Valuing School Quality, Better Transport and Lower Crime: Evidence from House Prices

Stephen Gibbons* and Stephen Machin**

December 2007

* *Department of Geography and Environment, Centre for the Economics of Education and Centre for Economic Performance, London School of Economics*

** *Department of Economics, University College London, Centre for the Economics of Education and Centre for Economic Performance, London School of Economics*

Acknowledgements

We would like to thank Brett Day, John Muellbauer, and participants in the Oxford Review of Economic Policy Housing Markets Seminar at Saïd Business School on 12 September 2007, for a number of helpful comments.

Abstract

Housing prices within urban areas exhibit highly localised variation that cannot be explained solely by differences in the physical attributes of dwellings. We consider the role of local amenities and disamenities in generating price variation within urban areas, focussing on three highly policy-relevant urban issues - transport accessibility, school quality and crime. Our survey of the recent empirical literature highlights what is known and what is not known on these issues, and considers the relevance and reliability of this evidence for policy design and evaluation. Although there are serious empirical challenges, we argue that research on housing values based on careful research designs can offer credible estimates of the social value of place-specific attributes and amenities.

Key words: House prices, transport, school quality, crime

JEL codes: R21, H4

1. Introduction

Macroeconomic models of the housing market highlight the role of national or regional-level fundamentals in driving housing supply and demand. At the sub-regional level, New Economic Geography and urban economic models can explain other broad housing price gradients (see other papers in this volume). But at the sub-regional and sub-metropolitan level there is much highly localised variation that is not easily explained through either of these frameworks, nor by simple differences in physical housing quality.

These points are illustrated in Figure 1, which maps house price contours for the Greater London region in 2001. The Figure contains three panels. In the top panel, the map has been drawn by 'smoothing' the prices of houses geographically so that we can pick out the kind of broad mono-centric land value pattern that is consistent with the simplest urban economics models: land prices rise towards the centre of the city (albeit to the west of where we would usually place London's central business district) because central city locations are most highly valued by business, and because residences here provides the lowest-cost access to centrally located jobs and amenities. But the second panel focuses in on much more localised price variation (by reducing the degree of 'smoothing' applied to the data in producing the map) and it is clear that there is a lot going in here in terms of intra metropolitan price variation that requires other explanations. Part of this localised variation can be put down to local differences in housing quality – but not all: The third panel adjusts for observable differences in housing size and type, and strong local patterns remain.

In this paper we consider what factors drive these micro-geographic price patterns and what policy-relevant information they contain. Localised variation in housing prices is linked to the desirability of location, but the vector of relevant choice attributes is high dimensional. A diverse range of factors has received some empirical attention: some rather specific examples include water accessibility and water quality, views, local churches, and the availability of local retail outlets. To narrow down the range of enquiry, we focus on evidence of the role of local public amenities and

disamenities - in particular the key drivers of transport accessibility, school quality and crime - and in turn consider what information these patterns reveal about the demand for accessibility, school quality and other neighbourhood attributes.

There is good reason to focus on the house price premia attached to these three factors. Transport, schools and crime are three of the most talked about urban problems, and a proper focus of attention for urban researchers. The issue which has attracted most research attention to date and for which the research agenda has advanced furthest, is the capitalisation of school quality in housing prices. The perennial interest in this question stems from its relevance to the social valuation of school quality, because of its journalistic value, and because it has been assumed (probably based on the US experience, and research momentum) that schools are one of the main factors determining residential decisions of families. Moreover, data availability and institutional arrangements mean that schooling lends itself nicely to this line of enquiry, as we shall see in due course.

Encouragingly, recent estimates, in a range of international contexts, have converged towards something of a consensus on the contribution of schools to housing prices. Even so, it has to be said that schools seem, *a priori*, to be unlikely objects of preference to many home buyers[1] and that an even more important determinant of house price variation must be accessibility to employment (and to consumption opportunities), which in many large metropolitan zones in the UK means accessibility to the public transport network. Research on this question also has a long history, but solutions to the empirical challenges are harder to come by and the answers provided by the literature are more varied. Although everyone would recognise that crime matters for neighbourhood quality and for housing values, there are relatively few studies that take on this empirical challenge. We look briefly at what answers exist in the literature and consider ways potential forward towards answering this question.

[1] Though see Hilber and Mayer (2004) for a discussion why even those without children might care about school quality.

In the remainder of this paper, we first outline the theoretical background to the use of housing expenditures in eliciting the prices of, or willingness to pay for, local amenities. We then go on to explain the challenges in empirical implementation and the direction in which applied work has moved in terms of addressing these challenges. Next we review the recent UK and international evidence on the influence of schools, transport and crime on housing prices. Finally, we conclude by discussing the potential policy applications of this evidence, in terms of education transport and criminal justice policy, and in terms of housing policy.

2. Theoretical background and empirical challenges

Regression-based property value models based on micro-house price or geographically disaggregated data are most easily interpreted as simple reduced-form models that try to estimate how changes in property characteristics and neighbourhood attributes affect housing sales prices in local markets. The hedonic framework of Rosen (1974) provides a rigorous theoretical grounding, and underpins the use of these models for eliciting willingness to pay, with potential application in cost-benefit analysis and other policy-related areas.

Estimation of the structural demand and supply parameters in the Rosen model presents a formidable challenge which has met with little success over the years. In what follows, we outline these issues, but do not dwell at length on them. Our main focus is on estimates of equilibrium prices of component attributes in housing models. There are empirical challenges even in this less ambitious project. Most notably, the full range of relevant housing characteristics and neighbourhood attributes are never observed by econometricians, meaning that estimates are plagued by standard omitted variables and endogeneity problems. We briefly explain the methods that have been used in recent literature to try to circumvent these problems and tease out causal relationships.

2.1. The structural 'hedonic' model

The idea of using land values to value "place" has a very long history and it is quite easy to grasp the intuition that the value of a piece of land reveals something about the demand for the location of that land. Less obvious, is what we can learn when each place provides a wide range of commodities of different types – related to the environment, schooling, labour market, accessibility etc. – and we are interested in the value consumers place on each of these commodities separately. Just to muddy the waters further, pure land values are rarely observed. Instead, the underlying value of place needs to be disentangled from the overall expenditure on whatever structure has been built on it.

This problem can be approached from a purely statistical angle – using multiple regression analysis to separate out housing expenditures into various components associated with the characteristics of the house and its location. However, most economic research prefers to draw on theoretical work relating to the demand and supply of composite goods – in particular the work of Rosen (1974) is often cited – to underpin what could otherwise be rather shaky economic foundations. The Rosen model describes a market equilibrium in which consumer choice over a composite good – like housing – amounts to choosing an optimum bundle of commodities – like house size, local school quality and transport access.

The first, and most widely used insight, is that in equilibrium, for a given consumer preferences and income, the marginal benefit of improving any one part of that bundle (e.g. by finding a bigger house) must be offset by the utility costs of the additional expenditure involved. This straightaway provides a rationale for using the expenditure on a house to monetise the benefits of its observable attributes: if we can estimate how much housing expenditures change with marginal changes in one attribute (holding the others fixed), then we can interpret this as the marginal willingness to pay for that attribute – or its 'implicit price'. The locus that traces out the relationship between housing expenditures and the quantities of its composite attributes has become known as the 'hedonic' price function.

The second insight from the theory is that buyers in this kind of market are very heterogeneous in their preferences and income, as are sellers. This heterogeneity means that the price of any particular housing attribute is not unique even in single housing market. For instance, the 'price' associated with an improvement in school quality may be low in areas of the market where school quality is generally bad, because buyers and sellers here place little value on school quality (e.g. if buyers do not have children). Conversely, the price of school quality in high-quality areas may be very high, because buyers in this area of the market are willing to pay heavily for marginal improvements in their children's academic achievements. In other words, the 'hedonic' price function can be highly non-linear, with implicit prices that vary over the distribution of housing and neighbourhood characteristics. What anchors the slope and shape of this relationship is the relative number (or density) of consumers (buyers) and suppliers (sellers, property developers) in different parts of the market (Epple, 1987).

Other factors influencing the supply of attributes will also interact with characteristics in the hedonic price function, especially alternative sources of supply for the commodities embodied in housing location. For example, it seems natural that the price of high quality private education might cap willingness to pay for state school quality via the housing market (Nechyba 2000). Similarly, if there is a lot of choice and competition amongst good local state schools, conditional on where a person lives, then housing prices might be very unresponsive to inter-school differences in quality within the choice set. The issues are ones we will return to when we look at empirical evidence on the value of schooling.

So, it turns out that if we can estimate the hedonic price function correctly – that is estimate the equilibrium relationship between housing expenditures and all the component attributes of housing an its location – then we can calculate the implicit prices of all these attributes. Referring back to the 'statistical' approach, if we can estimate the hedonic price function using some (possibly non-linear) regression of housing expenditures on housing attributes, then the implicit price can be calculated as the estimated derivate of housing expenditures with respect to attributes.

Are these estimated 'implicit prices' useful? Indeed, if derived from a properly specified regression model they provide estimates of *marginal* willingness to pay for changes in the corresponding housing attribute. However, for welfare analysis of non-marginal policy changes one would wish to estimate the underlying consumer demand functions (or the parameters of consumer utility functions), at least for a representative consumer, and possibly for the different types of consumer in the market.

Estimation of these demand functions using estimated implicit prices is, nonetheless, often very difficult. The problem is analogous to the standard 'identification' problem of supply and demand equations in econometrics. We can observe variation in quantities of attributes (embodied in housing) and variation in the corresponding implicit prices, but this variation reveals only the equilibrium relationship between price and quantity and not the underlying demand or supply equations. In the hedonic framework, there are multiple demand equations and multiple supply equations in single market at a given point in time, representing heterogeneous preferences of consumers and heterogeneous cost structures of suppliers.

Rosen's (1974) paper proposed a two stage approach to estimate these demand functions (or inverse demand functions) and there have been many subsequent attempts to implement it. In the first step hedonic equation the implicit prices are obtained by regression of housing expenditures on housing and neighbourhood attributes. In the second stage demand equation, the implicit price estimates are regressed on the observed attributes, plus individual income and perhaps other buyer characteristics. However, since the implicit prices are simply calculated in the first stage as non-linear combinations of the observed attributes, this approach relies for identification on ad-hoc assumptions about functional form for the hedonic price function and demand function[2].

Alternatively, identification of the second stage demand functions requires some source of variation in prices and quantities that is driven only by supply shifts, and not by demand shifts, as in

[2] For instance, if the estimated hedonic price function is $m = ax + bx^2$, then the implicit price of x is $p=a+2bx$, and regression of p on x recovers the coefficient 2b.

'multiple markets' and instrumental variables approaches approach (Tauchen and Witte, 2001). Recent work by Ekeland, Heckman, Nesheim (2002, 2004) has returned to the idea of using non-linearities in the hedonic price function to allow estimation of the demand functions. Their papers show that the hedonic price function is inherently non-linear, so the old idea of recovering the implicit prices from the hedonic price function and regressing these prices on a linear demand function is not as arbitrary as it may first seem.

However, before we can even begin to get estimates of the demand functions, we need estimates of the implicit prices, and this in itself is a major challenge because of basic omitted variables and simultaneity (endogeneity) problems that plague all empirical research that is based on observed outcomes rather than experimental evidence. So, in practice, the recent focus of most applied empirical work on micro housing models – particularly when considering local public goods, neighbourhood and community attributes, including like schooling, transport and crime – has shifted away from attempting to estimate demand function parameters. Instead, the focus is on proper estimation of the equilibrium implicit prices – that is the equilibrium change in housing expenditure in response to changes in characteristics – using the kind of tools prevalent in other areas of empirical economics, particularly the research design approach prevalent in labour economics (see Card, 2006). Moreover, even though implicit prices do not provide a basis for rigorous welfare analysis of policy changes, they can inform policy and provide a useful general guide to the values of un-traded spatial commodities and locally provided public services. In the next section we discuss developments in this line of inquiry.

2.2. The equilibrium 'implicit' price approach

Setting aside estimation of the demand structure, we consider now why estimation of the implicit prices of local public goods, neighbourhood and community attributes presents such a challenge. Remember, the basic statistical approach is to regress house sales prices (i.e. the present value of housing expenditures) on housing characteristics and neighbourhood attributes. There are three fundamental and common situations under which estimation of the implicit price of local

public goods, community related amenities and other spatial goods via property value models presents the researcher with severe problems, and why incautious application of these models should come with a health warning. These situations all relate to the process of supply of spatial amenities and disamenities: 1) The supply of an amenity is partly determined by the socioeconomic composition of the community; 2) The supply of other, potentially unobservable local amenities, is correlated with the supply of the amenity in which we are interested; 3) There supply of an amenity that is accessible from a given residential location is hard to measure or uncertain

Take schools as an example. On point 1), suppose the neighbourhood characteristic of interest is the quality of the neighbourhood school represented by mean pupil test scores (assume for the moment that there is a one to one mapping between place of residence and school attended). Well, ample evidence exists that tells us that children's academic achievements are correlated with the income and income-related characteristics of their parents (Blanden and Machin, 2004; Cameron and Heckman, 1998). It is also obvious that richer families live in more desirable, high-house price neighbourhoods. Thus, and fairly obviously, we would expect children in schools located in richer, higher house price neighbourhoods to be doing better academically than children elsewhere. A correlation between house prices and school quality – measured in terms of the average achievements of pupils – will just pick up the fact that richer children on average do better at school, unless we can effectively control for *every* desirable and undesirable factor that influences housing prices and hence influences the sorting of rich and poor families into different neighbourhoods. In the US, and other places where local property taxes provide the bulk of funding for local schools, there is an even more direct link from housing prices to school quality that works through the level of public expenditure on schooling. In other words, the supply of local school quality is partly determined by the type of people who live in local houses, which in turn depends on all factors that contribute to making different places different. Similar considerations apply to crime, because local crime rates will be related to the socioeconomic status of residents and hence to housing costs, either because lower-income individuals more likely to commit property crime, or because higher-income individuals are more likely to be the target of property crime, or are more

likely to report crime (see Freeman, 1999, for a review of these issues in his survey on the economics of crime).

Continuing the schools example on point 2), it seems highly unlikely that the site of schools is randomly determined. Schools may have been sited for historical reasons close to existing residential areas, near town centres, or near other facilities – such as churches, in the case of Faith schools. Hence any measure of school accessibility which takes into account the distance between a house and, say, its nearest school could easily capture accessibility to any number of other local amenities. Taking a different example, points of transport access such as train stations are very likely to be historically associated with the location of employment centres, retail, and leisure facilities, either because the stations were located near existing facilities or because shops and other services were attracted to stations. So, a statistical link between residential house prices and proximity to rail stations may simply reveal preferences for proximity to employment, shopping and leisure opportunities rather than rail accessibility per se. In fact, a moment's reflection reveals that almost everything is closer together in the city than it is in rural areas and closer together in central city locations than in the suburbs. Hence, great care is needed to disentangle the effect of the distance of a house to one amenity from the effect of distance to any other amenity, and from urban-suburban-rural differences more generally.

The most basic and traditional way of tackling both these problems is to use multiple regression techniques to control for as many observable house price determinants as possible, and to hope that whatever price variation is left is essentially random noise. Given the wide range of housing characteristics, this approach yields unwieldy 'kitchen-sink' regressions whose specification is governed largely by data availability. The decision about what neighbourhood characteristics to include in such specifications remains largely ad-hoc and so estimates are hard to interpret. Indeed, this traditional method is not an attractive way forward if we want credible amenity prices for policy purposes.

Most recent research in this field has adopted a number of empirical strategies to try to tackle the problem in a more sophisticated manner. All of these strategies are based on isolating sources of

spatial variation in supply of a specific amenity that are uncorrelated with other determinants of housing prices. The aim is to pin down the contribution of an amenity to housing costs by measuring the statistical association of housing costs with these sources of variation. We will give examples of these methods briefly when we come to consider the evidence in the next section on the value of school quality, transport and lower crime. Such studies have employed one or more of the following:

a) Instrumental variables approaches: this well-known general method relies on finding one or more specific causes of variation in amenity supply which is, or are, otherwise unrelated to housing prices. If this assumption holds, then any correlation of housing prices with this source of variation in supply is surely due to variation in the supply of the amenity, and not to other unobserved confounding factors. In practice, it is hard to find appropriate 'instruments' for variation in transport, schools, crime or most other neighbourhood amenities and studies rarely use this method alone

b) Parametric and non-parametric modelling of unobservable factors. In traditional regression-based methods, the idea is to include a large number of observable housing and neighbourhood characteristics in the house price model. An alternative or complementary approach is to model part of the 'unobserved' spatial variation in prices directly using information on the geographical location of house sales. So, for example if there is an east-west downward trend in prices, and no observable demographic or physical characteristics explain this trend, then why not just include the geographical coordinates of the house sales (e.g. degrees of Latitude in the global geographic reference system) just as one might include a time trend in a temporal model? More generally, house price models can include polynomials or elaborate parametric functions of x and y coordinates, or use "non-parametric" statistical methods to allow very flexible price surfaces in the x-y plane. The drawback in this method is that researcher must make some judgement about when to stop in eliminating 'nuisance' spatial variation, since the most flexible of specifications would eliminate the localised variation in prices and amenities that the researcher wishes to investigate.

c) Discontinuity designs using administrative boundaries. As we have explained, the fundamental underlying problem in empirical micro housing price models is salient unobserved differences between properties that have different levels of access to amenities. But casual empiricism would suggest that close-neighbouring houses often tend to be quite similar and self-evidently have similar neighbourhood environments. So, one way to eliminate area effects in a house price model might be to work with differences between houses that are in close proximity, because the difference in price between two houses that are, say, 100 metres apart is less likely to be due to unobserved neighbourhood differences than the difference in price between two houses that are, say, 10km apart[3]. A moment's reflection tells us that the difficulty here is that neighbouring houses also have access to the same local amenities, so surely any attempt to eliminate common neighbourhood factors will eliminate the very amenity differences we want to explore? Well, there are cases where this is not the true: for example, if school admissions authorities organise admissions on the basis of rigidly defined 'catchment' areas, then two close-neighbouring properties either side of a catchment area boundary can provide access to schools of very different quality. This kind of boundary 'discontinuity' in amenity quality provides a powerful methodology for measuring the causal effect of some types of amenity on house prices, and has been used in other settings, for example when looking at the effects of local taxes on firm behaviour (Duranton et al, 2006).

d) Difference-in-difference, repeat sales and quasi-experimental methods. Methods a)-c) are appropriate for cross-sectional analyses when there are no observed changes in the supply of amenities over time. Given additional information on changes in the level of local amenities over time, there is scope for examining how the prices of individual houses, or the prices of neighbourhood clusters of houses, respond to these changes. This approach has the advantage of abstracting from differences between houses or locations that are fixed over time, but does not help

[3] This fairly common-sense observation is sometimes referred to as Tobler's first law of geography after Waldo Tobler (1970).

much if unobserved area or property characteristics are also changing over time, since these changes could be inducing price and amenity supply changes. However, coupling this approach with information on specific incidents of policy-driven changes in provision of local amenities – opening of new schools, opening of rail stations, new crime prevention strategies for example – can provide one of the most powerful 'quasi-experimental' methodologies. It is occasionally possible to combine this approach with method c), for example if school catchment area boundaries are suddenly introduced, withdrawn or re-drawn.

Returning to the last point (3) above (that the supply of an amenity at a given location is hard to measure or uncertain) the important question is how we can know what amenities are available at a specific residential location. Again consider schooling. If there is a rigidly defined system of catchment areas or attendance zones as is common in the US then the task is greatly simplified since there is a one-to-one mapping between residential location and school attended. But in the UK and elsewhere this is quite rarely the case. We can, given appropriate data, easily ascertain which schools lie close to specific property in a data set. But which of these school(s) are the right ones to consider? Is only the nearest relevant? Probably not, since many pupils do not attend their nearest school (Briggs et al 2006, Gibbons, Machin and Silva 2007). Some average of the characteristics of local schools? Possibly, but how many local schools and should nearer schools be weighted more heavily than those further away? Without clearly defined catchment areas there is inherently some ambiguity, and considerable efforts need to be made to ensure that the link between residential location and accessible schools set up in empirical analysis is a reasonable representation of the situation on the ground. Similar considerations apply in the case of rail access, since there can be more than one local station, and different stations may offer different service levels. In the case of crime and other fuzzier neighbourhood amenities and dis-amenities the situation is even worse, and any choice is bound to be somewhat arbitrary. Moreover, there are inevitably doubts about the extent to which home owners can observe local crime rates and make meaningful judgements about the expected risks at the time when they make their purchase decisions. To this extent, valuing

neighbourhood attributes like crime through property value models suffers many of the drawbacks commonly linked to the valuation of environmental air pollution.

3. Valuation of amenities: some evidence

Anecdotal evidence, media reports and even dinner party discussions all lend credence to the claim that good schools raise local house prices. But is this claim really true, and how much are home owners really willing to pay for access to good schools? In the past, US research has led the way in answering these questions, but as better data became available the field has opened up internationally. Here, we will not attempt to review all the evidence on the effects of schools on house prices, but instead highlight some of the more recent findings based on the current state of the art in terms of empirical methodology. The recent evidence is summarised in the first panel Table 1.

In the right hand "Findings" column we have reported the principal results, where possible standardised to give the percentage effect of a one-standard deviation change in school quality. We have focussed here on studies that measure 'quality' in terms of academic outcomes – usually school mean test scores, which are typically treated as a sufficient statistic for school quality. This is clearly a shortcut, since there must be certain characteristics of schools that raise standards – teaching quality, peer groups, leadership – but most papers are rather silent on identifying which of these factors matter. Looking at the summary results in the table, it can be seen that whilst there is certainly some variation in the point estimates from one study to the next, they all fall within a reasonably tight range. Although we make no attempt at a proper meta-analysis, it is worth noting that the median figure from these studies about 4%, with an inter-quartile range of 4%. This stability is remarkable considering the diverse international contexts on which the estimates are based and provides some reassurance that the methods are uncovering a fairly universal figure for the valuation of school quality, at least when standardised in terms of percentage value relative to local housing costs. In Section 2 we discussed some of the econometric challenges and solutions applied in the field and the "Methods" column outlines the techniques applies in each study.

Approaches using boundary discontinuities have proved popular in recent years, measuring house price differentials between closely spaced properties on either side of catchment area boundaries. The figures generated by this method from Australia, the US and UK tend to be very closely aligned (with one exception), providing a median figure of 3.5% and an interquartile range of just 1.3%. Other methods have, however, produced results that are not far out of line.

An obvious question to ask is whether these figures are at all plausible as monetary estimates of willingness to pay for school quality. Is there any other accompanying evidence that lends support to the idea that the regressions really detect what they claim to detect? A number of the studies have translated the capitalised values into monetary equivalents: for example, Black (1999) prices a one-standard deviation increase at around $4000 in mid-1990s Boston; our work (Gibbons and Machin (2006)) places the figure at about £9000 in London in 2004. In annualised, interest only terms, these figures do not seem unreasonable: roughly £450 per year in London, 2004 prices for our own study, when the average per-pupil spend in England's primary schools was £2750. These figures can also be benched marked against the costs and availability of private schooling, providing some complementary evidence of their validity. For example, we show (Gibbons and Machin, 2003) that payment for state schools via the housing market does not exceed private school fees for a single child in London, and Fack and Grenet (2007) come to similar conclusions for Paris, further demonstrating that local market penetration by private schools decreases the premium attracted by good state schools. By way of further cross-checking, we made some back of the envelope calculations of the implicit expected returns to primary education (Gibbons and Machin, 2001), given that parents have the option of transferring wealth directly to their children rather than paying more for their education. By our calculation from the housing market premium, parents must have judged achievement of the national target level in age-11 tests to generate earnings returns of 20-30% in the labour market, a figure that seems plausible considering that around 75% of pupils achieve that grade.

Obviously these figures are average valuations of school quality, estimated across many types of household, locality and sometimes in multiple housing markets. Many other factors will come

into play in interaction with the house price premium and some studies have highlighted some important examples. Cheshire and Sheppard (2004) focus in particular on the role of uncertainty, noting that various neighbourhood risk factors such as new building and admission rule uncertainty can generate localised variation in the schools-house price link. Hilber and Mayer (2004) and Brasington (2002) point to evidence of a possible role for land availability and housing supply in reducing the capitalisation of local amenities in housing values, though the theoretical arguments for any long run effects from housing supply are not completely clear cut. We find evidence (Gibbons and Machin, 2006), that, as one might expect, it is the most popular over-capacity schools that attract the highest premium for improvements in academic standards and that willingness to pay for school quality decreases quite rapidly with home-school distance. There are many other interesting and illuminating questions regarding attitudes to school quality and parental choice behaviour that might be answered by careful analysis of the housing market response to school quality and school admissions systems. But even with what we know so far, it is clear is that schools can generate a large amount of variation in property prices: by our estimation, a move from a weak school to a top ranking over-subscribed school was worth about £61000 in London in 2004.

Whereas there is a large academic literature on schools, much of what we know (or do not know) about the effects of rail transport on property values comes from reports by transport consultants, property consultants and others working in the real estate industry. Almost invariably, this work is based on case studies, simple cross-sectional regression estimates, or comparisons of outcomes before and after particular transport projects. A lot of the most well known work is based on the BART system in San Francisco, but there are many case studies from elsewhere in the US and around the world. Comprehensive summaries of this literature up to 2002 are available in RICS (2002), Wrigley and Wyatt (2001) and there is little else to add: the findings reported there are generally mixed, with many showing positive associations between rail access and residential rents, land values and prices, but others finding nothing or even adverse impacts.

On balance, it is difficult to be convinced by a lot of this transport-related research. Only the most basic attempt is made to attribute price differentials to pure difference in transport access,

rather than other unobserved spatial differences. Although attempts are made to separate out the accessibility benefits of transport proximity from the potential environmental costs (e.g. noise) and social costs (e.g. crime), this is not always the case. Moreover, it is always very difficult to compare or generalise the results from this diverse body of work, firstly because the results tends to be very context-specific, and secondly because many different definitions of proximity are employed without any attempt to standardise on a common metric (e.g. distance) or to convert into valuations of travel time savings.

Given the importance of accessibility in urban economic models and models of agglomeration, it is quite surprising that sound empirical analyses are fairly thin on the ground in the academic literature. Few studies really exploit changes in transport infrastructure to full advantage – in part probably because of the relative scarcity of new transport projects on which to base the analysis. There are some early exceptions, for example Dewees (1978) and Bajic (1983) both of whom look at new subway lines in Toronto. Bajic looks at how housing prices reacted to changes in commuting time, and estimates that the commuting time savings in the affected area raised prices by $2237 on average, implying a $120 valuation of the average 34 hours of time saved annually. This turns out to be about 40% of the local wage rate, which is comparable to figures for the valuation of travel time savings from the transport literature, and close to the highest of our own back of the envelope calculations based on walking time savings attributable to new Jubilee Line stations in London.

To our knowledge, our work (Gibbons and Machin 2005) is the first to evaluate properly how housing prices reacted to localized changes in accessibility using a difference-in-difference and 'quasi-experimental' approach (although Baum-Snow and Kahn (2000) carry out a similar but more aggregated analysis of transport improvements in a number of US cities in the 1980s). The study considers changes arising from the new stations built in London for the Jubilee Line Extension (JLE) and for the Docklands Light Railway (DLR) extension at the turn of the millennium. We make no attempt to evaluate the impact of these new rail links on accessibility across the whole of London, or even the entire Jubilee Line and DLR corridors, but look instead at the localised impacts

in the areas of South East London where new infrastructure had a marked effect on accessibility (see the maps in Atisreal and Geofutures, 2005, for evidence on these changes). Our approach is fairly simple: the main impact of new stations on existing residential housing is to reduce access times to the London Underground network from streets near the stations. Some streets experience no distance reduction because they already have another station that is closer; streets in the immediate vicinity experience large distance reductions. Our study attributes the house price rises associated with these distance reductions to the benefits of shorter commutes (essentially walking times) to the nearest station. Depending on the stringency of our specification we find effects ranging from around 1% to 4% on prices for each 1km reduction in station-home distance. This estimate implies a 7-20% shift in prices for a one standard deviation reduction in distance, suggesting that metro station access has an even greater part to play in determining local house prices than school quality.

Other recent studies are summarised in Table 1, but, again, some are based on cross-sectional relationships between prices and transport access, which, as our own work illustrates, may substantially overestimate the influence of rail transport accessibility. Having said that, looking at how prices react to new transport policy in the short run is not without its drawbacks: McDonald and Osuji (1995) and McMillan and McDonald (2004) argue that housing markets reacts well in advance of the time when new projects come on line because housing prices reflect the present value of the future rise in rents. If this is the case – which it will be if housing is treated as an asset rather than a consumption good – then it is necessary to compare prices over a longer time horizon, going back to before project announcement, if we are to observe the full impact of transport infrastructure changes.

Overall, there is nothing approaching consensus on the influence of transport changes on property prices. This is hardly surprising given that the value of new infrastructure or other transport policy change is likely to depend heavily on what economic opportunities the new transport gives access to, and how it is priced. The benefits of better transport are heavily context

dependent, unlike the case of schooling, which has a relatively standardised value in the wider economy.

Crime and fear of crime are self-evidently major issues in modern urban economies, and seem to be at the forefront of many peoples worries about urban life. New policy to tackle crime and anti-social behaviour is never far out of the news, and yet many decisions regarding where and on what to target resources have to made with only partial information on the social costs of crime. One way to get at the costs of crime is to derive estimates based on the direct costs reported in victimisation surveys, such as the British Crime Survey, accumulating information on loss of property, loss of earnings through incapacity, costs to the health service resulting from injury, and so on (Brand and Price 2000). Inevitably, calculations made in this miss out on many of the psychological costs associated with the real risk of being a crime victim, and the fear of crime. But just as we might expect house prices react to good schools, good transport access and good air quality, we would expect them to react fairly vigorously to local crime rates – at least if there are persistent and observable differences between places in terms of the risk of victimisation. The question is, do house prices react strongly to local crime rates, and can we then use this information to value lower crime in the same way as we can value school quality, transport accessibility and other local goods?

Only a few recent studies have attempted to provide answers, although there were one or two very early investigations (Thaler, 1978; Hellman and Naroff, 1979). Recent studies are presented in the third panel of Table 1, where it can be seen that the range of estimates is on a par with those from the school quality and rail transport literature. The challenges here are greater than in either the school or transport contexts, since disentangling the influence of crime from other neighbourhood influences is difficult. Crime recognises no boundaries that would support a geographical discontinuity design, and data limitations have, so far, made analysis of the links between changes in crime and changes in housing prices quite infeasible. In the absence of these research designs, the approach taken in Gibbons (2004) is to eliminate unobserved neighbourhood attributes as far as possible using a non-parametric modelling approach (method b outlined in Section 2.2. above), coupled with instrumental variables techniques. Surprisingly perhaps, the

results from this study indicate that a high incidence of burglary has no effect on housing prices, possibly because home buyers are not well informed of local burglary rates or can install effective security measures relatively cheaply. On the other hand, highly visible, but ostensibly more trivial offences – criminal damage, including vandalism, graffiti, arson and damage to property – seem to impose high costs on residents. A one standard deviation decrease in the incidence of these crimes has a capitalised value of around £20,000 in London at year 2000 prices. The costs imposed by crimes of this type seem high relative to their seriousness, which may mean that these crimes are taken as signals or symptoms of community instability, disorder, lack of social cohesion and neighbourhood deterioration in general.

4. Policy summary and conclusions

This section concludes with discussion of the relevance of the literature for policy along two dimensions. Firstly we assess the usefulness of the models in providing inputs into cost benefit analysis evaluation of policy. Secondly consider how the field provides insights into the influence of transport, education and criminal justice policy on housing prices, and consequences for spatial sorting and access to amenities.

The examples described in Section 3 illustrate the potentially important role that local public goods and neighbourhood attributes play as drivers of localised house price variation, of the type illustrated in the lower panel of Figure 1. What information is there here that can help policy makers? Firstly, as we have already highlighted, the implicit prices provide shadow prices of non-market goods for input into cost-benefit-style analyses, a feature that has been recognised in environmental economics since the pioneering applications of hedonic analysis to air pollution (Ridker and Henning, 1967). The reliability of using single estimates from hedonic models to value environmental goods has long been called into question (Kerry Smith and Huang, 1995), but we have demonstrated that it *is* possible to uncover stable, plausible and meaningful valuations of spatial goods from variation in the housing market, in cases – such as school quality – where robust

design strategies have been found for empirical analysis. Even in the field of air quality valuation empirical technology has moved forward since the early cross-sectional studies – see, for example, Chay and Greenstone (2005).

It is unambiguous from nearly all the literature on school quality and housing prices that people value academic quality in state schools, even if the precise source of that quality remains obscure. It is also emerging that willingness to pay through housing costs in the state sector is high, possibly on a par with fees in the private sector, which provides some benchmark as to the level of resourcing in state schools that could be socially desirable. In the field of transport project appraisal, measuring willingness to pay for better transport through the housing market should provide a useful adjunct to measures of the value of time obtained from mode choice and stated preference approaches in transport economics (for which see, for example, Mackie et al, 2001). The latter methods measure only the value of direct time savings through transport mode choice, whilst the housing market responds to much wider range of benefits (and costs) linked to better transport connectivity. There are empirical challenges in pricing crime reduction or other fuzzy neighbourhood goods – like educational and social capital (Gibbons 2003, Hilber 2007) – but there are very few other ways to really get a grasp of the social value of policy targeted at these outcomes. Future research in these areas, drawing on changing patterns of prices in relation to localised policy changes, could prove fruitful. One of the biggest obstacles remains, in the UK at least, a lack of the highly geographically detailed, time varying information on neighbourhood characteristics – including crime rates – that would make this kind of analysis feasible.

Households' willingness to pay for the goods and services provided by places within cities lies the heart of standard urban economic theory about the structure of cities and the "sorting" of different types of people into different locations. In the theory of Tiebout (1956) people face a trade off between the local taxes they have to pay for public services and the quality of local services on offer, and sort themselves into different communities accordingly. In bid-rent models of monocentric cities, it is willingness to pay for proximity to city centres that bids up land prices towards the centre of the city and sorts those who are willing to pay for central city proximity from

those who prefer more space towards the suburbs. The reaction of housing costs to local amenities is a manifestation of these processes at work. If, as has been shown, improvements in the quality of neighbourhoods and local public services influence housing costs, then these factors become important determinants of city residential structure. These linkages need to be taken seriously when designing and targeting policy aimed at neighbourhood improvement and the quality of local public services.

For example, the case of "selection by mortgage" in the school sector is well rehearsed: When admission to schools is limited to local residents, it is inevitably those who are willing to pay more for school quality that out-bid the rest in competition for local housing. And since we would expect demand for schooling to increase with income, this inevitably means it is the better educated, higher-income families that win out (assuming low-income parents cannot borrow off the back of their children's expected future educational gains!). This has clear theoretical consequences in terms of sustaining inequalities and reducing social and economic mobility across the generations. Whilst there is no direct evidence that access to schooling is a key factor, there must be suspicions that it is issues like these that have led to the apparent fall in intergenerational mobility in recent decades (see Blanden, Gregg and Machin, 2005). With this in mind, policy that seeks to break the link between place of residence and school admission seems attractive (such as the lottery systems implemented in some places in the US and proposed recently in some places in England, such as Brighton). Increasing parental choice amongst schools in this way holds the promise of eroding the linkages from school quality to local housing costs – indeed this insight has been used to differentiate between high and low competition school markets in the analysis of the impacts of school competition in the US (Bayer and McMillan 2005). However, expansion of choice along these lines – and lottery systems in particular – have their own potential problems in terms of increased journey-to-school times and a shift in the basis of 'selection' from 'mortgage' to willingness and ability to bear the transport costs.

Although we necessarily painted a rather more hazy landscape in terms of the precise valuation of transport improvements, it is certain from existing empirical analysis that there are

quite strong linkages between transport accessibility and housing values. Again, we emphasize that this has an important bearing on transport policy, both its rationale and its likely impacts. Consequently, transport policy needs to go hand in hand with housing policy if, say, it is to be effective in increasing labour supply. With inelastic supply of housing, the potential for new transport infrastructure to pull large numbers out of inactivity and into employment or to increase work hours may be very limited, because local reductions in transport costs raise housing costs and are not necessarily fed through to workers in terms of real wages in the long run. Transport policy that increases accessibility in one residential location and not others will tend to increase housing costs there, making the location more attractive to workers and less attractive to non-workers, and aggregate labour supply increases may be very limited. It is important to take these considerations into account. For instance, it is true that those without work tend to live in areas with poor access to transport and jobs. On this basis, it is often tempting to propose better transport as a policy lever for moving people back to work (SEU, 2003), without acknowledging that the housing market will tend to sort individuals who are less employable (for whatever reason) into less accessible, low housing cost residential locations. A similar theme is found in the 'environmental justice' literature, which postulates that economically disadvantaged households are disproportionately and unfairly exposed to environmental hazards (see Bowen 2002 for a survey), a situation that is unsurprising given that the housing market is likely to sort low income households into less popular places.

It is also evident, to the extent that crime (and possibly fear of crime) is capitalised into housing values, that spatially targeted crime policies can influence local house prices. The UK government has focused on some area 'place based' initiatives (like the Street Crime Initiative and the Profilic Offenders Programmes studied in Machin and Marie, 2005, 2007) which have scope to alter the spatial distribution of house prices by reducing the contribution that differences in criminal activity (like street crime and prolific offending) make to housing values.

This discussion makes it transparent that government policy links closely to some of the findings in the literature on hedonic valuation of local amenities. The ones we have focussed upon in this paper are better school quality, improved transport and lower crime, all three of which are

significant targets of government policy design and implementation, and all of which are significantly capitalised into higher local housing values. In our view, very useful policy-relevant information about the values of local goods and the variation in these values across people and places can be extracted from simple empirical house price models that pay very careful attention to basic identification issues.

5. References

Atisreal and Geofutures (2005) Property value study – Assessing the changes in value attributable to the Jubilee Line Extension, Transport for London

Armstrong, R.J. and D.A.Rodriguez (2006), An Evaluation of the Accessibility Benefits of Commuter Rail in Eastern Massachusetts Using Spatial Hedonic Price Functions, Transportation, 33, 21-43

Bajic, V (1983) The effects of a new subway line on housing prices in metropolitan Toronto, Urban Studies 20: 147–158.

Baum-Snow, N. and M. E. Kahn (2000), The Effects of New Public Projects to Expand Urban Rail Transit, Journal of Public Economics, 77, 241-263

Bayer, P. and R. McMillan (2005) Sorting and Competition in Local Education Markets, NBER Working Paper No. 11802.

Black, S.E. (1999) Do Better Schools Matter? Parental Valuation of Elementary Education, Quarterly Journal of Economics, 114: 578-599.

Blanden, J., P. Gregg and S. Machin (2005) Educational Inequality and Intergenerational Mobility, in Machin, S. and A. Vignoles (eds.) *What's the Good of Education? The Economics of Education in the United Kingdom*, Princeton University Press: Princeton.

Blanden, J. and S. Machin (2004) Educational Inequality and the Expansion of UK Higher Education, Scottish Journal of Political Economy, Special Issue on the Economics of Education, 54: 230-49.

Bogart, W.T. and B.A. Cromwell (2000) How much is a Neighbourhood School Worth?, Journal of Urban Economics, 47: 280-305

Bowes, D., and D. Ihlanfeldt (2001) Identifying the effects of rail transit stations on residential property values,' Journal of Urban Economics, 50: 1-25.

Bowen, W. (2002) An Analytical Review of Environmental Justice Research: What Do We Really Know? Environmental Management 19: 3-15

Brand, Sam and Price, Richard (2000). Home Office Research Study 217: The Economic and Social Costs of Crime, London, Home Office Research Development and Statistics Directorate

Brasington, D. (2002) Edge versus center: finding common ground in the capitalization debate, Journal of Urban Economics, 52: 524-541

Brasington, D. and D. R. Haurin (2006) Educational Outcomes and House Values: A Test of the Value Added Approach, Journal of Regional Science, 46: 245-268.

Briggs, A, S. Burgess, B. McConnell and H. Slater (2006) School choice in England: Background facts, CMPO working paper, 06/159

Cameron, S. and J. Heckman (1998) 'Life Cycle Schooling and Dynamic Selection Bias: Models and Evidence for Five Cohorts of American Males', Journal of Political Economy, 106: 262-333

Card, D. (2006) Research Design and the Practice of Labor Economics. 2006 Royal Economic Society Lecture.

Cervero, R. and J. Landis (1995) Development impacts of urban transport: a US perspective, in D. Banister (ed.) Transport and Urban Development, London, E & F.N. Spon

Cervero, R. and J. Landis (1997) Twenty Years of BART: Land Use and Development Impacts. Transportation Research A, 31: 309-333, 1997

Cheshire, P and S. Sheppard (2004) Capitalising the value of free schools: The impact of supply characteristics and uncertainty, Economic Journal, 114: F397-424

Clapp, J., A. Nanda and S. L Ross (2008), Which School Attributes Matter? The Influence of School District Performance and Demographic Composition on Property Values Journal of Urban Economics, 63: 451-466

Dewees, D.N. (1976) The effect of a subway on residential property values in Toronto, Journal of Urban Economics 3: 357–369.

Davidoff, I. And Leigh, A., (2006) How Much Do Public Schools Really Cost? Estimating the Relationship Between House Prices and School Quality, Australian National University mimeo

Duranton, G., L. Gobillon, H.G. Overman (2006), Assessing the Effects of Local Taxation Using Micro Geographic Data, London School of Economics, Centre for Economic Performance Discussion Paper CEPDP0748

Ekeland, I, J. Heckman and L. Nesheim (2002), Identifying hedonic models, American Economic Review, 92: 304-309

Ekeland, I, J. Heckman and L. Nesheim (2004) Identification and estimation of hedonic models, Journal of Political Economy, 112 (S1): S60-S109

Epple, Dennis (1987) Hedonic Prices and Implicit Markets: Estimating Demand and Supply Functions for Differentiated Products. Journal of Political Economy, 95: 59-80

Fack, G. and J. Grenet (2007) 'Do Better Schools Raise Housing Prices? Evidence from Paris School Zoning', mimeo

Figlio, D. N. and M.E.Lucas (2004), 'What's in a grade? School Report Cards and the Housing Market', American Economic Review, 94, 591-604

Freeman R (1999) The Economics of Crime. In: Ashenfelter O, Card D (eds) Handbook of Labor Economics 3C, 3529-3571 Elsevier Science, Amsterdam

Gibbons, S. (2003) Paying for Good Neighbours: Estimating the Value of an Implied Educated Community, Urban Studies, 40: 809-833

Gibbons, S. (2004) The Costs of Urban Property Crime, Economic Journal, 114: F441-F463

Gibbons, S. and S. Machin (2001) Valuing English Primary Schools, London School of Economics Centre for Economics of Education Discussion Paper CEEDP0015

Gibbons, S. and S. Machin (2003) Valuing English Primary Schools, Journal of Urban Economics, 53: 197-219

Gibbons, S. and S. Machin (2005)Valuing Rail Access Using Transport Innovations, Journal of Urban Economics, 57: 148-169

Gibbons, S. and S. Machin (2006) Paying for Primary Schools: Admissions Constraints, School Popularity or Congestion, Economic Journal, 116: C77-C92.

Gibbons, S, S. Machin, S and O. Silva, (2007) Competition, Choice and Pupil Achievement, forthcoming in the Journal of the European Economic Association

Hellman, D. A., and J. L. Naroff (1979): The impact of crime on urban residential property values, Urban Studies, 16: 105-112

Hilber, C. (2007) New housing supply and the dilution of social capital, London School of Economics, Research Papers in Environmental and Spatial Analysis No 123, August

Hilber, C. and C. J. Mayer (2004) Why Do Households Without Children Support Local Public Schools?, NBER Working Paper w10804

J.F. McDonald, C.I. Osuji (1995) The effect of anticipated transportation improvement on residential land values, Regional Science and Urban Economics 25: 261–278.

Kane, T, D. Staiger and S. Riegg (2005) School Quality, Neighbourhoods and Housing Prices: The Impacts of Desegregation, National Bureau of Economic Research Working Paper 11347.

Kenneth Y. Chay and Michael Greenstone (2005) Does Air Quality Matter? Evidence from the Housing Market, Journal of Political Economy, 113: 376–424

Kerry Smith, V. and J. Huang (1995), Can Markets Value Air Quality? A Meta-Analysis of Hedonic Property Value Models, Journal of Political Economy, 103, 209-227

Leech, D. and E. Campos (2003), 'Is Comprehensive Education Really Free? A Case Study of the Effects of Secondary School Admissions Policies on House Prices in One Local Area', Journal of the Royal Statistical Society Series A, 127, 135-154

Lynch, A. K., and D. W. Rasmussen (2001) Measuring the impact of crime on house prices, Applied Economics, 33: 1981-1989

Machin, S. and O. Marie (2005) The Street Crime Initiative, Centre for Economic Performance Discussion Paper 680.

Machin, S. and O. Marie (2007) Crime Concentration and Targeting Prolific Offenders, Centre for Economic Performance mimeo.

Machin, S. and K. Salvanes (2007) Valuing School Choice and Social Interactions: Evidence From an Admissions Reform, mimeo

Mackie, P., S. Jara-Diaz, A. Fowkes, (2001) The value of travel time savings in evaluation, Transportation Research E 37: 91–106.

McMillen, D. P. and J.McDonald (2004) Reaction of house prices to a new rapid transit line: Chicago's Midway Line, 1983-1999, Real Estate Economics 32: 463-486.

Nechyba, T. (2000) Mobility targeting and private school vouchers, American Economic Review, 90: 130-146

RICS (2002) Land value and public transport, Stage 1 Summary of findings, Royal Institute of Chartered Surveyors Policy Unit

Ridker, Ronald G. and Henning, John A. (1967) The Determinants of Residential Property Values with Special Reference to Air Pollution, Review of Economics and Statistics, 49: 246-257

Rosen, S. (1974) Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition, The Journal of Political Economy, 82: 34-55.

Rosenthal, L. (2003), The Value of Secondary School Quality, Oxford Bulletin of Economics and Statistics, 65, 329-355

SEU (2003) Making the connections: final report on transport and social exclusion, Social Exclusion Unit, Office of the Deputy Prime Minister, London

Tauchen, H. and A. Witte (2001) Estimating Hedonic Models: Implications of the Theory, NBER Technical Paper 271.

Thaler, Richard (1978). A Note on the Value of Crime Control: Evidence from the Property Market, Journal of Urban Economics, 5: 137-145

Tiebout, C. (1956) A Pure Theory of Local Expenditures, Journal of Political Economy, 64: 416-424

Tobler, W (1970) A Computer Movie Simulating Urban Growth in the Detroit Region, Economic Geography, 46: 230-240

Wrigley, M and P. Wyatt (2001) Transport Policy and Property Values, University of the West of England, Paper presented at the RIC "Cutting Edge" conference 5-7 September 2001

Figure 1: House price contours for Greater London, 2004

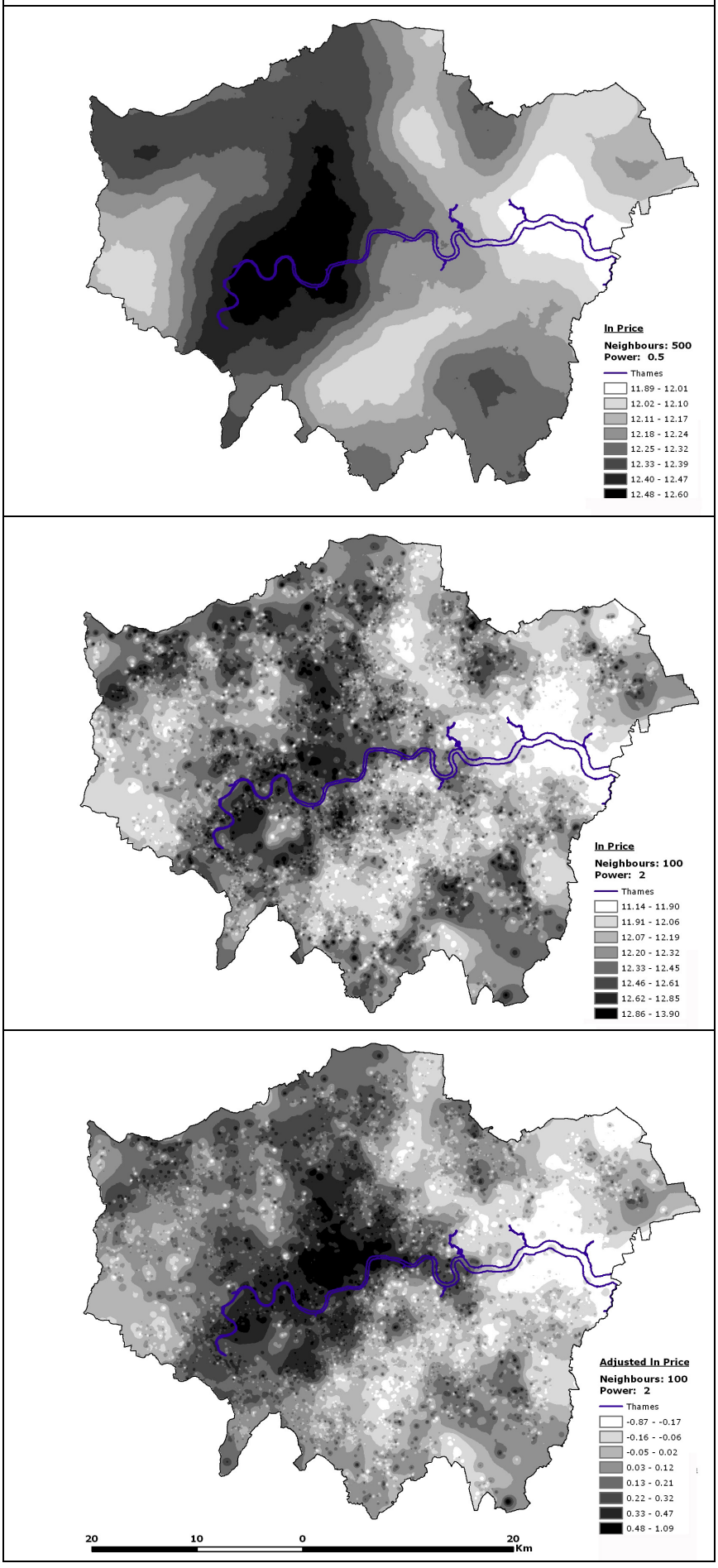

Table 1: Effects of schools, rail transport and crime on housing values: selected international research from the past 10 years

Schools

Study	Scope	Methods	Findings
Clapp, Nanda and Ross (2007)	Connecticut, 1994-2004 8th Grade maths scores and demographic characteristics	Changes over time in school district characteristics (within towns and census tracts)	1.3-1.4% increase in prices for one standard deviation increase in maths scores. Proportions Black and Hispanic more important when looking at long run changes.
Machin and Salvanes (2007)	Average pupil marks (in mathematics, Norwegian and English) in secondary schools, Oslo	Admissions policy reform generated switch from zone based to open enrolment in 1997/8 (with boundary discontinuities)	House price premium for better school performance falls after reform. Before reform 2%-4% increase in prices for one standard deviation increase in school average pupil marks.
Fack and Grenet (2007)	Middle school maths, geography history and French assessment, Paris 1997-2003	Discontinuities at school attendance zone boundaries	2% for one-standard deviation increase in performance
Davidoff and Leigh (2006)	High school test scores, Australian Capital Territory, 2003-2005	Discontinuities at school attendance zone boundaries	3.5% for one standard deviation increase in performance (5% increase in test scores)

Brasington and Haurin (2006)	Percentage of pupils reaching 9th grade proficiency in Ohio, 2000/1	Controls for neighbourhood characteristics and correlation between neighbouring housing values	7.6% for one standard deviation increase in performance (a 19.8% increase in proficiency rates)
Gibbons and Machin (2006)	Proportion reaching target grade in primary school maths, science and English tests, London area, 1996-2001	Discontinuities at school district boundaries, changes over time within geographical school clusters, and instrumental variables	3.8% for one standard deviation increase in performance.
Cheshire and Sheppard (2004)	Primary schools: Proportion reaching target grade in primary school maths, science and English tests; Secondary schools: proportion gaining 5 grade A-C GCSEs; Reading England, 1990s		Primary schools: 9.8% for one standard deviation Secondary schools: 4.0% for one standard deviation (own linear interpolation from authors reported results)
Kane, Riegg and Staiger (2005)	Maths and reading scores in elementary schools, Mecklenburg County North Carolina, 1994-2001	Discontinuities at school attendance zone boundaries, and difference-in-difference based on boundary changes	10% for one standard deviation increase in mean test scores
Figlio and Lucas (2004)	Elementary school grades based on government evaluation, Florida, 1999-2001	Repeat property sales within small neighbourhoods in Florida	10% premium for schools receiving an “A” grade in each year
Rosenthal (2003)	Proportion gaining 5 A-C GCSEs in Secondary schools, England, 1996-	Cross-sectional regression and instrumental variables approaches	5% elasticity

	1998	(school inspections as instruments)	
Gibbons and Machin (2003)	Proportion reaching target grade in primary school maths, science and English tests, England, 1996-1999	Semi-parametric modelling of unobservable factors, discontinuities at school district boundaries, and instrumental variables	4% - 9% premium for one-standard deviation increase (3.3-6.9% for 10 percentage point increase)
Leech and Campos (2003)	Well known popular secondary schools in Coventry, 2000	Sample design to minimise unobserved neighbourhood differences	16-20% premium for two most popular secondary schools
Bogart and Cromwell (2000)	Loss of neighbourhood schools and re-districting, 1983-1994, Shaker Heights Cleveland US	Difference in difference methods using re-drawing of school district boundaries	Disruption of neighbourhood school assignment reduces prices by 10% reduction
Black (1999)	Maths and reading scores in elementary schools in Boston Massachusetts, 1993-1995	Cross-sectional study using attendance boundary discontinuities	2.5% premium for 5% relative increase (one standard deviation)
Rail transport			
Gibbons and Machin (2005)	Distance of house sales from London Underground and Network Rail stations, and impact of Jubilee Line Extension	Repeat-sales/quasi-experimental type, based on the change in station-home distance resulting from new Jubilee Line stations.	7-20% decrease for a one standard deviation increase in home-station distance (1-4% per km)

Armstrong and Rodriguez (2006)	Drive time and proximity to commuter rail stations, Eastern Massachusetts, 2000	Cross-sectional regression with modelling of unobserved spatial factors	10% premium for properties within 1/2 mile of a station. 15% reduction per minute of additional home-station drive time. 10% for station in home municipality. Increase in prices with distance from rail lines.
Baum-Snow and Kahn (2000)	Distance of census tracts from rail transit in 5 US cities, 1980 and 1990	Difference-in-difference approach based on mean census tract housing prices and the reduction in census tract to rail transit distances arising from new transit lines	$4972 increase in mean prices for a reduction in distance from 3km to 1km
McMillen and McDonald (2004)	1983-1999 of proposal, construction and opening of Midway Airport – Downtown Chicago rail transit line (opened in 1993)	Repeat sales of single family homes	4-21% decrease in property values per mile distance from proposed and completed transit line station. Evidence of pre-opening anticipatory effects
Bowes and Ihlanfeldt (2001)	Proximity to Metropolitan Atlanta Rapid Transit Authority (MARTA) stations 1991-1994	Cross-sectional analysis of direct price effects, and price effects operating through crime and local retail employment	Complex interactions between station distance, distance to CBD and local income levels. Negative effects in very close proximity, and in low income neighbourhoods. Positive effects beyond ½ mile from station, further out from CBD and in higher income neighbourhoods

Cervero and Landis (1995, 1997)	Review of land use and development impacts of the Bay Area Rapid Transit System over 20 years	Review articles. Figures based on comparison of matched pairs of locations near rail stations and elsewhere	Mixed and localised effects. 12% premium for location "near" BART station relative to freeway junctions. 16% premium for apartments "close" to BART stations in edge locations. $2 decrease per metre distance.
Crime			
Gibbons (2004)	London, 1999/2000, impact of local burglary and criminal damage (incidents per km2)	Semi-parametric modelling of unobserved spatial factors. Crime in non-residential dwellings and location of bars as instrumental variables.	10% decrease in price for a 1 standard deviation increase in local density of criminal damage. No significant impact from burglary
Lynch and Rasmussen (2001)	Jacksonville Florida, impact of violent and property crime	Cross-sectional regression with control variables	4% decrease in price for 1. standard deviation increase in violent crime (elasticity of -0.048). Prices show insignificant positive association with property crime
Bowes and Ihlanfeldt (2001)	Atlanta, 1991-1994, impact of crimes per acre in the census tract	Cross-sectional regression with control variables	3%-5.7% decrease in prices for one additional crime per acre (sd unreported)