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**CHAPTER 37**

**THE PREDICTIVE USE OF GIS TO MODEL PROPERTY VALUATIONS**

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## Research Paper

### The predictive use of GIS to model property valuations

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**Abstract.** GIS is a technology which is ideally suited to analysis of the market values of properties, since such values are based upon spatial comparisons as well as individual property attributes. Great Britain now has a new mechanism of local taxation, the council tax, which is based upon the capital values of properties. Central to the implementation of this tax has been the potentially controversial assignment of properties to valuation 'bands'. This paper posits that a geographical model embedded within a GIS provides an alternative means of devising credible capital values, and anticipates some of the prospects for the use of GIS in local revenue-raising.

#### 1. Introduction

The last five years in Britain has been a turbulent period for local government revenue-raising, with the replacement of the domestic rates system first with the community charge ('poll tax') and then by the council tax. What appears at first to be an abrupt change from a property-based taxation system to one based upon personal charges and then an abrupt reversion to property in fact transpires to be a graduated shift between the person- and property-based components of successive hybrid regimes. This hybridization is in part an artefact of the central revenue-raising mechanisms themselves, although successive overhauls of these mechanisms have been eased by transitional arrangements which have, to some extent at least, been formulated on an *ad hoc* basis as the inequities and inadequacies of each system have become apparent. Quite a lot is now known about the socio-economic and demographic implications of these changes (Hills and Sutherland 1991, Paddison 1989), yet much less is known about the detailed geography of these changes: even the few analyses which do adopt a geographical perspective are restricted to coarse areal aggregations such as Regional Electoral Divisions (McCormick 1992).

These changes each have important spatial manifestations, and GIS provides a most appropriate vehicle for their analysis. In this paper we report on the development and use of a street-based geographical information system which we have previously used to model the capital values of each of the addresses in the Inner Area of Cardiff,

Wales. In a paper which was written in advance of the compilation of the official valuation list (Longley *et al.* 1993) we have described how our comprehensive capital value estimates were based upon a survey of asking prices of properties offered for sale, coupled with pre-1990 rateable values (originating in the previous domestic rates regime) and a knowledge of the geography of the study area. In this paper, we will focus upon the match of our GIS-based predictions with the 'reality' of the official valuations, now that the latter have become available for public scrutiny. We will appraise the efficacy of our model in generating plausible capital values, and suggest that GIS provides a suitable means for devising property assessments based upon comparisons with the asking prices of 'similar' properties within any given area. We also suggest that the surveying profession should more fully recognize the potential of spatial analysis within GIS.

## 2. Background and data sources

Each of the taxation regimes that has been used over the last five years in England and Wales has in practice constituted a mixture of person- and property-based taxation, although it is the property aspects of local taxes which will be our focus here. The domestic rates (in place until April 1990 in England and Wales, April 1989 in Scotland) was based upon 'rateable values' which represented fractions of the increasingly notional annual rents that each dwelling was thought able to command. Over time, various local and systematic inconsistencies in the system had become apparent, such as the low rateable values of ageing but improved owner-occupied stock relative to those of more spacious local authority accommodation or recently constructed purpose-built flats. It was a revaluation of domestic rateable values in Scotland which triggered popular protest against the system and contributed to its demise.

The recently-introduced council tax is based upon capital values of domestic properties, as more befits a housing market dominated by owner occupation. The basic procedure is that professionally-trained valuers are responsible for assigning every property to one of eight council tax bands. The cut-off points for the bands vary between England, Wales and Scotland as shown in table 1 as a response to differing average prices in Great Britain. In the first instance the overwhelming majority of property valuations were based upon external inspections, usually of the front elevation only. In areas of homogeneous stock, a procedure of assigning 'beacon' values to a single dwelling deemed representative of its neighbours was used in order to infer values for surrounding properties. A number of assumptions were invoked in order to simplify the valuation procedure, for example: that the property was available for sale with vacant possession; that every property was freehold or on a long (99 year) lease; that the property was in a state of reasonable repair; and that the state of both the property and its locality were substantially the same in April 1991 as at the time of inspection (some months after that date).

Central to our reasoning in this paper is the assumption that the asking prices for properties actually offered for sale at and shortly after the valuation date bear an identifiable correspondence with such valuations. In fact, the official valuation procedure was also guided by Inland Revenue returns pertaining to actual sale prices over an (undisclosed) period around the April 1991 base date. Our own property assessments for capital values are thus based upon the assumption that similar properties in an area will attract similar values and be worth similar amounts, and that a GIS-based spatial analysis provides a powerful means of defining such 'similarity'. Of course, other assessments and valuation regimes are possible (e.g., based upon insurance

Table 1. Property values and Council Tax bandings in Great Britain (Wales figures relevant to case study in bold).

Band	Ratio to std. charge	Property value (per £'000)		
		England	Wales	Scotland
A	6/9	Up to £40	<b>Up to £30</b>	Up to £27
B	7/9	£40–£52	<b>£30–£39</b>	£27–£35
C	8/9	£52–£68	<b>£39–£51</b>	£35–£45
D	9/9	£68–£88	<b>£51–£66</b>	£45–£58
E	11/9	£88–£120	<b>£66–£90</b>	£58–£80
F	13/9	£120–£160	<b>£90–£120</b>	£80–£106
G	15/9	£160–£320	<b>£120–£240</b>	£106–£212
H	18/9	£320 plus	<b>£240 plus</b>	£212 plus

values), but our contribution here is the construction of a transparent model of capital valuations against which the official council tax valuations may be compared. Our analysis is explicitly geographical in that use is made of small geographical areas along with the geography of (pre 1989–90) rateable values in order to model capital values.

Our own geographical study arises out of funded work on the design and analysis of the 1989 Cardiff House Condition Survey (Keltecs 1989). This Survey was intended to provide a detailed picture of the state of repair of the housing stock in the so-called 'Inner Area' of the City (see figure 1), an area of predominantly Victorian and Edwardian housing which remains a focus of sustained improvement and repair activity by the City Council. In future work, we hope to link this large and complex data set to our digitized street base in a range of geographical analyses of co-variation of household characteristics and dwelling attributes across Cardiff's Inner Area. In the present context, however, its primary relevance is that it is structured about a division of the Inner Area into 81 'House Condition Survey' areas, on the basis of the perceived within-area homogeneity of built form and dwelling conditions.

A copy of the draft Council Tax Valuation List for the Inner Area of Cardiff has been made available to us by the Valuation Office Agency. More generally, the status of access to the council tax register remains ambiguous: individuals have the right to inspect hard copies of the registers at council offices and public libraries, although as yet few non-governmental organizations have gained access to computerized lists. The council tax register contains a record for every residential property, including a brief description of the property (e.g., maisonette, bungalow), the council tax band and a Unique Property Reference Number (UPRN).

Cardiff City Council has made two important public domain data sources available to us in machine readable form, namely the most up-to-date (in 1991) domestic rates register (which included the results of all valuation appeals heard after 1989) and the street level electoral roll. The former source would enable us to identify the geographical pattern of rateable values within the Inner Area, whilst the latter gives some estimate of the geography of single person discounts within the study area. The focus of this paper is upon property valuation *per se* rather than the geography of revenue-raising, and thus we have not used the electoral roll to model discounts and rebates. The rates register represents the historical origins of the UPRNs used in the council tax list, although the two differ in practice as a result of a number of *ad hoc* and possibly idiosyncratic procedures by the Valuation Office Agency. We have created two geographical data sets in order to structure this information: a digitized street

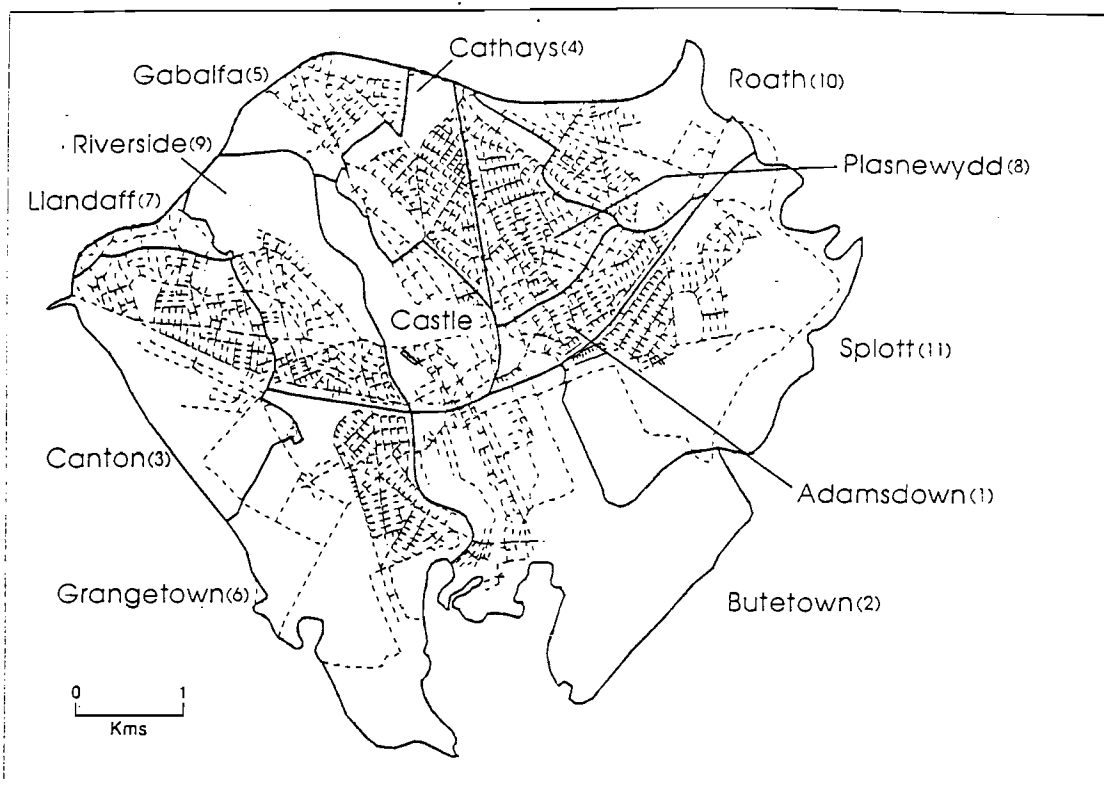


Figure 1. The digitized street network of Cardiff's Inner Area showing Community areas.

network, and a mosaic of digitized HCS areas. The initial purpose of creating the street network was to create a common geographical framework for two hitherto unmatched files, namely the person-based electoral register and the dwelling-based rates register. The purpose of digitizing the HCS boundaries was to generate appropriate small area building blocks which could be used to evaluate the means by which some of the changes in local taxation were being effected. This was, in practice, a significant task, involving as it did the detailed investigation of mismatches between the two very different registers, for example because of residential demolition and new construction, and reconciliation of slightly different methods for identifying street segments in the two files. We are, to our knowledge, the first researchers to have accomplished this task, and our data base makes it possible for the first time to compare the spatial effects of the different tax regimes.

### 3. The scope for geographical analysis

Our research has centred around a number of analyses of the street level database, using the ARC/INFO GIS together with custom-written programs for list matching and data analysis. Given disaggregate information about the geographical distributions of individuals, addresses and address attributes within the Inner Area, it has become a reasonably straightforward procedure to compare the detailed geographies of revenue raising under the rates and the community charge (Martin *et al.* 1992). In this empirical work we have produced estimates at the street level of resolution although as yet these do not incorporate spatial overlays pertaining to the geographical pattern of discounts, reductions and exemptions.

Following our initial study of the geography of revenue-raising under the domestic rates and the community charge, our attention shifted in 1992 towards the then proposed

(and now implemented) council tax. Our initial interest arose from reports in the press that the council tax valuation procedure was overly simplistic, in that it was to be based upon external inspection of the front aspect of addresses only, and that a number of seemingly heroic assumptions were to be invoked with respect to state of repair and availability for sale on the open market. In practice we understand that valuation of most properties (including all of those in Cardiff's Inner Area), is likely to have been rather more sophisticated than such reports suggest, although the negative skew in the distribution of property bandings in Wales does suggest that systematic under-valuation may have taken place relative to early estimates of the distribution of property values. The valuation process does, however, remain quite opaque, in that whilst we understand that Inland Revenue data pertaining to house sales were used to interpolate values for properties, the locations, prices, and procedures for grossing or discounting sale prices from earlier points in time do not constitute information in the public domain.

The methodology that we developed in order to anticipate capital values has been described by Longley *et al.* (1993). The essence of the approach was to conduct a survey of asking prices of properties actually for sale for an almost contemporaneous time period (December 1991) to the actual valuation data (April 1991). On the assumption that these prices bore an identifiable correspondence with capital values, we devised a geographical model which would allow us to impute the capital values of all properties which were not in the process of being offered for sale. The house price survey of the asking prices of 796 properties (2.1 per cent of all properties in the Inner Area) was carried out in December 1991, some eight months after the date of the retrospective official valuations and during a period in which local house prices were at best stable, at worst slightly falling. We have previously shown (Longley *et al.* 1993) that the spatial distribution of 'price survey' properties was reasonably even across the study area. Imputation was based upon information on rateable values, dwelling type (collected in our house price survey and identifiable from the domestic rates register), House Condition Survey area of location, and aggregate regression relationships between asking prices and capital values. The sequential procedure of assigning capital values, together with the number of capital values allocated at each stage, is summarized in figure 2. Of particular note is the use of the rateable value of each price survey dwelling relative to the distribution of rateable values within its street, in order to ascertain whether the value of a price survey dwelling can legitimately be used to impute the values of some or all of its neighbours.

In spirit this procedure is not radically different from that of the official valuation process, in that 'beacon' properties are used to assign guide values to non-surveyed properties. Indeed in some respects, our procedure may represent an improvement on the official valuations, in that property valuations carried out when a property is to be put on to the market include a far greater range of (internal as well as external) dwelling attributes than can be included in the valuation process. In so far as the official valuation procedure is reliant upon historical inflation from property sales, our procedure has the strength of pertaining to asking prices at a single point in time, and is not vulnerable to the vagaries of applying possibly inappropriate regional or national house price inflation or deflation factors. Both procedures have their weaknesses as regards how representative is the state of repair of any 'beacon' property of its neighbours, although our own approach may offer better prospects for decomposing house prices into land value and building attribute components. A particular weakness of the house price survey method is that only quite limited information is available for properties which are atypical of their neighbours—the capital values of properties which have rateable

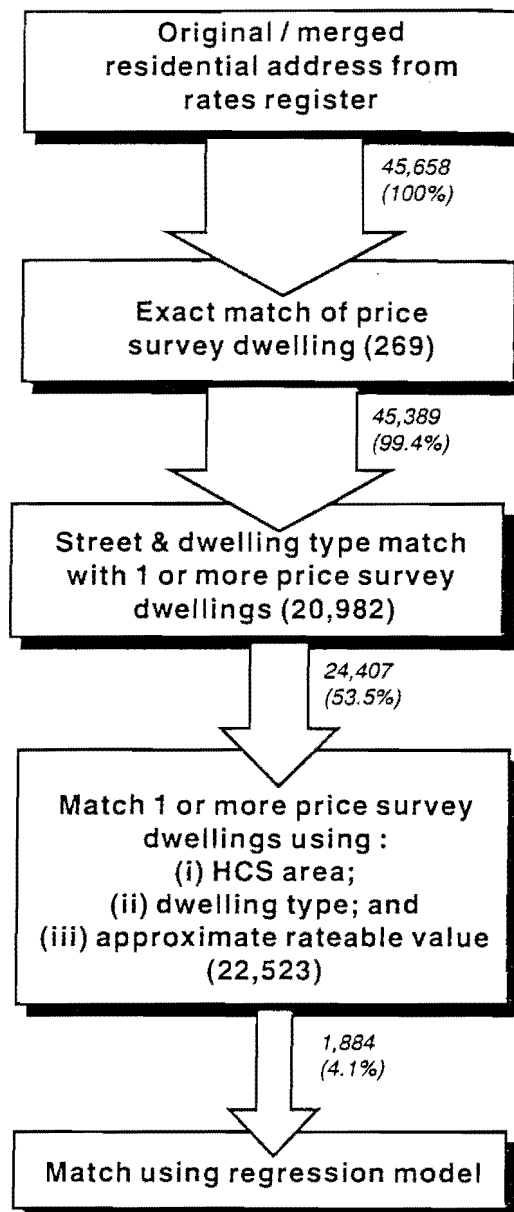


Figure 2. Assignment process for modelled capital values.

values quite different to their neighbours are usually assigned capital values by a regression relationship in the final stage of the assignment process. In contrast, unusual properties are targeted for special attention in the official valuation process, and thus official capital valuations are more likely to be reliable in such instances. If frequently carried out, both methods offer the prospect of costing the effects of planning policy interventions with respect to changes in the local revenue base.

In practice capital valuations are likely to be inaccurate for a number of reasons. Both the official valuations and our price survey have been retrospective valuations, carried out over a year and eight months (respectively) after the April 1991 benchmark date. We understand that the official valuations were carried out more often than not by estate agents and other valuers who were not local to the area, and that as such the values might not be expected to capture the full effects upon values of local neighbourhood externalities. Our price survey data might be expected to include a

'valuation gap' between asking prices and realizable capital values in the stagnant market conditions of late 1991: informal enquiries to estate agents at the time the survey was conducted suggested that prospective purchasers who were ready, willing and able to proceed might expect a discount of the order of 8–10 per cent on the asking prices. A countervailing tendency, however, would have been that the gradual downward drift of prices during 1991 would already have been reflected in the asking prices at the time of the house price survey in December 1991. Over-all, our partly intuitive belief is that our house price survey should certainly have provided a reasonable ball-park estimate of realizable capital values as at April 1991. In the following section, we will assess the predictive success of our model, and will then go on to look at some ways in which it might be refined in further research.

#### **4. Observed and predicted council tax bandings**

As suggested in the introduction to this paper, our model represents a genuinely predictive application of GIS to anticipate a geographical patterning of capital values which was not known at the time that the exercise was undertaken. Figure 3 shows the modal band for each street in the Inner Area derived from the draft Council Tax Valuation List. Our detailed analysis suggests that these maps provide the best means of depicting this information, given the high level of within-street homogeneity of built form in this urban core area. The maps illustrate that the most common modal street bands are clustered in spatially contiguous areas. In view of the vagaries of the valuation procedures, however, these official valuations cannot be regarded as absolute: here we will begin the process of comparing these valuations with our model predictions and, by implication, will begin to identify those circumstances and areas in which the official valuations may prove to be suspect.

Our model replicates the official banding for 19 151 of the 45 899 modelled properties. Figure 4 compares the actual allocation of properties between bands with the allocation based upon our model and shows that the actual distribution of council tax values exhibits a strong negative skew, a result which, contrary to intentions at the earlier stages of the introduction of the council tax, is likely to have been reproduced at the scale of Wales as a whole (Welsh Office 1994). The distribution of modelled values exhibits a less strong skew, and records higher numbers of properties in all but the lowest two categories. The negative skew might be viewed as consistent with either an over-inflation of asking prices in anticipation of arbitrage behaviour in a stagnant housing market, and/or as a consequence of general undervaluation. Any under-estimation of the true capital values of properties would, of course, have redistributive implications, since (all other things being equal) an overly negative-skewed distribution of values would require a higher standard charge in order to recoup the same revenue: we will investigate this scenario in our discussion below.

The magnitudes of mismatches between observed and predicted council tax bands is shown at the level of the community in figure 5. In this figure, negative (positive) differences in banding represent instances in which we have under-predicted (over-predicted) the official valuations. The most common category over-all and in nine of the twelve communities or part communities is zero mismatch, i.e., a coincidence of observed and predicted banding. In eight of these nine communities the distribution of mismatches is very closely aligned about this median category. A negative skew is evident in all but one of the communities (the exception being Splott), although distribution of these discrepancies varies quite markedly between communities. Our experience of the study area leads us to suggest that the number of incorrect predictions

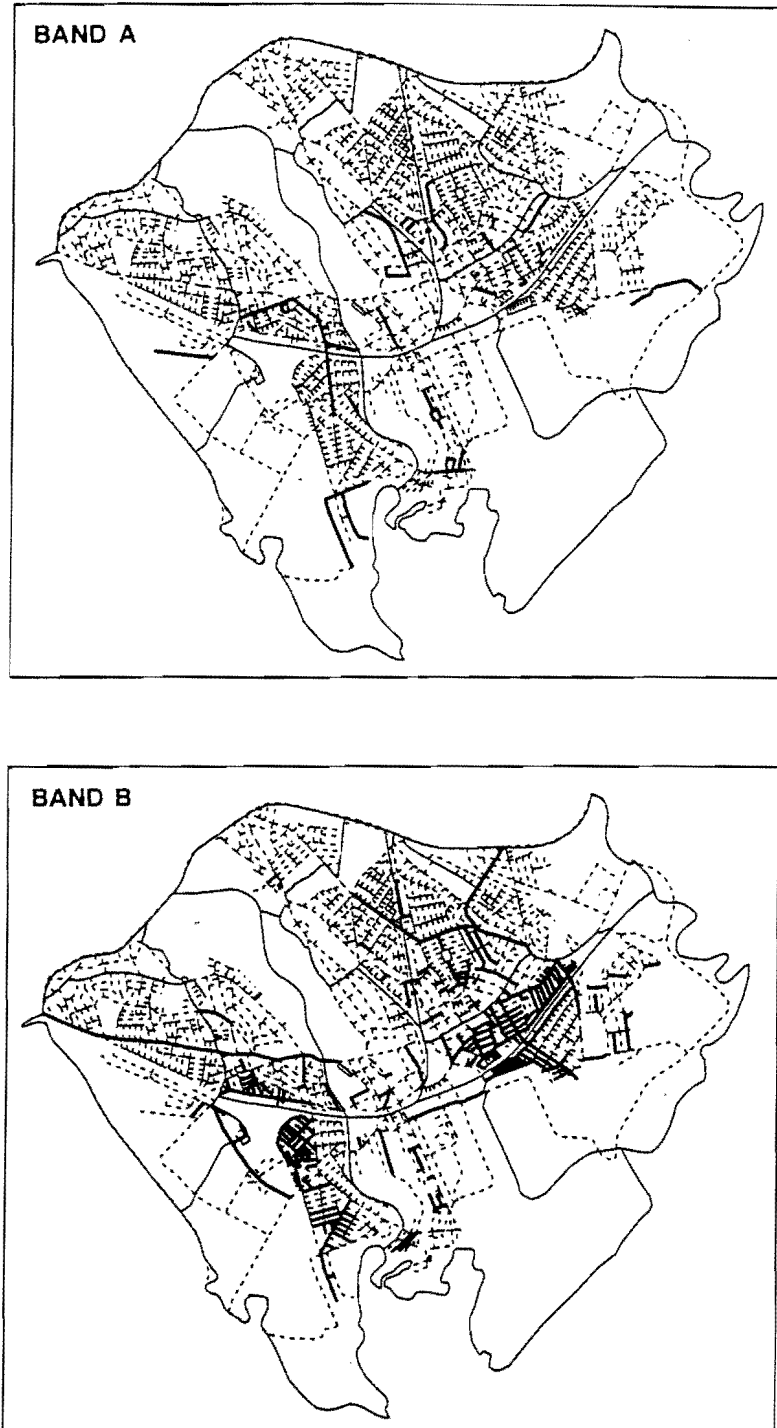


Figure 3.

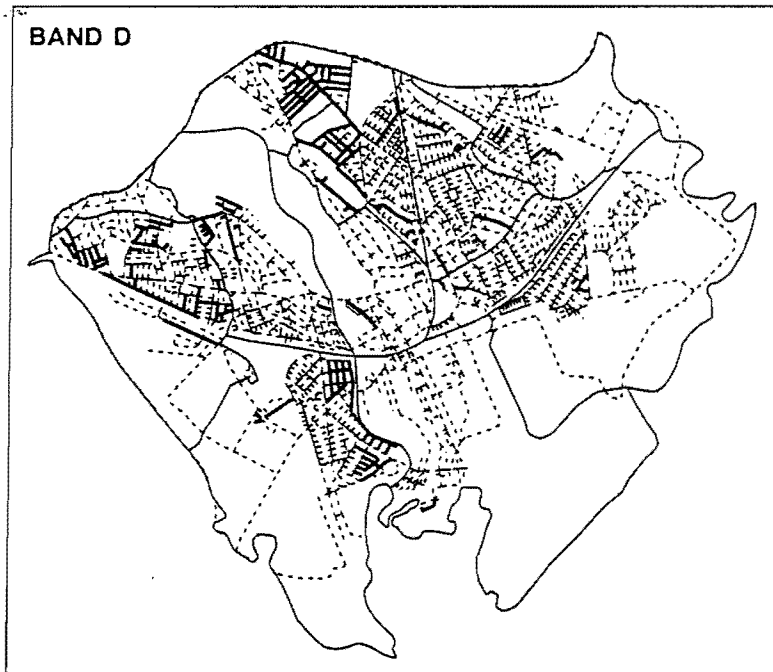
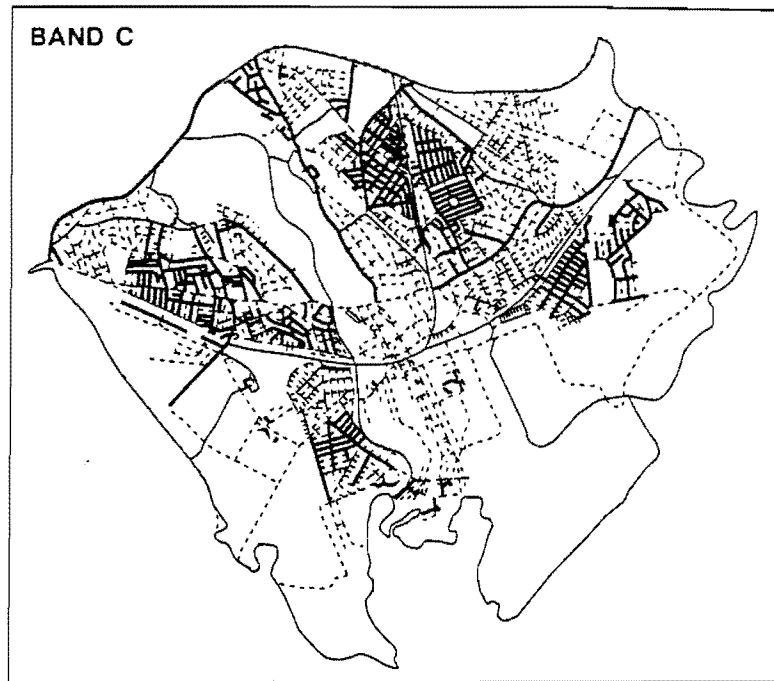


Figure 3. (continued)

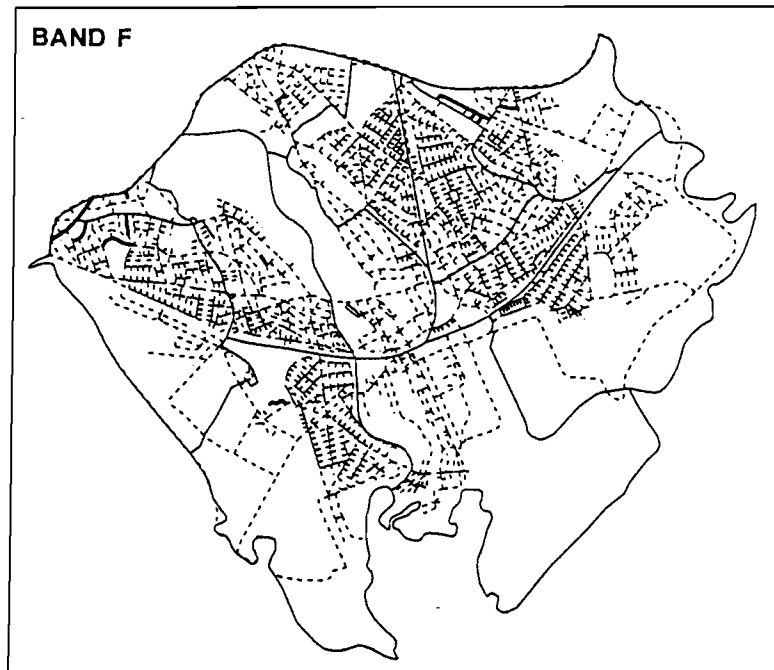
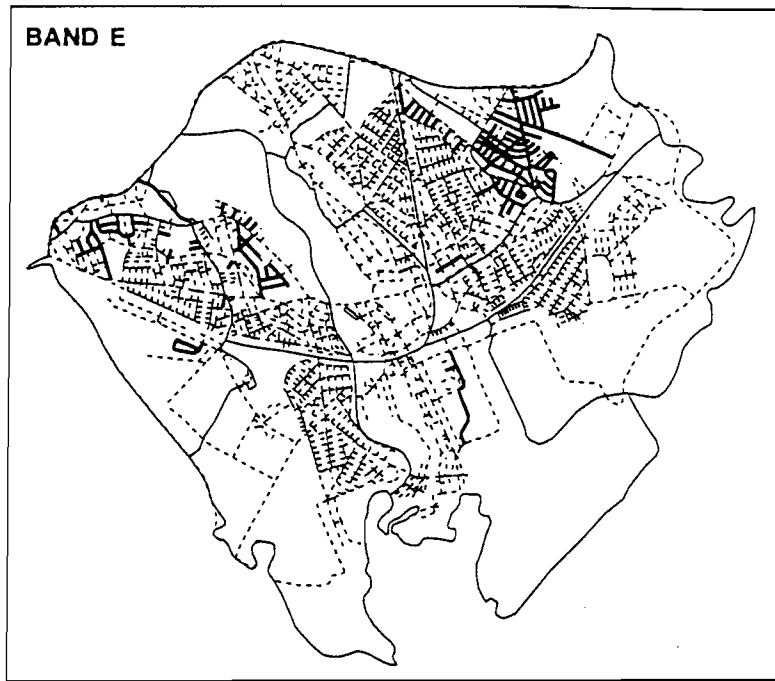


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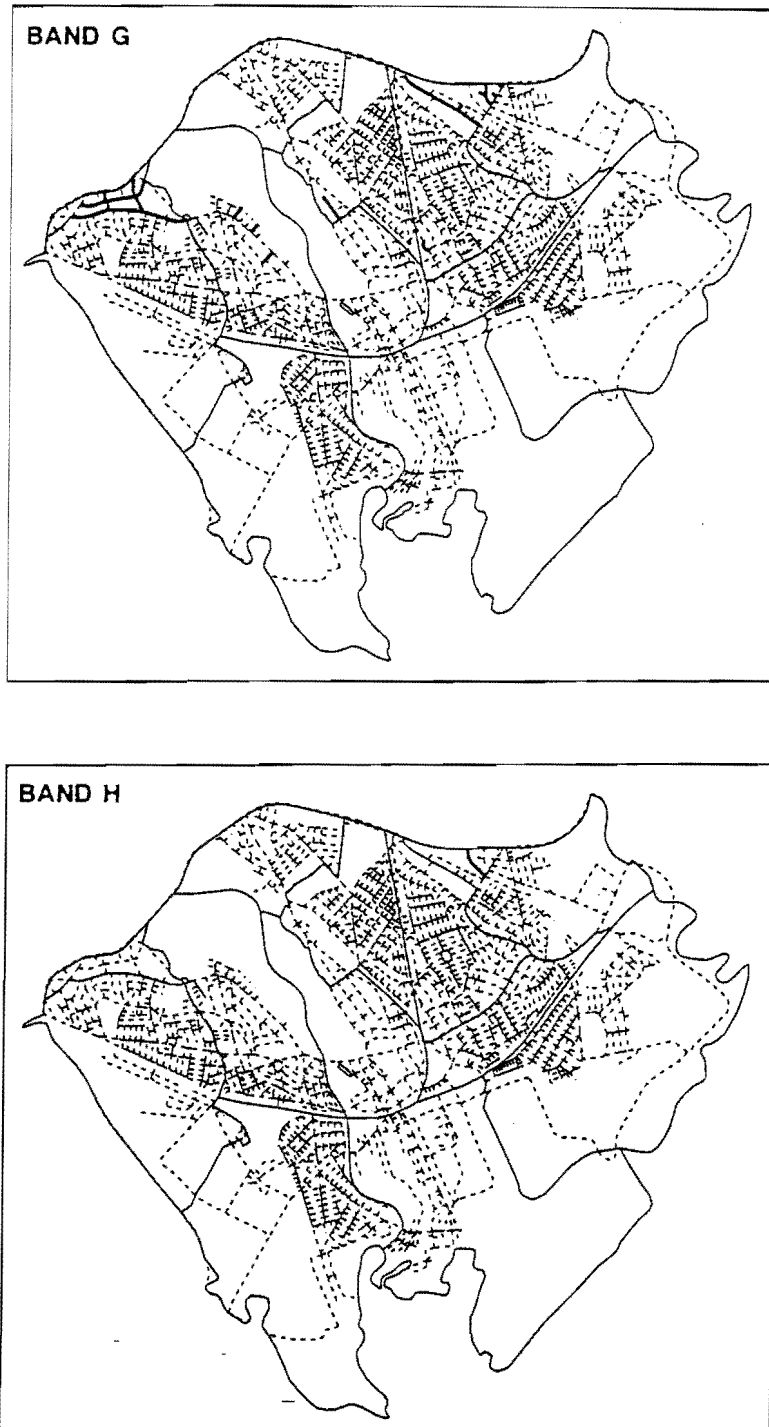


Figure 3. Actual inter-band allocation of modal street bands.

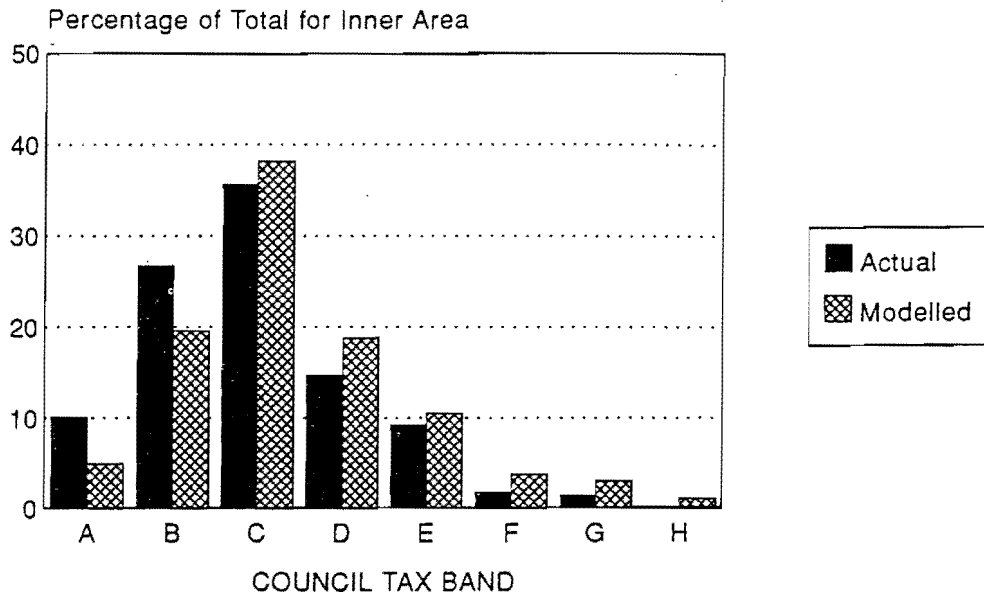


Figure 4. Allocation of properties between bands for the Inner Area of Cardiff.

and the magnitude of negative skew are greatest in those communities with greatest heterogeneity in dwelling types and the widest range in house values. Misclassifications of two or more bands' magnitude certainly need to be evaluated in the context of possible model refinement, and in our conclusions we discuss these as part of our ongoing research agenda.

Figure 6 uses the street modal band as a baseline from which to predict the geographical patterning of deviations between the actual and the predicted council tax bandings. It is apparent that there exists some basic patterning to the incidence of both over- and under-predictions. There is some limited evidence that the actual council tax bands are less than those predicted by our model for smaller, older yet popular housing in the more fashionable areas of Riverside, whereas the converse is true for enclaves of housing constructed by the local authority, such as Tremorfa. It is not the purpose of this paper to seek to explain these apparent discrepancies in substantive terms and will be the role of further research to assess whether it is the official valuation process itself which has led to systematic patterns of under- and over-valuation across the city as a whole. Once we have been able to merge the Cardiff House Condition Survey data set, it should also be possible to identify which dwelling attributes (ranging from age and construction type to tenure and perceived neighbourhood amenity) are associated with the apparent patterning of under- and over-predictions.

Under the arrangements for the introduction of the council tax, residents generally have had the right of appeal against valuation bandings. Under the present system of local government finance, the council tax represents only a small proportion of total local government expenditure—it is estimated that the council tax will raise £6.2 million (just less than 4 per cent) of the £159.5 million of budgeted expenditure in Cardiff in 1993/4. This £6.2 million is to be raised as levies on property in the ratios set out in tables 1 and 2. Local authorities have estimated the standard (Band D) charge based upon the provisional estimates devised using the known distribution of properties between bands.

We have undertaken a preliminary sensitivity analysis of the financial implications of possible widespread under-valuation of properties in the following manner. First, we

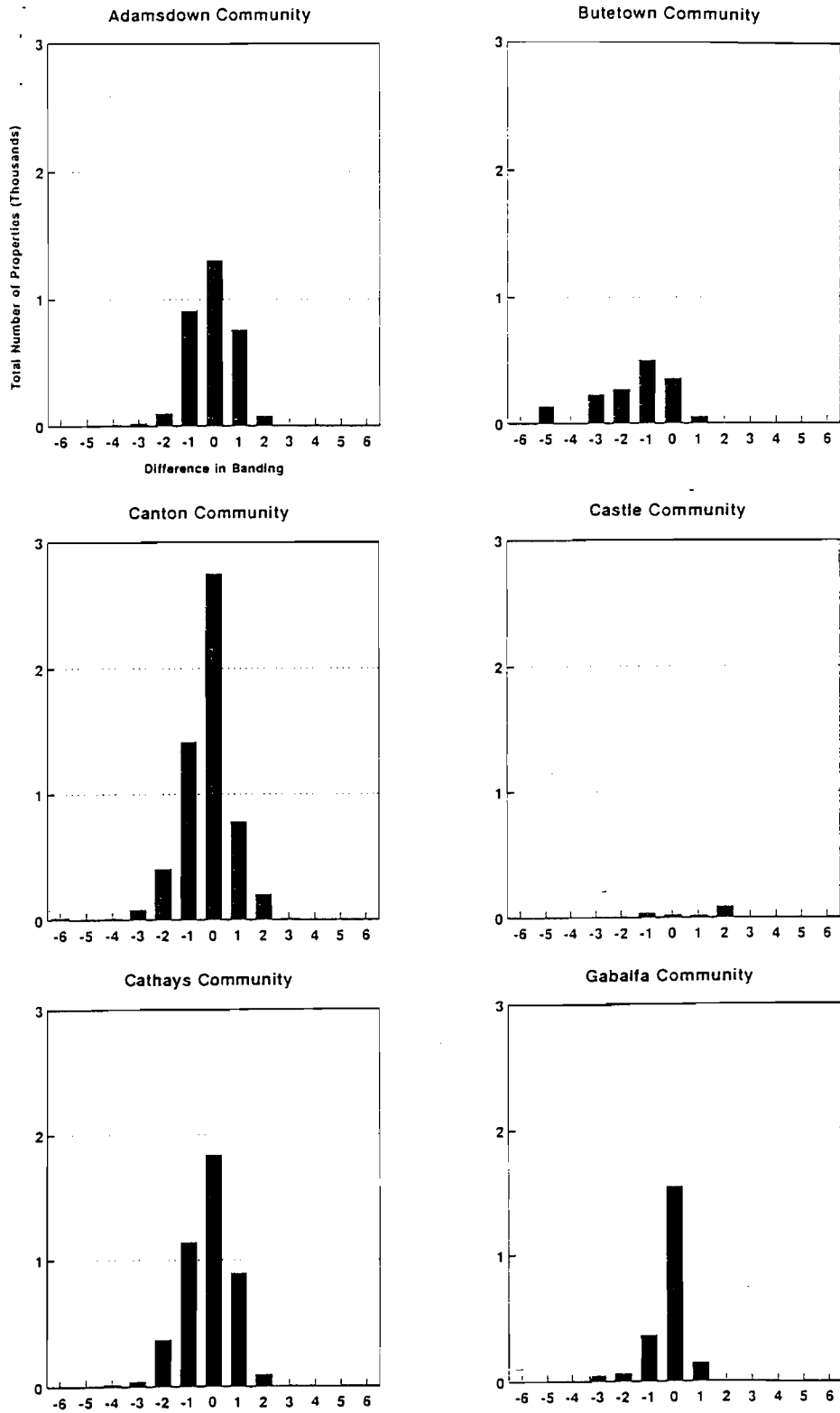


Figure 5.

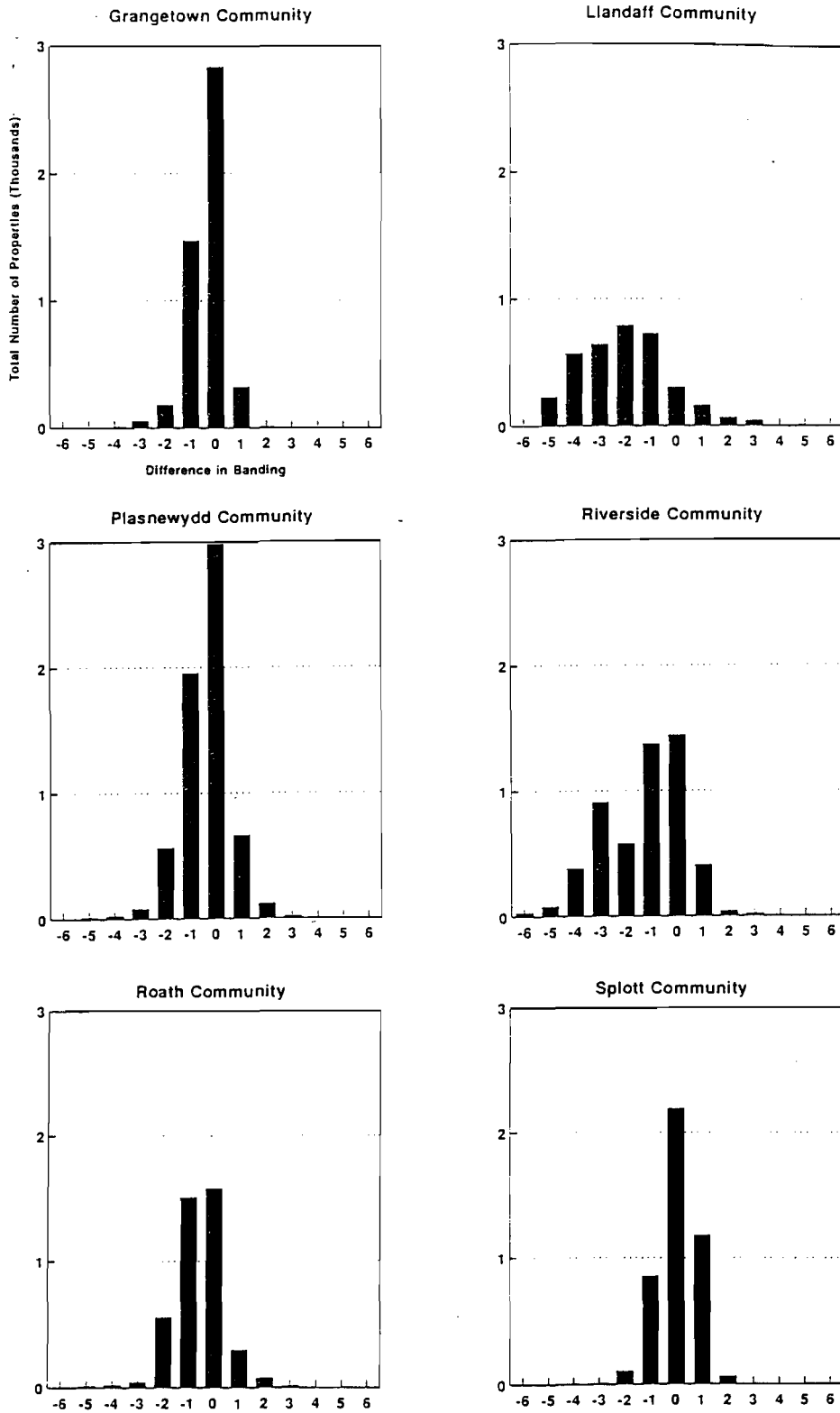


Figure 5. Comparison of modelled and actual council tax bands by property and by community.

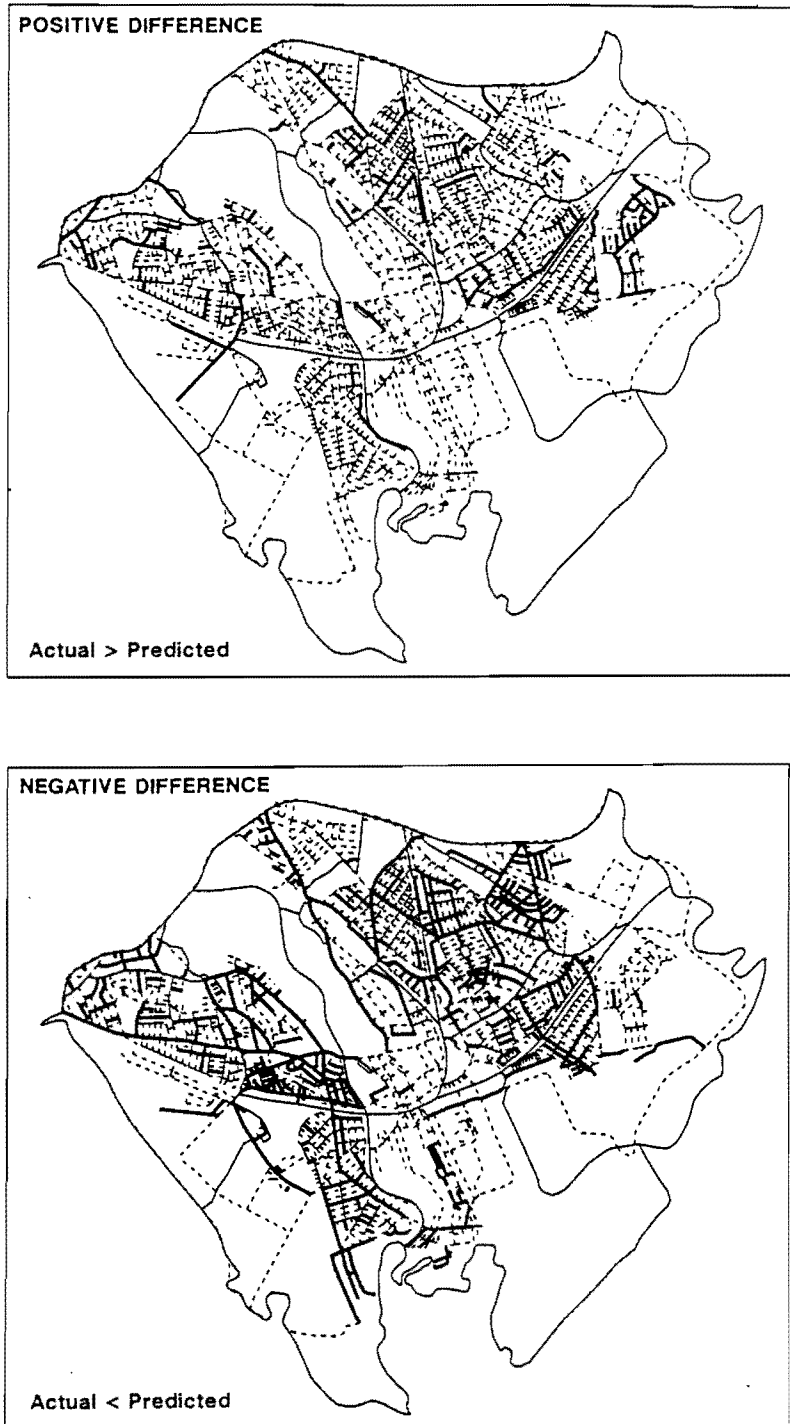


Figure 6. Differences between actual and predicted valuations.

Table 2. Aspects of actual and modelled Council Tax bandings in Cardiff.

I Value (£'000)	II Band	III Ratio to std. charge	IV Actual tax (£)	V No. props	VI Predicted tax (£)	VII No. props
Up to £30	A	6/9	193.04	4082	186.24	2298
£30-£39	B	7/9	225.21	11412	217.28	9027
£39-£51	C	8/9	257.39	15661	248.33	17636
£51-£66	D	9/9	289.56	7307	279.37	8672
£66-£90	E	11/9	353.90	4995	341.45	4852
£90-£120	F	13/9	418.25	1437	403.53	1738
£120-£240	G	15/9	482.60	1113	465.61	1423
£240 plus	H	18/9	579.12	151	558.73	512

have calculated the total revenue that will be raised by the 46 158 properties that are recorded on the Valuation List in the Inner Area and are allocated between bands as in column V of table 2, ignoring all single person, non-qualifying person and empty property discounts. Based on this simplifying assumption, the Inner Area could yield £12 498 222.18 in council tax revenues based on the actual tax figures shown in table 2 (column IV). In our model we are able to predict capital values for only 41 675 properties because of simplifying assumptions that we have invoked in amalgamating flatted properties and because our model is reliant upon rateable value information from the domestic rates register which does not include properties constructed since 1989. We have therefore assumed that the difference of 4483 properties is spread between bands in direct proportion to the numbers of properties recorded in each of the bands in our predicted distribution. Applying a constant inflation factor to our modelled inter-band distribution yields the figures in column VI of table 2. It is then straightforward to use the ratios governing relative payments between bands (table 2 column III) to predict the standard band charges which would raise the same revenue total based upon the modelled inter-band distribution.

The standard (Band D) charge based upon the modelled distribution is £279.37, a decrease of £10.19, representing a reduction of 3.5 per cent on the actual standard charge. This reduction is made possible because the modelled distribution of capital values is less negatively skewed than the actual distribution (figure 4). If our modelled values do in fact paint a more representative picture of realizable capital values than those on the Valuation List, then the implication is that households will pay a higher charge (ranging from £6.79 for a Band A property to £20.38 for a Band H property) *unless* the lower valuation of their own (Band B through Band H) property is one of the minority that is allocated to a lower band as a result of the under-valuation. These figures are small in absolute terms, but it should be remembered that they are payments made to Cardiff City Council under a local government funding regime in which just 4 per cent of local expenditure is raised through the council tax: were local government revenue-raising to be increased to the higher levels of the fairly recent past, then the financial implications of under-valuation would be much more severe (as they already are in areas in England where standard charges are considerably higher).

##### 5. Monitoring local taxation: an evolving agenda

In this paper we have begun to highlight the ways in which GIS may contribute towards the more effective monitoring of the mechanisms and redistributive consequences of different local taxation regimes. Our house price survey was not a

labour intensive exercise, and the greater part of our effort by far involved the construction of the street-based data base and the developmental work in linking the rather diverse data sets. We suggest that in these circumstances our application has shown that GIS provides a flexible and cost effective tool with which to gauge the implications of a variety of aspects of local taxation. Our application illustrates some of the obstacles facing local government organizations who wish to integrate existing records in a GIS framework but are faced with difficulties of matching property lists derived from different sources and pertaining to different points in time. Specifically, it is extremely difficult to unambiguously relate UPRNs based on street geography with the small policy areas whose boundaries cross many streets. Many such registers held by local government use local property referencing systems which are hard to integrate with national data series, although considerable effort has been applied to the postcoding of the new council tax registers. The Council Tax Valuation List potentially fulfils an important integrative role as a data-linking mechanism in local government research and policy-making, although there is still some way to go in even the more innovative local authorities before the organizational prerequisites to GIS-based data management are fully in place. Resolution of confidentiality issues associated with the Valuation List would be a further prerequisite to substantial progress in this direction. There are a number of important issues that such a spatially referenced and integrative data-base might make more transparent.

First is the important issue of the local scale redistributive effects which have accompanied the introduction of the council tax. Using known information about population size and the distribution of rateable values for a given area, it is possible to identify the level of community charge or the domestic rate poundage that would be required (with or without transitional relief), to yield the same revenue as the council tax. The linking mechanisms between the geographical layers of rateable values, community charge-payers and council tax capital values would enable identification of precise patterns of those households and/or individuals that would be best off under the rates, community charge or council tax regimes. There also exists the prospect of modelling the patterns of 'gainers' and 'losers' with the aid of secondary data sources (e.g., see Longley and Williams 1993), in order to identify those individuals and households that would have benefited from a range of different rebate schemes. In this way, it would prove possible to identify or estimate the household characteristics and dwelling/neighbourhood attributes which are associated with geographical patterns of gain or loss, as well as the geography of the burden of transitional relief.

A second focus should be upon the assumptions inherent in the official valuation procedure and the relationship between valuations and the asking prices of identical or directly comparable properties offered for sale on the open market. Factors such as tenure (particularly of local authority dwellings which may or may not have been sold, and streets still dominated by the private rental market), dwelling condition, the state of different housing sub-markets and neighbourhood externalities are likely to create discrepancies between capital valuations and asking prices. GIS offers the prospect of analysis of the geographical pattern of mismatches of official capital valuations with the generalized 'asking prices' produced by exercises such as ours. Discrepancies might then be reviewed with reference to factors such as the assumptions inherent in the official valuation process (e.g., with respect to state of repair), and the local level of improvement and repair activity.

An important political issue at the present time concerns the general, but spatially variable, falls in house prices that have been characteristic of most of Britain (including

our study area) since the late 1980s. Government adherence to the April 1991 valuation bench-mark is unambiguous, but what is not clear at the time of writing is the degree to which systematic under-valuation may have been used, not least in order to minimize the burden on the appeals system. Any such systematic under-valuation would, of course, have a similar kind of effect upon the levels of standard charges to that calculated above.

An immediate application for this GIS would appear to be to act as a 'first filter' to focus upon those areas where any appeal against official valuations is likely to be upheld. With appropriate refinements, GISs should be able to present broad pictures of the accuracy or otherwise of the official valuations. A strength of the GIS approach is thus that insights into the valuation process can be obtained over a range of scales: other approaches (such as private surveys commissioned by residents in order to contest valuations) can only consider a valuation relative to immediate neighbours, and this will tend to presume that the street modal band assessment is an accurate one. Our community breakdown of discrepancies between actual and modelled council tax bands suggests that there might be coarser scale anomalies in the treatment of different parts of our study area. If there were any city-wide systematic trend towards under-valuation at a city-wide scale, smaller area discrepancies might nevertheless not result in successful valuation challenges, yet a measure of error would nevertheless have been incorporated into the valuation process. GIS provides a useful means of identifying and monitoring any such possible discrepancies.

Finally, the seeds to the demise of the domestic rating system arguably lay in the unpopularity of the infrequent revaluations which were used to adjust the relative burden of taxation borne by residents of different properties. Applied to the council tax, such revaluations should take on board relative price movements of dwellings within and between urban areas. Our final point is that house price models developed within GISs might be used to devise models which will take into account market information (e.g., rates of regional and local house price inflation) in order to update the Council Tax Valuation List relative to Lists for other areas of the country. It is possibly in this respect that the contributions of GIS may be of greatest and most lasting importance.

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