centrally located region would have led to a greater share of regional production and higher wages at any reasonable level of transport costs. The effect of reducing transport costs between one peripheral region and the centre is to shift production towards, and increase wage rates in, that peripheral region at the expense of the other peripheral region. There is little effect on the central region. However, in this case, all regions make a welfare gain, most for the peripheral region whose transport connections are improved, rather less for the central region and less again (but still positive) for the non-connected region which clearly benefits from the overall reduction in transport costs in the network.

The three region network case considers the same geography as the previous example, but in the case where both links are improved. In this case, for similar reasons as in the previous case, both peripheral regions benefit at the expense of the centre region for which the initial dominant position is reduced. Both peripheral regions make substantial welfare gains and rather higher ratios of total benefits to transport benefits are achieved. The overall improvement in welfare from improving both links is greater than the sum of the improvements associated with each link independently as the effect is to enlarge the total market.

The overall conclusion of this consideration of geographical effects is that transport improvements may generate either increases or decreases in regional inequalities depending on their incidence on particular regions and on the initial level of transport costs. Transport improvements may be a way of reducing inequalities, but the effects do depend on other factors leading to agglomeration; stable regional industrial structures can become suddenly unstable at critical levels of transport costs. Again this suggests that there is no simple rule which can be applied to predict the regional outcomes of transport projects; the outcome will depend on a particular set of regional and sectoral circumstances. There do, however, seem to be quite strong grounds for expecting substantial effects from the development of networks, so-called super-additivity effects.

Transport and labour markets

Thus far we have assumed a neutral impact of the labour and land markets, effectively they are assumed to be in perfect competition and to adjust quickly and efficiently into equilibrium.

Transport interacts with the labour market in two major ways for our analysis. First, labour is a major input to all activities and is, in most cases, locationally specific in that it has to be physically present for the activity to take place. Secondly, transport affects labour both as an input to production (commuting), and as an input to other activities (social, leisure, etc.) which constitute the final demand for activities.

Consider a transport scheme which reduces commuting costs in an area, this could have two complementary types of response. First, there is a commuting response which causes labour markets to increase in size. As transport costs fall the search area for jobs increases and workers are prepared to make longer journeys for the same generalised cost (i.e. money price plus the cost of time spent in commuting). Labour market areas thus tend to become larger. This introduces more competition from outside a given region for jobs inside, which would have the effect of depressing wages, but also opens up opportunities in other regions to workers from within the region, which could have the effect of bidding up wages as firms seek to retain staff. The impact on unemployment and on nominal wages is thus ambiguous depending on the relative characteristics of workers and jobs in the different regions.

The impact on any one region may be ambiguous depending on the relative size of these effects, whether the region is a net importer or exporter of labour. Reductions in transport costs may be expected to lead generally to a reduction in both intra- and inter-regional variations in wage levels if labour markets are assumed to be reasonably perfect. Where there is persistent stickiness in wages this may be less true. The overall effect could be ambiguous in a way analogous to the behaviour of product markets.

Secondly, there is a migration response. The impact of lower commuting costs may cause migration into the region from those employed in other regions searching for higher real incomes due to lower house prices or improved living conditions. This increased local labour supply may also put pressure on wages and/or unemployment in the local labour markets, whilst at the same time placing upward pressure on local house prices which will have a downward impact on real wages. This may or may not outweigh any increase in nominal wages from the increased competition for local labour from outside the region. Falling real wages may lead to outmigration and counter balance the increased labour supply.

Any change in real wages may impact on firms' unit labour costs and their competitiveness which impacts on labour demand which through interaction with labour supply feeds back to nominal wages. A further feedback loop is that increased commuting may lead to congestion effects and this will reduce the benefits of the initial transport improvement. This complex set of interactions shows clearly how the actual outcome may involve a balance of different responses to any given initial change working through parallel responses in both the labour and housing markets. In particular much will depend on the degree of slack in both of these markets which will determine whether prices change rapidly or slowly.

The increased size of labour markets is a natural parallel in the input market to the normal market size effect in output markets claimed for transport improvements. This again raises a number of complex issues. First, labour markets cannot be treated independently of other markets, particularly that for housing. The housing market is known to display fairly close relationships with transport improvements and it may be that much of the potential gain is captured in the housing market rather than in the labour market. Secondly, labour markets overlap, not least in the increasing importance of the multi-worker household.

It may be that the constraints of the housing market are a more serious determinant of commuting change as a substitute for migration even in the longer term. Recent evidence for the U.K. by Cameron and Muellbauer (1998) suggests that the housing market has a strong effect on decisions to migrate between regions. High relative house prices discourage in-migration, though expectations of future house price rises may encourage it. Increasing owner occupation has reinforced this effect. Because of this, differential labour market effects in contiguous regions lead to commuting being substituted for migration, and for nearby regions there is a stronger labour market effect on commuting decisions and a stronger housing market effect on migration decisions (see also Gordon, 1975; Molho, 1982; Jackman and Savouri, 1992).

These findings are important since they suggest that improvements to transport between labour market areas may have both commuting and migration impacts which could work differently according to the existing relative states of the labour and housing markets in the regions affected. In some circumstances attempts to use transport to open up labour markets may have perverse effects if the housing market is not flexible.

The role of the land and property market

This suggests a need to look more closely at the workings of the land market. There is a long tradition of relating land values to transport costs. From the early work of von Thünen (1826) this 'trade-off' approach shows how the increased costs of access as one moves further from a market centre lead to a reduction in the price which potential users will bid for the use of land at a particular location. In equilibrium the total value of land rents in a market will equal the sum of all the transport costs such that there is a clear link between the quality of an area's transport and the total price of land.

If transport is improved, the value of land at a particular location will rise and since there is an incentive, both for individuals to move outwards looking for cheaper land and for more land to be converted to urban use at the margin, the urban area will increase in size. It is also suggested in such urban models that, if the transport costs fall faster than the costs for the use of land rise (e.g., because land can be developed at increasing densities), the overall urban cost of living will fall (i.e., real wages rise) and workers will be induced to move into the city. Thus transport improvements can be seen as an agent of urban growth. Although this is an accepted theoretical proposition, it has been difficult to produce convincing empirical evidence, in particular it is difficult to ascribe specific impacts to specific transport improvements.

Some conclusions on a conceptual model

The above discussion suggests three broad elements which are important in conceptualising the problem of the relationship between transport and economic growth: the role of imperfect competition; the importance of general equilibrium; and the need for disaggregation,

Imperfect competition is relevant in both the transport using markets and the transport providing markets. In the transport using markets the relevance is the extent to which departures of price from marginal cost (and wage levels from the value of marginal product) leads to a gap between the willingness to pay for transport and the actual price paid. This can occur both ways, where price is greater than marginal cost the likelihood is that transport improvements will have a greater value than conventionally assumed, where price is less than marginal cost they may have a smaller value. In the transport providing sector there are two elements of imperfection, one is the competitive structure of the market between different firms (both within and between modes) which again leads to prices not reflecting marginal private costs directly, the second is the problem of market failure with respect to the external effects of transport. Thus again, simply taking the observed price at which transport is sold in the market may either over or undervalue the benefits to any improvement.

Table 1 summarises the various arguments advanced in this section. It shows the way in which different possible outcomes will emerge from different combinations of market imperfections in the transport providing sector (the rows) and the transport using sector (the columns). These two effects will interact, it is conceivable that any of the nine cases identified in Table 1 may occur. The central cell, five, is the pure case assumed by conventional cost benefits analyses of transport in which all externalities in transport have been fully internalised and that transport serves perfectly competitive sectors.

Some, possibly the more likely cases, will give the uncertain outcomes in cells three (top right) and seven (bottom left).

The work of Venables and Gasiorek (1999) has demonstrated the importance of a general equilibrium framework which allows for linkages both within and between sectors. These linkages are the critical elements through which the firms' responses to a change in transport provision are transmitted. Where firms in different sectors have different degrees of competition this will produce different transmission mechanisms. The stronger the linkages, the more widespread will be the impact and thus the greater the chance of unmeasured benefits.

Within the general equilibrium approach the key role of labour markets has emerged. In the earlier work of Krugman a mobile labour force provided the adjustment mechanism by which wages and prices adjusted (e.g Krugman, 1991b). The application of such models to stickier labour markets in Europe, both within and between countries led to the development of the linkages within and between sectors as the equilibrating mechanism (see, for example, Venables, 1995). However, it is now clear that simply assuming that labour markets clear internally within a region is not an adequate explanation. In a dynamic model, the labour market forces for both temporary and permanent movement, whether or not that movement actually occurs, are string and need to be accounted for. The key issue here is the extent to which enhancements to productivity (for example, those implicit in transport time savings) are taken in increased wages or increased employment (Lee and Pesaran, 1993)

However, it is also increasingly clear that there are too many conflicting forces to be able to distinguish all these effects at an aggregate level, even at an aggregate regional level. The need for disaggregation in the evaluation of transport changes has been expressed strongly by Gramlich (1994) in his commentary on the Aschauer debate. However, it goes further than the problem of identifying the actual impact of a transport change beyond the value of the capital investment. We need to be aware of the relative sectoral and spatial impacts of a change. For example, a given transport interventions may impact very differently on different sectors according both to the overall contribution of transport to value-added and the relative location of markets; compare, for example, the cement and semi-conductor industries. However, different transport interventions designed to achieve the same end goal (for example, a comparison of a policy to introduce road pricing and one to subsidise rail transport as a second-best intervention) may have very different impacts on any one sector depending to its ability to switch modes or change market areas.

Towards the evaluation of wider economic effects

In the previous section we have reviewed at length the interactions between the different factors when there is a change in transport provision. We have shown how this is both complex, and difficult to predict, on *a priori* grounds - the final outcome both as to whether there are wider economic effects which will change the level or rate of growth of the economy and, if so, how large these are is likely to be an empirical question the answer to which will be highly case dependent. In this section we look towards ways of limiting this complexity and producing some guidance on the evaluation of the way a given project may have an impact.

First, consider the objectives of a transport sector intervention. This can have a number of differing goals: as a means of correcting imperfections within the operation of transport sector; as a means of correcting imperfections due to the external environmental impacts of the transport sector, as a means of contributing to the overall growth of the economy (at national, regional or local level); as a means of redistributing economic activity between different groups (social inclusion) or regions (cohesion).

The analysis above suggests that transport sector interventions will be much more limited in their usefulness as instruments to achieve wider economic growth or redistribution objectives than transport sector efficiency and sustainability objectives. This suggests a limited role for transport interventions as a means of achieving policy objectives in these areas. However, there could be cases where transport interventions will have impacts which need to be taken into account. There is no general rule which implies that transport investments will necessarily enhance economic growth and improve cohesion and that interventions which aim to improve environmental sustainability by raising transport prices will necessarily harm economic welfare. In this sense transport growth and economic growth appear to be able to be decoupled, but this will require a case by case analysis to examine the sectoral and spatial distribution of market imperfections in transport-using sectors.

How should such an analysis be constructed? In an ideal world detailed regional input-output information would enable us to identify both the importance of transport in the value-added of each sector and the degree of deviation of that sector's prices from marginal costs as an indicator of the degree of imperfect competition (see Harris, 1999, Davies, 1999). Such information on a multi-regional basis would also enable identification of trade flows by sector, which could then be linked to traffic flow data and a link between the transport and wider economy models established. Such data is typically not available in most countries in sufficient detail although attempts have been made to build models which do allow for regional variations in input-output relationships to model the possible impacts of transport investments (see, for example, Rietveld, 1989; Jensen-Butler and Madsen, 1996). The problem with such an approach is that the standard input-output analysis assumes fixed Leontief technical coefficients when we need to examine how firms respond to changing effective transport prices through input substitution as well as output effects

Computable general equilibrium modelling offers an approach which can deal with these factors more effectively, although typically at some greater remove from real data. Venables and Gasiorek (1999) use a computable general equilibrium model to explore the relationships discussed above and this approach has been widely used to explore the effects of changing international trade barriers (see for example, Gasiorek *et al*, 1991; Bröcker, 1998a) and increasingly to examine some of the more macroeconomic consequences of major European transport infrastructure investments (Bröcker, 1998b, c). The problem faced here is the data requirements to be able to apply such a model at a geographical scale below that for example explored by Bröcker. Calibration of the model requires correct identification of the relevant elasticities. This type of approach may, therefore, be employable only at the fairly aggregate macro-level to explore the wider effects of broad policy measures, and not at the local level to examine the impacts of individual investments or implementation of local policy. It may, however, give general guidance as to the sort of industrial or spatial structures at a regional or local level where imperfect competition could pose a significant problem,

A step by step approach is suggested. At the first stage the key issue is to identify the objective of an individual transport intervention. However, this is to assess the efficacy of the intervention in achieving its stated aim, not only projects which are claimed to have wider economic effects should be assessed against a fuller set of criteria than just the transport impacts. It is important to assess whether other projects may have wider impacts, including those which may have negative impacts on the wider economy.

Secondly, the spatial impact of the project has to be established. It is particularly important to ensure that all potentially affected regions or areas are included - too often studies are undertaken only for the immediate vicinity of a project (or for the government authority area which is responsible for the decision) and this will ignore the redistributive (two-way road) effects which the project may have.

Thirdly, the sectoral impact of the project has to be established. This is partly about traffic mix: freight or passenger, work or leisure travel etc., but also about which industries are affected; whether these are industries which have large transport costs relative to value-added and the price/cost margin in the sector. This establishes the extent to which a project may have wider impacts than just the measured transport benefits, those in columns 1 or 3 of Table 1.

It is important to note, however, that Table 1 is about the interaction between sectors, not about the definition of projects or areas. Projects or areas will typically be a weighted sum of a set of interactions which fall into different cells of Table 1. This weighting may in many cases be endogenous and thus change as a result of a project as sectors expand or contract or relocate in response to changes in transport provision, transport characteristics and competition within the sectors.

Conclusions

This paper has had the aim of summarising the arguments which can be used to link transport and economic growth and suggesting the elements of a conceptual model to address these issues. This is a complex and diverse area, which has suffered from misunderstanding on the nature of the relationships involved and a failure in policy terms to make the right linkages between policy instruments and policy objectives.

The main conclusion we can draw from this review is that conventional evaluation tools do run the risk of mis-estimating the total economic benefits from transport interventions of all types, but that these mis-estimates could be either over- or under-estimates of the true situation. Whilst there are cases where wider benefits can be identified than those which would be produced by a conventional transport cost-benefit analysis, there are also circumstances where this may not be the case, and even ones where the conventional approach may fail to identify real economic costs from an intervention.

For policy this has a number of important implications. First, much more care is needed to define the conditions surrounding a particular project, whether an investment or a traffic restraint or pricing measure, there is no general formula which can be applied. Secondly, it is equally clear that any intervention which enhances transport provision or

its conditions of supply does not automatically guarantee an increase in economic growth and that any restraint measure does not automatically impede economic growth. It is just as possible that socially optimal pricing of transport increases efficiency and promotes reorganisation within the transport sector sufficiently to enhance the rate of economic growth as would the provision of additional infrastructure. Thirdly, whilst there is an argument that improving transport would tend to reduce the barriers behind which inefficiency and imperfect competition can be defended, it also seems likely that using transport alone to improve competition in the economy as a whole (particularly in a developed economy with a high level of transport provision) would be an expensive option.

References

- Aschauer, D.A., 1989, Is Public Expenditure Productive?, *Journal of Monetary Economics*, **23**, 177-200
- Bröcker, J. 1998a, How would an EU-membership of the Visegrad countries affect Europe's economic geography, *Annals of Regional Science*, **32**, 91-114
- Bröcker, J. 1998b, Spatial effects of trans-European networks: preliminary results from a spatial computable general equilibrium analysis, *Diskussionsbeiträge aus dem Institut für Wirtschaft und Verkehr, Nr 4/98*, Technische Universität, Dresden
- Bröcker, J. 1998c, Spatial effects of transport infrastructure: the role of market structure, *Diskussionsbeiträge aus dem Institut für Wirtschaft und Verkehr, Nr 5/98*, Technische Universität, Dresden
- Brülhart, M, 1998, Economic Geography, Industry Location and Trade: The Evidence, *The World Economy*, **21**, 775-802.
- Cameron, G and Muellbauer, J, 1998, *The Housing Market and Regional Commuting and Migration Choices*, CEPR Discussion Paper 1945.
- Davies, S.W. 1999, Review of the Incidence of Imperfect Competition in the UK, in SACTRA., *The Welfare Implications of Transport Improvements in the Presence of Market Failure, Part 2* DETR, London
- Dodgson, J, 1974, Motorway investment, industrial transport costs and sub-regional growth, *Regional Studies*, **8**, 75-80
- Duffy-Deno, KT, and Eberts, RW, 1991, 'Public Infrastructure and Regional Economic Development: A Simultaneous Equations Approach', *Journal of Urban Economics*, **30**, 329-343
- Ford, R, and Poret, P, 1991, 'Infrastructure and Private Sector Productivity', *OECD Economic Studies*, 17.
- Fujita, M., Krugman, P. and Venables, A. 1999, *The Spatial Economy*, MIT Press, Cambridge, Mass.
- Gasiorek, M., Smith, A. and Venables, A., 1991, Completing the internal market in the EC: factor demands and comparative advantage, in Winters, L.A, and Venables, A. eds. *European Integration: Trade and Industry*, Cambridge UP
- Glaeser, E. 1998, Are cities dying?, *Journal of Economic Perspectives*, **12**, 139-60.
- Gordon, I, 1975, Employment and housing streams in British inter-regional migration, *Scottish Journal of Political Economy*, **22**, 161-177.
- Gramlich, E. 1994, Infrastructure Investment: A Review Essay, *Journal of Economic Literature*, **32**, 1176-1196.

Harris, RID, 1999, Incidence of Imperfect Competition in UK Sectors and Regions, in SACTRA, *The Welfare Implications of Transport Improvements in the Presence of Market Failure Part 2*, DETR, London

Holtz-Eakin, D, 1993, State Specific Estimates of State and Local Government Capital, *Regional Science and Urban Economics*, **23**, 185-210

Holtz-Eakin, D and Lovely, ME, 1996, Scale Economies, Returns to Variety and the Productivity of Public Infrastructure, *Regional Science and Urban Economics*, **26**, 105-123

Holtz-Eakin, D and Schwartz, A, 1995, Infrastructure in a structural model of economic growth, *Regional Science and Urban Economics*, **25**, 131-151.

Hotelling, H, 1929, Stability in competition, *Economic Journal*, **39**, 41-57.

Hulten, C, and Schwab, R, 1991, Public Capital Formation and the Growth of Regional Manufacturing Industries, *National Tax Journal*, **44**, 121-134

Jackman, R, and Savouri, S, 1992, Regional Migration versus Regional Commuting: The Identification of Housing and Employment Flows, *Scottish Journal of Political Economy*, **39** 272-87

Jara-Diaz, S.R. 1986, On the relations between users' benefits and the economic effects of transportation activities, *Journal of Regional Science*, **26**, 379-391

Jensen-Butler, C. and Madsen, B. 1996, Modelling the regional economic effects of the Danish Great Belt Link, *Papers in Regional Science*, **75**, 1-21

Krugman, P. 1991a, *Geography and Trade*, MIT Press, Cambridge, Mass

Krugman, P, 1991b, Increasing returns and economic geography, *Journal of Political Economy* **99**, 183-199

Krugman, P, 1998a, Space: the Final Frontier, *Journal of Economic Perspectives*, **12**, 161-174

Krugman, P, 1998b, What's New about the New Economic Geography? *Oxford Review of Economic Policy* **14(2)**, 71-17

Lau, S.H.P. and Sin, C.Y. 1997, Public Infrastructure and Economic Growth: Time Series Properties and Evidence, *Economic Record*, **73**, 125-135

Lee, K.C. and Pesaran, M.H. 1993, The Role of Sectoral Interactions in Wage Determination in the UK Economy, *Economic Journal*, **103**, 21-55

Lynde, C. and Richmond, J. 1993, Public Capital and Long Run Costs in UK Manufacturing, *Economic Journal*, **103**, 880-993

Marshall, A. 1920, *Principles of Economics* 8th ed., Macmillan, London

Molho, I, 1982, Contiguity and Inter-Regional Migration Flows in Great Britain, *Scottish Journal of Political Economy*, **29**, 283-297

Munnell, A.H. 1990, How does Public Infrastructure affect Regional Economic Performance?, in Munnell, A.H. (ed.) *Is there a shortfall in public capital investment*, Conference Series 34, Federal Reserve Bank of Boston.

Munnell, A.H. 1992, Infrastructure investment and economic growth, *Journal of Economic Perspectives*, **6**, 189-198

Newbery, DM, 1999, *Measuring the Indirect Benefits of Transport Costs Reductions*, report for ME&P, Cambridge (available from HETA, DETR, London).

Rietveld, P. 1989, Infrastructures and regional development, *Annals of Regional Science*, **23**, 255-274

Standing Advisory Committee on *Trunk Road Assessment, 1994, Trunk Roads and the Generation of Traffic*, HMSO, London.

Transportation Research Board, 1997, *Macroeconomic Analysis of the Linkages between Transportation Investments and Economic Performance*, NCHRP Report No. 389, Washington DC: National Academy Press.

Venables, A., 1995, Equilibrium locations of vertically linked industries, *International Economic Review*, **37**, 341-359

Venables, A, and Gasiorek, M, 1999, *The Welfare Implications of Transport Improvements in the Presence of Market Failure Part 1*, SACTRA, DETR, London.

von Thünen, JH, 1826, *Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie*, Hamburg.

Table 1 The Interaction of Imperfect Competition and External Costs on the Evaluation of Transport Projects			
	Transport-Using Sector		
Transport Sector	p < mc (pmb > smb) <i>subsidies</i>	p = mc (pmb = smb) <i>perfect competition</i>	p > mc (pmb < smb) <i>imperfect competition</i>
p < lrmsc <i>adverse externalities congestion user charges too low</i>	Cell One: B < 1 Negative external effects exacerbated by overvalued output in transport-using sector; may be substantial benefits from reducing use	Cell Two: B < 1 Traditional external effects case; no offset from transport- using sector; conventional CBA overestimates total economic benefits.	Cell Three: B = ? Transport and transport-using sector benefits are of opposite sign. CBA is appropriate in transport sector if adjusted to allow for externalities but not on implications of imperfect markets.
p = lrmsc <i>non externalities optimal capacity user charges correct</i>	Cell Four: B < 1 Subsidy to transport-using sector means total economic benefits < transport benefits Conventional CBA overestimates the value of transport improvements.	Cell Five: B = 1 No market failure. Economic benefits equal transport benefits; conventional CBA fully adequate.	Cell Six: B > 1 Extra output in transport-using sector and job creation in assisted areas; total economic benefits exceed transport benefits.
p > lrmsc <i>positive externalities spare capacity user charges too high</i>	Cell Seven: B = ?; Transport benefits and transport-using sector benefits are of opposite sign for conventional CBA. Indeterminate case.	Cell Eight: B > 1 No market failure in transport-using sector; standard case for expanding transport usage by reducing user charges.	Cell Nine: B > 1 Spare capacity in the transport sector and transport benefits understate total economic benefits; reduction in user charges may give big welfare gains.
<p><i>Notes.</i> B is expected value of total benefits relative to those measured by a conventional transport CBA pmb = private marginal benefit; mc = marginal cost; smb = social marginal benefit; lrmsc = long run marginal social cost; p = price</p>			

Source: Amended from SACTRA (1999), Table 4.2

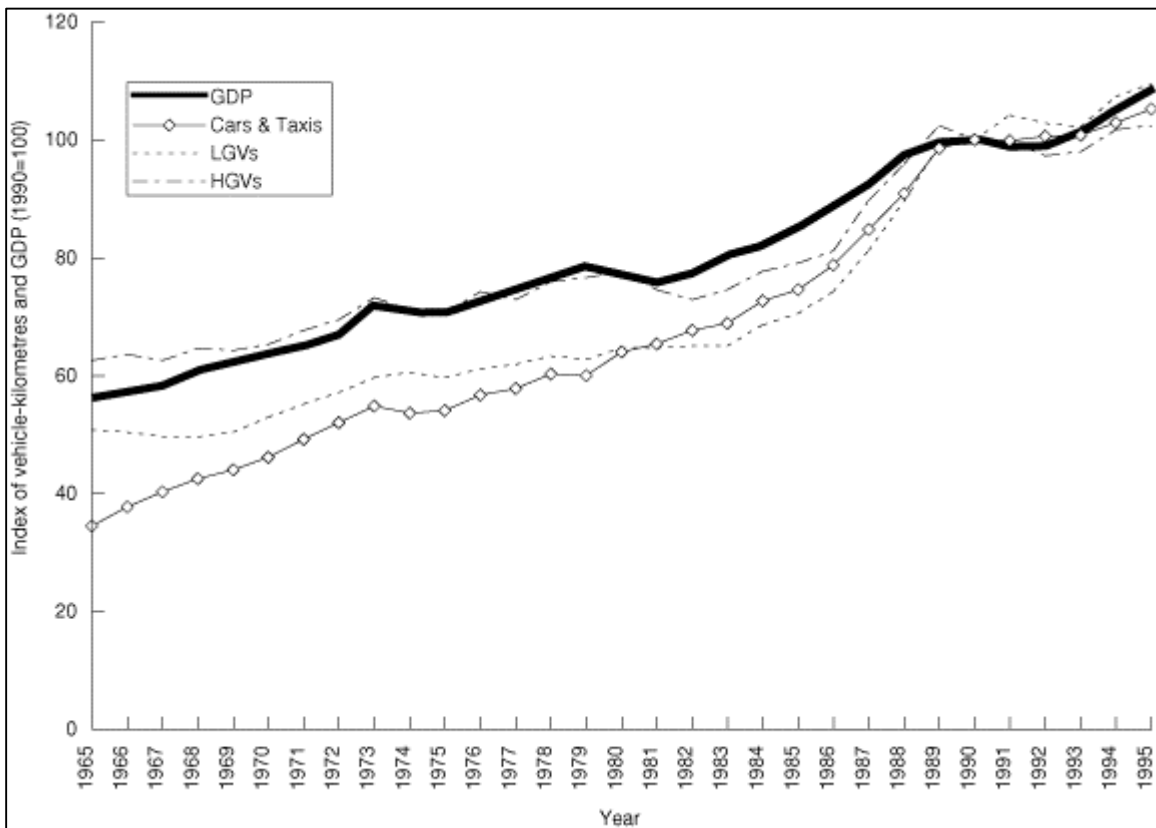
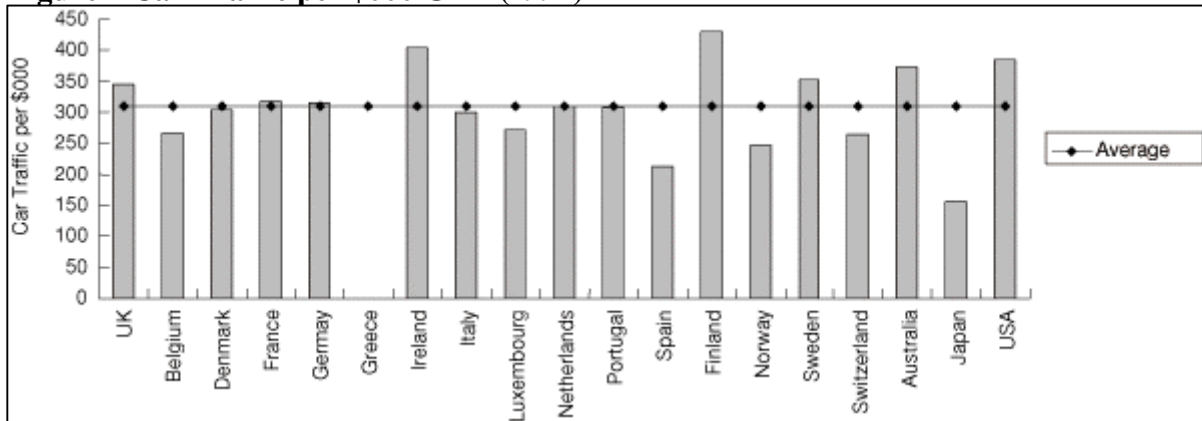


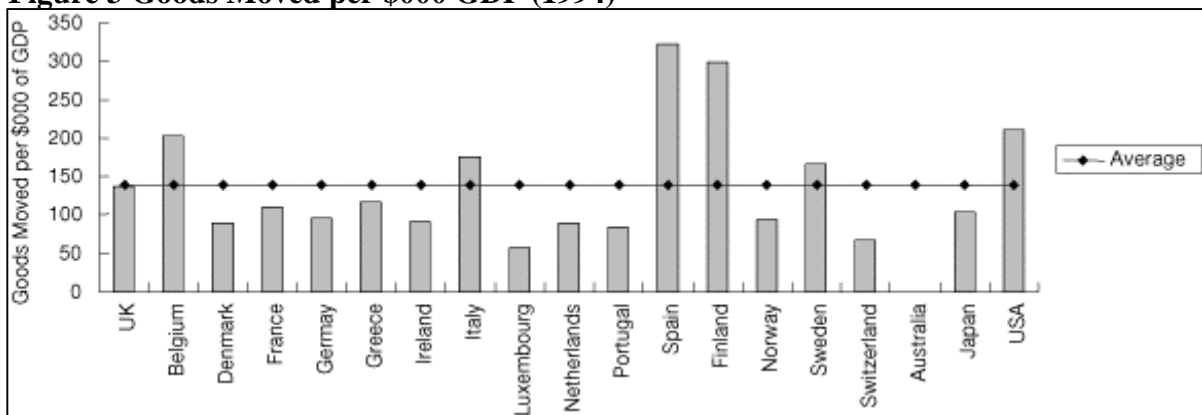
Figure 1 Road Traffic and GDP: UK 1965-95
Source: *Transport Statistics Great Britain 1997*

Figure 2 Car Traffic per \$000 GDP (1994)



Source: National Road Traffic Forecast (GB) 1997, Transport Statistics Great Britain 1997

Figure 3 Goods Moved per \$000 GDP (1994)



Source: National Road Traffic Forecast (GB) 1997, Transport Statistics Great Britain 1997

Figure 4 Car Traffic Intensity by GDP per capita

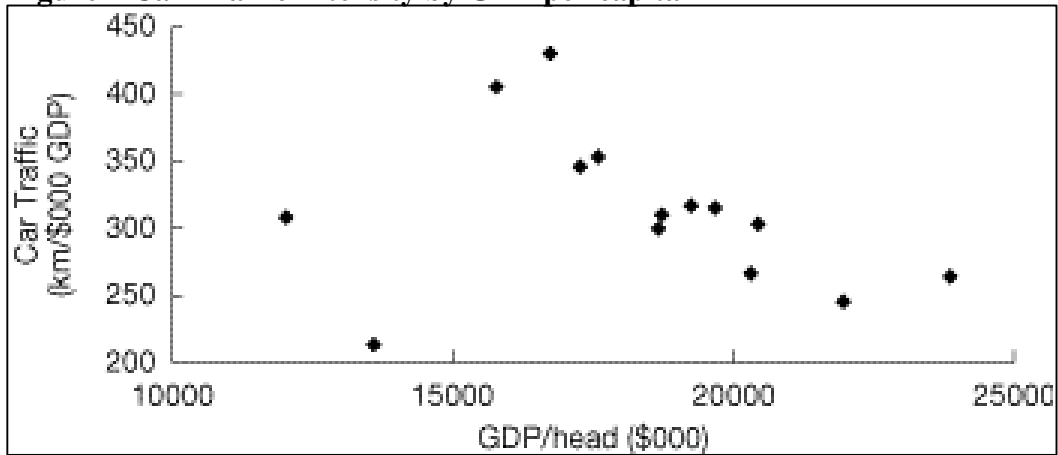


Figure 5 All Passenger Traffic Intensity by GDP per capita

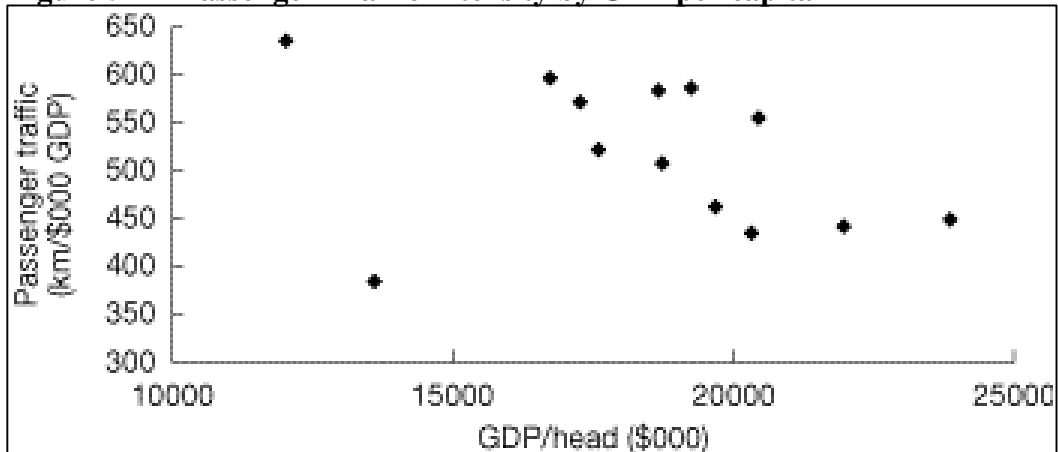


Figure 6 Freight Traffic Intensity by GDP per capita

