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Hedonic Analysis in a Spatial Context: Theoretical Problems in Valuing Location-Specific Amenities*

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Hedonic analysis is frequently implemented to generate implicit prices for location-specific amenities within single markets, either in cross-city wage differentials or in intra-city rent gradients. Amenities are shown to be generally priced in both land and labour markets, with single-market valuations tending to understate true amenity values. Establishing a correct multi-market amenity valuation model is seen to depend on the resolution of a host of additional issues.

I Introduction

Rosen's (1974) development of hedonic price analysis has led to many attempts by economists to explain price differences consistent with equilibrium, and to generate implicit prices for traits and amenities which would otherwise be difficult or impossible to value. We are concerned here with the existing attempts to value amenities, such as climate, environment, and infrastructure which are locationally fixed. That is, one would expect a 'desirable' location, in terms of amenities, must be equivalently undesirable in some other respect (e.g. by possessing higher rents or lower wages or, in general, lower levels of certain other amenities). Were this not the case, equivalently situated individuals would be better off in some locations than in others, which is incompatible with equilibrium in a world characterized, even approximately, by perfect information and mobility. Since it is the location decisions of firms and consumers which generate the wage and rent variations necessary to yield equilibrium and to infer amenity values, amenities are also seen to importantly shape regional growth and decline (see Graves and Linneman, 1979, or Graves, 1979, 1983).

A broad range of policy issues hinge critically on knowing what amenities are worth to society. For example, concerns for the proper levels of environmental quality or for the future sizes of various regions will not lead to appropriate policy unless amenities are properly valued. We argue here that existing efforts to value amenities hedonically are critically flawed in ways which are likely to result in understatement of the value of non-marketed amenity goods, leading to potentially significant resource misallocations (e.g. too little environmental quality). In brief, the principle problem is that existing valuation approaches have failed to recognize that hedonic compensation for location-specific amenities occurs in more than just one market, although other problems will be touched on here.

Section II presents an intuitive discussion of why

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erroneous valuations are being made—this discussion is sympathetic in that under certain apparently plausible assumptions these approaches seem reasonable. Section III goes into greater theoretical depth, with more specific references to the literature, while Section IV provides a number of real world examples of the hedonic valuation problem. Section V presents the conclusions and some indicated directions for future work.

II An Intuitive Background

It is by now well known that variations in the equilibrium price of a good will reflect implicit valuation of the various attributes of that good. If, for example, two otherwise identical automobiles differ in that one has power steering, the difference in sales price will reflect the value implicitly placed on power steering. If power steering can be added at constant cost, regardless of whether the car is new or used, the sale price differential will come to equal the cost of providing the trait. If the price differential were larger, power steering would be added to new and used cars, while if the differential were smaller—power steering were not worth the cost—new cars would not be produced with power steering. If there are important 'people-differences' (tastes, income, and the like) which affect the demand for power steering, some cars will have power steering and others will not and the people-differences will determine who has what type of car.

In the case of location-specific amenities, the critical question that must be raised, but has not yet been carefully considered in the literature, is: 'In what market is the implicit valuation of location-specific goods captured?' The case of the automobile is instructive; unlike that case, there are at least two possibilities. The value of clean air, for example, could be reflected in either or both of the land or labour market. Hence, one might expect that clean areas would rent for more than otherwise similar areas, paralleling the automobile example. On the other hand, unlike the case of the automobile, wages might be lower in the cleaner location than in the more polluted location. Thus, payment for the trait of 'clean air' can occur in either, and in general both, the land and labour markets. This would have been the case for automobiles, as well, if automobiles were distributed in some random spatial pattern. But in the case of the automobile, their mobility would guarantee that profit-seekers would allocate the power-steering equipped cars to, say, higher income locations (if this trait is superior). Hence, one would not expect to observe implicit payments for power steering in labour markets.

These points were not realized when the hedonic valuation approach was extended by urban/regional and labour economists, respectively, to traits which were spatially variable, but which could not be varied *in situ*. Since urban economists deal largely with property values or rents, while labour economists deal largely with wage or income data, an unrecognized assumption began to creep into the literature. It was presumed that trait variation within a city would be valued in land markets, while variation in traits across cities would be valued in labour markets. Under this notion location-specific amenities could be valued in either market—they were alternative ways of measuring the same thing. Thus, average differences in pollution levels in a system of cities would be picked up in wages, while differences in pollution levels within one city in the system would be picked up in rents, *ceteris paribus*.

The intuition underlying the preceding argument was that land markets were 'local' (and not national) and labour markets were 'national' (and not merely local). Recent work in migration (e.g. Bartel, 1979; Linneman and Graves, 1983) strongly indicates that both long-distance and short-distance moves—moves across and within cities—occur due to a mix of residential and job-related motivations. This is as one would expect in that utility can be higher in one area than another because of any mix of lower rents or higher wages. Indeed, a long-distance move to a low-wage location is plausible when that low wage is offset by even lower rents or by some other living cost component. Similarly, a short-distance move can be wage-related as well as being related to demands for various residential traits. Hence location-fixed amenities will be capitalized in varying degrees in both the land and labour markets. With this as a background, we turn now to a more detailed discussion of the literature.

III Hedonic Studies in the Land and Labour Markets: A Schism

Expanding on the original Alonso (1964) and Muth (1969) rent gradient analysis, the urban approach considers amenities in the context of the intra-urban location problem (see Ridker and Henning, 1967, for an early contribution or, more recently, Polinsky and Rubinfeld, 1977, as an example of a large body of work). In this approach, rental variation capitalizes amenity variation, such as pollution. Indeed, while the early travel cost models viewed rents as capitalizing travel cost

savings, an alternative and more general interpretation is to view access to the central workplace as an amenity directly entering utility—this latter view makes clear that the efforts of Alonso and Muth represented an early use of the hedonic pricing technique. Rosen (1979) and Roback (1982) show that if land does not enter in the production decisions of firms and if wages are nationally determined, rents can embody inter-city amenity variation as well.

Labour and migration theorists began, at about the same time, to develop models where wage differentials capture amenity values. Starting from a dis-equilibrium model (unlike the urban model which relies on equilibration to capture amenity values) in which wages are monotonically related to utility, the expectation was that migration would occur to high-wage areas. In turn, that migration would lead to a rough convergence of wages as labour influx lowered wages in high-wage areas while labour outflows raised wages in low-wage areas. The persistence of wage differentials over time led to the inclusion of amenities to explain the substantial differentials which remained after accounting for human capital differences. That this was a rather pronounced change in modelling stance (mixing equilibrium and disequilibrium influences in the same equation) was not emphasized, the notion being merely that the amenity variations must be held constant in the appropriate conceptual experiment. Since the coefficients on the amenity variables were significant, and of interest in their own right, the wage–amenity gradients began to be discussed, the slope representing amenity valuations (see Rosen, 1979).

Growing out of the debate about the causes of regional development are analogous differences in the treatment of amenities. The demand-driven approach (see Blanco, 1963; Lowry, 1966; or Mazek, 1969) relies on productivity differences where the resulting wage differences lead to labour migration. In this framework, the larger output at the relatively more productive locations enables labour to be compensated for any local disamenities which may exist. The supply-driven approach (Borts and Stein, 1964) emphasizes labour movements as the prime factor; firms seek lower wages by following labour. This approch is easily generalized to include amenities—with consumers (hence labour) relocating in order to consume site-specific amenities, the lower wages generated attracting firms.

While not estimating a complete model, Graves and Linneman (1979) and Graves (1983) provide some insights into the nature of a more general model. Both argue that in an equilibrium setting rising per capita income levels will lead to changing demands for amenities. These changed demands will lead to migration flows to more desirable locations, if amenities are normal goods as one would expect (see Graves, 1983). Although essentially a labour supply driven model, the expansion of this model to consider firm location decisions (such as Roback, 1982) allows for a more general method of valuing various amenities, accounting for both firm and household behaviour.

With a few notable exceptions, the wage-oriented and rent-oriented approaches to amenity valuation are seldom synthesized. Ridker and Henning (1967) assume land is fixed in supply and worker mobility fixes wages with the result that land rents capitalize amenity values. Henderson (1982) considers amenity valuations only at city edges where rents can only reflect the opportunity cost of land in agriculture, so only wages can reflect amenity values. Most wage models (Smith, 1983; Henderson, 1982; and Cropper and Arriaga-Salinas, 1980) consider deflating wages by 'cost-of-living' including rents. As will be discussed below, this is only valid in the unusual case where rents do not reflect amenity capitalization.

Rosen (1979), Cropper and Arriaga-Salinas (1980), and Polinsky and Rubinfeld (1977) show that regardless of the actual form of compensation in the market, specific knowledge of underlying utility functions can in principle generate amenity values in wage terms. Thus, competing methods of pricing amenities should be comparable. Yet the existing measures of various amenity values are not, in fact, consistent since different basic assumptions are being employed regarding which market capitalizes the amenities when in fact both markets are generally involved in the compensation process. Wage models implicity assume uniform intra-city amenity levels, while rent models imply that the only relevant amenity variation is intra-city.

In short, the assumptions necessary to eliminate one of either rent or wage capitalization, to concentrate on the remaining factor, render all existing models insufficient to adequately reflect how amenities are valued in reality. By assuming single-market capitalization these models are able to avoid identifying the precise roles of consumers and firms in generating amenity valuations. This issue is somewhat obscured by choosing particular types of amenities. Following Rosen's analysis of heterogeneous products in pure competition, it is

often assumed that consumers derive satisfaction from an amenity which is costly for firms to provide, as suppliers of the amenity. Air pollution (Henderson, 1982) and job risk (R.A. Smith, 1979) provide clear examples where this dichotomy seems appropriate. While Smith argues that the sign of the wage–amenity gradient is unambiguously negative, this is valid only when the amenity has contrary impacts on firms and consumers. In the more general cases the wage and rent gradients are of uncertain sign: if the amenity positively affects both firms and consumers, rents will unambiguously rise but the effect of the amenity on wages is ambiguous; if, however, the amenity affects firms positively and consumers negatively, wages will be unambiguously higher where this amenity exists, but rents may be either higher or lower. The technically inclined reader may envision indirect utility functions (upward-sloping) and cost functions (downward-sloping) in wage-rent space, where the amenity shifts these functions, to hold utility and cost constant as necessary for general equilibrium. A number of examples will clarify the need to interact wage- and rent-amenity gradients to avoid mis-specification (and generally undervaluation) of amenity values.

IV Examples of Problems with Single-Market Efforts to Value Amenities

The first general problem relates to the degree of disequilibrium versus equilibrium in the location possessing the amenity. Consider, for example, an amenity-rich area such as Sydney. Labour will be attracted to this area, hence lowering wages. Firms will be attracted and the city will become larger, causing rents to rise. Ultimately, the higher rents will choke off the inflow of population. But, depending on the phase of urban growth, amenities will be valued to a greater or lesser degree in each of the markets. That is, in the early phases of urban growth, a greater percentage of the amenity value of Sydney will be capitalized in labour markets while at later development phases relatively more of the amenity value will appear in land markets. This presents difficulties for both the urban and the labour approaches since the wage capitalization studies will be dealing with a sample of cities at various phases of urban growth (from the perspective of 'ultimate' city size equilibrium) and the urban studies will yield different valuations in the rental markets in different cities for the same reason. With this general problem in mind, we turn now to examples of other problems with existing amenity valuations, all stemming from failing to interact the land and labour markets properly.

Following Roback (1982), consider a productive amenity, for example the Sydney harbour, which increases firm productivity and which also raises consumer utility. Since firms seek lower wages and consumers seek higher wages, *ceteris paribus,* and both seek the amenity, rents in the amenity-rich areas will unambiguously be high. The sign on the wage–amenity gradient is, however, unclear in this case. Rents reflect benefits and not merely costs to consumers and firms alike—only if one can rule out consumer amenities can rents be considered merely a cost-of-living component to be used to deflate wages. Hence, the standard wage model mis-specifies the measure of costs (in the entirely legitimate attempt to calculate 'real' versus 'nominal' wage differentials), by labelling as costs of living what are in fact benefits of living in such places as Sydney. Note that this hedonic valuation difficulty is not related to the degree of disequilibrium, but rather is present in full equilibrium.

Urban areas are, of course, not characterized well by the simple one-amenity model; consideration of additional scenarios further complicates the process of inferring hedonic valuations. The character of urban areas is related to scale economics, agglomeration economies and, particularly important for present purposes, to something that we will call 'endogenous disamenities'—traits such as crowding, pollution, and so on which reduce the desirability of nice areas as they become larger. The interaction of these factors will confound efforts to value individual amenities. Consider attempts to value ozone pollution in a city such as Athens, Los Angeles or Sydney. Since a nice climate is present in these areas and causes wages to be lower (holding skills constant) and rents to be higher, the value of pollution will be very difficult to infer from any of the standard hedonic approaches—failing to account for climate will undervalue the ozone disamenity since wages and rents reflect the climate as well as the pollution. This is particularly so in the ozone example, since this pollutant is not only positively related to city size as is the case with many pollutants, but is also a product of photochemical reactions which are directly related to the amount of sunshine present.

Taking the preceding example one step further, suppose our interest were in assessing the value of a nice climate. As indicated above, the nice climate in Los Angeles relative to, say, Chicago would be reflected in some mix of lower wages and higher

rents in Los Angeles (the mix depending on the degree of disequilibrium, the extent to which the supply of land is constrained at the city's edge and other factors). However, even a carefully constructed model which interacted land and labour markets appropriately to gauge the value of climate would fail to pick up its full value. As labour moves to a desirable area, depressing wages and driving up rents, it is also the case that the undesirable endogenous disamenities such as congestion, pollution, and crime, also increase. One must hold constant these city size related disamenities before being able to assess the value of the amenities which gave rise to the initial growth. Failing to do so will lead to undervaluation of the desirable amenity.

Related to the preceding points is the difficulty of using the standard economic variables to project regional growth and decline or migration patterns among urban areas (see Graves, 1979; Langley, 1977). Since those amenities which are desirable (e.g. climate, culture, scenic views) will have positive income elasticities and those which are undesirable will have negative income elasticities (e.g. congestion, pollution, and crime) the net effect of rising national income on the degree of urbanization is ambiguous. This is a ready explanation for the 'migration turnaround' experienced in the US and other countries in recent years, a phenomenon which is likely to spread to still other countries if disamenities of urban life increase with city size in those countries as one would expect.

One does not need to argue that labour markets are fragmented to obtain wage variation within a city (see Straszheim, 1984, for a discussion of this possibility). Freely mobile labour implies that wage acceptance schedules will reflect adjustments not only for local cost of living but for local amenities not fully captured in the land market. We merely require that local factors can exert a systematic influence on wages (e.g. a firm located in a desirable part of the city can offer less wages to acquire labour, even though some of the amenity value of that part of the city will generally be capitalized into rents as well).

In Australia's case, wages are to a large extent nationally determined, hence it is likely that the burden of adjustment for valuing amenities falls predominantly on the land market. This creates the possibility of some unknown bias in regional development. For example, a uniform amenity such as climate is often thought to be capitalized into wages if the urban area is sufficiently expandable so that land is not a constraint at the city's edge. If wages are set nationally, locations with high levels of ubiquitous consumer amenities will be more attractive to consumers but less attractive to firms. The net effect is ambiguous.

The preceding arguments indicate that efforts to value amenities in either land or labour markets (or both, in light of the endogenous disamenities) are fraught with difficulty, even when all individuals have identical preferences. Suppose, as is exceedingly likely in the real world, that preferences do vary either because of income differences or because of taste differences. This confounds the argument immensely, and even gives rise to ambiguity in the sign expectations on wages and rents. We will illustrate this with the 'Malibu maid' example (Malibu is an exclusive suburb of Los Angeles which is low in pollution, has beautiful beaches and mountains and in which it is not at all unusual to see homes selling for several million dollars. One could, in the Sydney case, think of St Ives, Cremorne, Double Bay, or Vaucluse). It is likely that examples abound in the environs of any large urban area which is broken into separately zoned municipal jurisdictions.

To keep the argument simple, assume that there are but two different skill levels, high-skilled and low-skilled labour. The high-skilled labour, having correspondingly higher income, will have outbid the low-skilled labour for the desirable Malibu location. However, the low-skilled labour will be demanded by those in the desirable locations for employment as domestic help, petrol pumping, and so on. Will workers in these occupations be willing to work in Malibu without compensation exceeding wages in other areas? The answer to this is clearly no, since the high rental cost for Malibu amenities reflects the valuations of the rich, and the poorer would (while being made somewhat better off due to the amenities) require compensation either for the higher rents associated with living in Malibu or for the cost of travel to and from their job. The rich would have to be willing to pay whichever form of compensation was lower in order to be able to hire domestic help. Indeed, one might usefully think of the wealthy residents as 'firms' producing consumption experiences where the site specific amenities and domestic help are inputs. The premium paid for domestic help can be thought of as raising the costs of 'firms' located at high-rent sites. This cost effect will, of course, reduce the benefits the rich receive from occupying the site.

This example has a number of implications for present concerns. Suppose one wished to infer the

value of the amenities in this location. The compensation paid the domestic help would result in their receiving higher, not lower, wages, suggesting that the amenities were in fact undesirable to them! If the wage compensation paid to the domestic help were high (perhaps because of great scarcity of the desirable locations combined with substantial travel cost from the locations demanded by the low skilled), and if demands for such help are high by the high-skilled rich, the rich would be willing to pay less for the land at those locations. Looking at average incomes in the desirable and undesirable locations to gauge the superiority of the amenities would also lead to error of two types: the presence of the poor would tend to understate the superiority of the amenities while the compensation paid the poor would, in a disaggregated study, overstate the superiority of the amenities (since they would look less poor than they in fact are due to the compensation).

Notice that the shares of the amenity compensation coming in land and labour markets, in a world of people-differences, are not necessarily even positive fractions. That is, one might have suspected that the value of a desirable location would always be seen as some mix of higher rents and lower wages. The preceding example makes clear that, since land rents are determined by the highest bidder while incomes are productivity based, the high rents in desirable locations may more than compensate for the value of amenities received by the poor at those locations, hence wage compensation may be positive, rather than negative. The fractions of the amenity compensation occurring in the land and labour markets are not bounded by zero and one. This point has important implications for tests of the Tiebout, (1956) hypothesis that the existence of many jurisdictions allows individual choice in the consumption of public goods; the purchase of the public goods does not, in general, occur strictly in the land market.

V Conclusions and Indicated Directions for Future Work

The conclusions to be drawn from the preceding analysis and examples are not cheery. It is far more difficult to obtain valuations of location-specific amenities than has been supposed in the past. It is, moreover, very likely that past valuation efforts have understated the value of amenities by only considering either the land or the labour market, but not both.

One cannot merely adjust wage differentials by the cost of living as has been supposed by several of the wage-based studies valuing amenities. This stems from the fact that high rents can be due either to production amenities or consumption amenities. By way of illustration, consider two cities, each having equally high rents but for different reasons. One is a lovely place to live from a consumer perspective; the other has production advantages resulting in large size, with the usual urban-rent gradient cost-of-living argument applying. Suppose, for simplicity of argument, that the wages at each location were also the same (they will not be, in general): to 'correct' for rent in calculating a real wage would give the incorrect impression that real wages were equal, when in fact in the one city real utility would be mugh higher since the rents pay for goods people care about while in the other city rents represent true costs. In a sense, this is an index of number problem of the usual sort—one can hardly argue that the cost of food is necessarily higher in an area where large amounts of lobster are being eaten relative to another area where beans are predominant in the diet!

An additional difficulty which must be faced in future empirical studies stems from the fact that, even for a single amenity, the compensation shares occurring in each of the land and labour markets may not be constant. In the preceding verbal discussion the comparisons were always of a 'this location, that location' nature—but what if, as in the real world, there are many locations? To illustrate the problem with an extreme case, consider warmth as the sole amenity and three regions, a warm island, a warm mainland area, and everywhere else (taken to be colder). The land scarcity of the warm island would suggest that more of the amenity value of warmth will be capitalized in the land market than in the labour market, relative to the warm mainland area with an expandable urban fringe. This potential problem adds yet further difficulties in empirically implementing studies aimed at valuing amenities.

Conducting a proper analysis, then, which interacts the land and labour markets and which incorporates endogenous disamenities will not be easy. Sketching the essentials of even a simple model sufficient to capture the critical features of the real world is beyond the scope of the present paper. However, such a model will have to incorporate firm and consumer behaviour in a simultaneous profit-utility maximization which can distinguish between cases where rents are high because of consumer amenities or are high because of firm amenities. Such a model would not be

identifiable at the empirical level if the same amenities affect both firms and households, but we are fairly confident that this problem will not be insurmountable (for example, tax and other incentives for industrial relocation vary spatially and would be expected to have little impact on the utility of consumers).

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