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A STUDY OF HOUSE PRICES AS A MEANS OF ESTABLISHING
THE VALUE OF JOURNEY TIME, THE RATE OF TIME PREFER-
ENCE AND THE VALUATION OF SOME ASPECTS OF ENVIRONMENT
IN THE LONDON METROPOLITAN REGION

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This paper is circulated for discussion purposes and its contents should be considered preliminary.

A Study of House Prices as a Means of Establishing the Value of
Journey Time, the Rate of Time Preference and the Valuation of
Some Aspects of Environment in the London Metropolitan Region

1. Introduction

The critical data in this study is information on house purchase transactions for owner occupation which were financed with the help of a mortgage from the Nationwide Building Society (then known as the Co-operative Permanent Building Society) during the first three months of 1968. In this time period the Society was involved in some 1,800 house purchase transactions located in 539 different towns and postal districts in the South East Planning Region. This is a much wider geographical area than the London Metropolitan Region, the one under consideration in this paper. The Metropolitan Region is the area within a radius of approximately 40 miles from central London and the majority of these 1,800 transactions were in this area. For each transaction, 44 separate pieces of information were collected. The important data from the point of view of this study was that on purchase price, geographical location and physical aspects of the house such as its size, age, availability of central heating etc. All this wealth of data is stored on a computer at the Building Research Station, Watford ^{1/}. A preliminary study of the data by the Building Research Station has indicated that the houses in this particular building society's survey can be considered as typical of all transactions made by the larger building societies ^{2/}. The larger building societies account for the vast majority of all house purchases for owner occupation using building society finance.

^{1/} I am extremely grateful to the Nationwide Building Society for allowing me to have access to this valuable data. I am also indebted to Mr. A.G. Simms and Mrs. Carol King of the Building Research Station who made available to me the computer print-outs of the data I required. Mrs. Lesley Hancox of the University of Warwick provided invaluable assistance in the task of analysing the data.

^{2/} Data for a Study of the Price Mechanism of Owner Occupied Dwellings, 1968, Ministry of Public Building and Works Building Research Station note number IN 95/68, page 9. This document also gives a full description of the data available in the building society survey.

How are house prices determined at a particular location and at one point in time? Houses come up for sale for a variety of reasons connected with such factors as changing place of employment, retirement, the need for a different sized house etc. When a house is for sale we can imagine a Dutch auction, albeit a rather imperfect one, being held. The seller of the house sets a price somewhat higher than the one he can ever hope to attain given the locational aspects, the physical characteristics of his house and the prices attained by roughly similar houses in the immediate area. The price can then be considered as coming down in steps until a purchaser agrees to buy the house. The purchaser will take into account the same characteristics and will judge that in his opinion it is worth paying the extra for valuable features vis-a-vis another house or that the lower price at least compensates him for valuable features forgone in comparison to other properties. Thus, supposing that two houses are 'identical' in all respects except that one is closer to central London in terms of journey time, say a five minute time difference on a single journey. As a result of the high concentration of employment in central London there will be a greater demand for the house with the shorter journey time so that the best bid for this house may be £200 more than for the house with the longer journey time. This paper studies the influence of demand at this micro-level on the determination of individual house prices at one point in time, the first three months of 1968, for one large geographical area, the London Metropolitan region. It is this detailed level of analysis which provides insight into house owners' valuation of journey time, the value of environmental features and the rate of time preference. The paper is not concerned with studying the demand for housing at the aggregate level. This alternative level, which has been considered by Muth ^{3/}, will help to determine the overall price level of houses in the London Metropolitan region and their level relative to other regions of the country.

^{3/} Richard F. Muth, "The Demand for Non-Farm Housing" in The Demand for Durable Goods ed. Arnold C. Harberger (Chicago, 1960) pp. 29-96.

This concept of house price determination at the micro-level needs further elaboration. The price of an individual house will be influenced by a wide range of locational factors, among them being influences particular to the situation of the house within the borough. Such variables will include the distance to the railway station and other forms of public transport, distance to schools and shops, presence or absence of traffic noise, the general outlook of the house etc. It would have involved several man years of work to identify and measure these factors for each of the house transactions in the London region in this survey.

In any case this was not possible because, in order to respect the confidentiality of its borrowers, the building society was not prepared to divulge the addresses of the properties they mortgaged. The approach adopted in this study was only to consider locations within the London Metropolitan region for which there were at least six observations and to consider as the variable to be explained the average price of houses at each location. This approach assumes that within the borough location factors will balance each other out. Thus, when there are six or more house transactions it is assumed that some of the houses will be near to the railway station but their higher price will be offset by the fact that some of the houses will be more distant from the station. Again, some houses may be better located for facilities such as schools and shops but this will be balanced by the fact that some of the houses will not be so conveniently located. A total of 93 locations within the London region were used in this study and the analysis is micro in the sense that it seeks to account for the variation in the average price of houses between these different locations.

2. Explanatory Variables Considered in the Analysis

This study uses a least squares regression analysis, over 93 sets of observations, to measure the impact and significance of different explanatory variables in determining house prices. The explanatory variables can

be classified into two different categories, namely, locational parameters and house parameters. Locational parameters describe the geographical and environmental situation in each of the boroughs used in the analysis. The house parameters refer to the (average) physical characteristics of the houses in each of the 93 locations under consideration.

Locational Parameters

T. The average journey time in minutes for all trains, on both British Rail and the London Transport underground system, from the borough to the terminal station or stations in central London. If a borough is served by the underground system then the journey time to the underground station nearest the main-line termini was taken. The average journey time was calculated for all trains leaving the borough between 7.00 and 9.30 a.m.

The purpose of this variable is to get an idea of the nearness, in a time sense, of each borough to the central area. This is considered to be an important determinant of house prices because of the fact that the whole employment situation in the London area is dominated by the central area. Some six million jobs are located within the Metropolitan region and, of these, approximately 20 per cent are located within the geographically small area of central London. Thus an over-riding aspect of the demand for houses will be the desire of central area workers to have a convenient location, as expressed in terms of journey time to the centre. It was argued in the introduction that, other factors being equal, a house in a borough with a shorter journey time to the centre would command a higher price than one located in a borough with a longer journey time. If this hypothesis of a negative partial correlation between journey time and house price is substantiated then the direct implication is that a positive money value is being placed on the journey time to central London. The house purchaser is deciding that,

in his opinion, it is worth the higher house cost for a shorter journey in comparison with lower house costs and longer journey times ^{4/}.

P. The average price in pence for a single journey by train or under-ground from the borough to central London. Again the centre is taken as the main line termini or the corresponding underground station. These railway fares are determined on a distance travelled basis and are important because it is possible to have two locations with equal journey times to the centre but a different price for the journey. Because of the dominance of the centre as a place of work such a situation will result in a greater demand for houses at the location with the cheaper fare. Thus for a three pence lower single fare, other things being equal, a house purchaser will be prepared to pay a certain number of extra pounds for a house. This fare saving of three pence can be achieved on all journeys made towards and from the centre and, given the expectation that railway fares are always going to be based on distance, this benefit will accrue to the house in perpetuity ^{5/}. Thus the size of the negative price coefficient gives an indication of the current discounted value of the future time stream of possible savings and, in this way, it is possible to get some indication of the time rate of discount of house purchasers in the London area.

S.C. The number in socio-economic groups 1,2,3 and 4 per thousand occupied and retired males aged 15 and over ^{6/}. This information was

^{4/} Even if a purchaser does not work in the centre of London he still has to pay a premium of £x for the benefit of being closer, in a time sense, to the central area. Thus, his value on nearness to the centre is at least equal to that of a person who works in the central area.

^{5/} In early 1968 it was realistic to assume that railway fares would continue to be based on a distance basis. Since that time there has been discussion that such a principle should be abandoned.

^{6/} These four socio-economic groups cover the professional and white collar workers.

obtained from the 1966 sample census and the variable is included because it gives a measure of the social character of the boroughs. It has to be recognised that some boroughs are accepted as fashionable places to live. Even after allowing for all other factors such a situation will help to determine, in this case by increasing, the price of houses in the borough. Perhaps more important is the fact that this social class variable is likely to provide an accurate reflection of the level of amenities such as shops, schools, libraries etc. Thus it is expected that the higher the proportion in these social classes the greater the price of houses, other factors being equal.

P.D. The population density in the borough as measured by the number of persons per acre. This variable is again obtained from the 1966 sample census of population. The population density is considered to be a fairly objective criterion for judging the general environmental quality of the borough. The most important direct aspects of environment which it reflects are the density of housing in the residential areas and the amount of open space in terms of parks, squares and fields. Other things being equal, it is expected that there will be a negative correlation between house prices and population density in that lower population densities will be associated with higher house prices.

GB. This is a dummy variable to indicate accessibility to the green belt. A detailed consideration of the house prices showed that houses in boroughs on the periphery of the built-up area can command a premium over houses in other boroughs. This seems to be a favoured location presumably because of being able to get the 'best of both worlds'. Living on the edge of the urban area means that it is easy to take advantage of the shopping, cultural, sport and other facilities provided within the urban area and, at the same time, have easy access to the countryside for recreational purposes. This dummy variable takes the value unity if the central point of the borough is located within two miles of the boundary of the green belt, otherwise it takes the value zero.

J. Indicates the availability of local employment within the borough relative to the population. The variable is defined as the number of jobs in the borough filled by males per 1,000 of the resident male population aged 15 and over. The source of such information being the 1966 census. It was expected that the boroughs having a high concentration of local employment would, other factors being equal, have a higher demand for houses within the borough and higher house prices. However, this expectation of a positive partial correlation between these variables was not borne out in the results obtained.

House Parameters

A. The average floor area, measured in square feet, of the houses sold in each borough. For each house sold there was coded information on the number and type of rooms and the size of the floor area. These are alternative ways of considering the size of the house purchased and it was thought that floor area, by virtue of being a continuous variable, would be the most important in determining the price of the house. The partial correlation coefficient between house price and average house size is naturally expected to be a positive one.

D. This variable indicates the average data at which the houses were built. For each house built this century, this covers the majority of the houses sold in the boroughs being considered, the date of construction was coded by taking the last two digits from the year of construction. Thus a house built in 1965 was coded 65 and one constructed in 1909 was coded 9. Any house constructed before 1900 was given the value zero. The average for this code indicates the average age of the houses sold, the higher the value the newer the house. It is considered that the newer and hence more modern houses will command a higher price than older houses, other factors being equal. That is to say a positive

partial correlation coefficient is expected between these two variables. However, there is one aspect, namely garden size, in which newer houses might compare unfavourably with older ones. If, as is thought to be the case, there has been a tendency though time to build houses on smaller plots of land then this could offset the advantage of buying newer houses. As a result the average date of construction may not be a significant explanatory variable ^V.

CH. This variable indicates the availability of central heating. For each house sold a three-fold coding system was utilised. Houses with full central heating were given a value of one, houses with part-central heating were given a value of two and houses with no central heating were allocated a value of three. For each location the availability of central heating was taken as the average number with respect to this three-fold classification. Thus, if all the houses sold had full central heating this variable has the value one. If none of the houses sold has central heating the variable is equal to three. Between these two limits the higher the value of CH, the lower the proportion of houses sold with central heating and the lower will be the price of the houses, other factors being equal.

G. This variable indicates the availability of a garage for the houses sold at each location. This information is coded in a similar form to that for central heating. Houses with a garage are given the value one, houses with a car port or garage space are given the value two and houses with none of these facilities have the value three. Variable G is defined as the average for this coding. The higher the value of G the lower the proportion of houses which have a garage and the lower, presumably, will be the price of houses, other factors being equal.

^V The ideal situation would be to include both average date of construction and average garden size as explanatory variables. However, no information was collected on the latter variable.

TABLE 1. DETERMINATION OF AVERAGE HOUSE PRICES

Regression Coefficients and Standard Errors

Explanatory Variables	Equation 1	Equation 2	Equation 3	Equation 4
T Time	-20.38 (5.72)	-20.50 (5.76)	-21.71 (5.73)	-21.89 (5.78)
P Price	-18.74 (5.46)	-18.65 (5.49)	-17.06 (5.51)	-16.91 (5.54)
SC Social Class	3.42 (0.43)	3.44 (0.44)	3.20 (0.45)	3.22 (0.45)
PD POP. Density	-23.08 (4.98)	-23.38 (5.10)	-22.80 (4.95)	-23.18 (5.06)
GB Green Belt	276.46 (70.52)	277.76 (70.95)	290.72 (70.50)	292.60 (70.94)
J Jobs			-0.17 (0.10)	-0.17 (0.10)
A Area	3.59 (0.24)	3.60 (0.24)	3.55 (0.24)	3.57 (0.24)
D Date	16.29 (4.77)	16.67 (4.96)	16.35 (4.73)	16.86 (4.92)
CH Cent. Heating	-285.87 (102.97)	-285.95 (103.40)	-302.47 (102.67)	-302.79 (103.08)
G Garage		26.48 (89.25)		34.59 (88.67)
Constant Term	3235.68 (539.52)	3166.47 (589.88)	3430.96 (548.30)	3343.10 (594.76)
R^2	0.900	0.900	0.902	0.903

3. Results of the Regression Analysis

The results of the regression analysis are given in Table 1. Equation 1 shows all the explanatory variables which have both the correct sign, as hypothesised in the previous section, and emerge as statistically significant determinants of the level of average house prices in the London region. The eight explanatory variables in equation 1 account for 90 per cent of the total variation in average house prices.

Two of the variables discussed in the previous section, namely job and garage availability, have the "wrong" sign for the regression coefficient. The results obtained when these are added as explanatory variables are given in equations 2,3 and 4. The jobs variables has a negative coefficient indicating that average house prices are in fact depressed by higher levels of local employment. This may be because high levels of local employment reflect the degree of industrialization in the area and hence the quality of the environment. However, the jobs coefficient in both equations 3 and 4 is not significantly different from zero. Much more worrying is the fact that garage availability, see equations 2 and 4, is not a significant determinant of house prices. This is the only surprise in the results obtained and no satisfactory explanation has occurred to the author ^{8/}.

The rest of this paper will be devoted to a detailed discussion of the results obtained in equation 1. Table 2 shows the change in average house prices resulting from a ten per cent increase in the average values of the explanatory variables and thus enables the impact of the different explanatory variables to be compared. The time, price and date variables all result in an approximately equal numerical impact (ignoring the sign) on house prices. However, the resultant change in average house prices is small in relation to the average value of the

^{8/} Mr. Bateman of the Research Section, Nationwide Building Society, has pointed out that the Society's surveyors include integral garages in their estimation of floor space. He also thinks that other garage space may sometimes be included in floor area. Thus it appears that garage availability may be subsumed by the floor area variable.

TABLE 2. CHANGE IN AVERAGE HOUSE PRICES AS A RESULT OF A TEN PER CENT INCREASE
IN THE AVERAGE VALUE OF EXPLANATORY VARIABLES

Explanatory Variable	Average Value over 93 Observations	Regression Coefficient from Equation 1	Change in Average House Price
T Time	32.5	-20.38	-66.2
P Price	38.3	-18.74	-71.8
SC Social Class	186.8	3.42	63.9
PD POP. Density	12.4	-23.08	-28.6
A Area	929.0	3.59	333.5
D Date	45.0	16.29	73.3

dependent variable which is equal to £5664. A ten per cent increase in the average floor area has an impact on house prices which is some four to five times greater than that for the three variables just considered. The regression coefficient for area indicates that house prices rose by £3.59 per square foot of floor space. This is very much in line with the working value of £4 per square foot which seems to have been the one generally used by architects in early 1968 for costing the construction of new houses.

House purchasers do place a positive value on both lower population densities and higher social class composition. However, comparing the impact on house prices of a ten per cent increase in the proportion in socio-economic groups 1,2,3 and 4 and a ten per cent decrease in the population density, both from average values, shows that the former change increases house prices by an amount which is more than double that resulting from the latter change. Such a result is an interesting reflection on the relative value of the two aspects of amenity represented by these variables.

An interesting aspect of the results is the high value for the constant term. This can be interpreted as the average plot or land value of houses in the London region. In equation 1 the constant term of £3,235 accounts for 57 per cent of £5,664, the average value of the dependent variable. For locations with easy access to the green belt this average plot value is increased by £276. Finally, the central heating variable indicates that the jump from all houses without central heating to all houses with full central heating increases the average value by £572 (285.87 multiplied by two) other factors remaining the same. Such a change seems a little on the high side. However, this may not be so as the coefficient probably reflects the value attached to other desirable features often associated with centrally heated houses such as double glazing of windows and roof insulation. It may also be the case that houses with full central heating have a higher standard for internal fittings in such places as kitchens and bathrooms.

The price coefficient in equation 1 indicates that a one penny decrease in the cost of the journey to central London was associated with an increase of £18.74 in the level of house prices. It was argued in the previous section that this capital sum represents the discounted present value of a one penny saving made on all future journeys towards and from the centre of London. If it is assumed that, on average, one person from each house travels towards the centre for five days a week and 48 weeks a year a one penny saving per journey amounts to a saving in fares of £2 per year. If this average saving accrues in perpetuity then the average time rate of discount for house purchasers in this area in early 1968 was 10.67 per cent ^{2/}. The time rate of discount is an important practical economic concept on which there has been little or no empirical evidence. A value of approximately ten and a half per cent is certainly one which economists would consider reasonable. What is less clear is the extent to which such a figure might be the correct one for the large non-house purchasing sector of the population and for house purchasers in other parts of the country. Such questions need to be considered before any such number can be used as a "social" or "community" time rate of discount.

Equation 1 shows that a one minute decrease in the journey time to the centre is reflected in house prices to be worth £20.38, a value somewhat greater than that attaching to a one penny saving in the journey cost.

^{2/} The present value of £2 per annum in perpetuity is $2/i$ where i is the rate of discount.

Taking the ratio of the time and price coefficients, 20.38 divided by 18.74, indicates that one minute is being valued at 1.0875 of one penny. Multiplying by sixty gives an hourly value being placed on the journey time to central London equal to 65.25 pence. Such a valuation of time is not inconsistent with that obtained in other studies although the method used here to arrive at such a value differs substantially from that used in other work ^{10/}.

Having an estimate of the time rate of discount enables some further consideration to be given to the value being placed on accessibility to the green belt. If it can be assumed that the green belt is inviolate then a house favourably located in this respect will always be in such a situation. Thus £276.46 represents the discounted present value to the house purchasers of all future benefits accruing to such a location. With a rate of discount equal to 10.67 per cent this represents an annual valuation on this favourable location of £29.50 or 11.35 shillings per week. It is not possible to repeat such a calculation for the environmental aspects represented by the social class and density variables as it is not clear over what time period any benefits due to differences in these variables are being valued.

10/

See N. Lee and M.Q. Dalvi, "Variations in the Value of Travel Time", Manchester School, September 1969, Vol. 37, No. 3, pp. 213-36 for the most recent attempt in the U.K. to arrive at a value of time. This same paper also contains a critical survey of previous attempts to estimate the value of travel time.