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TRANSPORT POLICY AND PROPERTY VALUES

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Abstract

New transport infrastructure may increase residential property values due to improved accessibility and increase commercial property values due to improved accessibility and possible agglomeration benefits. Classic urban location theory states that lower transport costs will result in higher land and property values. Theoretical parameters limit this relationship to an individual piece of transport infrastructure in a monocentric city but what if there are several transport modes and access is shifted relatively in the city or sub-region as a whole? In such cases the potential for redistribution of land and property values is a key issue.

Research at the University of the West of England, Bristol, UK is determining whether there is a relationship between investment in transport infrastructure and land and property values. Current research is establishing a methodology that will attempt to identify a relationship between accessibility and land and property value. In doing so it will be necessary to look for a relationship at the city/region level and at the local level. This will capture any relative shifts in values across the city/region as well as any absolute shifts in values near the transport improvement itself.

This paper presents the findings of the review of literature relating to infrastructure investment, property value and land use change. Specifically the review considers the emerging transport framework and its potential impact on the property market. It examines the classical theories of the relationship between the location of urban land uses and values, and provides a critique of empirical urban rent and price determination studies with an emphasis on studies of transport influences on property values.

The paper will then outline the methodology of a study devised to link an urban rent determination model to an accessibility model. This will test whether there is a relationship between land and property values and changes in accessibility caused by transport infrastructure improvements, and whether it is robust enough to handle changes in accessibility patterns.

1. Introduction

Congestion and unreliability of journeys add to the costs of business, undermining competitiveness particularly in towns and cities. The Confederation of British Industry has put the cost to the British economy at around £15 billion every year, some estimates are lower but agree that the cost to the nation runs into billions of pounds every year and is rising. More than four-fifths of domestic freight tonnage goes by road. Domestically, the convenience of the car is eroded by congestion and driving is increasingly stressful. On the busiest roads in cities journey times in the rush hour could lengthen dramatically, by as much as 70% over the next 20 years. Already in outer London one-fifth of the time taken to make a journey during rush hours is spent stationary. In central London, at any time of the day, drivers face the prospect of spending a third of their journey at a standstill (DETR, 1998).

Transport and environmental policy in the European Union and within the UK is increasingly concerned with the harmful effects of traffic. Investment in public transport is being promoted as a means of tackling traffic congestion. Stringent controls, on motor cars in particular, are also being proposed and implemented. In the UK, for example, these controls include the exclusion of cars from certain streets and areas, road pricing and taxation of workplace parking. The benefits of such schemes are measured in terms of the environmental improvements that will accrue: reduction in air pollution, noise, vibration and visual intrusion, increased pedestrian safety and potential financial redistribution towards public transport. But the vitality and viability of urban areas are based on having high levels of accessibility. Accessibility is a key determinant in the location decisions for a range of land uses. What will be the effect on the economic vitality of urban areas, measured using property values and land use change data, if levels of accessibility are altered?

In response to the Transport White Paper (DETR, 1998), the RICS (1998) commented that transportation networks have a major impact on land uses and land values. In particular, increased accessibility leads to higher land values and therefore car parking becomes a less viable option for town centre space. With the introduction of road pricing in urban centres, areas outside a ‘priced’ zone may become more attractive and increase in value. Policies may increase congestion in areas where it is less easily handled and therefore reduce values. The RICS suggested that it is vital to recognise the significance of transport and its effect on land use and property values if development opportunities on previously developed land are to be maximised. It is argued, therefore, that the economic impact of public transport investment is usefully measured by monitoring property values and land use change over a period of time.

There is growing interest then among policy-makers in how public transport policy and the general rise in traffic congestion may affect property values by altering the pattern of accessibility in terms of transport mode, infrastructure provision and cost. A key issue is whether the accessibility and agglomeration benefits from public transport investment outweigh the accessibility that is lost due to increasing restraint on other modes of transport. These benefits are measured in terms of property values and land use change. Restrictions in private motor transport must be implemented in parallel with investment in public transport in order to maintain levels of accessibility.

The aim of this research is to determine whether a change in the pattern of accessibility due to transport policy impacts on land use and property values. This paper presents the findings of a literature review undertaken as part of the research project and is structured as follows. Section two reviews the classical theories of the relationship between urban location of land uses and rent. Section three provides a critique of empirical studies of urban rent and price determination with particular emphasis on studies of transport influences on property value. Section four examines the extent to which geographical analysis techniques have been used to help model the relationship between accessibility and property value and suggests the key methodological issues for a study of transport policy and property values. This section is followed by some concluding comments.

2. Classical theories of urban location and rent

Consideration of the relationship between the location of urban land uses and rent began in earnest at the beginning of the twentieth century. Hurd (1903) applied the theory of economic competition among farmers for agricultural land, developed by Adam Smith, David Ricardo and Johann von Thunen, to businesses in an urban area. Hurd attempted to explain the cause of different land values within an urban area and suggested that "since value depends on economic rent, and rent on location and location on convenience, and convenience on nearness, we may eliminate the intermediate steps and

say that value depends on nearness." Theoretically, in a monocentric urban area, the centre is where transport facilities maximise labour availability, customer flow and proximate linkages (Kivell, 1993) and therefore attracts the highest values and rents.

Haig (1926) suggested that "rent appears as the charge which the owner of a relatively accessible site can impose because of the saving in transport costs which the use of the site makes possible." His theory emphasised the correlation between rent and transport costs, the latter being the payment to overcome the 'friction of space'; the better the transport network, the less the friction. The theoretically perfect site for an activity is that which offers the desired degree of accessibility at the lowest costs of friction. Haig's hypothesis was therefore "...the layout of a metropolis ... tends to be determined by a principle which may be termed the minimising of the costs of friction" (Haig, 1926).

Haig's hypothesis concentrated on the cost-side of profit maximisation. Some land uses such as retail are able to derive a revenue-generating advantage from certain sites, particularly those most accessible to customers. Therefore, the revenue-generating potential of a site must be weighed against the costs of friction for these land uses. "In a free economy, the correct location of the individual enterprise lies where the net profit is greatest" (Losch, 1954). Thus classic theories posit that spatial variation in cost and revenue determines the optimum profit maximising location (Dunse *et al*, 1998). In attempting to quantify spatial variation in rent Alonso's general theory of land rent (Alonso, 1964) asserted that rents decline outward from the CBD to offset declining revenue-earning ability and higher costs such as transport. Rent gradients emerge consisting of a series of bid-rents for each land use where the steepest gradient prevails. This competitive bidding between perfectly informed landlords and occupiers within a simplified market allocates sites to their optimum use.

The classic economic theories of urban land use and value have been criticised by a number of authors, primarily due to their simplifying assumptions and the influence of modern working practice and living habits. These criticisms are summarised below:

- a change in income level or distribution or a change in the spatial pattern of consumer demand will cause a change in urban land values and the pattern of uses;
- a change in transport costs will have a greater effect on those uses that depend more heavily on transport;
- the theories have no regard for land use interdependence, sometimes referred to as complementarity between neighbouring land uses;
- a change in land use is long term because of the long life of buildings, lease contracts, neighbourhood effects, expectations and uncertainty. Consequently, adjustments in supply and demand towards an equilibrium are slow;
- no uniform plane - geographical and economic factors, rank size, proximity to other centres, history, favoured areas, cultural dispositions, existence of publicly owned land and ethnic mix all distort the perfect market assumption;
- the theories unrealistically assume a free market with no intervention and perfectly informed market players;
- owners of property have monopoly power due to heterogeneity of property;
- the theories ignore spillover effects such as the filtering of land uses and property types.

The emergence of greater locational flexibility as a result of increased car use, lower transport costs and better information and communications technology meant that, in the 1960's, the classic economic approach to explaining land use allocation, growth and pricing was challenged; see Meier (1962) for example. Yet, despite these shortcomings, the classical theories retain a logical appeal that is difficult to counter.

The relationship between urban location and rent is thus seen as an increasingly complex one. Land supply in the centre is limited and competition increases rents. At a certain size and level of transport provision, diseconomies of scale set in and lead to congestion. Other influences include planning, declining importance of manufacturing, rising administrative employment and more multi-regional and multi-national organisations. These influences, together with disadvantages of city centre locations such as congestion, parking, high rents and taxes, have led to decentralisation. But despite predictions that decentralisation would continue at an increasing rate, there has not been a wholesale abandonment of the city centre. The need for face-to-face contact with clients or complementary

activities remains crucial to many businesses and economies of concentration, agglomeration and complementarity can outweigh the problems associated with general accessibility in the city centre.

In summary, as Henneberry (1998) points out, the relationship between accessibility, property values and land use patterns preoccupied early theorists. Travel costs, it was suggested, were traded off against rents and population densities, from the CBD to suburbs of a monocentric city. The CBD has declined as the predominant location of employment and services in the modern city because accessibility is now heavily car-dependent and peripheral centres of activity have grown. In short, accessibility has become a more complicated phenomenon requiring more sophisticated treatment and it is important to study accessibility more rigorously in order to understand the locational advantages of individual properties rather than rely on traditional bid-rent theory that places the peak rent contour in the CBD. For example, if the relative transport costs of a site were reduced (either directly via a transport subsidy or indirectly via an increase in accessibility due to public transport investment) this will result in increased demand, leading to a rise in land and property values. If the changes in value are substantial enough they may trigger property investment and development, causing a change in or intensification of land use (Henneberry, 1998). Property values and land use change data are therefore good proxies for occupier demand in response to changes in accessibility.

3. Hedonic analysis of transport influences on property values

"It has long been recognised that the provision of public infrastructure has a profound influence on the pattern of urban development and the spatial distribution of urban real estate values" (Damm *et al* 1980). Empirically, the impact of changes in accessibility on property values, prices and yields may be measured using hedonic pricing models (HPM). This section considers studies that have used HPM to assess the impact of transport influences on property values.

In HPM multiple regression analysis is used to derive a mathematical relationship between the value of a property and its locational, physical, legal and economic attributes. It is the favoured technique for empirical studies of urban rent determination in general and the impact of transport investment on property values in particular. Central to most built environment decisions are issues regarding proximity, neighbourhoods, accessibility, separation and complementarity. These issues and, in particular, their effect on property values are usually handled using neighbourhood and distance variables in rent determination studies. The inclusion of sophisticated proximity variables appears to be increasingly popular as technology becomes available by which to calculate the values easily, such as Geographical Information Systems (GIS). Recently, distance mapping, network and gravity modelling represent more sophisticated techniques for handling locational influences on property value. In many of the HPM studies neighbourhood factors and access variables emerged as powerful determinants of price.

Dunse and Jones (1998) highlight the limitations of hedonic price modelling. Many HPM studies assume that the hedonic prices are the same across markets and property types. But different attributes are valued differently when combined with other attributes. For example, parking is more valuable in the CBD. Also HPM studies that have attempted to quantify the influence that various property attributes have on value reveals consistently higher explanatory powers when regressing residential property variables than is the case for office property. This may be partly due to the fact that office rental values are standardised with respect to size (rent per unit area is adopted as the dependent variable), whereas capital values are used in many residential models and one (or more) of the independent variables either directly measures or acts as a proxy for size. The size variable can be expected to contribute significantly to the explanatory power of the model. For example, Hoesli *et al* (1997) examined the rental values of residential apartments in Bordeaux and concluded "most of the explanatory power for the different variables results from the surface area component."

In the 1920's Spengler (in Damm *et al* 1980) examined assessed land (as opposed to property) values from the early 20th century near most of the rail routes in New York at that time and concluded that:

- the new routes shift values rather than increase aggregate land value and tend to increase land value in the centre at expense of periphery (probably due to the radial nature of the network)
- rail routes are one of many factors influencing land values and thus may be outweighed by other factors that depress land values

- existing urban areas tend not to show a marked increase in land value when new routes are opened. Similarly, an area already served by rail routes will show only a small increase in land value if another route is added
- in developing areas with a rail route increased land values are due largely to subdivision rather than increased accessibility.

Many of the studies discussed below that examine the effect on property values of changes in transport infrastructure largely confirm the findings of Spengler's analysis of land values.

A study of property values following the opening of the Victoria Line in London in 1969 by Wacher (1971) estimated that values in the catchment area of the line had increased between one and five per cent compared to properties outside the catchment, although this result needs to be put into the context of general price increases of over ten per cent per annum at that time. In Philadelphia Allen and Boyce (1974) the impact of the Lindenwold High Speed Line on residential property values was confirmed using sales data for the corridor through which the line passed.

Dewees (1976) examined residential sale prices to isolate the relationship between land values and transport facilities in Toronto. The study focused on changes in relative values along and perpendicular to a particular street by simulating door-to-door access costs before and after construction of a subway. The main effect was an increased rent gradient near the subway stations. The study differed from many by modelling price effects around a subway station rather than the distance to the CBD. Dewees remarked that the higher the price paid for land, the more capital will be applied to it – increasing its productivity and intensity of use, and thus increasing the gradient in the centre and flattening it on the periphery. Further, polycentric cities will distort the neat cone-shaped rent surface into one with smaller peaks on the periphery where suburban centres are located. Dewees also drew attention to the possible effects of a multi-modal transport model. When modelling the effect on property values of a new subway station, the impact will be reduced if say half of the residents do not use the subway. This will manifest in a shallower slope near the station. Dewees (1976) argued that "proper definition of accessibility requires that the transportation performance of all modes be expressed in dollars per mile, based on the many characteristics of each mode."

Multiple regression analysis was used to study the effect of the opening of the Bay Area Rapid Transit (BART) in San Francisco on property values (Dvett *et al*, 1979). Independent variables included proximity to BART stations and tracks, parking and proximity to freeways, schools and parks. A small but significant positive effect on the value of single family dwellings at three of the six stations studied was found.

Damm *et al* (1980) examined the response of residential and retail property values in anticipation of the development of a rail transit system. No analysis was undertaken to determine whether property values shifted as a result of the Metro development. This was reasoned by the fact that potentially large increases in value for a relatively small number of properties near the stations would be outweighed by negligible decreases in value for the remaining substantial majority of properties. Consequently, aggregate property value for the urban area would remain unchanged and intra-urban shifts would be virtually undetectable unless an enormous sample of real estate transactions was collected. Damm's study used cross-sectional data spanning 1969-76. The results showed that the distance to the nearest Metro station was a statistically significant determinant of the transaction price; the greater the distance the lower the value and the distance effect seemed to decline quite rapidly. The effect was more pronounced for retail property. The effect of opening date of a particular station had a substantial effect. Damm *et al* (1980) suggested that further analysis should be undertaken to determine whether the anticipatory effect on values continued. Also it would be useful to examine the effect on values of different modes of transport such as light rail, buses and conventional heavy rail networks (see Dewees, 1976 *op cit*). Damm *et al* drew attention to the combined nature of urban investment programmes. Transport improvements may be part of a comprehensive (re)development and identifying implicit price effects of one element of the investment programme is difficult. The authors also suggest that as well as examining changes in property value, changes in land use pattern should also be studied. If, as empirical evidence suggests, retail values rise faster than residential values, there will be pressure for land use change near transport nodes.

In Glasgow the underground system was modernised between 1977 and 1980 and the mainline railway under the city opened in 1979 to link the north west and south east rail corridors. The Glasgow Rail Impact Study (Martin Vorhees Associates *et al*, 1982) found evidence of a positive effect on house

prices since 1978 in those areas associated with the new rail services. Bajic (1983) examined the impact of the Spadina Subway Line on Toronto house values. The change in transportation infrastructure was treated as a change in the locational attributes that serve as proxies for accessibility to employment centres in a hedonic pricing model. The study concentrated on work trips and concluded that direct savings from transport improvements had been capitalised into house values.

Pickett and Perrett (1984) studied the effect of the then new Tyne & Wear Metro on residential properties in districts through which the lines pass. The aim of the study was to determine whether improved accessibility due to public transport investment in the area had any effect on residential property values. They found that there was an average increase of 1.7% in values of properties near to the Metro stations during the two months either side of the date on which each section of the line opened. Methodology suffered from small sample size and use of valuations rather than actual sale prices. A follow-up study using transaction data found no relationship between house price rises between 1984 and 1987 and the Metro system (CURDS *et al*, 1990). However, the timing of this later study may have been too late to capture possible increases in prices because the Metro opened in 1980. Also, the study used sale prices aggregated to postcode sector level.

Laakso (1992) conducted an empirical study of the impact of various factors on residential house prices in Helsinki using an hedonic price model. Particular attention was given to the effect of the new metro rail system. The study used cross-sectional data from three years, 1980, 1985 and 1989, one before and two after the metro became operational. The results showed that time distance to the city centre and proximity to metro stations had a significant impact on the market price of dwellings. Also in Europe, Walmsley and Perrett (1992) reported that there was no detectable difference between house prices near to and far from the Metro in Marseilles in the first year of opening. A similar finding was reported for Nantes.

In their literature review, Gatzlaff and Smith (1993) argued that previous studies of the impact of rail improvements on property values suggest that they only play an indirect role in urban revitalisation and were best targeted at areas with land availability, are attractive for development and have favourable planning policies. The greatest impact is in the CBD but again “only if coordinated with other public investments and incentives, and in areas with available land and a demand for space.” Where transport improvements occur in existing urban areas (most these days) and / or follow existing routes of a previous network, the benefits are difficult to isolate and therefore hard to measure. Gatzlaff and Smith argue that there is little consensus in the literature about the effect on house prices of rail investment largely due to city-specific factors, the long term nature of the effects but the short term nature of the studies. It would appear though that transit is most successful when developed in dense corridors and coordinated with other land use policies. Public transport routes have a much greater effect on values when an alternative road transport network does not exist.

Gatzlaff and Smith (1993) examined the impact of the redevelopment of the Miami Metrorail system on the values of residential properties proximate to its stations. As a study area Miami is unusual because it lacks a large CBD and its rapid development was orientated around the car as a transport mode. The results revealed only weak influence of the announcement of the redeveloped system on residential values. Also there was no discernible variation with distance from the station. There was a variation across neighbourhood types with the greatest effect in higher-prices neighbourhoods. Investment in the Metrorail did not lead to significant regeneration of neighbourhoods. As with previous studies it would appear that transport investment should be part of a larger package. The development of a Metrorail seems to have had only a marginal impact on residential property values in a decentralised city like Miami, “indicating that the system has had little effect on accessibility.”

In Manchester, UK Forrest *et al* (1997) examined the relationship between the availability of commuter rail services and the pattern of house prices in an urban area. HPM was used to identify price differentials between properties with good access to rail services on the new Metrolink routes or existing rail routes and those that do not, before and after the opening of the Metrolink service. The results suggested that house prices increase with distance from the CBD. This rather counter-intuitive effect is probably due to the fact that plot size was not recorded and plot size increases further away from the CBD. An alternative explanation was that residents are willing to pay more to escape problems associated with living in a city centre. The results also revealed that proximity to stations tends to lower property price. Forrest *et al* explain this result by associating location in the railway corridors with older (and therefore less valuable) neighbourhoods. The attractive areas of the city have shifted away from these neighbourhoods. The authors argue that their result thus raises a problem with

the hedonic method. They argue that Damm *et al*, who found a positive association between house prices and proximity to new or projected stations, may exaggerate the benefits of the line because the "stops are not located randomly as they would need to be to secure unbiased estimates." Instead the stops are positioned at locations that are themselves currently attractive areas or are planned for regeneration, usually in conjunction with the new transport infrastructure. Consequently, as Forrest *et al* argue, "observed residential price differentials may give the verdict of the housing market not on the transit line *per se* but on the advantages of living near all the amenities associated with the route of the transit line." Similarly, Henneberry (1998) refers to the diminishing returns that set in when a locality, already served by transport facilities receives new transport investment. Clearly the effect on land and property values will be less than if such investment was made in a locality that had little or no transport infrastructure (cf. Victorian railway building). Laakso's (1992) study also suffers from this problem. Laakso, who studied the effect of the Helsinki Metro on house prices, created models for three years – the first of which was before the metro opened. By failing to include a variable that measured distance to the non-existent metro in this first year, the apparent advantages of living near the metro in the latter two years may be the result of being proximate to locations that are attractive enough to warrant metro stations. Forrest *et al* conclude by saying that the Metrolink in Manchester was an upgrading scheme, developed on brownfield land. Further hedonic analysis undertaken once the service is well established may reveal a switch to positive influence on house prices. This would be similar to the result of Bajic (1983) and represents a longitudinal solution to this problem of 'historical collinearity'.

So *et al* (1997) argued that changes to the transport infrastructure will alter the implicit prices paid for housing attributes – it will not be a linear effect on the accessibility attribute alone. Also, the effect that each attribute may have on value may change over space, for example, valuation of accessibility tends to depend on income level but so does the valuation of environmental quality. They examined the importance of transport on house prices in Hong Kong. To control for various internal attributes and environmental characteristics a sample was chosen for hedonic analysis that comprised households with similar locational characteristics and income levels. Transport accessibility was measured as distance to nearest stop on the mass transit railway (MTR) bus or minibus route. Also, walking time was measured and dummy variables represented dwellings with greater or less than 10 minutes walk from a transport node. The results revealed an insignificant explanatory power for bus routes, but this may be due to the fact that the analysis did not include frequency of service. Accessibility to minibuses emerges as the most influential effect on house prices. A number of the variables in the analysis were correlated, such as floor level and view quality. But also the main variables under consideration (accessibility to MTR, bus and minibus stops) would be correlated because in many cases they may be co-located with one another and with other variables such as shopping centres and sports facilities.

Henneberry (1998) examined the effect of the development of the Sheffield Supertram on residential property values. It was therefore an urban area already served by a transport infrastructure. Hedonic analysis was used to control for other influences on value. Henneberry conducted before and after studies using asking prices as the dependent variable because of their availability, together with physical details and addresses. No price adjustment was made in respect of time because the study was cross-sectional over three snapshot years. The sample was stratified using areas defined by local estate agents for marketing purposes. The main variable under scrutiny was distance from tram route. A GIS was used to measure distances from tram routes and stops to individual dwellings. The results suggested that "anticipation of the construction of the Supertram acted to reduce house prices… On completion of the Supertram, the negative impact has disappeared. However, the analysis of prices was undertaken only four months after the full opening of the system. It may take much longer for the benefits of Supertram to be fully appreciated by homeowners." Also there was no fine-grained contouring of price effects near the tram stops. A uniform price effect was evident and limited to nearby properties. This may have been due to data deficiencies – the number of houses on market in any one year was not sufficient to reveal such detailed price differences.

Chau and Ng (1998) suggested that improvements in public transport links between urban and suburban areas normally result in decentralisation of population. This may affect the price gradient of properties along the transport route. There may be two effects: decline in price gradient as prices in suburban areas rise relative to those in urban areas due to increased demand for suburban residential accommodation. Alternatively the price gradient may increase as population density rises and environmental quality falls in suburban locations. To examine these issues a study was undertaken of the price effects in the two areas connected by the Kowloon-Canton Railway (KCR) before and after it was electrified in 1983. The study focused on the price gradient for residential properties along the route by comparing relative transaction prices of residential properties at two stations on the KCR route

before and after electrification. To control for other factors relatively homogeneous samples were constructed and an HPM was used to 'control' the effects of other price influences that were entered as variables. The results suggested that the electrification of the KCR reduced the price gradient but it took time for the relative price levels to stabilise due to peoples' expectation and adaptation to change. Chau and Ng concluded that an improvement in public transport provision reduces transportation costs measured in terms of commuting time and this results in a reduction in the price gradient along the route. The study was however limited to price data from one residential apartment block at each of the two stations and provides little information on the geographical extent of price changes.

Finally, Chesterton plc (1999) were commissioned by London Transport to undertake a study of the impact of the Jubilee Line Extension on property values. The study, which is ongoing[1], will assess whether there has been a rise in values due to increased accessibility and whether this leads to a change in the nature and scale of development activity and intensity. As with other studies, the improvement in accessibility is assumed but because of the non-substitutability between car and public transport in London this is probably acceptable. The methodology set out in the scoping study accounts for different economic and physical characteristics around each station as reflected in land use and values. It does this by being flexible in the delineation of data collection areas around each station. The study also attempts to look at significant influencing factors such as other transport improvements, regeneration initiatives and changes in market perceptions. It is a before-and-after study that will capture immediate and longer term impacts using an hedonic price model.

In summary, most of the literature relates to the assessment of the impact of a single piece of infrastructure development or improvement (often a rapid transit system) on the values of owner-occupied single family residences. There has been relatively little research into the effect on commercial property values. The identified effect of transport infrastructure on house prices was generally small and the impact of rail-based transport systems on property values is very localised and contextual (Henneberry, 1998). Early studies mapped accessibility using Euclidean distance from the CBD under the monocentric city assumption. Later studies used network models that more accurately reflected movement in an urban area. Cost associated with accessibility has been measured using distance and travel time as proxies. An assumption of many studies is that there is an absolute increase in accessibility as a result of a single new piece of transport infrastructure. The studies then attempt to determine whether this improvement in accessibility has translated to an increase in land and property values. Very few studies tested whether there had been an absolute improvement in accessibility or whether there had been a modal shift as, relatively, other modes of transport became more efficient in terms of capacity loading. To achieve this, a comprehensive definition of accessibility requires transport performance of all modes to be incorporated into the model. Many studies focused on one mode only. The length of the study should also be long enough to cover the period before any possible effect, any anticipatory period and post opening periods - both short and long term.

4. Transport networks and property values: a methodology

The central aim of the research is to determine whether there is a quantifiable relationship between investment in public transport infrastructure, land and property values and land use change that is sufficiently robust to handle significant changes in accessibility patterns.

Figure 1 provides an illustration of the methodology. There is an underlying assumption in much of the previous research that new infrastructure does improve accessibility. In this context a number of the studies concentrate on identifying the impacts on the property market and but make no attempt to quantify the actual changes in accessibility that the new infrastructure has brought about. The assumption of improved accessibility needs to be tested and this requires a multi-mode transport accessibility model to test for shifts in accessibility across transport modes. The output from the transport accessibility model (generalised transport costs or accessibility indices) can then be tested for correlation with property values. It could be, for example, that new infrastructure has led to shifts in property values but that the actual changes in accessibility have been marginal. Thus it might be concluded that the changes are due to other factors such as environmental impact or change in image rather than any real change in the levels of accessibility. A more sophisticated measure of accessibility is therefore required.

[1] The results of stage 1 of the study (analysis of the property market prior to the opening of the JLE) is due to be published at the end of May 2001 and Stage 2 (analysis of the property market after the opening of the JLE) is just starting.

A GIS can provide more accurate distance measures by using the actual transport network rather than straight-line distance and by assigning various impedances to traversal along sections of the network. GIS can provide spatial statistical analysis capability such as tests and corrections for spatial autocorrelation (Clapp *et al,* 1997).

Despite the above the predominant use of GIS and geographical analysis in hedonic modelling of property values has been limited to the display of resultant values or residual errors and the measurement of Euclidean distances for proximity variables. For example, Des Rosiers and Theriault (1992) used GIS to display the results of a regression analysis using 'isovalue' curves and a three dimensional representation of the value distribution. In another study Longley, Higgs *et al,* (1994) used GIS to display deviations between predicted house values and council tax assessments. In a mass appraisal study by McClusky *et al* (1997) the application of GIS was limited to a visual analysis of the pattern of predicted values. Location was handled in the MRA model by specifying 'ward group' as a variable by which comparables are selected and their values adjusted. Bible and Cheng-Ho (1996) used a GIS to generate distance variables (to work, schools, shopping malls, etc.) in a study of apartment rents.

Recently, more sophisticated use of geographical analysis has been evident. For example, Rodriguez *et al* (1995) used a shortest path algorithm to calculate the route along the road network between each property and the central area. More sophisticated models have used generalised travel cost which includes impedance, stops and other barriers to flow. Recent work has utilised the network analysis capabilities of GIS to examine the relationship between accessibility and value.

Wyatt (1997) sought to correlate 'locational' values of shops with an 'accessibility' index. The methodology used expert system heuristics to select comparable properties from a database by asking a series of questions about the subject property. The values of the comparables are adjusted to account for all physical differences between them and the subject property. Value maps displayed values that have been reconciled for all differences except those attributable to location. A network model was devised to test for correlation between the accessible locations and high value areas displayed on the value maps. The network was constructed using a GIS and comprised road centre-lines and pedestrian routes. Movement along the network was influenced by link impedance, which refers to the cost associated with traversing the network in either direction and was based on connectivity, impedance, demand, barriers, turns, centres and capacity. The accessibility index value of a property on the network is an aggregate measure of how reachable it is from other properties. A gravity model that assumes that the effect of one location on another is directly proportional to its attractiveness and inversely proportional to its distance was used to calculate the index values. A variety of impedance and distance decay functions were used to evaluate the optimum correlation coefficient between accessibility and locational value. A relatively simple log-linear model that distinguished vehicular and pedestrian routes performed well and there was a significant positive correlation between locational value and accessibility. Wyatt (1999) found that two influences in particular were found to affect the accessibility calculated using the network model. These were the configuration of the route network and the impedance for traversal along the routes. This has obvious implications for transport planning and its consequent effect on property values.

Desyllas (1998) undertook a similar study but used a regression model rather than an expert system to adjust for non-locational factors. Desyllas studied office rents in Berlin between 1991 and 1997. MRA was used to derive a residual figure for the amount of rent not explained by non-locational factors, what Desyllas terms 'location rent'. These residuals were plotted using a GIS and non-random patterns emerged. To model and predict location rent, a spatial variable that correlates with the pattern of residuals is required. Desyllas (1998) suggests that "one approach to finding an independent variable is to model the street system as a network and calculate accessibility values based on the relationship between individual streets and the configuration of the system as a whole." Desyllas' suggestion for a location variable is based on the hypothesis that the spatial pattern of rents in an urban area correlated with the spatial pattern of streets. As Desyllas states "when many individual firms make complex location decisions based on accessibility to specific places important to their business, the pattern of demand that emerges mirrors the general configurational structure of the street grid."

The methodological issues that will need to be considered are:

?? Whether more then one mode of transport should be considered in order to capture modal split and changes in travel patterns that public transport investment may cause. For example, the

Jubilee Line Extension (JLE) study, whilst clearly being one of the most rigorous carried out in the UK, may not have universal application. London is different to most other towns and cities in the UK because the principal competitors to the Underground are alternative types of public transport. Consequently, the JLE study may not detect any significant modal shift, especially between car and public transport.

?? The key issue of the availability of comparative data over a period of time in order to measure accessibility, values, land use change and intensity of use. Such data needs to be consistent over time. For example, the 'before' value of the land or property affected by the infrastructure is vital information. Clearly, a site which is landlocked or which has a very poor level of accessibility (and thus low value) will benefit greatly from new infrastructure. However an area that already has high land value (perhaps due to very good car accessibility) may benefit only marginally or may even suffer if its current level of public transport accessibility is improved at the expense of accessibility by car.

?? Many previous studies use refer to land and property values in the same context. In reality it is very difficult to obtain land prices or values because transactions are infrequent in comparison to commercial and residential properties. Therefore it may be more productive to focus on latter. It may also be more objective to use sale prices, yields and agreed rents rather than valuations such as asking prices, quoted rents and rateable values. For example, rateable values are an estimate of price and are likely to prove insensitive to variations in factors such as accessibility in the short to medium term and over small geographical areas. Price per unit of area should be used because the effect of subdivision on land price will mean that purchasers will pay more per unit area in the centre than on the periphery because bigger plots are bought further out.

?? Whether the exercise be conducted at the local level and city/regional scales in order to (a) capture agglomeration and network effects (such as a relative shift in property values across urban areas from, say, city centre to periphery) as well as any absolute shifts in values near the transport improvement itself, and (b) establish a control for other influences that may affect property values. The approach will also need to consider geographical differences in the magnitude of influence of public transport on property values. For example, an effect in London and the South East may not be comparable with the effect in rest of the UK.

?? The need to establish a time series study so that value effects resulting from anticipation of transport development and the actual outcomes in terms of property value and land use change can be monitored. Perception of benefits may differ from actual benefits so property values may not react rationally within the time period expected. Landowners will seek to maximise the return from land by allocating to it the highest and best use. Thus, shifts in levels of accessibility may be measured not just in terms of value, but also in terms of land use change and intensity of use. Land use change surveys will therefore be important. Alternative early indicators of land use change are planning applications, records of building regulations approvals and the rate of re-investment in or renewal of a property. Measurement of land use change (as a proxy for occupier demand) will help identify possible distortions in property values over the short term. The approach will also consider the range of land uses to be monitored in order to control for historical collinearity. A distinction may have to be drawn between studying the effects on property values of major public transport infrastructure developments and more gradual changes in accessibility due to introduction of measures such as bus-lanes, park-and-ride schemes and traffic-calming.

5. Conclusions

So *et al* (1997) argue that the influence of transport on property values depends on four factors; the availability of transport, transport costs, travel time and the convenience of transport modes. Most of the literature in this area relates to the assessment of the impact of a single piece of infrastructure (often a rapid transit system) on property values. Early studies mapped accessibility using Euclidean distance from the CBD under the monocentric city assumption. Later studies used network models that more accurately reflected movement in an urban area. Cost associated with accessibility has been measured using distance and travel time as proxies but more sophisticated models have used generalised travel cost which includes impedance, stops, etc.

The literature review findings suggest that a study of the impact of transport policy on property values should begin with a test for evidence of improvement or shifts in accessibility and should:

- ?? Consider more than one form of transport in order to capture modal split and shift
- ?? Consider more than one land use in order to capture land use change and control for historical collinearity
- ?? Be longitudinal rather than cross-sectional so that value effects resulting from anticipation and reality can be monitored
- ?? Be conducted at intra-urban and regional scales in order to capture agglomeration and network effects (such as a relative shift in property values across an urban area from say city centre to periphery)
- ?? Use a combination of area dummy variables and proximity variables; the former due to the fact that the effect of some variables may differ depending on location (for example a higher premium might be paid for parking in the city centre than on the edge of town) and the latter due to their superior explanatory power
- ?? Control for the effect that size has on the explanatory power of residential property values.

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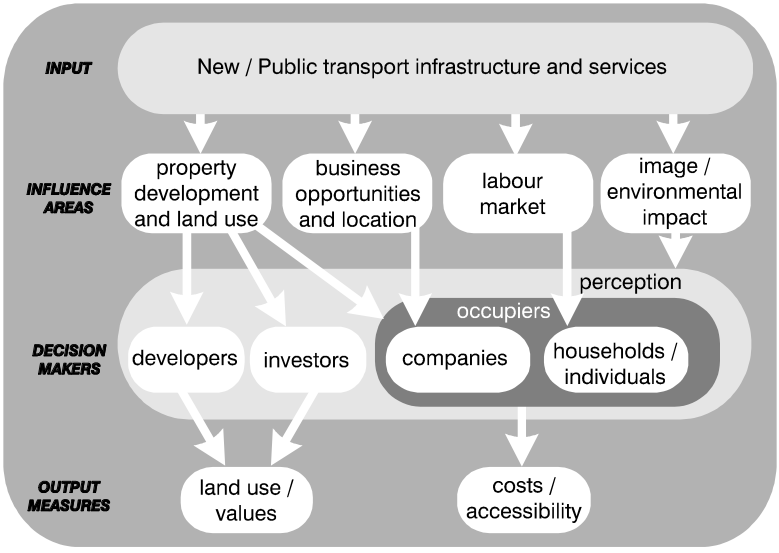

Figure 1 - Methodology