THE RELATIONSHIP BETWEEN URBAN STREET CONFIGURATION AND OFFICE RENT PATTERNS IN BERLIN

A Thesis submitted in partial fulfilment of the requirements of University College London for the degree of Doctor of Philosophy in Architecture

Jake Desyllas

September 1999
Resubmitted with minor amendments June 2000

University College London

THE RELATIONSHIP BETWEEN URBAN STREET CONFIGURATION AND OFFICE RENT PATTERNS IN BERLIN

A Thesis submitted in partial fulfilment of the requirements of University College London for the degree of Doctor of Philosophy in Architecture

Jake Desyllas

September 1999
Resubmitted with minor amendments June 2000

University College London

ACKNOWLEDGEMENTS

I would like to thank my supervisor Alan Penn both for his invaluable support during this thesis and his challenging questions. At the Bartlett I would also particularly like to thank Bill Hillier who was an inspirational source of ideas during the EU funded research project that I worked on whilst undertaking this research. The experience taught me a great deal about how to analyse spatial problems. I would like to thank Tim Stonor and everyone at the Space Syntax Laboratory for providing me with so many research opportunities that stimulated my own work during the writing of this thesis. At the Centre for Advanced Spatial Analysis I would particularly like to thank Mike Batty, Simon Doyle and Muki Hakalay, who were very helpful during my education in the use of relational databases and Geographic Information Systems (GIS) that were instrumental in the methodology of this thesis.

This study would not have been possible without the support of Jones Lang LaSalle, who provided the primary sample of rent data. I am particularly grateful to Nigel Roberts, Sascha Hettrich and everyone at JLL Berlin for their foresightedness in supporting research and their willingness to offer their time and assistance. The research has also benefited from the support of the UCL Graduate School, the Deutscher Akademischer Austauschdienst and the Abgeordnetenhaus Von Berlin to whom I am very grateful.

I would like to thank Dr Thomas Dietrich, the Fechnerstraße clan and the many other Berliners who provided a wide eyed visitor with guidance and inside stories in that strange world that was Berlin in the 1990s. Last but not least, many thanks to my family, friends and those close to me between 1991 and 1999 who put up with my preoccupation with Berlin, space and the property market. Responsibility for the contents remains of course mine.

THE RELATIONSHIP BETWEEN URBAN STREET CONFIGURATION AND OFFICE RENT PATTERNS IN BERLIN

Jake Desyllas
[redacted]

ABSTRACT

This thesis presents a study of the influence of urban street configuration on the pattern of commercial office rents in Berlin. The hypothesis is that there is a relationship between the two, and that the alteration of the street network with reunification has precipitated a spatial reorganisation of office rents.

The identification of an independent spatial variable that can be used to account for the pattern of rent is a key problem in office rent studies. Unlike previously used distances to a point in the Central Business District (CBD) or other destinations, this study uses 'space syntax' measures of the morphology of the street network. 'Global integration' is used to measure the role of each street within the entire configuration, revealing fundamental changes in the spatial structure of Berlin both with the city's historical development and with reunification.

Whereas most previous office rent studies have used yearly average asking rents per building for a short period, a sample of 412 achieved rents over a 7 year period was collected to control for the influence of lease provisions and the effect of market change over time on rents. The spatial pattern of 'location rents' is investigated through visual representations using GIS. Significant variation from street to street and a marked rise from periphery to centre are found. Unlike previous studies, spatial changes over time were investigated: a marked shift in the pattern of rents from West Berlin to the East has occurred in the 7 years following reunification. This shift corresponds to the changing spatial structure of the city revealed in the spatial analysis.

Multiple Regression Analysis (MRA) is used to quantify the importance of spatial variables (space syntax measures) in rent determination but also taking non-spatial variables (time, building quality, and lease provisions) into account. The main findings are that rents in West Berlin can be explained by the date of lease commencement (falling with the recession) and the global spatial integration as it was in divided Berlin. In East Berlin the global integration pattern of *reunified* Berlin is most important and secondly the date of lease commencement. Other variables such as floorspace and lease length are not found to have statistical significance. It is concluded that the change in Berlin's spatial structure that occurred with reunification led to a spatial reorganisation of prime office rents from the West Berlin CBD into the former East Berlin district of Mitte. It is argued that 'location value' will be an emergent property of any spatial system because a differentiated potential for co-presence is created.

CONTENTS

FIGURES

TABLES

MAPS

AXIAL MAPS

1 INTRODUCTION

The main task of the theoretical social sciences is to trace the unintended social repercussions of intentional human actions.

(Popper 1992)

The ways in which real environments work- either well or pathologically- are as often as not the *unintended* by-products of declared 'purposes' which designers have attempted to realise in a way that disregards morphological constraints and laws.

(Hillier 1985)

1.1 Research Field

Within the field of social science, there are a number of research programmes that look at different aspects of the relationship between society and its spatial structure. Hillier has made a distinction between research into the effects society has on space and the effects that space has back onto society (Hillier 1985; Hillier 1999). The first strand of research inquires into the way in which society creates spatial structures for its own reproduction. Research of this kind seeks to answer questions about the mechanisms and rules by which buildings and cities are created for social needs.

The second kind of research looks into the often-unintended social consequences that these spatial structures then have back onto society. Once a spatial structure such as an urban area has been created, it seems to offer unexpected social potentials and problems. The way that people use an area depends not on what planners or architects might have expected but on these potentials offered by the spatial structure itself. What are the laws that govern the use of spatial structure that we find, however it was created and for whatever original purpose? This is the starting point for a research programme that attempts to isolate the independent role of spatial structure onto the functioning of society, to which this thesis seeks to contribute.

The thesis investigates the effect of urban layout on the pattern of office rent. Urban layout will be defined as the morphology of the street network- the configuration of streets and public spaces. The pattern of rent will be defined as the spatial differences in rents that cannot be explained by intervening variables and are assumed to be a premium for location. Location can justifiably be treated as an independent variable in rent determination because individual tenants cannot be said to change the pattern of streets for themselves by letting office space at a higher or lower rent. There are some interesting theories about long term mechanisms that condition the layout of streets in response to rent patterns (Ratcliff 1949). However, in the short to medium term any causality can safely be viewed from layout to rent pattern and not vice versa: companies are faced with a series of location choices on the market and they value each through their bidding more or less for each.

For most office-based companies, the question of paying for location is a question of renting, not buying or building space. In the City of London, 73% of firms do not own their own premises (Crosby and Murdoch 1998). A recent US survey in 50 metropolitan areas similarly found that 75% of firms did not own (Wheaton and Torto 1994; Dipasquale and Wheaton 1996). So the relationship under investigation is that between the spatial structure of the street network and the pattern of office rents within it.

1.2 The Case of Berlin

The case study for this thesis is the city of Berlin since reunification, especially the years 1991-1997. Berlin is a particularly interesting case study for the problem of location and rent because of the dramatic transformation of both the city morphology and the property market since the wall fell. The reunification of East and West Berlin presented a unique spatial restructuring of a city. After three decades of physical division, East and West Berlin suddenly formed one reunified urban system. Everyone involved in the property market has had to adapt to this new urban geography. This study uses a method of urban morphological analysis called space syntax to measure the spatial structure of Berlin's street system. In particular, the analysis provides measures of how the reunification of the city changed the spatial structure against which rent patterns can be compared.

Not only has there been a fundamental change in the spatial structure of the city, there has been a profound spatial reorganisation in the property market since reunification. Over 9.5 million square metres of office space were completed between 1989 and 1995. An enormous boom in office rents directly after unification turned to recession in 1992 with average office rent prices being halved between 1992 and 1997.

The most interesting facet of the property market has been its spatial reorganisation in response to Berlin's new geography: there has been a *re-valuing* of locations by the market. Office rent maps have shown two peaks in value, one in the West Berlin CBD and a new one in the formerly Eastern district of 'Mitte'. According to property agents' reports, in the short time since reunification it is this Eastern centre that has become the higher of the two rental peaks. Mitte has gone from a run-down eastern district hemmed in on 3 sides by the Wall to the area of prime office rents.

The thesis will present an analysis of the relationship between these two fundamental spatial changes in Berlin: the morphological restructuring that has been precipitated by the fall of the wall and the spatial restructuring of the office property market that has followed in its wake.

1.3 Location and Rent: Three Questions

In order to investigate the role of street layout on office rents for the particular case of reunified Berlin, a sample of office lease data has been analysed. This data is linked to the analysis of the configurational properties of street system that are presented in the earlier chapters to test the influence of urban street configuration on rent patterns. The empirical data is a sample of 412 office leases from Berlin for the period 1991-1997. The empirical study of a rent sample seeks to answer the following three main questions:

1.3.1 How much does a tenant pay for location as distinct from other factors?

The first question concerns the technical and methodological problems involved in isolating the *location variable* in rent from a multitude of other intervening variables. How much of the rent on an office space is a premium for location as distinct for the amount paid for other factors such as the quality of the unit, characteristics of the building and provisions of the lease? The literature review of chapter 2 outlines previous research into this problem. One strand of research has been in the field of econometrics, where Multiple Regression Analysis (MRA) has been used to isolate variables involved in rent determination. Another strand has come from the surveying and property research community, which has evaluated the nature of lease contracts more closely to ascertain what tenants are actually paying and under what conditions or terms (Crosby and Murdoch 1998).

The thesis takes its cue from both research strands by using MRA to look at the influence of variables but on a sample of office leases that has been individually evaluated in detail. Chapter 3 presents the methodology used in this thesis to analyse the leases within the context of these previous approaches. Chapter 6 of the thesis then tackles the question of non-spatial influences on rent for the sample of office leases from Berlin, most importantly the factor of time and the difference in building quality. The effect of other variables on rent is accounted for in a location blind MRA, leaving a *location rent*.

1.3.2 What does the pattern of location rents look like?

The second question refers to the spatial patterns that location rent values form in a city. In the literature review of chapter 2 it is shown that a great deal of urban economic theory has involved location rents within a more general model of the urban economy. These theories have posited models in which rent has a simple spatial pattern, traditionally this has been mono-centric (Alonso 1964) but more recent work has aimed to show that rent patterns could be potentially polycentric (Heikkila, Gordon et al. 1989).

The literature review also shows that despite the importance of rent within these larger models of the urban economy, there has been surprisingly little empirical research into the real spatial patterns of rent found in cities. In particular, econometric studies of office rents have presented surprisingly little evidence of spatial patterns against which to test models of rent determination. Of the empirical research that has been undertaken, large differences have been shown in office rents at the street to street scale (Hurd 1903; Brennan, Cannaday et al. 1984) and changes in the pattern of rents have been recorded over time (Anstey 1965; Howes 1980).

Within this thesis, the empirical pattern of rents is considered as an important object of research interest and stands alongside the issue of theory and measuring the location variable. In order to see whether the urban layout has an effect on rent patterns is necessary to measure the pattern of rent within the layout as sensitively as possible. Chapter 5 presents an analysis of the available published material on rent patterns in Berlin and how they have changed since reunification. Published sources show a pattern of rents that is focussed on two centres- the West Berlin CBD and the new Eastern district of Mitte. In chapter 7 this pattern is investigated in more detail using the empirical sample of rents. Taking the location rent values isolated in chapter 6 and using more rigorous data visualisation techniques within a Geographic Information System, representations of the pattern of office location rents in Berlin are created. Street based differences are found and a shift in the global pattern of rents since reunification is represented.

1.3.3 What spatial variables can explain the pattern of office rents?

This question- why the market leads tenants to pay a premium for certain locations over others- requires some measure of each location's position relative to other locations within the city that can be compared to the value that tenants ascribe to it. In the literature review of chapter 2, the various existing theories about the independent spatial variables in rent determination are presented. A historiography of theories that have taken distance from the

Central Business District as the spatial structure of significance to rent patterns is presented. Other approaches that have attempted to measure multiple-destination accessibility and a further approach that measures the configuration of the street grid itself are presented.

The spatial variables used in this study have been obtained using the space syntax analysis of the street system. The methodology this analysis of urban form is presented in chapter 3. In chapter 4 of the thesis the historical development of Berlin's urban morphology is traced to show what kind of a spatial object Berlin was by the late 1980s. The relationship between the spatial structure of the city and the pattern of land use and rent value over time is explored, showing how the complex pattern of commercial land uses in Berlin developed. In chapter 5 the spatial change of occurred with the reunification of Berlin is analysed in detail and the response of the property market is shown from published sources. In chapter 8 the space syntax analysis is linked to the sample data to undertake a more detailed statistical analysis of the role of street configuration in rent determination.

1.4 Hypothesis

The hypothesis to be tested in this research is that *there is* a relationship between street grid configuration and the pattern of office rents. As will be discussed in the literature review, the most common approach in previous studies of rent value has been to investigate the spatial pattern of rents with reference to the pattern of land uses, commonly defined as the distance to a point in the Central Business District. This thesis seeks to investigate whether the spatial configuration of the street system itself can be shown to have a relationship with rent patterns. If there is a functional relationship between the two, then the changes to spatial structure in Berlin (such as those that occurred with reunification) should produce concomitant changes in the pattern of rents.

In order to test this hypothesis, it is necessary to calculate a *measure of location* from the characteristics of the street grid itself that is independent of rents. This independent spatial variable must then be shown to statistically correlate with the empirical location rent values. Chapter 8 of the thesis presents the culmination of this analysis: the sample of office leases is linked to the spatial measures in a Multiple Regression Analysis (MRA) for the determination of rents. In particular, the changes in the spatial structure of Berlin's street grid that occurred with reunification are investigated with respect to the spatial reorganisation of office rents.

1.5 The Scope of the Research

It is necessary at the outset to define the limited scope of this research and also define the limitations of the findings of this study. Firstly, there is an important limitation in the kind of research question that is being investigated with respect to urban configuration and rent patterns. The changing spatial structure of Berlin provides a wealth of phenomena that can be considered effects of society onto spatial structure and would be suited to the kind of research programme that treats urban layout as the outcome of a social process, as described in section 1.1 above. Urban morphology is of course built by society and there is a long-standing debate about how and why society builds urban layouts in the way that it does (Ratcliff 1949; Hillier and Hanson 1984; Batty and Longley 1995; Hillier 1998). In Berlin, the social reasons for the creation of a divided city, the particular spatial location of the wall and the occurrence of reunification of 1989 are legitimate subjects for research. For the period of reunified Berlin one might legitimately also ask why major projects that have had an effect on the urban layout have been planned in a particular way (for example, the Potsdamer Platz redevelopment or the federal government area around Spreebogen).

To tackle such questions about society's effect of spatial layout more than superficially would constitute not just a separate piece of research but a fundamentally different kind of research. This thesis does not seek to contribute to this debate but rather takes the layout of the city as an *independent* variable. Taking layout as independent does not mean that it will be disregarded, on the contrary, much of the thesis is devoted to as clear an analysis of it as possible. Chapters 4 and 5 present a detailed analysis of the historical development and current state of Berlin's urban morphology using the space syntax method. However, the *reasons* for the urban layout having in the shape that it does are not a subject of analysis. Therefore, for the purposes of this thesis, urban layout is taken as given and the huge change in layout (reunification) as something that *just happened* to the Berliners for whatever complex geopolitical reasons. What the effects of reunification on the spatial structure of the city were, and the way that tenants responded to this spatial change is the subject of the thesis.

It is also to be noted from the outset that the thesis is a demand side study, and it is the valuation of location by tenants not by landlords or developers that is of concern. Demand and supply are of course inextricably related and it is indeed an understanding of the mechanisms of their relationship (particularly the *spatial* characteristics of their relationship) that this thesis seeks to contribute to. Of course, it is also necessary to analyse the behaviour of tenants within the context of supply and this is undertaken throughout the thesis. The constraints of supply within which tenant preferences are evaluated both through the historical development of Berlin's land use pattern in chapter 4 and the recent development of supply in chapter 5. In chapters 8 and 9 conclusions of a theoretical nature are drawn about the role that demand pressures have within the property market and the implications for the supply side to respond to them.

However, it must be recognised that the contribution of a demand side study can only be to clarify the *pressures* of tenants on developers and not to model the actions of developers within their own constraints. A separate line of inquiry could evaluate particular constraints of the supply side that condition their response to demand pressures (for example; planning, the land market, site availability and construction methods). This is not the focus of this thesis. The thesis therefore does not seek to answer questions such as why the planning system chose to allow development in some areas and not others and why developers built where they did. These questions are also recognisably of the society-onto-space kind of research, whereas this thesis seeks to understand the unexpected effects of space back onto society. For this reason, the study focuses on how tenants responded to the supply of office space rather than how developers created it. The focal questions outlined and the hypotheses being tested relate solely to the value of location for tenants.

It can be argued that the study of the demand side of the property market provides a particularly interesting example of the response of society to spatial structure because of the clarity of rent data. According to the theory of utility maximisation, tenants motives to pay more or less for various locations should not be expected to bear any relationship to those of other agents (such as the profit of a developer or the wishes of a planning authority). Tenants should be expected to attempt to minimise their rent cost at the expense of the landlord within the constraints of price-bid competition for the same location by other tenants. Spatial differentials in rent can therefore be viewed as quite direct indices of the value of intra-urban location to companies: when renting a space, tenants are '*voting with their wallets*' on the value of location amongst other variables. The aggregate spatial pattern that this voting leads to is what the study seeks to analyse and explain.

It should also be noted that the focus of this study is an investigation of the role of *location* on rent patterns in which methodological innovations will be suggested and empirical findings from the Berlin case will be presented. The focus of the research is not the creation of a model for predicting rents, as the prediction of rents is far more complex than just providing a measure of location that reflects value differences to some degree. As will be seen in the literature review, capturing the factors that influence rent is a complex research problem and there are a number of open methodological debates about the best way to do so. This thesis focuses on one factor (the location factor) and looks at ways of creating objective, comparable measures of different locations. An evaluation of the role of other factors in determining rent is necessary in order to see if results that are attributed to spatial factors could actually be explained by the hidden influence of non-spatial variables. But the test of whether spatial patterns in rent can be excluded by reference to other intervening factors is not the same as a test for the significance of all potential variables that may influence rent levels.

1.6 Summary

As part of a wider research programme looking at the effects of spatial layout on social organisation, this thesis looks at the influence of street grid configuration on the pattern of office rents. The case study is reunified Berlin, where fundamental changes in the spatial structure of the street grid have taken place as well as a fundamental spatial reorganisation of office rents. An analysis of the street grid will be presented that provides measures of the spatial changes that occurred with reunification. A sample of 412 office rents will be analysed to test the relationship between the changes in rent patterns and the spatial reorganisation of the street network using multiple regression models for location and non-location variables.

2 LITERATURE REVIEW

> Much urban theory in the last 50 years has been unable to link the underlying economic and ecological theory of cities to the actual spatial patterns which we observe
>
> (Batty 1995, pg. 574)

> Like geologists who could not really look at where mountain ranges are located because they had no model of mountain formation, economists avoided looking at the spatial aspect of economies because they had no way to model that aspect
>
> (Krugman 1995, pg. 36)

2.1 Introduction

The purpose of this chapter is to review previous research into the relationship between urban spatial structure and rent patterns. This is in order to clarify what findings have already been made on this subject and what major methodological and theoretical issues have been identified. Because the research question is cross-discipline in a fundamental sense, literature from a number of fields has touched upon it. As well as architectural theory and property market research, the review covers the 'urban' end of social theory, economics, and geography as well as cartography and geoinformation. A necessary selection has been made within these fields, and this selection is focussed on the relationship between urban street configuration and rent and how it has been studied previously. Firstly, the theoretical background that has most influenced studies of office rents will be reviewed. Secondly, previous empirical studies of office rents themselves are presented. The measures of urban spatial structure that have previously been used in studies of office rents, as well as other measures that are potential candidates for understanding office rents are presented. Lastly, the findings of previous empirical studies on the spatial pattern of office rents are evaluated.

2.2 The Agricultural Antecedents of Urban Rent Theory

Rent, as a value in marketplace transactions, falls within the traditional concerns of economics from the very beginning. The *spatial* characteristics of rent were, however, not the initial concern in the early development of economics. Adam Smith's great theoretical contribution in 'The Wealth of Nations' was to posit value not as inherent to the object itself but rather as an emergent consequence of the interaction of supply and demand (Smith 1776). Smith's 'hidden hand' of the market is a mechanism of an emergent process and it made economics a pioneering science in the study of emergence (Krugman 1996). By introducing emergence Smith had a huge impact on the way that economics and social science was to develop.

However, Smith's concern was with regional and international economic trade and he was not concerned with intra-urban commerce or spatial organisation. His spatial units were, if not entire nations, then region of cities with their surrounding agricultural hinterlands. This viewpoint was important because it began a tradition in economics of disregarding the spatial organisation of society except in the very macro-scale: intra-urban processes were seen as secondary to the primary generator of longer distance trade between rural areas and towns and even between nations. Writing at the time of the explosion of agricultural productivity that occurred in Britain with the beginnings of rapid urbanisation, Smith's interest in trade between the city and the county was founded on an explicit assumption about the fundamental dependency of the town on the rural economy:

> The town, in which there neither is nor can be any reproduction of substances, may very properly be said to gain its whole wealth and subsistence from the country
>
> (Smith 1776, pg. 479)

Ricardo placed rent more in the focus of his work, but reflecting the concerns of the time like Smith before him, he focussed on agricultural rent patterns exclusively. Ricardo's contribution was to frame the rent problem mathematically as one of fertility differentials inherent in the land. He pointed out that most fertile land was used preferentially and less fertile land comes into use only as demand increases enough to make it worthwhile (Ricardo 1817). Ricardo did recognise the role of distance to market in transport costs and through competition to rent but the focus was clearly on fertility differentials. In his historiography of spatial economic theory, Ponsard points to the long-term neglect of the spatial dimension in Anglo-Saxon economics that this began:

> by explicitly reducing the differences in location to differences in fertility of the soil, (Ricardo) completely eliminates the spatial factor in his framework... starting with Ricardo, the great majority of the nineteenth century economists engaged in abstract analysis
>
> (Ponsard 1983, pg. 11)

2.2.1 The Von Thünen Model of Agricultural Rents

Ricardo had posited a model of rent that is based on fertility differentials in the land. This meant that land value in general was seen as originating *out there* in the countryside and not in towns because of the ability of land to support agriculture. However, this was at odds with a fundamental spatial characteristic of rural land rent patterns: the distance to a town had a huge influence in agricultural land values. The towns were the *focus* of land value.

The German farmer and economist J.H. Von Thünen (1783 - 1850) posited a model that addressed this empirical fact by reversing the spatial focus of land value. His model posited distance from the town marketplace as the spatial variable that organised both the pattern of agricultural land values and land uses (Von Thünen 1966). The model turned the whole focus of value away from the fertility of soil (i.e. the characteristics of the countryside 'out there') and directed it to distance from the town. The town as the marketplace is seen as a *generator* of value through distance relationships. Von Thünen explicitly removed all interregional trade from the model of rent in order to generate the stable pattern of urban-rural relations. As in the title of the work, 'the isolated state' suggests, the single town-country relationship was fundamentally abstracted from more complex settlement patterns.

As the American economist Paul Krugman has noted (Krugman 1995), the Von Thünen model was able to treat spatial issues with the mechanisms of emergent systems that pervade mainstream economics:

- the idea of equilibrium (a pattern emerges in rings from the town)
- the idea that value is not inherent but instead is an emergent consequence of market (rent comes from the interaction of bidders)
- the simultaneous determination of goods and factor prices (land price is determined by price reachable for goods grown on it)
- the ability of markets to achieve efficient outcomes (the highest bidders are on the closest land)
- the role of prices in providing incentives that promote efficiency (the more efficient the use the higher it is possible to bid)

It is because the Von Thünen model was framed in terms that paralleled the mainstream concerns of economists that it was so influential in the thinking on the subject. Von Thünen established a relationship between land use and land value that has been accepted by the mainstream ever since. However, although the spatial relationship of land uses around the aggregating pull of land value towards the town centre was a theorem of the model, there was no explanation for the emergence of the centre and the underlying land value pattern that comes with it:

> It simply assumes the thing you want to understand: the existence of a central urban market. Indeed the whole thrust of the model is to understand the forces that spread economic activity away from the centre, the "*centrifugal*" forces if you will. About the "*centripetal*" forces that create centres, that pull economic activity together, it can and does say nothing.
>
> (Krugman 1995, pg. 53)

Whatever the centripetal forces that Krugman refers to above are, they are expressed in the rent mechanism. But the existence and shape of this rent pattern are a *given* in the model, not an explanation.

2.2.2 *Central Place Theory*

Whereas the mainstream economists of the Anglo-Saxon world moved towards a complete abstraction from space following Ricardo, in Germany a more spatial tradition developed in economic geography known as 'central place theory'. The development of the theory arose from an empirical interest in the distribution of settlements within the landscape, reflecting the geographer's perspective. Christaller's work on the location of towns in Southern Germany (Christaller 1933) began this tradition. Central place theory developed the idea of a relationship between distance from settlements and market size and experimented with spatial forms of its solution. It was concerned with the geometry of location hierarchy on a two dimensional landscape.

Whereas the Von Thünen model had been confined to a single city, central place theory attempted to handle the geography of multiple settlements. Causal relationships were suggested between location and settlement size through the function of market size within the region. The idea that a functional relationship existed between economic and social parameters and the *location* of cities was highly influential in geography, as Batty has noted:

> central place theory is the cornerstone of human geography because it explains how economic dependence within the hierarchy of cities translates into their location
>
> (Batty 1995, pg. 574)

But the geometric view of urban market formation embodied in central place theory suffered from a huge disadvantage in its theoretical formulation that prevented it from making headway in describing the market process as a whole. It did not seem to attempt to come to terms with the main 'problem' for social science as perceived by the economists: how can we explain the emergence of social phenomena that are constructed by individuals and yet independent of any particular individual. The problem for economists, as Krugman has noted, was that these geometric approaches were 'not about how sensible actors should make decisions nor...about how the decisions of these actors might interact to produce a particular outcome' (Krugman 1995, pg. 39). The absence of rent from these models is symptomatic of this lack of an accounting for emergence in the model. The spatial variable was a matrix of location advantages upon which towns developed. Yet it is not clear how the actions of individuals acting within social constraints can be derived from such higher order phenomena as this pattern of settlements.

2.3 Beginnings of Urban Rent Theories

Some of the first writings on urban economics were by the British economist Alfred Marshall (1842-1924). Marshall formalised many of the concepts employed in contemporary valuation practice by surveyors, such as the valuation methods of the market comparison approach, the replacement cost approach and the capitalisation of income approach. He discussed *situation value* as the sum of the money values of the situation advantages of a site. He posited efficient land use outcomes from price bidding: the use that captures the site is the one "from which the most profitable results are anticipated" (Marshall 1890, pg. 445). Marshall also discussed the specifically urban consequences of the trade-off between value and site size, such as the increase in building density in more valuable areas:

> If land is cheap he [the developer] will take more of it; if it is dear he will take less and build high
> (Marshall 1890, pg. 448)

This is a clear formulation of the role of rent as the price signal in the mechanism of land use and land building density distribution by the market. However, Marshall did not develop a spatial theory of rent. The comparative method has been fundamental to valuation for surveyors and is used in other approaches to value (Appraisal Institute 1992). But there is no attempt to explain why rents in an area should be of a specific value, they are taken as given and the method allows for valuation of a new building on the basis of a controlled comparison with them.

Interest in urban rent grew in the twentieth century because patterns of land use became an important issue for the rising profession of planners with a role in control over land use patterns. The thrust of research on rent was therefore to understand land values within the context of the problem of the pattern of land use. Writers of the Chicago sociology tradition in the early part of the twentieth century such as Park and Burgess began to show an interest in the role of land value in the process of land use determination and urban morphological change. The theory, or rather metaphor, of the *city as organism* that is a feature of all their writing shows that they were concerned with trying to understand the emergent processes in the urban system (Burgess 1925; Park 1925). They had an interest in morphology, as can be seen in the model of Chicago land uses in Figure 2.1. This was very similar to the concentric ring theory of agricultural land uses by Von Thünen.

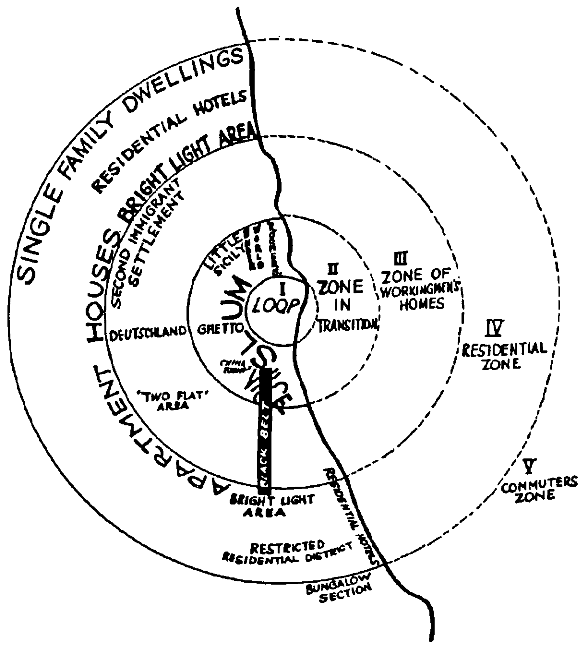


Figure 2.1: Park and Burgess concentric ring model

But their main concern was sociological so they did not interest themselves with commercial rents as much. This led them to consider a wide array of 'soft' location variables that they thought might influence land values for housing. What remained lacking was a more quantitative and statistical treatment of the importance of these variables in the determination of rent or its relationship to land use.

As economists began to take more of an interest in urban processes, a debate emerged that can be viewed as a parallel to the two research approaches outlined in chapter 1 (research into the impact that society has on space and vice versa). Some models were built to explain how economic and social criteria lead to street systems being built with a certain shape. In the case of Haig, this meant the minimising of friction of distance for economic transactions:

> while transportation overcomes friction, site rentals and transport costs represent the cost of what friction remains...the layout of the metropolis ... tends to be determined by a principle which may be termed the minimising of the cost of friction
>
> (Haig 1926)

This is a clear exposition of a theory to tackle the first issue raised in the introduction- how society influences spatial structure. It was reflected in the writings of Ratcliff, where the role of the market on spatial structure was made even more explicit:

> It is the total effect of the competition for sites to minimise the aggregate of inconvenience and frictions, as evaluated in terms of the local value systems, and hence to maximise the efficiency of the conduct of those human affairs in the community which require movement. The processes of the urban land market tend to produce the most efficient urban pattern... The perfect land market would produce a pattern of land uses in a community which would result in the minimum aggregate land value for the entire community. The most convenient arrangements result in the lowest aggregate transport costs; in terms of saving of transportation costs, the advantages of the more convenient sites are reduced.
>
> (Ratcliff 1949, pg. 385)

There was an interesting debate about how to view the role of value in the relationship between land use and spatial structure. If value was a *mechanism*, which way did the causality run? Park explicitly saw land values *determining* the spatial patterns in land use:

> Land values are the chief determining influence in the segregation of local areas and in the determination of the uses to which an area is put
>
> (Park 1925, pg. 203)

Haig disassociated himself from Park's view and countered that it is the uses which determine land values rather than vice versa (Haig 1926). The debate did not reach a resolution because neither view presented a plausible model of the mechanism linking the three phenomena (urban layout, land value and land use) together.

2.3.1 The 'New Urban Economics'

In the post war period, the mainstream of economic writing on land value moved away from the debate about the role of value in the formation of urban spatial structure. Economists began to concentrate on the role of land value as variable in the trade-off between plot size and distance from a central point for different land uses. This approach was essentially an extension of Von Thünen's model to urban land uses. Von Thünen himself had anticipated the extension of his agricultural theory of rent to the city:

> If we investigate the reasons why site rent increases towards the centre of the city, we will find it is the labour saving, the greater convenience and the reduction of the loss of time in connection with the pursuit of business
>
> (Von Thünen 1966, pg. 212)

In fact the general assumption of a relationship between distance and value was generally accepted long before the postwar period, for example Hurd noted:

> Since value depends on economic rent, and rent on location, and location on convenience, and convenience on nearness, we may eliminate the intermediate steps and say that value depends on nearness
>
> (Hurd 1903, pg. 77)

By far the most influential book in the debate about location and rent in the post-war period was William Alonso's 'Location and Land Use: Towards a General Theory of Land Rent' (Alonso 1964)[1]. However, despite the description of the book as a theory of land rent, a crucial element of Alonso's theoretical model of the land market is that the spatial pattern of land value is actually exogenous to the model, not produced by it. This is a critical aspect of the model without which it does not function, as Alonso made explicitly clear in the introduction:

> It will be assumed here that the price of land decreases with increasing distance from the center of the city. Below it will be seen that this is a requirement for the existence of both individual and market equilibrium as well as essentially true for most cities
>
> (Alonso 1964, pg. 20)

At the beginning of the book a pattern to rent decreasing from the centre of the city is thus established as a central *axiom*, not a theorem to be proved. This is an exact mirror of the Von Thünen model. On top of this axiom of declining land value from a city centre, Alonso makes a simplifying assumption:

> The city is viewed as if it were located on a featureless plain, on which all land is of equal quality, ready for use without further improvements, and freely bought and sold.
>
> (Alonso 1964, pg. 15)

This is the *central* simplifying assumption of the model. It relates the model output very closely to the central axiom by removing intervening morphological constraints on urban development. All models must have simplifying assumptions that exclude certain phenomena and it is by clarifying the limits of the model that its real purpose is explained. Alonso discusses the limits on his model imposed by the central simplifying assumption:

> This plain may contain lakes, or reserved land such as cemeteries, which are holes on the surface of the plain. In this sense our featureless plain is not featureless. What it does not have are such features as hills, low land, beautiful views, social cachet or pleasant breezes. These are undoubtedly important but no way can be found to incorporate them into the type of theory that will be presented
>
> (Alonso 1964, pg. 17)

This is a somewhat misleading passage, as Alonso attempts to downplay the effect of the crucial simplifying assumption on the model. The idea that the bounds of the model do not permit an accounting for such things as 'beautiful views, social cachet or pleasant breezes' trivialises the real problems that the central simplifying assumption creates.

---

[1] It should be noted that Wingo's 'Transportation and Urban Land' (Wingo 1961) written during the same period presented a

Alonso does not confront the most fundamental omission of the model: the topology of the city. The model simply has no urban morphology. The concluding chapter of 'Location and Land Use' is devoted to a discussion of the importance of the problem of morphology but this is not discussed with reference to his central axiom. It is also not strictly speaking true that the model is not featureless, as is asserted in the above citation. The model cannot contain holes that create an *ambiguity* in the shortest route to the centre from any given point. As soon as enough holes are present to create an anti-isotropic network, like a street network, the assumptions of isotropicity break down. Under these more complex spatial conditions, a different set of assumptions would be required about the shape of the land value pattern upon which the different land uses can compete. Consequently only the most trivial deviations from a featureless plain are permitted.

Perhaps in Von Thünen's rural case, where transport routes represent a very small part of the overall land area, the implications for using a distance variable without a transport network are less important. Yet in cities this surely merits discussion. It seems entirely reasonable to view such phenomena as 'pleasant breezes' as being removed from the model, and Alonso freely discusses these. It is strange that he does not even acknowledge the omission of urban street and block structure from the model.

2.3.1.1 The output of the Alonso model

If the Alonso model does not determine the pattern of rents, what is the output of the model? The Alonso model produces equilibrium for the distance from CBD and size of site occupied by three land uses (residents, urban firms and agriculture). In the land market of the model there are 2 goods- land (which is effectively plot size) and distance. This equilibrium is determined by use of bid-price and bid-rent curves for each different land use within the framework of a distance-value relationship posited by the main axiom. Thus it is not the pattern of rent that is determined, its relation with distance is given and the users bid price curves set the equilibrium level at any particular point (the envelope of all bid-price curves). At equilibrium the supply and demand quantities and prices are equal. Every user determines location by point of tangency of lowest bid price curve to come into contact with price structure. At least one bid price curve of each user is in contact with price structure:

> The price structure is... the least upper bound of the equilibrium bid price curves of the users of land. As their name implies, the equilibrium bid price curves are the demand price; their envelope, the price structure, is the supply price
>
> (Alonso 1964, pg. 76)

---

very similar model to that of Alonso. However, his version has been cited much less in the literature on urban rent.

Thus Alonso's model is a model of *land use allocation* with a spatial pattern of rent as a given axiom of the model. It is really a model about the tradeoffs for three different land uses in location decisions between the amount of space let and distance from the centre, between travel costs and rent price. It is an exposition of the logical consequences of a trade-off between distance and site size for competing land uses of differing requirements *given the central axiom and the central simplifying assumption* described above. When certain secondary assumptions are made about the individual space and travel needs of the three land-uses (houses, commercial units and farms) a simple spatial model of the land use pattern can be derived. It is only because of the trade-off (between distance and space let) and the different preferences of the three land uses that any spatial pattern emerges at all:

> If the only criteria for residential location are accessibility to the centre and the minimising of the costs of friction, and considerations of the size of the site are excluded, all residence would be clustered around the centre of the city at a very high density.
>
> (Alonso 1964, pg. 9)

However, it is not possible to use the model to understand anything about the reasons for rent pattern because of the devastating effect of the central axiom and the central simplifying assumption on the ability of the model to handle morphology. The model cannot describe the effect of urban morphology on rent patterns because it cannot *recognise* urban morphology given the central simplifying assumption of a featureless plain. The central axiom of a distance to CBD relationship for land value also prevents any further investigation of how or why such a pattern evolves or is changed.

In fact, if the names of different agricultural uses in the Von Thünen model (dairy farming, crop farming etc) are replaced with the land uses of Alonso's model, there is no real difference in the model formation or the axioms it leaves unquestioned:

> The new models also shared the basic vice of Von Thünen: the (literally) central fact, the existence of a central business district around which the city was organised, was left uncomfortably unexplained.
>
> (Krugman 1995)

2.4 Empirical studies of office Rent

The main concern of the new urban economics was with abstract modelling of how distance could play a role in the marketplace and give rise to land use patterns. Efforts were focussed on conceptual models of the land market rather than empirical studies. Partly as a consequence of the wish to construct universal and very general models and partly because the lack of empirical data did not necessitate it, writers such as Alonso did not concern themselves with "the thorny definitional problems that abound in the theory of rent" (Alonso 1964).

However, the impetus for a more thorough empirical study of rent came from two communities in the postwar era. The first of these was the surveying and property development profession. The variables that determine rent form a vital question for surveyors whose job is to value buildings in real markets. Most general urban economic writing on rent had simply assumed, as Alonso did, that rent 'price' can be considered as 'the amount of money the occupant pays or would pay to the landlord for the right to use the unit of land... for a given period of time' (Alonso 1964 page 16). For surveyors, this amount was a value that they had to determine in real markets.

The second impetus for empirical work on rents came from the rise of positive quantitative economics that developed in the 1960s that used econometric models of rent. This tradition took a statistical approach in order to overcome the complex ambiguities involved in studies of location preference. While the meaning of what tenants say about locations in their *stated preferences* can be very complex and ambiguous, what they are actually prepared to pay can be captured in their *revealed preferences* by examining the factors involved in the determination of achieved rent values statistically. Empirical data on rent values is gathered and these are treated as the dependent variable to be explained. Hypotheses are made about the potential independent variables involved in rent determination- both spatial and non-spatial. These potential independent variables are quantified and Multiple Regression Analysis (MRA) is used to establish the relative importance of each of the explanatory variables. Starting in the 1950s, MRA was used by property professionals in the USA to undertake mass appraisals of house values, as described by Renshaw:

> While it may be hopeless to isolate all the factors which buyers take into consideration when purchasing a property, it is possible to establish a correlation between real estate values and a select subset of determining variables. Although the choice of the function and its mathematical form is somewhat arbitrary, it is not necessary to choose the best possible function, but only the one which predicts real estate values with sufficient accuracy in a statistical sense, for the type of appraisal under consideration.
>
> (Renshaw 1958)

Beginning in the late 1970s, academic economists began to apply the methods of econometrics to empirical data on office rent. (Clapp, 1980; Hough, 1983; Brennan, Cannaday et al., 1984; Vandell and Lane, 1989; Glasscock, 1990; Mills, 1992; McDonald, 1993; Sivitanidou, 1995; Dunse, 1996). The attempt has been to demonstrate through statistical inference the hedonic price of various spatial and non-spatial variables in the determination of rent. This means that the multiple regression analysis provides a prediction of how much rent a company would be prepared to pay given a certain space at a certain location under certain lease conditions. The method was summarised by Hough:

> we may establish a general hedonic price function for office space where R= R(**Z**) where *R* is the rental price of a given office building, and **Z** = (z_1, z_2, ...z_k) is the vector of *k* intrinsic and extrinsic characteristics of which the rent depends. The coefficients associated with each characteristic yield the implicit or hedonic prices. The implicit price functions themselves may be increasing, decreasing or constant, depending on the functional form of *R(***Z***)*. ... Estimation of R(**Z**) requires 3 things: selection of sample, enumeration of appropriate characteristics, and specification of functional form.
>
> (Hough and Kratz 1983)

Table 12.1 provides an overview of the econometric studies of rent and location.

2.4.1 Definitions of Rent as the Dependent Variable

A number of different kinds of data have been used under the loose term 'rent price' in econometric studies. These are summarised in Table 2.1 below. The lower the type in the chart, the more closely it may be considered to reflect the actual cost to the tenant of renting a space.

RENT TYPE	NAME	DESCRIPTION	STUDIES
1	Asking Rent	The advertised starting figure for negotiations	(Clapp 1980; Hough and Kratz 1983; Cannaday 1984; Vandell and Lane 1989; Glasscock 1990; Mills 1992; Sivitanidou 1995; Dunse 1996)
2 (a & b)	Headline Rent	The initial rent price per square metre per month stated in the lease. 2a is the nominal price without adjustment for inflation. 2b is the real rent expressed in constant prices.	(Brennan, Cannaday et al. 1984; McDonald 1993)
3	Consideration Rent	The average rent of type 2b adjusted for the incentives in the lease	(Wheaton and Torto 1994)
4	Effective Rent	Rent type 3 calculated as a discounted cash flow	(Webb and Fisher 1996)

Table 2.1: Types of Office Rent Data

2.4.2 The source and type of rent data in empirical studies

The empirical study of rent is hindered by the sensitivity of the data. Landlords, in particular, are often reluctant to release detailed information about their dealings with individual tenants, lest it affect the balance of their negotiating power (Wheaton and Torto 1994). The most readily available rent data is the asking rent. This is the rent that is advertised in the marketplace and therefore it is data in the public domain. Most academic studies of office rents have relied on asking rent data provided by property agents (Clapp 1980; Hough and Kratz 1983; Cannaday 1984; Vandell and Lane 1989; Glasscock 1990; Mills 1992; Sivitanidou 1995; Dunse 1996). The assumption, mostly implicit, in studies that use asking rent as the dependent variable is that the asking rent will correlate well with achieved rents. This means that it has been considered a fair proxy for the real dependent variable of interest, the achieved rent that a real tenant would be prepared to pay.

The headline rent is the actual rent price written into contract once negotiations between a real landlord and a real tenant have been successfully concluded[2]. This means the starting rent, without adjustment for increases or incentives (discussed below). This data is much more difficult to obtain than asking rent as it is confidential and highly sensitive information. Consequently there are far fewer published articles that use headline rents in an MRA with location. The only published academic study that uses headline office rents with location variables is Brennan's early work using individual office leases for Chicago (Brennan, Cannaday et al. 1984). This study did attempt a cross-sectional analysis of the market but the sample size was only 29.

2.5 Non-Spatial Influences On Rent

As well as the differences in rent value that might be attributable to spatial or location factors, there are a number of non-spatial characteristics of rent data that must be controlled for.

2.5.1 Lease Provisions

Given that most of the published econometric studies of office rent used asking rent data aggregated at the building level, the influence of lease provisions on rental value has been neglected. However, as surveyors have to use leases for valuation purposes, they are confronted with questions of lease comparability on a daily basis. This practical problem has given rise to a body of work that assesses the extent to which different provisions can be considered to have an effect on rent value. This is especially important when provisions are more idiosyncratic and valuers must control for differences in leases in order to use them as comparative evidence:

> Before adjusting for locational and physical differences, the valuer has to determine what the comparable property/ properties would have let for under this range of alternatives [in lease provisions]. The goal should be, in our opinion, the rent with no incentives, apart from a normal fitting out period.
>
> (Crosby and Murdoch 1991, pg. 52)

2.5.1.1 Incentives

Studies of landlord-tenant relations have revealed characteristics of leases apart from the actual rent price that may be considered to have an influence on the effective value for the tenant. Particularly with the move to recession in Western European property markets during the early 1990s, the change in negotiating power from a landlord's to a tenant's market was reflected in changes in the conventional lease provisions. Crosby's study of changes in UK commercial lease provisions found that during the recession of the early 1990, landlords were increasingly offering rent free periods in UK office leases as an incentive. Rent free periods peaked at 18 months in the West End of London in 1992 and 36 months in central London in 1992 but the whole market average peak in 1993 at 12 months (Crosby and Murdoch 1998).

In recent years interest has grown in the methodological problem of how to calculate a rent price that more closely reflects the real cost of a lease if the other provisions of the lease are considered. In the UK, the debate about the significance of incentives has been important because of the issue of the rent review, where a valuer must make a determination of how much a tenant should pay to reflect the current market price (Crosby and Murdoch 1991; Murdoch and Crosby 1991).

Incentives are very common in a recession because landlords attempt to conceal the fall in the *effective* value of their rental income in order to protect expected capital values. As Davidson and Darlow noted in their influential reference book on lease incentives (Davidson and Darlow 1993), this is a rational policy for landlords: as well as protecting capital values it means that rent review negotiations at the end of the contract begin from a higher starting point. Davidson and Darlow list a number of ways in which incentives can affect the value of the lease:

1. A reduction in rent through

a) a rent free period

---

[2] Definitions of terms such as headline rent can be found in the Glossary for reference purposes.

b) staggered or stepped increases

c) fixed rent during an initial period followed by a reduction at the next rent review

2. Contribution from the landlord to fitting out costs for particular occupational requirements
3. Premium or capital payment to the tenant on signature of the lease.
4. The acquisition of the tenants present lease by the landlord.

Figure 2.2 below shows how these other provisions of a lease that act as incentives can affect the income flow of rent over the length of a lease.

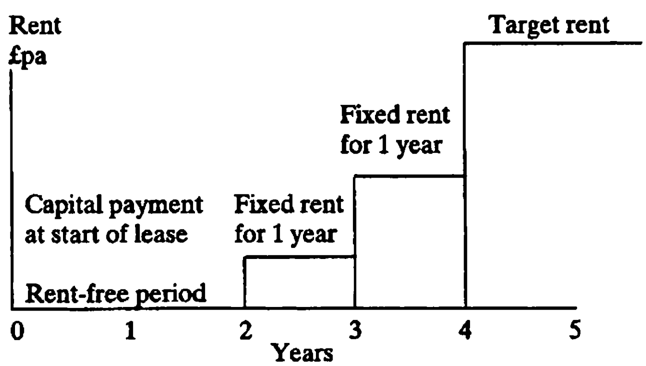


Figure 2.2: The effect of incentives on the actual rent paid in each year of the lease(Davidson and Darlow 1993)

If the monetary values of other provisions in the lease are calculated, the nominal headline rent price can be adjusted to reflect the *effective* value. As Derek Epstein of the property consultants Jones Lang Wootton noted, the necessary assumptions are that the tenant is willing and that the same willing tenant could have been induced to take the same lease of the same premises on the basis of a lower headline rent payable immediately (Epstein 1993).

However, the property profession is still debating the most appropriate practices to be adopted in valuing lease inducements and no common practices have yet emerged (Davidson and Darlow 1993; Crosby and Murdoch 1998). One problem for researchers is that the data itself is both complex and difficult to obtain. There are often agreements made between tenants and landlords that have a value, but that value may be near impossible to obtain data on or measure. Wheaton found this problem for tenant improvements in the leases he used: the exact definition of the work to be done normally is specified in a side "letter of agreement" and not in the lease itself and is therefore beyond the reach of the researcher (Wheaton and Torto 1994).

Another problem in the methodology of effective rents for surveyors is that the establishment of common practices of valuation is hindered by entrenched views. These arise from differences in the interests of landlords and tenants in value determinations for rent review purposes leading to different agendas for the methodology (Crosby and Murdoch 1991).

The idea of effective rent is to arrive at a rent which has the same net present cost to the tenant and the same net present value to the landlord as the package of rent plus incentives comprising the actual open market letting (Epstein 1993). However, as many writers have argued (Davidson and Darlow 1993), the relative cost-benefit of particular provisions may not be the same for both the landlord and the tenant and the method of valuation used depends on whose costs and benefits are relevant.

Effective rent has often been defined as 'the rent payable after inducements have expired' (Estates Gazette 1995). This definition assumes that a stable rent is reached after an initial period of inducements. However, there are some lease clauses that can be viewed as inducements that do not expire after a short period but rather vary for the whole length of the lease. There is also the question of their relative value earlier or later in the lease.

A distinction can be made between two kinds of effective rents. 'Type 3' rent in Table 2.1 above (see page 34) represents the most basic adjustment for the effect of incentives on the cost to the tenant. It is the average rent price per annum of the jagged income flow of a lease with its incentives such as that in Figure 2.2 above. Wheaton has referred to this as the '*consideration rent*' in his study of a huge database of 60,000 leases from the property company CB commercial (Wheaton and Torto 1994).

The rent calculation of Type 3 does not take into account the time aspect of money. Incentives have a differing impact dependent on the year that they are implemented, because of depreciation. Rent-free months at the beginning of a contract are worth significantly more, especially in terms of the cash-flow advantage to the tenant:

> From the tenants point of view, he is obtaining a short term cash flow advantage - borrowing from the landlord on an unsecured basis, receiving an upfront cash benefit ("loan") of say 3 years' rent in return for a quantified future additional liability ("repayment") in years 4 and 5 and a possible unquantifyable additional liability thereafter
>
> (Epstein 1993)

This means that a discounted cash flow (DCF) analysis is appropriate for the calculation of effective rents. It is unclear what method should be used to discount the incentives. A major issue is at what rate they should be discounted[3]. Webb's study of effective office rents was explicitly 'from the perspective of property owners' and prices were discounted at the contemporary treasury bond rate for maturity period of the lease (Webb and Fisher 1996). Kishore has also discussed the use of bond rates for the valuation of office building investments (Kishore 1996) but this is for the investment perspective and not the perspective of cost to the tenant. Epstein argues that to take the tenant's perspective, the benefit of incentives should be measured by reference to the cost to the individual tenant of unsecured borrowings depending on how close to the limit of borrowing capacity he is. This would of course make a comparison of a larger dataset not only prohibitively expensive but also methodologically very problematic. Because of these methodological uncertainties, Epstein concludes that effective rents 'may be indeterminate' (Epstein 1993).

Very few empirical studies of effective rents for offices exist, the only notable example is Webb and Fischer's study of 228 Koll & Rubloff leases from 7 buildings in Chicago (Webb and Fisher 1996). Webb and Fischer found that owners receive less effective rent for new tenants (due to higher tenant improvements) and less effective rent when a broker represents the tenant in the negotiations. They also found that concessions increase before vacancy rates increase, as landlords are prepared to adjust effective values by offering incentives before they are prepared to send out clear price signals to the wider market.

Brennan looked at incentives in his small study of 28 leases and found that concessions such as a workletter from the landlord were not significant. He explained this in terms of the changes that a landlord may have to make being 'in line with bringing the office space up to some generally expected standard rather than meeting highly specialised needs of particular tenants' (Brennan, Cannaday et al. 1984).

2.5.1.2 Lease Term

As well as incentives that directly influence the amount of rent that a tenant must pay, there are other lease terms that may vary in a way that has value implications to the tenant or landlord, however hard it is to measure them. Crosby found that during the recession in the UK of the early 1990s, tenants were able to press landlords for much shorter lease terms. Whereas the standard office lease was 25 years during the 1970s and 1980s, by the mid 1990s this was down to an average of 10-15 years for standard lease terms and there was a much

---

[3] Not only is the appropriate rate for the discounting procedure unclear but there is also the question of what period should be used to discount to. Bond believes that incentives should be discounted over the full period of the lease term certain(Bond 1991). This is less controversial, although some other possible methods have been noted (Estates Gazette 1995).

greater diversity within the market (Crosby and Murdoch 1998). This means that tenants were not neutral to lease terms, they value shorter leases and will push for them in negotiations if they can. As Lizieri et al. have noted:

> There might be a structural trend towards shorter leases and more varied contractual forms. This trend may be resisted by landlords in normal markets. However, when markets are out of equilibrium, tenants are able to secure more advantageous terms.... Presumably there is a floor to lease length since tenants will require some stability and security in order that they may amortise the costs of tenant improvements, fitting out and their removal costs. In the tenant dominated market this may be achieved by very short leases with a right to renewal.
>
> (Lizieri, Crosby et al. 1997)

Brennan investigated the length of lease as an independent variable in office rents but found it to be insignificant (Brennan, Cannaday et al. 1984). One explanation for this was that lease length was highly positively correlated with the size of the unit (r squared 0.81) This is to be expected if larger firms are less mobile and therefore more likely to trade off flexibility against their high moving costs. Another explanation that Brennan gave was that in certain conditions there may be no clear advantage to tenants or landlords from leases being longer or shorter:

> The role of the length of lease depends on the expectations of landlords and tenants. If rents are not expected to change by landlords, they would prefer longer to shorter leases so as to reduce transaction and vacancy costs. However, if landlords expect rents to rise somewhat, they may be neutral as to length of lease
>
> (Brennan, Cannaday et al. 1984)

2.5.2 Building Quality

A number of variables have been tested to measure the effect that the quality of the building or unit has on the amount of rent that a tenant is prepared to pay.

2.5.2.1 Building Age

Building age has been used in previous studies as a measure of the quality of the office space. The assumption has been mainly that the newer buildings will command a higher rent because the rented space will be more suitable to modern office requirements. Clapp found that building age had a strong effect in his sample of Los Angeles asking rents with the expected sign (Clapp 1980). Vandell found that the age of buildings had a negative effect but the relationship was not statistically significant (Vandell and Lane 1989).

2.5.2.2 Building Size and Unit Size

The trade-off between the cost of location and of plot size in Alonso's work has influenced econometric studies of office rents to measure a number of size variables and see if they have any role in rent determination. In Alonso's model the 'site' means the plot of land itself (Alonso 1964). No attempt was made to specify a distinction in his conceptual model between the landlord of a site who develops the building to a certain land use and the tenant who pays rent in the building.

In office rent studies, building size has been one of the most widely tested non-spatial variables in the econometric analysis of rents. The variable has been used to measure the effect that the size of the building has on rent price either as a proxy for average unit size or as a direct indicator of the potential for expansion within the building that tenants may have. These two separate measures are treated somewhat interchangeably in the literature although it is unclear how reliable the size of the building is as an indicator of average leased unit size.

The classical expectation for the role of unit size might be that there is an economy of scale effect that leads to a lower rent per m^2 for larger leases. However, Wheaton found the opposite effect in his large study of leases:

> of the five cities reported, only two have a discount in rents for larger leases...supply and demand conditions for large blocks of space could actually lead to larger lease premiums. Significant blocks of contiguous space are highly valued by large firms and frequently are in short supply...space discounts may well vary between markets and over time
>
> (Wheaton and Torto 1994)

2.5.2.3 Architectural Quality

The architectural quality of a rented space is possibly the most problematic aspect of building quality for the purposes of studying location rents because it seems intuitively clear that some buildings are much 'better' than others but unclear as to how to measure their use value. Alonso's consideration of the problem went as far as to suggest that plot shape might be a significant variable as another distance to consider- mean distance from the plot edge- in terms of local accessibility (Alonso 1964).

Hough and Kratz's study of 103 office buildings in the Chicago CBD (Hough and Kratz 1983) explicitly addressed the issue of architectural quality and office rent. Their study started from the assumption that 'architectural quality is a public good characteristic of a building for which market failure may occur'. Their main interest was thus in the quantification of the value of aesthetic quality within hedonic regression, which was undertaken by looking at a sample of buildings that have been given architectural awards against those that had not. The problem with this definition is that the architectural quality itself might co-vary with some location advantage.

However, Hough and Kratz did introduce a number of more functional characteristics to the study of building quality. The idea of 'building responsiveness' was tested. This was an attempt to use the area per floor as a proxy for the potential for each firm to expand without vertical floor segregation. The area per floor and total area per floor was found to be highly significant (Hough and Kratz 1983).

2.5.2.4 Vacancy Rate

One factor that can only be assessed if the building is the unit of analysis is that of vacancy rates. In the absence of available rent data, Hanink used vacancy rates in a sample of office buildings from a number of American cities as an index of demand. He found vacancy rates to be strongly spatially organised within each city:

> both by average and by extremes, downtown office vacancies were consistently lower than suburban office vacancies
>
> (Hanink 1997, pg. p397)

2.5.3 The factor of time

To undertake an analysis of the location variable in office rents is to attempt a cross-sectional analysis of data that is essentially time series dependent (Fraser 1993). Rent data is taken from some point in the office cycle but the conditions of the market vary greatly through this cycle, as represented in Bond's model of the office market cycle shown in Figure 2.3 below. Bond's model shows a number of temporal relationships between the variables that may influence rent under discussion. He posits that incentives peak long after vacancy rates and also that vacancy shifts to older buildings before recovery:

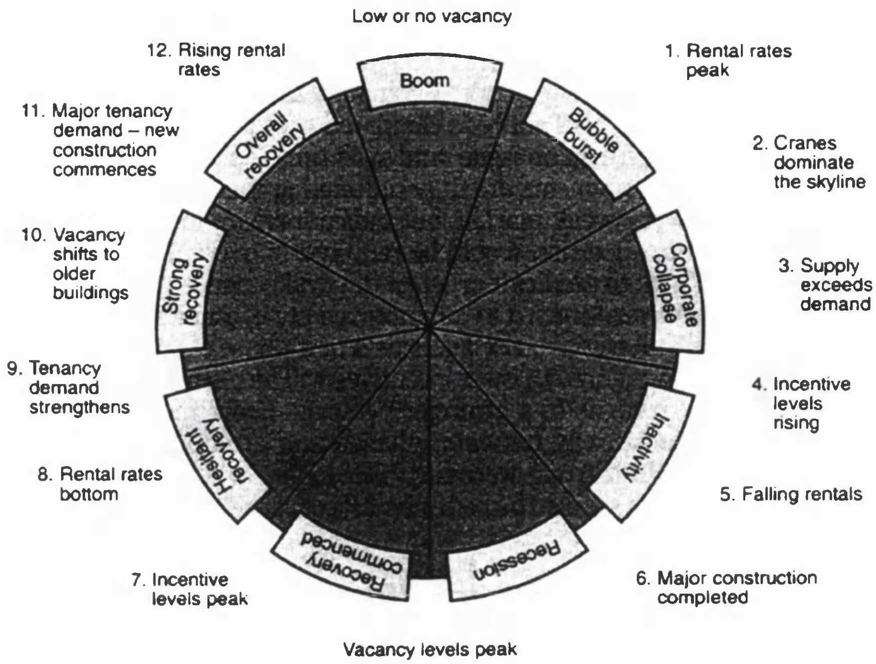


Figure 2.3: The Office Market Cycle (Bond 1991)

All of the published research has had to confront the time-series dependency of rent data and essentially two different approaches have been adopted to control the time variable. The most common approach has been to use data from a single year and therefore control for time by taking a sample at a static point in the cycle of Figure 2.3. This has been adopted by 6 of the 10 published econometric studies of location and office rent shown in Table 12.1 on page 301 above.

Other studies have used data from a number of years and have taken time to be a variable in the MRA. The number of years is usually fairly small with an average of 3 years for the 4 studies in Table 12.1 that cover more than a single year. The studies that do include time take the year of letting as a dummy variable in the MRA (Glasscock 1990). This use of time as a dummy variable seems strange given that time can be clearly viewed as a continuous variable. It would be possible either to use the continuous variable of time itself or to find some other proxy for the point in the property market cycle. Brennan excluded the time dummies because he found that they were not significant. His explanation was that rents were falling in real terms at roughly the rate of inflation (Brennan, Cannaday et al. 1984).

2.6 Measures of the Independent Spatial Variable

Underlying any consideration of how important location is in the determination of office rent is the more fundamental question of what exactly is meant by location and how it can be measured. What independent spatial variable can be said to influence the spatial pattern of office rents? What is it about the spatial structure of the city that leads to a higher rent in some areas than others? What is the location variable that tenants are paying for? This section looks at a number of measures of urban spatial structure that could provide that variable. Some of these have already been used in econometric studies of office rents and some have not. The potential of each one as a measure and the methodological issues relating to each are considered.

2.6.1 Non-independent location variables

Before looking at independent measures of urban structure, it should be noted that a number of non-independent spatial variables have been used in MRA for rent. The most widespread technique for the inclusion of a location variable used in the econometric studies is to divide the study area into sub-areas that are considered in some way different from each other as locations. The statistical treatment of the location variable used in this approach is simply to define areas as dummy variables- thus a datum has the binary characteristic of being in area x or not. In multiple regression, a long list of area variables that differ from the background area are thus included and the importance of location is measured by the significance of these dummy variables in the MRA (Brennan, Cannaday et al. 1984; Glasscock 1990; Mills 1992; McDonald 1993; Dunse and Jones 1997; McCluskey, Deddis et al. 1997).

The appeal of dummy variables has been that they offer an alternative to the implicit theoretical assumption of Alonso's model that rent is simply a factor of distance to the centre of town. In order even to begin challenging this idea it is necessary to have an alternative spatial variable, and dummy variables are the simplest alternative on offer. Dunse makes the identification of sub-markets simply by dividing the city into areas. These areas are used as dummy variables in the multiple regression equation for rent, to see if the sub-area regression is an improvement on a single distance measure. The improved regression is taken to be evidence that sub-markets do indeed exist by area. The problem of course, is that this result does not explain how the specific areas are formed or what processes lead to spatial sub-markets in general. McDonald in his study of office rents in Chicago, found that the location dummies used, with one exception, did not attain a statistically significant effect (McDonald 1993). It is difficult to tell whether the importance of dummy variables found by Dunse and the lack of importance found by McDonald reflect differences in the spatial structures of the markets that they studied or are simply artefacts of the two different ways in which they chose to construct the dummy areas.

Dummy area variables have not been defined by any clear urban morphological criteria in the office rent studies listed above, although they could be. The purpose of these variables is to define 'neighbourhood' areas whose characteristics can be compared. If there was a morphological definition of the areas then the use of area dummy variables would attain a methodological logic that is universal and independent of the particular circumstances of the city that is under analysis. A number of definitions might conceivably be derived from the layout of the urban grid, relating for example to the areas between main streets of some description or between natural barriers of some size. If such a definition could be derived that was applicable to any street system, then any differences in the importance of spatial neighbourhoods (such as the differing findings of the Dunse study and the McDonald study) could be properly compared as evidence of market differences rather than methodological ones.

As the technique stands at present, dividing the city up into area dummies has not particular logic and consequently the areas defined tend to reflect the pattern of rent that has emerged. This results in a circular argument: area boundaries are defined with reference to the similarity of rent levels achieved in the locations that they contain, and the rent of particular location is explained by its presence within areas of similar rent. The spatial structure has not been analysed at all except to say that location differences in rent have been described.

Gallimore used the statistical surface generated from his house price data as the location variable to be used in a multiple regression of house price determination (Gallimore, Fletcher et al. 1996). The residual value from a *location blind* MRA was plotted as a surface and then interpolated values for locations were fed back into an MRA as one of the independent variables. This technique poses some very important methodological questions, as it appears to allow for auto-correlation of the dependent variable with itself. A variable that is derived from the *dependent* variable (the statistical surface derived from prices themselves) is being used as an independent variable (location value) in the determination of the same *dependent* variables. The location-blind MRA can be used to produce an approximation of 'location rent' which can then be investigated visually using maps, as Gallimore does. However, Gallimore's use of the same location-blind MRA to produce a 'location variable' (i.e. an independent variable that would live on the right hand side of a regression equation) is highly problematic because it leads to a tautological model whereby location differences in rent are being explained by the differences in rent by location. This problem will be discussed in more detail in the representation chapter 7 below[4].

In order to use MRA as a model of rent determination, it is necessary to make a strict division between the independent and the dependent variables. The location dummies and the rent surface produced by Gallimore outlined above do not achieve this division and as such, can only be used to describe spatial differences in rent but not to explain them.

2.6.2 Distance Variables

The specification of dummy location variables and isoplethic surfaces of rent are highly influenced by the pattern of the dependent variable. However, a number of distance-based variables have been used in previous studies in an attempt to represent a value of location within the urban spatial structure that is independent of actual rent values.

2.6.2.1 Euclidean Distance

The simplest independent spatial variable that has been used is Euclidean distance (or 'as the crow flies' distance) from a central point. The classic example of this is Alonso's model, which uses the measure of distance from the centre of the CBD as the spatial variable (Alonso 1964) based on the original idea of distance to the town to be found in Von Thünen (Von Thünen 1966). As has been argued in section 2.3.1 above, the possibility of Euclidean distance measures was the central simplifying assumption of Alonso's model:

> [the city] lies on a featureless plain and transportation is possible in all directions. All employment and all goods and all services are available only at the center of the city.
>
> (Alonso 1964, pg. 18)

However, the use of Euclidean distance for Alonso was to represent a universal generalisation about cities, and he did not explicitly advocate its use as a variable for the analysis of individual cases (see for example Alonso 1964, pg. 17). Nonetheless a number of studies have used Euclidean distance from a chosen central point as the spatial variable in an MRA for office rent (Clapp 1980; Hough and Kratz 1983; Cannaday 1984; Vandell and Lane 1989; Dunse 1996).

---

[4] It may be noted that although a location-blind MRA is used to map and represent location rent for the empirical data studied in this thesis, it is not used to create a pseudo-independent location variable.

2.6.2.2 Street Distance

The obvious limitation of the Euclidean or aerial distance approach is that in ignoring the topology of the city it does not reflect the actual routes or distances travelled by people on the ground. The assumption has been made that the Euclidean distance variable is simply good enough as a proxy for street distances. O'Hara built a justification for this on the basis that within a perfect grid, accessibility from all points to all points would lead to rent contours that were similar to a Euclidean distance despite the topology of the grid:

> Empirical investigations of rent profiles often find that the radial distance performs reasonably well as an explanatory variable, despite the presence of rectilinear streets. The ...model provides one explanation for this result, in that travel costs depend on radial distance to the centre even though travel to the centre is no more important than travel to any other point in the CBD. The implied rent function is, however, quadratic rather than linear in radial distance.
>
> (O'Hara 1977, pg. 1193)

Alonso similarly theorised about the effect of a perfect grid. In the last chapter of 'location and rent' Alonso approached the issue of morphology and relationship between distance and rent was finally represented in maps of cities (albeit using highly symbolic representations). Firstly by relaxing the Euclidean distance assumption and considering a regular grid, he produced square isochrones rather than circular rings for the measure of distance to the centre. Then by allowing for a differentiation of road type, distortions are made to the isochrones (Figure 2.4 and Figure 2.5).

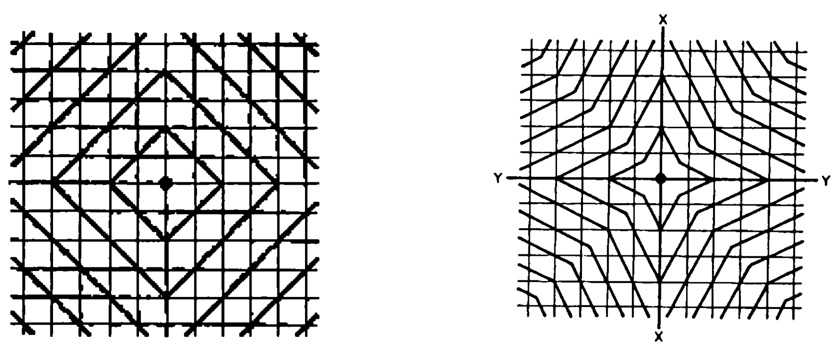


Figure 2.4: Isochrones on a uniform rectangular street grid (left) and with two intersecting highways added (right)

(Alonso 1964)

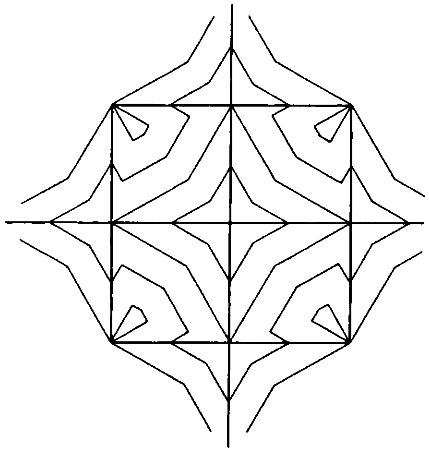


Figure 2.5: Isochrones on a rectangular street grid with two intersecting highways and a rectangular loop (Alonso 1964)

Alonso explicitly postulated that differences in distance to the centre were created by a town's street morphology and that these would lead to difference in rent isochrones. However, he did not specify how this street morphology should be taken into account within the model. He also did not discuss whether this caused problems for the simplifying assumption of a featureless plain.

Although the street distance variable is a much closer proxy for the kind of accessibility to the CBD than Euclidean distances, it has been used much less frequently than Euclidean distances. However, studies that have used street distances have found them to be better correlates. Clapp tested the spatial variables of distance from a point (the civic centre of the CBD) as both Euclidean and Freeway based distances (Clapp 1980). He found that Freeway distances were consistently more significant and better correlates, despite a high correlation between the two measures themselves. Clapp was remarkably sophisticated for the time in testing both kinds of distance measure, as the majority of studies after his did not bother.

Knos carried out one of the most thorough studies of the relationship between street distance and value for the city of Topeka, Kansas (Knos 1962). The dependent variable was not office rents but assessed land values and Knos provided a reasoned judgement about the limits of assessed values. He undertook an MRA to test the extent to which assessed urban land values vary inversely with distance from the centre of the city. He measured this as the shortest street distance from "the centre of the central business district and the centre of each block in the sample". He found a log-linear relationship of R^2= .6392.

2.6.3 *From Distance to Accessibility*

Although distance from a central point has been widely used as a spatial variable, it has always been recognised in the literature as a simplification of a broader spatial 'accessibility' variable that is the real hypothesised cause of differences in location rent values. The axiom underlying the majority of econometric studies of office rents is summarised by O'Hara:

> In choosing a location, each firm will consider travel costs between that location and all other locations
>
> (O'Hara 1977, pg. 1190)

In this view distance is still the important spatial variable, but it is an accessibility value of distance to all possible destinations that is thought to be of importance, as the American Appraisals Institute proposes:

> the quality of a property's location can be quantified by calculating the time-distance relationships or linkages between the property and all possible origins and destinations of customers coming to and going from that property
>
> (Appraisal Institute 1992)

As well as considering the implications of urban morphology, Alonso also considered the possibility of multiple distances in rent:

> There might be a variety of centers... which are separated in space. Different people might be differently oriented towards these centers, and this would be reflected in both their utility and their commuting costs functions. A number of distances, t_1, t_2, et cetera, would have to be considered, each corresponding to the distance to one of these centers, rather than the single distance t to the all purpose center of the simpler case.
>
> (Alonso 1964, pg. 137)

Alonso went on to discuss the pattern that two neighbouring centres with overlapping rent curves might form, as can be seen in Figure 2.6 below. This shows Alonso's speculation about how the bid price curves of two centres might intersect to form a pattern of rent that had more than one peak. In the figure on the right, the pattern of two centres with unequal attraction is supposed.

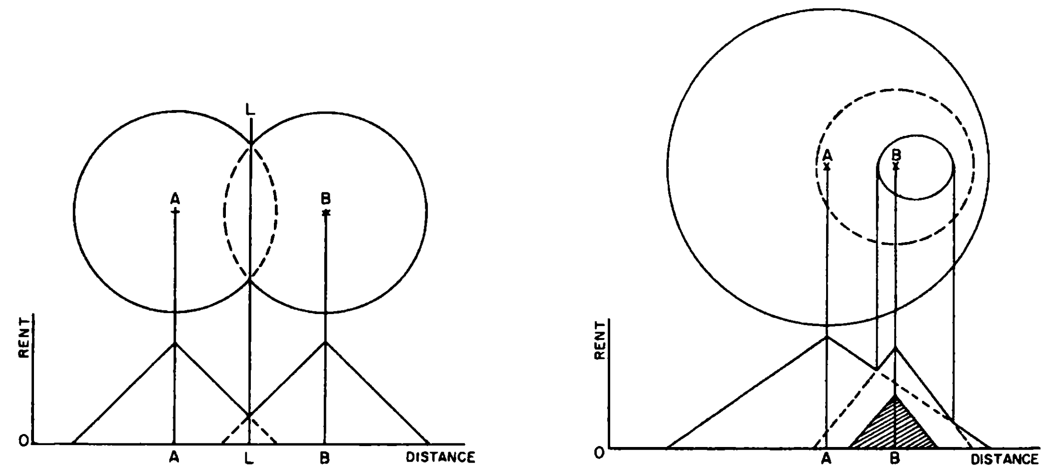


Figure 2.6: Rent patterns of two competing neighbouring centres of the same size (left) and unequal sizes (right)

(Alonso 1964, pg. 137)

The speculations about multiple centres provided by Alonso in his discussion chapter are clearly a recognition that in real cities such patterns do exist. The problem is that although he recognised that such outcomes could exist in the real world, there was not formalisation of them within the equilibrium model that was the most influential part of his book. This is because the central axiom of the model (that rent declines from the CBD) does not permit any formal treatment of rent rising and declining from multiple CBDs. Alonso explains the purpose of the model's central axiom thus:

> Though not all employment, shopping et cetera are at the center, this will be the point of greater accessibility to these activities. The center of a city is analogous to the center of gravity of a physical object
>
> (Alonso 1964, pg. 134)

If the central point in the model is analogous to a centre of gravity, how can there be more than one centre of gravity? The model does not allow for this solution because the middle point of the two maps in Figure 2.6 above would become the new centre of gravity. According to Alonso's model, in both of the cases of Figure 2.6 there ought to be a central point between the two centres around which values are arranged (or perhaps *rearranged*?) but there cannot be an equilibrium with two centres because it makes a nonsense of the model's axiom.

Because Alonso's recognition of the possibility of multiple centres were not formalised in his model, many writers since the 1980s have ignored the fact that he mooted these possible cases and launched a critique of the monocentric paradigm with his theoretical model as the main focus. The challenge has come because single distance from CBD variable did not seem plausible in light of the real pattern of values in cities. Alternative ideas to the Alonso model developed especially in the field of residential land value theory. These were significant for office studies too because they were stated as a critique of the axiom of land value overall being synonymous with distance from the CBD. For example, Heikkila's work on residential land values makes this idea explicit:

> The key idea of this research is that residential land values might be affected by accessibility to each of *n* nodes
>
> (Heikkila, Gordon et al. 1989)

Two critiques of the conceptual model of rent gradients as monocentric developed in the academic debate. The first was that the advantages of the CBD to firms are not as great as might be expected and therefore distance from the centre is not so important. This kind of argument is expounded by Sivitanidou, who argues that rent contour gradients are flattening because of IT leading to weakened centre access advantages (Sivitanidou 1997).

The idea that distance from the CBD is economically not as significant as the Alonso model might assume was also the basis of Heikkila's espousal of the need for a multiple-distance measure of accessibility. He posited that distance matters for workers in a household but there might be more than one worker in each household leading to multiple distances. Hanink criticised the monocentric view on the grounds that rent gradients are not uniform because the office market is segmented:

> the market is not differentiated with respect to any singe location but the market is segmented, or disintegrated, within the metropolitan area
>
> (Hanink 1997, pg. 392)

This idea was echoed by Sivitanidou who posited that the city consists of i "open" competing office-commercial nodes (i=1,2,...,n) surrounded by urban residential "villages" (Sivitanidou 1995).

The other kind of critique is that distance from the centre is less important because the spatial development of land use and land value centres is more random and this means that subcentres might just *emerge*. Krugman posited that it might be possible to generate patterns of land value and land use that are polycentric simply through an aggregation process that has some random component (Krugman 1996). The problem for conceptual models of polycentrality has been that they have not provided any theoretical guidance on what to use instead of the classic single distance to the CBD. As Heikkila noted:

> Usually nonmonocentric models have been developed that explain how policentric spatial structures might emerge, but they have not specified how many subcentres will develop or where they will be located.
>
> (Heikkila, Gordon et al. 1989, pg. 221)

The theoretical confusion about polycentrality is matched by a methodological confusion in the econometric studies concerning what to use for multiple-distance accessibility. A plethora of different distance variables have been suggested other than just the distance from a central point in the CBD. Clapp tested distance to the nearest road junction (Clapp 1980), Hough and Kratz tested distance to the nearest train station (Hough and Kratz 1983), Cannaday tested distance to the nearest shopping centre (Cannaday 1984), Glasscock tested 6 area dummies (Glasscock 1990) and Dunse tested postcode dummies (Dunse and Jones 1997).

The results from MRA tests of multiple distances have often been ambiguous and confusing. Cannaday and Kang found that Euclidean distance from a shopping centre was significant for a linear model of rent but insignificant for a log-linear model (Cannaday 1984). Hough and Kratz found the Euclidean distance variables inconclusive. Distance from downtown centre was significant and of the expected sign but distance from rail interchanges was not (Hough and Kratz 1983). Vandell found that the Euclidean distance from town centre variable provided in the agents reports that they used was significant and negative, however the increased distance to a transit stop tended to increase rents. They were not able to find a satisfying explanation for this (Vandell and Lane 1989).

This is the state that empirical studies of location and office rent have reached: a common method of evaluating factors that influence rent has been adopted by the majority of studies (multiple regression analysis). The method promises to provide some transparency, objectivity and comparability between studies of different markets so that general conclusions can be drawn about the importance of factors that influence rent.

However, there are still very open debates about the best way to measure those factors and the most open is the factor of location itself. Location measures used in many studies (such as Euclidean distance or location dummies) are of little help in comparing the role of urban spatial structure from one case to another because they are based on spatial reference points specific to the case under analysis (an example would be the distance from the intersection of Madison and LaSalle used in Brennan's study of Chicago). Until some objective measures of location are adopted to describe how 'close', 'far', 'accessible' or 'inaccessible' each rented building is to any other locations, it is not possible to move beyond intuition into quantifiable comparisons.

2.6.3.1 Large Scale Urban Models(LSUMs)

In the postwar period, various analytical and modelling tools were being developed that provided the hope of an alternative to the axiom of distance from the CBD through some measure of accessibility. These were not developed specifically to look at the question of office rents, but are evaluated here because the represent the alternative measures of location and accessibility within the city that may serve as an alternative measure of location when looking at office rents.

'Regional science' developed as a research programme that attempted to fashion analytical tools from earlier theoretical contributions on location theory (Krugman 1995). Walter Isard's 'Location and Space Economy' provided a synthesis of Von Thünen, Weber, Christaller and Lösch and presented a reformulation of the problem of firm location as one of a substitution trade off of transport costs and production costs just like any other trade off (Isard 1956).

In a very influential work, Lowry proposed a gravity model of land use within the city of Pittsburgh (Lowry 1964). Lowry's work was part of a burgeoning quantitative movement in urban planning that was concerned to apply urban modelling techniques to the problem of land use allocation. A number of 'Large Scale Urban Models' (LSUMs) were developed, mainly in the United States. These models shared a number of characteristics summarised by the former practitioner of urban modelling Douglas B. Lee:

> A prototypical land-use model is broken down into sub-areas (called zones or districts) generally larger than census tracts in size, for which various activities (population, basic employment, commercial employment) are recorded. Categories are disaggregated (e.g. age, income, industry) along with the basic exogenous data and structural parameters. The model begins operating at some point in time and allocates new activities to zones, in discrete lumps that represent periods of two or five years.
>
> (Lee 1973)

LSUMs began to attract criticism from the late 1960s, most famously in Lee's critique 'Requiem for Large Scale Urban Models' (Lee 1973; Lee 1994). Lee's critique contains a large number of arguments, of which some are directly relevant to the potential for use of LSUMs as spatial models for econometric studies of office rent.

Many of the aspects of Lee's critique such as 'data hungriness', 'expense', 'wrongheadedness' and 'hypercomprehesiveness' (Lee 1973) relate to the fundamental problem of increasing complexity that the models reached. The increasing complexity relates partly to the very broad aims of the models- their so-called 'hypercomprehensiveness' in attempting to predict several dependent variables for each zone. So many variables were being used both as model inputs and outputs and so many interactions were taking place that it became unclear, even to the model builders, why a particular outcome was being produced.

From the perspective of LSUMs as spatial models, the complexity is also an aspect of the problems relating to the loss of a central distance axiom. Without this clear guiding structure, the question is raised as to which distances are relevant. The LSUMs tended to add as many variables as might be considered relevant: employment density, shopping, housing density and so on. These were given as destination weightings within each zone. This leads to a problem of burgeoning complexity in the model.

However, for the purposes of empirical studies of rent, the critical issue is the extent to which LSUMs might provide a spatial measure that can be used as an independent location variable in MRA for rent. A problem of the LSUMs that limits their potential to provide such a location measure for empirical studies is that in order to allow for this multiple-distance accessibility, the models tended to sacrifice spatial resolution. This characteristic has remained in recent approaches. Of the recent models reviewed by Wegener, those concerned with spatial parameters were also formulated at an aggregate zonal scale (Wegener 1994). Econometric studies that have looked at a small number of simple distance measures have been able to use street based distance that is sensitive to morphology, as shown in section 2.6.2.2 above. However, the LSUMs were principally formulated at a larger aggregate scale than the street level at which rent differences have been found. This aggregate level is a problem not just in the potential use of LSUMs for rent analysis but for their application generally:

> The actual level of detail was much too coarse to be of use to most policy makers...A lump of population, probably located within half-a-dozen census tracts, is helpful as a forecast to a very limited number of people.
>
> (Lee 1973)

These characteristics of LSUMs have limited their application in empirical studies not just of rent but of any urban social phenomena. Wegener noted that 'remarkably few validation exercises are reported in the modelling literature' (Wegener 1994). Consequently the quantitative movement in planning has developed away from LSUMs as spatial models of transportation and land use and focussed more on the idea of data-based spatial accounting:

> While models might have dropped from the agenda during the 1970s, data and information definitely remained.
>
> (Batty 1994)

The aim of computer assisted spatial accounting has been assisted greatly by GIS, a tool that is able to deal with any level of spatial resolution. Lee's original critique had advocated the use of spatial accounting style models (Lee 1973) and he specifically cites GIS as a flexible platform that can provide useful spatial accounting tools (Lee 1994). The move into spatial accounting modes of research has however been a move away from the explanation of the spatial dynamics of urban systems that was one of the promising original aims of the LSUMs.

2.6.4 Configuration

The goal of a location measure for office rents is the kind of general spatial accessibility suggested by Heikkila and the American Appraisals institute (page 49 above). However, in order to create such a multiple-distance measure, a solution is required to the problem of massive complexity that arises when the simplifying assumption of distance from the centre is removed. Alonso's distance from a single point of all employment is clearly too simple but the problem has been how to replace it with the vastly complex pattern distances to and from all relevant origins and destinations that a generalised measure seems to require.

One approach to the analysis of space that is relevant to this problem has been developed within the field of architectural morphology, especially by Hillier (Hillier and Hanson 1984; Hillier 1996) and the space syntax research group. Space Syntax is a research programme investigating the role of spatial configuration as an independent variable in social systems. This approach has been concerned with the development of the rigorous representation and analysis of the spatial structures that society uses, whether at the scale of interior domestic spaces or large scale urban systems.

In order to treat spatial configuration as an independent variable, the space syntax research programme has developed a number of analysis techniques to *measure* the configurational properties of any architectural object as an independent variable. The techniques have been used to produce both a rigorous description of the individual spaces in a layout but also the way that they fit together to form a large-scale spatial structure such as a building or a town. For urban scale research the most often used technique has been the axial map. This is a simplification of the spatial network as the set of fewest and longest axes that link all the convex spaces of a continuous street system together. The 'global' properties of the network are captured by using various graph-based measures to explore the relationship between every axis and all others within the network[5].

---

[5] These measures will be explained in detail in the next chapter on methodology.

The measurement of spatial configuration as an independent phenomenon has created a basis for the pursuit of both kinds of research into the relationship between society and spatial layout that were mentioned in chapter 1. These are the laws that govern the way that society chooses to mould spatial layout to suit its needs and the unplanned social consequences that the configuration of space may have back onto society.

2.6.4.1 The theory of natural movement

This approach to analysing space as an independent variable has led to many findings about the relationship between the configurational properties of spatial layout and the use of space by people. These findings are theoretically significant in terms of the research programme into the effect of space on society: if the independent characteristics of space can be shown to have an effect on society, then there is an influence of space on social life that is independent of individual human intentions or goals.

The most significant empirical results in the space syntax research programme have been in the measurement of pedestrian movement. Regression models that use 'configurational' or graph measures as the independent variable have been found to predict observed counts of pedestrian movement as the dependent variable to quite high correlations. Graph measures have been used because a number of studies have shown a strong relationship between such measures and pedestrian movement patterns in streets (these are summarised in Hillier 1996, chapter 4). The strongest relationships have been found between a measure of the average depth of a street within a restricted local surrounding area, termed 'local integration,' and observed pedestrian flows[6].

In order to compare the use of space syntax measures in regression models of pedestrian movement determination with econometric models of rent determination, it is interesting to inquire into the simplifying assumptions of the regression model used in such studies. The central simplifying assumption of the space syntax regression models is quite different to the simplifying assumption of Alonso's theoretical model and the MRA analyses of rent that are based on it. Rather than having to assume that the centre of a spatial system will be the point of all destinations, Hillier et al. assume that in relatively built up areas, there are potential origins and destinations dispersed throughout the city. Rather than attempting to describe the focal points or nodes of greatest pull in terms of gravitational theory, it is assumed that *everywhere* within the spatial network is as important a destination as everywhere else.

[6] This measure will be explained in section 3.7.6 of the methodology chapter.

This provides for a theory of movement. If (according to the central simplifying assumption) the weighting of origins and destinations can be ignored in dense cities, then the routes prioritised for movement will be dependent on the morphological characteristics of the streets themselves. This is the theoretical basis for the use of a morphological measure of route simplicity as a predictor of movement patterns:

> If we define an urban street network as a system of lines linking some set of origins and destinations, and to the extent that movement can occur from all origins to all destinations, then movement along the lines making up the network will be substantially determined by extrinsic measures of those lines[7].
>
> (Hillier 1998)

The measures used to predict movement patterns have typically been graph measures derived from depth calculations within the street network as a whole. Graph measures have been particularly fruitful as tools for testing the theory because they allow for a description of how strategically placed each street is within the network as a whole:

> A graph is a map of pure relations... in which elements (or nodes) have no attributes apart from being connected to others... (therefore) graphs measure 'extrinsic' or non-local properties of elements.
>
> (Hillier 1999)

Although this approach developed from a research programme that was initially aimed towards investigating and comparing architectural designs, it has led to the development of techniques for the accurate measurement of spatial layouts that are much more widely applicable and are relevant to the problem definition of this thesis. This is because the space syntax methods of analysis provide a way to isolate an independent spatial variable that can be used to track changes in spatial layouts and measure their influence on economic and social variables such as rent values.

For the purposes of this thesis, the space syntax approach to measuring urban configuration offers an alternative way of capturing the location variable to the techniques traditionally pursued by the large-scale urban models or the measures of multiple distances. The problem of complexity that has mired the development of useable multiple origin-destination matrices for a location measure in rent studies does not arise in the space syntax approach. This is because the complexity of origins and destinations is generalised completely as purely a spatial structure. Rather than having to model where each actor may need to come and go from, the space syntax approach has been to model the whole possible origin-destination set

---

[7] A clearer formulation of the theory might be "to the extent that origins and destinations are equally distributed throughout the system and movement *does* occur from all origins to all destinations" as it is only to the extent that such a simplifying assumption is valid that the model will predict

and provide measures of the relative spatial privilege within the network as a whole accorded to each location.

2.6.4.2 The movement economy

On the basis of this relationship between the layout of the city and movement, a further theory about the implications of the pattern of natural movement on the pattern of land use has been developed by Hillier et al. The theory of the *movement economy* is that the existing pattern of *natural movement* is exploited by those land uses that are more dependent on movement than others. Land uses that are 'movement dependent' (the most obvious of which is retail) select streets that have a high level of movement in order to take advantage passing trade. Those that are less movement dependent (such as housing) select lower movement routes to locate upon (Hillier 1999). Consequently the whole pattern of land uses becomes organised around the configuration-movement relationship.

The theory of the movement economy was developed in response to evidence from empirical studies that showed a concentration of retail on high movement streets was underpinned by the high spatial integration of those streets. A multiplier effect was detected whereby the relationship between measures of purely spatial accessibility (termed 'integration') and the flow of movement were found to be linear in single use areas such as residential suburbs but logarithmic in areas containing commercial uses (Hillier and Penn 1992). It was posited that the multiplier worked through the mechanism of a natural movement pattern arising from the layout of the city that benefits the retail uses. These uses in turn concentrate on high movement streets and attract more movement to them.

The theory of the movement economy has been tested by MRA models of the relationship between spatial configuration and higher order social and economic phenomena, for example, in a study of physical and social consolidation of informal settlements (Hillier, Greene et al. 1998). The study found important relationships between local retail development and social consolidation in which the movement economy seemed to be implicated as an important variable.

However, no work has previously been undertaken on the relationship between such spatial measures and rent values. It might be hypothesised that for retail, there would be a relationship between the spatial measures and rent because a location is more valuable for retail the higher the level of pedestrian movement outside and the spatial measures are a good proxy for pedestrian movement. However, the 'movement dependency' of office uses is far less obvious and there is no clear implication from the theory on how office rents might fit into the movement economy.

For location and office rent there might be a similarly overarching theoretical framework to be developed, such as the movement economy thesis does for retail at present. However, in order to move towards this kind of theoretical discussion, it is first necessary to demonstrate a relationship between office rent and urban spatial structure measured as an independent variable. This is the purpose of this thesis.

2.7 The Pattern of Rent: Representing the Dependent Variable

So far, the review has considered the theoretical background to rent theory, the development of empirical studies of rent data and the spatial variables that have been used to explain rent. Other approaches to the understanding of spatial structure have been discussed. In this section we come to look at what previous empirical studies have actually revealed about the spatial pattern of rents.

2.7.1 The role of representation in rent theory

In the field of urban economic theory, there has been very little research effort devoted to the empirical study of spatial patterns of rent. The empirical pattern of location rents has been largely ignored as a question of interest, often because certain assumptions about rent falling away uniformly from a town centre have been taken as given fact rather than a hypothesis worthy of testing. Consequently very little has been done in published academic studies to attempt to represent what location rent patterns actually look like.

The role of representation of rent patterns has often been seen as the required model output for a theory of rents, yet the empirical pattern against which such a model output should be tested is curiously absent. O'Hara explicitly provided a model of how a radial pattern of rents away from a central point in a town centre could develop in the case of a perfect orthogonal grid for movement (O'Hara 1977). The justification for the model was that the success of radial distance as a predictor of rents should be accounted for, yet the success of radial distance was not demonstrated with any empirical data. Sivitanidou raises the idea that rent contour gradients are flattening because of IT leading to weakened centre access advantages for firms, yet fails to provide empirical evidence of the regularity or shape of rent patterns (Sivitanidou 1997).

Although the econometric studies have been careful to isolate the spatial variable and to attempt to quantify its influence, there has been an almost complete lack of representations of this spatial variable. With the notable exception of Brennan's study of rent patterns in a small part of the Chicago CBD (Brennan, Cannaday et al., 1984) none of the academic studies of office rent data have attempted to represent the spatial pattern of office rents from their study sample.

There has also been almost no attempt to test representations of the model output against representations of empirical data, or to explain deviations in the pattern of rents from the supposed hypothetical model (Knos is a notable exception).

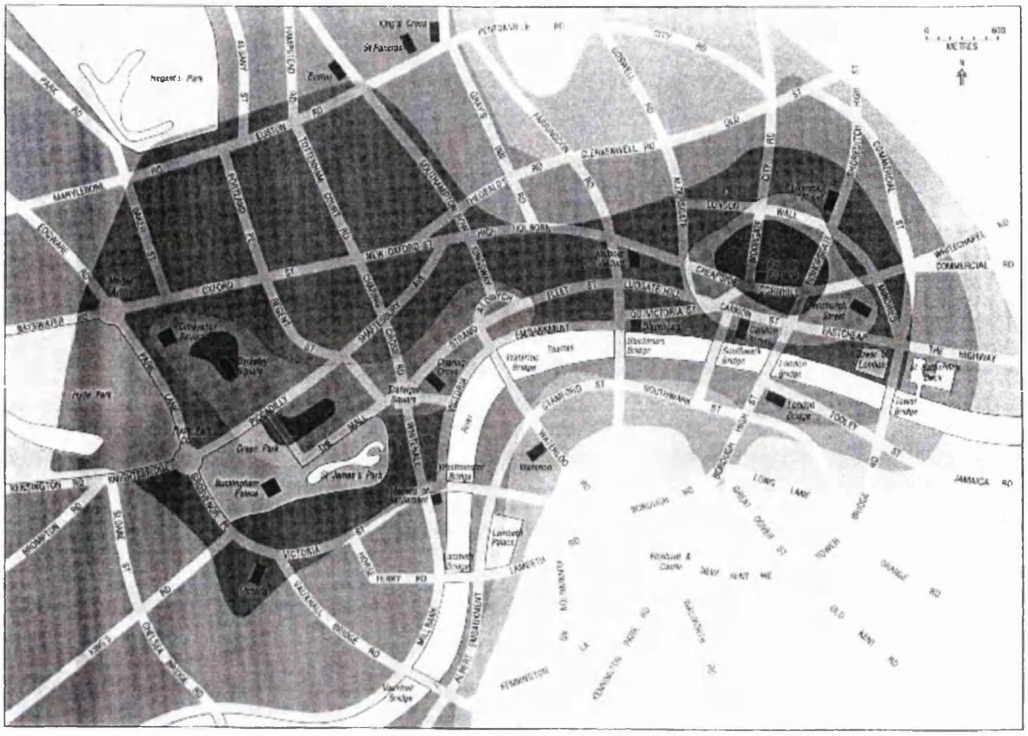
2.7.2 *What rent data is being represented?*

At the econometric studies have disregarded representation, studies that have created 'value maps' generally have not used a comparably rigorous methodology to isolate the location variable from other determinants of rent. This raises important questions about whether the values being represented can actually be ascribed to differences in location or whether some intervening variable that has not been controlled for plays a role. In a PhD thesis exploring the use of Geographic Information Systems (GIS) for surveyors' valuation purposes, Wyatt noted that there is confusion about the kind of values that are being displayed in many value maps:

> Arguably the most important criticism of traditional value maps is that they do not reconcile any differences in the physical and legal characteristics of the properties they displayed and therefore the contours and shading will be distorted because not all differences in value will be due to spatial factors.
> (Wyatt 1994)

The bulk of representations of rent patterns that do exist come not from the academic field but from commercial property consultants. Such companies often generate maps of office rent values for their city reports, some examples of which for Berlin are presented in Chapter 5 (Map 5.1 to Map 5.6 on pages 171-175). Although these studies do concern the representation of data on rents (the second of the three questions of the thesis listed on page 18 of the introduction above) they are for marketing purposes, not academic publication, and consequently the methodology used is variable and usually not explained. Their function is generally only to provide an overview of location trends. Thus it is often unclear how (or if) other factors have been controlled for.

The property company Hillier Parker attempted a more rigorous representation in the 1990 Atlas of European Office Rents (Hillier Parker 1990). A common rent representation technique was applied to a number of cities. The values expressed were 'open market value of a modern office of approximately 1000m2, but the methodology for deriving such a value was not given. The report was only intended to show the 'broad pattern of office rents' (Hillier Parker 1990). Map 2.1 below shows the Hillier Parker map of central London office rents.



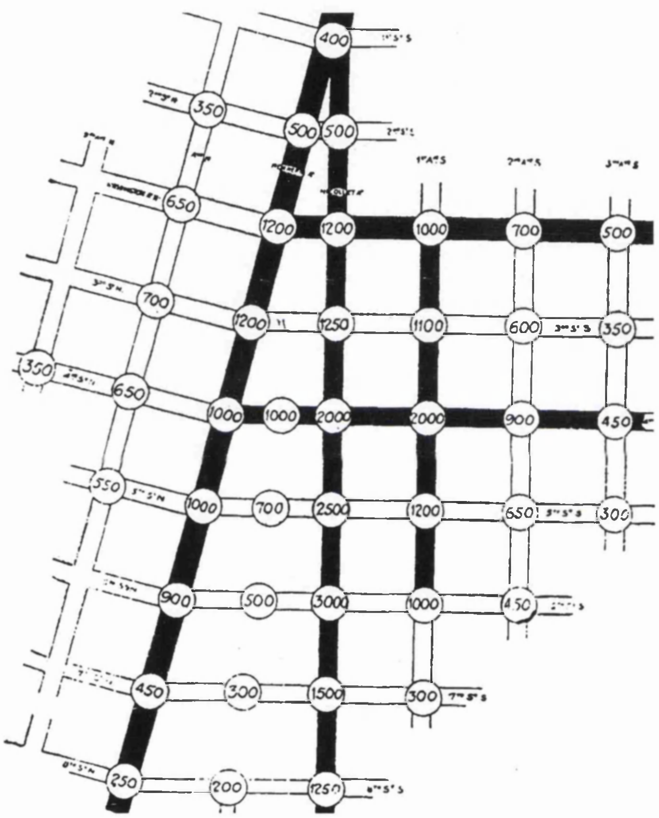
Map 2.1: Office rent map of central London (Hillier Parker 1990)

Gallimore et al. undertook a more sophisticated derivation of location values derived by MRA for data on residential sales prices in Stafford, England (Gallimore, Fletcher et al. 1996). Multiple regression without a location variable (a '*location-blind*' MRA) was used to find a residual that is attributable to location once other sales variables such as size had been accounted for. This is a far more rigorous attempt to represent location values because the use of multiple regression allows for the control of other variables that influence rent. The Gallimore study is quite unique among value maps in that it attempts to represent the spatial pattern of location rent after other variables have been controlled for in an explicit methodology.

2.7.3 How is the spatial pattern of rents to be represented?

Having outlined the paucity of representations in the literature on office rent, we now come to look at the methods that have been used in published maps of rental value. The issue of importance here is how accurately the mapping technique itself can be said to represent the spatial pattern of rent.

The first significant empirical study of rent was the Chicagoan Richard M. Hurd's 'Principles of City Land Values' (Hurd 1903). As the president of the Lawyers Mortgage Company, Hurd had access to a vast amount of property data and his book provided an excellent study of the US property market. Hurd also created the first major set of urban land value maps. 'Principles' provided land value maps for a number of cities showing the value in dollars per front foot of corner buildings at each street intersection, as can be seen in the Minneapolis example in Map 2.2 below. The detail of these representations was extremely high, with individual values provided for every intersection within the whole CBD.



Map 2.2: Commercial land values in Minneapolis, measured in $ per front foot (Hurd 1903)

In the post-war period, the most influential representation technique for rent has been that of the isoplethic surface. For this technique a standard representation of rents is taken whereby the colour-scale of the map is set in direct proportion to the rent values using a continuous surface to represent changes in value. This is known as isarithmic mapping. The technique is used in cartography and natural geography to map the form on the outside surface that encloses a geographic volume. It is normally used when the focus is on the attribute values at points on a truly continuous distribution, such as land elevation. Isarithms showing distributions of values that can be referenced to points (such as a point on a rented office floor) are called isometric lines. The surface can either be represented as contours on a plan view or explicitly as a three dimensional object in an axonometric view.

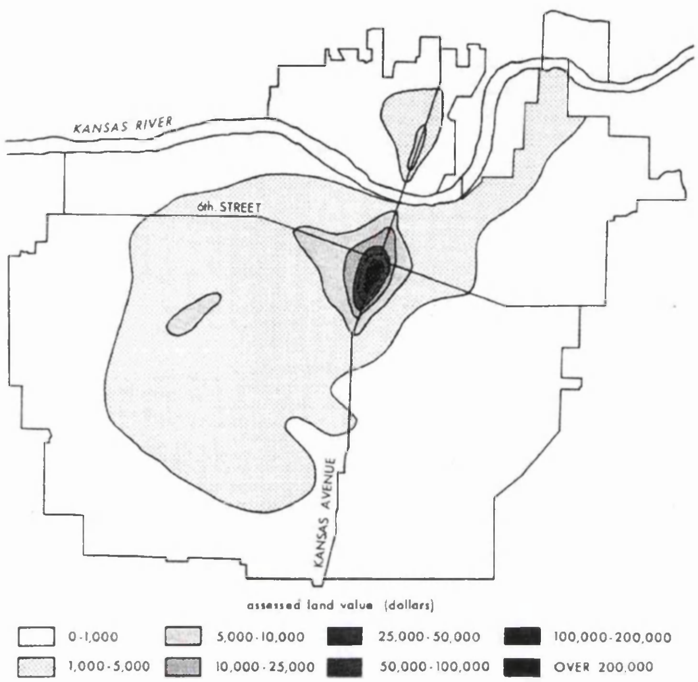
The use of this technique for land value maps was first proposed by Antsey in 1949 (Anstey 1949). Antsey advocated the use of this technique from natural geography in order to give planners a fast tool with which to represent values for the entire town. This was regarded as important because the 1947 Town and country Planning Act gave planners vastly increased rights of development control and land value was one criteria in their decision making process:

> The Administrator will often need to choose as between alternative Town Planning schemes what is of most economic value to the community and what best conserves the community's resources. Without information as to the value of the land with which he has to deal, and the effect upon that value of his schemes, his judgement is hampered.
>
> (Anstey 1949)

The perceived advantage of the technique is that it allows for what the cartographer Robinson refers to as 'cartographic induction' (Robinson 1995). Interpolating from a limited sample of points creates a continuous *statistical surface*. In natural systems this allows for the derivation of many kinds of gradients, such as land surface slope and temperature variation. An example of its application to create contours for commercial land values by Antsey is shown in Map 2.3 below:

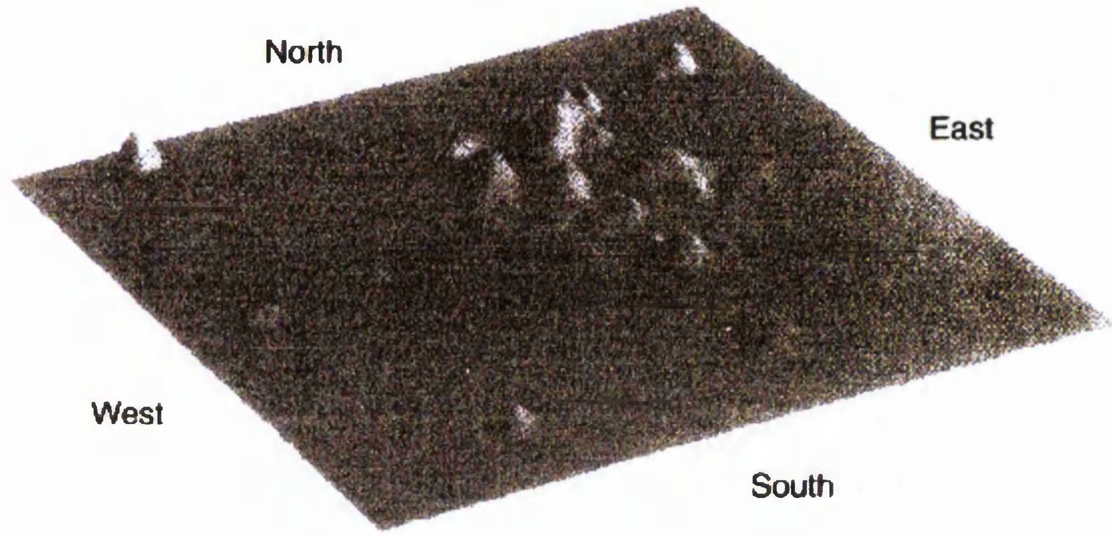
Map 2.3: Isoplethic Representation of land values in the City of London (Anstey 1965)

Knos created a statistical surface showing a logarithmic rise in values towards the town centre in his early study of assessed land values in Topeka, Kansas (Knos 1962), as shown in Map 2.4 below:



Map 2.4: Assessed land value surface for Topeka, Kansas (Knos 1962)

Gallimore et al. also used the isopleth technique to represent the rent values derived from their location-blind MRA discussed in section 2.7.2 above. This location rent was then represented as a statistical surface using the technique of surface interpolation available within the ArcView GIS software, as can be seen in Map 2.5 below. The use of a third dimension in isoplethic representations of rent data may be related to the historical origins of the technique in natural geography. The isoplethic technique was developed to allow for the derivation of many kinds of gradients in natural systems, such as land surface slope (Robinson 1995). Its application to rent values was extended to the creation of surfaces above the city rather than just the colouring of contours.



Map 2.5: Surface of Location Value for House Prices in Stafford (Gallimore, Fletcher et al. 1996)

The only attempt to apply such techniques to office rents was Brennan's study of Chicago rents (Brennan, Cannaday et al. 1984). It is possibly because Brennan was concerned with data from a small area compared to other econometric studies that his study is the only one that attempts a representation of the values. The representation shows isometric lines on a surface rising to the main streets of Madison and LaSalle. These streets were chosen in a trial and error manner using a simplified block distance measure from the main streets the surface was extrapolated from a very small sample of 29 leases over 3 years. The rent surface shown in Figure 2.7 below comes from a log-linear regression including two distance variables for the streets Madison and LaSalle (Brennan, Cannaday et al. 1984).

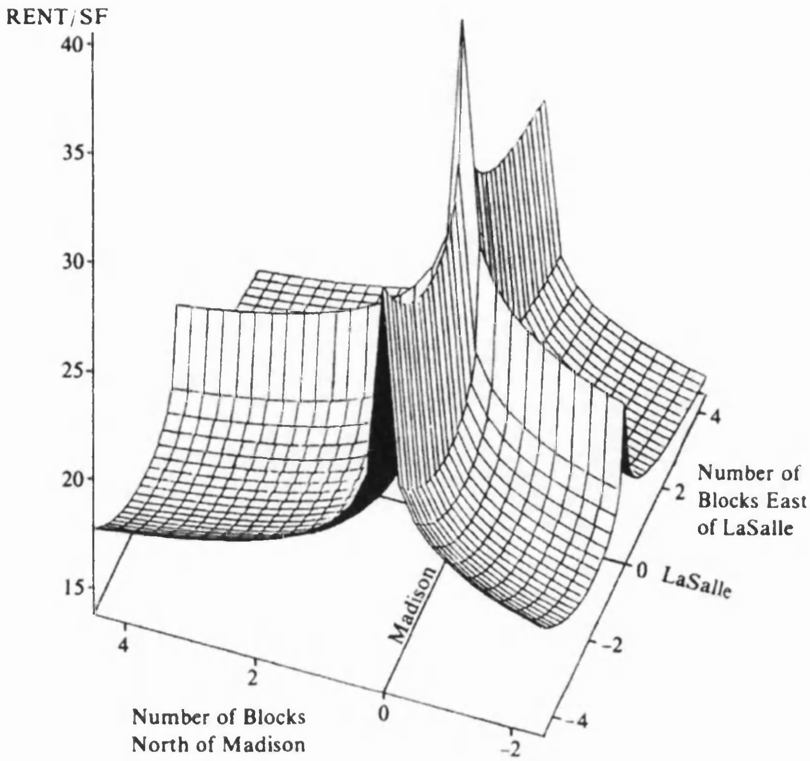
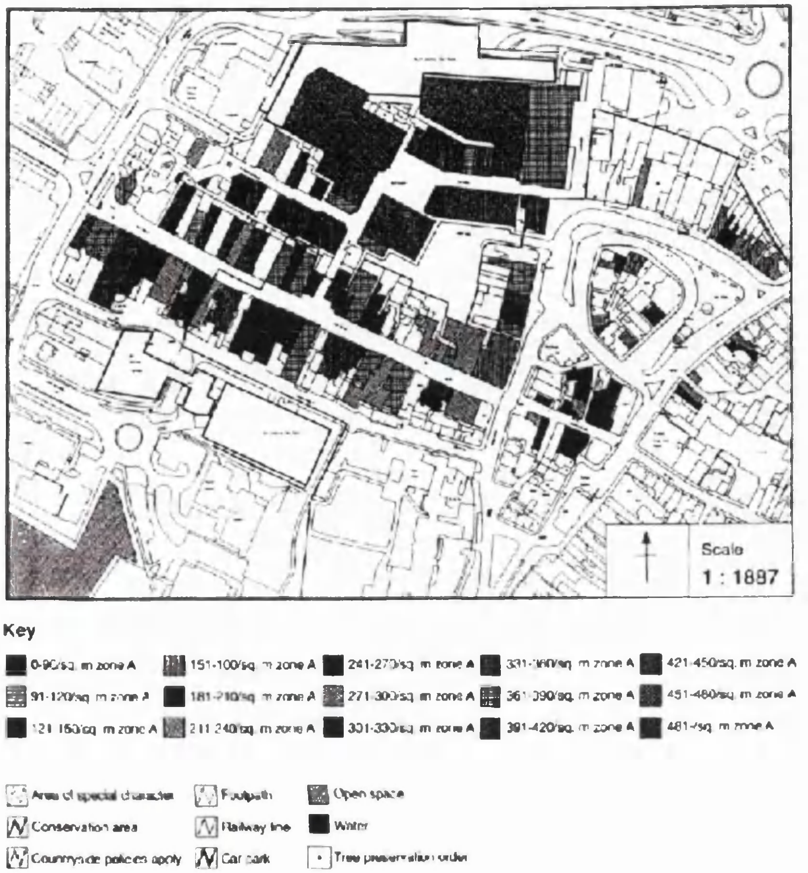


Figure 2.7: Rent Surface for the Chicago Central Business District (Brennan, Cannaday et al. 1984)

There are theoretical criticisms of the isopleth technique as a tool for representation. The technique necessitates the problematic assumption of an isotropic surface to the city. This assumption was one of the simplifications considered necessary by Alonso in the modelling of an independent location variable (Alonso 1964). However, it is not clear that this simplifying assumption should be required in order to represent the empirical data itself (the dependent variable) that the analysis is attempting to explain. The assumption of an isotropic surface means that the measure of distance (from a point) does not vary with the direction. As the cartographers Laurini and Thompson have noted, in systems where networks are involved (such a buildings facing onto streets) an antiisotropic condition exists (Laurini and Thomson 1995). This makes the assumption of an isotropic surface inappropriate.

There are some examples of rent representation that do not use the isopleth technique but rather show values at specific locations. The development of GIS allows attribute data of buildings to be easily represented in colour. Wyatt's work (Wyatt 1994; Wyatt 1996; Wyatt 1997) provides a recent example of the use of such GIS technology to go back to a more precise, plot based representation of values rather than the isopleth technique that has been so prominent. An example of a plot-based representation of retail rents by Wyatt is shown in Map 2.6 below:



Map 2.6: Plot based representation of retail values in a GIS (Wyatt 1996)

The other technique used to create rent maps has been the dasymetric technique, whereby the pattern of rents is split into a number of idiosyncratic areas rather than either a continuous surface or points with a scale of values. This means that the boundaries to the data mapped are independent of the data source boundaries (such as enumeration boundaries or office buildings). This is the technique often employed in representations of rent that appear in property agents reports. There are problems with the objectivity of representations created like this. As the cartographer Robinson has noted, each step of the dasymetric technique can add error to the map because almost every step requires some subjective decision (Robinson 1995). This makes it difficult to tell to what extent the resulting pattern reflects the vagaries of method, the opinions of the mapper or some underlying objective property of the distribution.

All the mapping techniques that have been used for rent raise a key issue in the requirement of additional theoretical assumptions in order to represent the empirical data. The isoplethic technique involves the assumption of an isotropic plain upon which a statistical surface can be generated. This is an assumption used widely in certain urban modelling techniques but one of a *theoretical* nature. For the representation of empirical data the approach that seems most fruitful is to minimise the theoretical assumptions necessary to understand the phenomenon being investigated: to learn from the data itself. The dasymetric technique involves the arbitrary assumptions about where the boundary of areas should be drawn. It might be possible to derive more objective boundaries using another variable (such as urban morphology) but this has not been the case on previous studies.

2.7.4 *What do empirical representations of rents show?*

Although examples of office rent representations are quite scarce, it is possible to piece together a number of spatial characteristics of office rents both from the few published value maps and the descriptions in the econometric studies.

2.7.4.1 Fine scale spatial differences in office rents

One of the most important characteristics to arise from the few representations of rents is that office rental values can vary greatly from street to street. Hurd notes differences in rentals for commercial buildings of as much as 20 to 1 between a main street and a side street (Hurd 1903, pg. 127). The pattern of rentals in Minneapolis reproduced in Map 2.2 above shows strong differentials both between the main streets and the side streets and also along the length of each street.

The street scale differences in office rents in the Chicago CBD shown by Brennan (Figure 2.7 on page 66) were of the order of above $25 per sqft per annum on Madison and down to less than $15 on the side streets. Rents on side streets fall to 60% of those on the main streets within the space of 4 blocks (Brennan, Cannaday et al. 1984). This is an important finding in view of the pervasive idea of a fairly smooth decline in values away from the CBD that originates from the Von Thünen and Alonso models.

2.7.4.2 Changes in the pattern of rents

Another spatial characteristic that value maps can show is that of stability or change over time. Value maps of general land value and retail value have shown distinct change over time. Antsey used the isopleths for the Barbican in 1939 and in 1969 to show how redevelopment had altered the pattern of land values (Anstey 1965). Howes produced value maps based on market retail values for retail property in 1965 and 1974 and the percentage change between these two years (Howes 1980). His study illustrated movement in the pattern of values showing this as an advantage of value maps (Wyatt 1994).

Hurd also described changes in the pattern of urban land values in his survey of the American property market at the turn of the century. Writing at a time of great expansion of the American cities, he posited a relationship between the changing spatial structure of the town and the shift in land values:

> The principal causes of the redistribution of values in all cities are, increase in population and wealth, especially in causing relocation or extension of the best residence district, changes in transportation, such as new surface, elevated or underground lines, new bridges, tunnels, ferries and railroads, and the readjustments of new utilities in new areas harmonizing the complex contending factors.
>
> (Hurd 1903)

There is no published research that explicitly looks at the stability or change in the pattern of *office* rents over time. However, a number of econometric studies have been undertaken on the same areas at different times, which would have allowed for a comparison. The most heavily studied city has been Chicago. Brennan et al. chose distance from the intersection of Madison and LaSalle as the best correlate for the pattern of office rents in a study of data from 1980-83. They explicitly acknowledged that in a previous study of rent data from 1978 for same area, Hough and Kratz had chosen the intersection of Madison and Clark as the central location for distance measures (Hough and Kratz 1983). However, Brennan et al. stated that Clark Street 'did not work very well' and so chose the intersection of LaSalle and Madison instead (Brennan, Cannaday et al. 1984). They did not discuss the reasons for this difference between the studies. One explanation could be that the finding was simply an artefact of the methodology used in the previous study (i.e. Hough and Kratz would have also found distance from Clark street as a better determinant). However, if it was not an artefact of the methodology, then this finding must be seen as evidence for a change in the pattern of rent between 1978 and 1980-83.

2.7.5 Monocentrism or polycentrism?

One issue that the representation of rents could show is the extent to which multiple hotspots of value exist. Although large differences have been seen from street to street, there is a question as to whether a core-periphery relationship exists in office rents or many independent centres of comparable value within a city. The representations of land values (Map 2.2 and Map 2.4) tend to show one peak rather than multiple ones.

Some of the findings of the econometric studies also tend to support a view of monocentric rent patterns. Clapp found that the most critical spatial determinant in the multiple regression was distance from CBD and that sub-centres were less important because the negative rent gradient from CBD is so strong. Access to the CBD was twice as important as any other spatial variables in his MRA (Clapp 1980). However some other authors have found evidence that rent patterns are polycentric. Dunse's work on Glasgow office rents addressed the issue of whether location differences in office rents lead to spatial sub-markets (that is, a set of areas which have their own importance for particular sections of the market rather than a unified office market that varies in rent spatially). This is a limitation on the ideal plane surface posited by the neo-classical bid-price model (Dunse and Jones 1997). They argued that there was evidence for spatial sub-markets and therefore a spatial pattern that was polycentric. The pattern of rents produced by the agents Hillier Parker in Map 2.1 above shows the two peaks in office rental values in London that occur in the centres of Westminster and the City of London.

2.7.6 The logarithmic pattern of rent

Although there is some debate about whether office rents are monocentric or polycentric, there is quite general agreement that the most fitting functional form for models of rent is a logarithmic one. The majority of studies listed in Table 12.1 on page 301 above have found the log of rent as the dependent variable provides the best models of rent. This means that rent patterns can in previous studies have risen in a curve towards their peak rather than a linear rise. This was the case in the representations produced by Knos and Brennan (see Map 2.4 and Figure 2.7 above) but only the functional form and not the geographical shape of the curve in office rents can be seen for other studies as no representation was provided.

2.8 Problems and Debates in the Study of Office Rent

The review of previous studies of office rents has raised a number of theoretical and methodological issues. Some of these issues have been the subject of debate within the field. Other issues have not been directly discussed in the theoretical literature but must be faced in any empirical study.

2.8.1 The limitations of asking rents

A methodological problem raised in the literature review is the reliability of asking rent data as a proxy for achieved rents. Although asking rents are the most widely used of rent variables owing to their availability, there are strong reasons to be cautious about the relationship between them and achieved rents. Webb and Fisher noted in their study of lease data for the Chicago CBD that the stability of asking rents may hide changes in achieved rents. This means that the asking rent may be inappropriate data to be used in tests of theories about location preference by tenants, as it is actually representative of the supply side:

> (the asking rent) is essentially supply side information that does not necessarily reflect specific transactions between a lessor and a lessee...(asking rents) have historically risen steadily even during periods of rising vacancy rates when one might expect the price of rental space to fall.
>
> (Webb and Fisher 1996).

Thus, although the asking rent is widely assumed for research purposes to bear some relation to the actual rent that is achieved, it may reflect more about the hopes and negotiation strategies of landlords than it does about the price that tenants are really prepared to pay. Asking rents are a measure of the responsiveness of lessors to the market and there may be some variability in the elasticity of asking rents to achieved rents.

2.8.2 The aggregation problem

As can be seen from Table 12.1 on page 301, the most common aggregation of the dependent variable used in previous empirical studies of office rent has been the average asking rent price for a *whole office building*. Brennan has criticised the use of building level data in MRA because it prevents a proper analysis of lease variables, the most important of which is the time of each lease:

> The use of the building as the unit of observation effectively precludes including the date of the lease transaction for each office unit within the building as an independent variable. Therefore, no variable is used in the previous studies to take into account the fact that transaction rental rates on which the average rate is based may have been negotiated at different points in the time when market conditions may have significantly differed.
>
> (Brennan, Cannaday et al. 1984, pg. 246)

Only two studies of location and office rent have been found that use original rent data not aggregated to average rents per building. Brennan's study of 1980-83 data from Chicago used headline rent from leases but the sample size was only 29 (Brennan, Cannaday et al. 1984). Dunse's study of Glasgow office rents in 1994-95 had a sample size of 477 (Dunse and Jones 1997) but these were asking rents, for which the problems outlined in 2.8.1 above apply.

2.8.3 Multi-colinearity of independent variables

A major source of concern in the use of MRA is always the potential for multicolinearity of the independent variables, which effectively invalidates prerequisites of the technique because it means that the effect of one independent cannot be disentangled from another. Vandell and Lane found this problem with their use of a design variable taken from a panel of architects. Although design was shown to account for almost 10% of the quoted asking rents in their MRA, it was not significant if other collinear variables were included (Vandell and Lane 1989). This is a typical characteristic of colinearity- a variable's showing in the MRA will be highly affected by the presence or absence of other colinear independents.

Colinearity of independents is a major concern for studies of office rents because a number of independent variables may be spatially related, and therefore are bound to be to some extent colinear. Brennan notes that total building size may be positively correlated with rent not because tenants are prepared to pay a premium for larger buildings but simply because tall or large buildings tend to get located where rent is high (Brennan, Cannaday et al. 1984). Brennan also noted that other independent variables may fall prey to the same colinearity: his *VERT* variable (vertical location of a lease in a building) may be a proxy for mean building height, which in turn may be located preferentially towards areas of higher rent.

The problems of colinearity tend to be particularly marked for variables that relate to the unit and building quality, as these tend to be proxies for each other. For example, Clapp found multicolinearity between building size and the number of floors (Clapp 1980) for obvious reasons. This makes it very difficult to isolate the influence of these variables from each other.

2.8.4 *Lack of a spatial hypothesis*

Almost all the studies have failed to provide a convincing hypothesis for the particular distance variable included. Even beyond the problems of oversimplification that have been noted with the use of a central distance variable, there have not been clear criteria about *where* the central point should be and *why*. The rationale for including other variables has often been carefully presented in terms of the influence that they might have on tenants, whereas the choice of a specific spatial variable has not been explained at all. A telling example of this was Brennan's use of Madison and LaSalle as the origin point for a distance variable rather than Clark Street which had been used in Hough's previous study. No explanation was given as to why one might be preferable over the other or what the difference in the two signified (see discussion on page 68 above).

Knos did provide a justification for the destination point used for the distance variable of his study:

> The center of the central business district is taken as the intersection of Kansas Avenue and Seventh Street, for it is here that the blocks adjoin that contain the highest intensity of business activity, the greatest pedestrian traffic, and the highest land values
>
> (Knos 1962, pg. 270)

This passage is revealing but it does undermine the independence of the distance variable as an explanatory one. If the area of highest value defines the distance measure used to explain value, then the model becomes tautological: rents are higher because they are closer to where rents are higher.

2.8.5 *The testing of alternative models*

A major issue in MRA is whether or not the model is actually a test of the hypotheses or whether other explanations for the results are possible. Clapp's study provided an exemplary case of methodological conscientiousness with regard to this problem. He tested a number of alternative distance variables (Euclidean distance, street distance and questionnaires of employee commuter time). He also tested alternatives to the CBD as a destination for distance variables. This allowed him to show that street distance was consistently a better predictor than Euclidean distance and that the distance from the CBD was far more important than other variables. He remained open-minded about the meaning of the regression analysis:

> The observed hedonic price equations might be consistent with models other than the one developed here; competing theories of office locations are lacking
>
> (Clapp 1980)

Knos actually tested other street based distance variables and was able to make comparisons on their efficacy in the regression model (Knos 1962). He reran the regression model with distance from the whole length of the two major thoroughfares that intersect in the centre, rather than just a central point. The correlation (R^2=.4639) was much worse than the distance to a single point (R^2=.6392). This was probably because the two streets in question were so long that the values varied considerably along their length, as can be seen in Map 2.4 on page 64 above[8].

Knos plotted the residuals from the model and was able to isolate spatial characteristics of the overestimation and underestimation of predicted versus actual values:

> It may be noted... that the higher land values extend farther to the south of the center than in the other directions...the equation, on the other hand, produces a profile that is symmetrical
>
> (Knos 1962)

Figure 2.8 below shows a representation of the difference between the predicted values and a isopleth surface of actual values. The main problems were caused by the failure of the model to show the morphological split in the town caused by the river. This can be seen in the difference between the regular surface from the regression model and the abrupt shift in the surface from the empirical data (the dotted line).

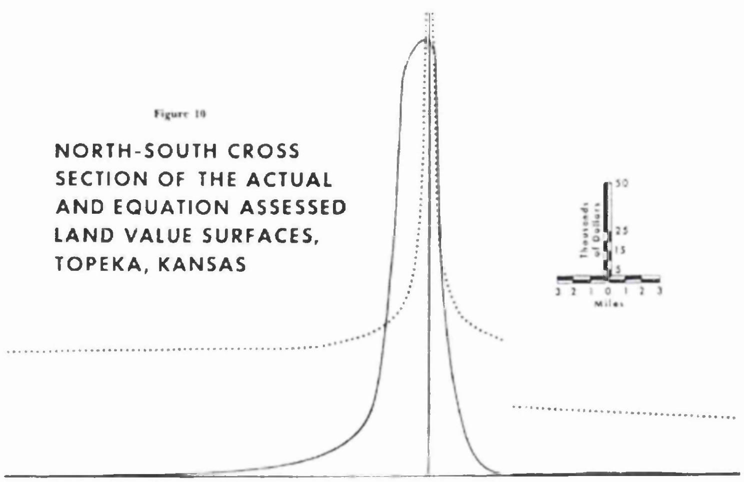


Figure 2.8: Knos' difference between actual and distance-predicted rents (Knos 1962)

---

[8] Knos also tested other spatial variables. He included the distribution of population potentials within the city as a variable in assessed land values determination, calculated by taking 35 control points and plotting isolines for population. These were not

Such a testing of the model's output as a map against the spatial pattern of the empirical data shown in maps has not been undertaken so far in the econometric studies of office rents.

2.9 Discussion: Rent and the problem of Space

At the beginning of this chapter, quotes from Michael Batty and Paul Krugman were reproduced that both stated similar arguments about the relationship between economic theory and space. From the fields of applied urban modelling research and pure economic theory, both authors converged on the argument that an important limitation of much economic and social theory has been the inability to tackle the spatial dimension. The literature review of office rent studies that has been presented in this chapter lends support to this view. Although a number of more general problems with data and methodology have been evaluated, the main problems with previous research on rent have stemmed from the difficulties involved in the treatment of the spatial dimension.

The most important weakness of the theoretical literature on rent was seen to be the inability of the main assumptions about the role of the spatial dimension in rent models to accommodate sophisticated patterns of rent. Distance from the CBD as a spatial variable has limited use as a tool to describe the intricate street to street differences or changes over time in rent that were seen in the few published maps. Empirical studies of office rent from the field of econometrics suffered from a lack of clarity about the spatial variable being tested because they drew on these simple measures of location based on Euclidean distance from a point. Without a clear and independent measure of the spatial dimension a proper comparison of the results of these studies is impossible. The difficulty of accommodating the spatial dimension within an economic and social framework is one reason for the paucity of representations of rent in previous studies. As was seen in section 2.7, very little work on the pattern of rents has been done.

In order to further develop theories about the spatial pattern of rent, the research community requires more comparable studies of location rent patterns. The philosopher of science Ian Hacking has referred to a process in research of 'the creation of phenomena' (Hacking 1983). According to Hacking, the first task in developing theory is to create the evidence for theorists to explain by investigating and isolating regular phenomena in a number of studies. The review has shown that one of the main problem in the comparability of previous studies

found to be significant. He tested for the importance of sectors of growth within the city by using four zone dummies, which showed some role in the multiple regression (Knos 1962).

of rent patterns has been how to measuring location in a comparable way and this has limited the available evidence base for theorists to work with.

The methodological problem of how to measure location as an independent variable is especially important for the question posed in this thesis (how far does the layout of streets itself influence rent patterns?) because it means that the choice of a method of measuring location must itself be a major aspect of the research question. In light of this problem, we have reviewed a number of techniques for measuring location as an independent variable such as Euclidean or multiple-distance measures, dummy variables, Large Scale Urban Models and space syntax measures. The convincing findings on the relationship between space as an independent variable and the pattern of movement generated by Hillier et al are based on the foundation of a methodology for measuring urban spatial structure as an independent variable that can be applied to a number of different cities. These findings have themselves been the basis for the development of a theory of the movement economy that posits that the whole pattern of land uses is organised around movement in some way.

As the purpose of this thesis is to seek to understand the relationship between one spatial phenomenon (the street layout) and another (the pattern of rents), this issue of how to treat spatial dimension is critical. In the next chapter on methodology, the criteria for choosing one method of these for this thesis will be defined and the choice of the space syntax method will be explained.

2.10 Summary

Theories about the spatial structure of urban rents were influenced by earlier models of agricultural rent patterns. The use of distance from a central point as the organising spatial variable in rent determination was a common axiom in both earlier agricultural rent theories that started with Von Thünen and in the urban economics of the postwar era characterised by Alonso.

Econometric studies of office rents have used multiple regression analysis (MRA) to measure the influence of a number of independent spatial variables on empirical rent data. A number of non-spatial variables have been suggested as influential in previous studies such as building quality and the time factor. As well as these econometric studies, a number of studies from the surveying profession have been reviewed that have tackled the issue of comparability of leases under variable lease provisions, such as incentives.

Measures of urban spatial structure have been evaluated and their past or potential use as location variables in a multiple regression for rent has been discussed. Dummy area variables and rent surfaces have been characterised as non-independent and therefore tautological for any regression model. The independent variables that have been used previously have been discussed. Problems that these have suffered from have either been that they are too simple to be plausible in rent theory (the simplest single distances) or so complex that they have become inapplicable (as in the Large Scale Urban Models). The use of an alternative approach to urban morphological analysis with space syntax techniques has been presented.

Previous studies have paid little attention to the representation of the spatial pattern of office location rents. However, from the available research, a number of spatial characteristics have been shown. Large differentials in rents are found at the fine scale of individual streets and block faces. Changes in the pattern of rents over time are implied by some studies (although the issue of change has not been tackled directly). Some debate exists over whether patterns are monocentric or polycentric, but the evidence seems to point more towards monocentric patterns. Lastly, the shape of rent patterns is a curve towards peaks rather than a smooth linear rise.

Lastly, a number of key issues and debates arising from previous studies have been raised. Methodological issues relate to the applicability of asking rents, the question of spatial aggregation and the question of multi-colinearity of independent variables. Theoretical issues raised by studies of rent relate to the question of the spatial hypothesis that is to be tested and the issue of testing and explaining the independent spatial variable's role. The spatial dimension has been discussed as a critical problem in the study of office rents, from the theoretical foundations to the representation of rent patterns and the choice of measures in models of their determination.

The next chapter will explain the methodology adopted in this study, in particular to tackle the spatial dimension of the hypothesis.

3 METHODOLOGY

3.1 Introduction

The purpose of this chapter is to define the methodology of the thesis and show how this relates to the methodological problems found in previous studies that were evaluated in the literature review. Multiple regression analysis or MRA was shown to provide a method with which the importance of a number of spatial and non-spatial independent variables in the determination of rent can be measured (the approach is discussed on page 32 above). This thesis seeks to utilise regression modelling techniques in order to test the hypothesis, as outlined in chapter 1, that there is a measurable relationship between the spatial configuration of the street system and the spatial pattern of office rents.

However, a number key methodological issues raised by the use of MRA in previous empirical studies of rent were found (summarised in section 2.8 on page 71 above) that this thesis seeks to overcome. Firstly, there is an issue of whether the rent data that is used provides a fair representation of what real tenants are bidding. To overcome this problem sample of office leases was collected rather than asking rents used by most previous studies. The methodology used for the sample selection is presented in section 3.2 below and tests of the representativeness of this sample are presented in section 3.3.

Secondly, the non-location characteristics of leases must be controlled for in order to calculate a '*location rent*' (the amount that a tenant would pay a landlord only to use a given unit of space at a given location for a given time). Lease transactions are not just for an abstract unit of land but real floorspace within a building of particular characteristics for variable and often quite flexible time periods. The methodology for enumeration of all non-spatial variables is explained in section 3.4.

The calculation of a location rent also allows for a representation of the spatial pattern of rents using the empirical data. As was noted in chapter 2, empirical evidence on the spatial pattern of rents is very patchy and the main representation methodology (isoplethic mapping) is problematic for theoretical reasons. In this study, the alternative representation technique of choroplethic mapping will be used as the main representation tool and isopleth analysis will be used for comparative purposes with previous studies. The methodology of representing rent patterns is presented in section 3.5.

Lastly, an independent measure of location itself must be found against which the rent variable can be correlated. This requires a *measure* of each building's location. More precisely in terms of the hypothesis, a measure of the location within the street grid configuration as a whole is required. The methodology of the spatial analysis, which has been used to provide the independent measure of location in this study, is presented in section 3.6.

3.2 Rent Data Sample Selection and Analysis

The first major methodological problem for studies of rent is the selection of an appropriate sample of data on which to test hypotheses about rent determination.

Although asking rents have been the most widely used rent data in previous studies, problems with the use of asking rents as a proxy for achieved rents have been outlined (section 2.8.1 on page 71 above). The reliability of asking rents was a particular concern for this study because the property market in Berlin since the wall fell has been a falling market (as is evaluated in chapter 5) and therefore asking rents may be very misleading. There has been much discussion in the German press about new buildings in Berlin failing to reach rents remotely close to the asking price (Volger 1994; Cash 1995; Westrup 1996) because tenants have been able to dictate terms in the over-supplied market. Consequently a sample of achieved rents was sought.

3.2.1 Source of the Data

As was shown in section 2.8.2 above, rent data is required at a precise, disaggregated level in order to control for the influence of lease provisions. Market reports and published material offer a broad overview of the property market in Berlin, and these are evaluated in chapter 5. However, the study of rental patterns is limited by the complete lack of detailed published material on rental leases. This section explains the source of the data used for this study and investigates its reliability as a sample.

Given the lack of any officially published disaggregated data on either asking or achieved office rents in Germany, the only potential sources of information for this research were commercial organisations active in the property market. As it would be too difficult to survey tenants or landlords individually, property agents were the only source that could provide a sample large enough to study.

The extremely sensitive nature of the data combined with a general lack of transparency in the German market made obtaining data a very difficult and time-consuming task. Attempts were made to procure lease data from many companies and institutions for this study. This was undertaken through a letter campaign to all the commercial property agents in Berlin. After an initial letter of request, further contact was sought and eventually made with 6 companies to discuss the terms of data use. After 14 months of contact with many sources, eventually only one property consulting group, Jones Lang Wootton[9] (JLW) were willing to co-operate with the research by providing rental data within the time limits of this study. The leases are in JLW's possession through two of their activities: agency leasing and property management.

3.2.1.1 Agency Leasing

Agency leasing is one of the core activities of JLW. Their involvement in a letting takes one of two forms:

1. The landlord as client: this takes the form either of consulting services or letting. Consulting services consist of marketing concepts and strategies, advice and critical analysis of detailed use concepts, advice on the construction of lease contracts, Supervision of letting strategy, regular market reports. Letting consists of targeting potential tenants, carrying out visits to the office leading rental discussions and negotiations and preparation of the negotiated final lease. Some of the rent prices where the entire lease was not available for analysis comes from these contacts.

2. Tenants as clients: in this case JLW acts as an agent on behalf of the tenant and seeks out the most advantageous letting in order to secure a commission before other agents do. Some major international companies such as Coca-Cola use JLW to organise all their commercial space lettings world-wide. Location needs of the tenant are assessed in terms of company profile, logistical structure, employment structure, infrastructure and economic structure. Property needs are assessed in terms of floorsize, functionality, floorspace efficiency, floor plans of typical floors, quality of the fit-out and critically rent price (Jones Lang Wootton 1996). Information that the agent can make available to the tenant as well as the list of potential spaces are analyses of current market rents and information about available and projected floorspace. JLW is also involved in advice on lease negotiations.

---

[9] Now called Jones Lang LaSalle after the 1999 merger.

3.2.1.2 Property Management

The other main source of rental lease information has been the role of JLW as property managers. This involves taking over the tasks of running the building on behalf of the owners. Services include:

1. Rental lease management (the letting and supervision of rental contracts and the management of rent reviews)
2. Tenant support and service: cost and yield management, testing of cashflow liquidity, production of yearly budgets and their control, personnel hiring, energy management
3. Co-ordination and supervision of technical personnel and service companies
4. Supervision of premises during handover to tenants and advice for contracts and legal matters.

Clients for property management services in Germany are mostly investors. 40% are from Germany and the biggest foreign contingent is Dutch and Scandinavian. Most properties are in prime locations. This has allowed access to some lease data for contracts where JLW was not the agent involved in the letting. This means that these leases are likely to be in more central locations than peripheral.

3.2.1.3 Inclusion criteria for JLW lease dataset

The study uses office lease data from the contracts kept in records of JLW's agency lettings and property management activities outlined above. Before this study, only the bare essentials of each office letting were kept on digital file by JLW for statistical purposes. A number of additional data have been extracted from the original lease documents for the purposes of this research. These leases are referred to as 'JLW's own leases'. The inclusion criteria for JLW's own lease dataset are set out in Table 3.1:

Criteria	Description
Purely office space	No retail, housing or other leases were used. The rent is calculated as the price per square metre per month in DM for the office floorspace and share of communal space (always charged at the same price) occupied by the tenant. All rents are exclusive of tax. The cost of service surcharges were not included in the rent. Prices did not include the rent on parking spaces or other uses.
Contract inspected	Lettings where the final contract details were not available for inspection were not used. This was necessary to ensure that all price data were calculated on the same basis and to allow for the calculation of effective rent, as the effective rent can only be calculated from the contract where any incentives can be valued.
Willing agreement	Only 'open market' transactions that were clearly willing agreements were used. This meant excluding leases for expansion of more space by in-situ occupiers as the tenant-landlord relationship under these circumstances may be different from an open market agreement.
Lease minimum of one year	Very short term leases (i.e. less than a year) may reflect a special bargain for a company requiring an address for a short time and are therefore not comparable with the longer term leases of companies that are looking for longer term office premises.

Table 3.1: Inclusion Criteria for JLW Lease Database

Crosby has noted for the UK market that the rules on statutory renewals can be very restrictive and that this can cause problems in terms of comparability (Crosby and Murdoch 1998). There were very few renewal leases available for inspection at Jones Lang Wootton. A proper consideration of differences between renewals and new lettings would require a much larger dataset of renewals for comparison and also lies outside the focus of this thesis, which is on the spatial pattern of rents. Consequently, the problem of compatibility between leases was avoided for the Berlin dataset by excluding the small fraction of leases that appeared to be renewals.

3.2.1.4 Landlord data

In addition to the records of contracts through the company's own work, JLW obtains information on other leases through contact with developers and landlords. Especially because of its role as agent for landlords as well as tenants, landlords often agree to provide information to JLW on leases even if they have not used the company as an agent (or perhaps not used any agent) for that particular letting. This information has also been used for this study.

The inclusion criteria for the landlord data were the same as those for the JLW database in Table 3.1 above except for the criteria of 'contract inspected' as this was obviously not possible. In addition to these criteria, it was also necessary to exclude some landlord data that did not have an attributable address. Where landlords had not given the precise location of the lease (either through a desire to retain a certain degree of anonymity or simply because they hadn't bothered to fill out the full address) the lease data was excluded. This was because this data could not be tested against location variables and was therefore not useable in the central aim of the thesis.

Because the information provided by landlords only covers the basic lease variables (no data on incentives is given), it is not possible to calculate an effective rent for the landlord's contracts. However, in a situation of scarce data it has doubled the size of the rent sample. It is therefore useful in plotting rent level distributions as long as the possible error margin owing to the unknown incentives is measurable and is kept in mind. In fact, one of the aims of the study has been to assess how useful the 'headline' rents are as data and how much error must be expected from the influence of incentives. This will be discussed in detail in chapter 6. As can be seen by Figure 3.1, no landlord data were recorded by JLW until 1994.

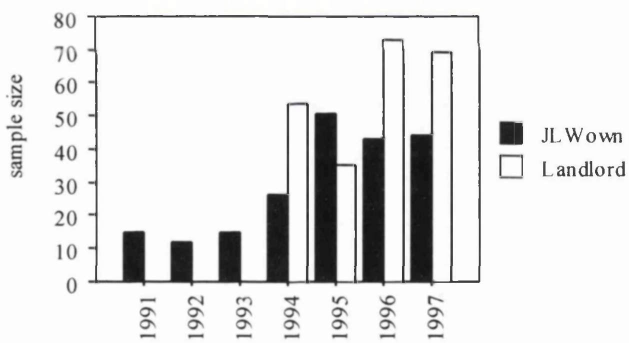


Figure 3.1: Number of Leases by Source

In Figure 3.2 below, the mean rent price per year for the sample of JLW's contracts are compared to those for the contracts provided by landlords. There is no major discrepancy in the prices[10].

[10] Rent in Germany is expressed as the price per metre per month. For a more detailed explanation see the glossary entry on Headline Rent.

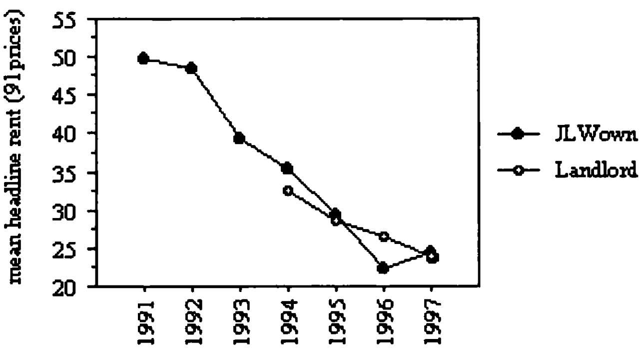


Figure 3.2: Mean Rent Price (DM/m2/month) of the two Data Sources

No major differences were found in the length of contract and option time between the JLW leases and landlord leases. However, the average floor area of the landlord's contracts was slightly larger, as can be seen in Figure 3.3 below. This may reflect the fact that information about larger lettings is more likely to be passed on by landlords and noted by JLW.

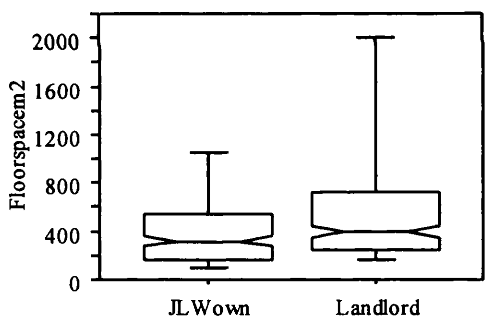


Figure 3.3: Unit floorspace size of leases by source of sample

3.3 Representativeness of the Lease Sample

JLW is an agent active in the market and for the purposes of this study the company itself is an information collector and filter through which the market as a whole is to be viewed. It is therefore important to estimate the representativeness and reliability of the data obtained from JLW. This is to assess the possible scope for inferences about the market as a whole on the basis of this sample. The representativeness of contracts obtained by JLW can be measured by three main criteria: the size of the sample, its composition and the extent to which the single company JLW as a source may have influenced the result.

3.3.1 sample size

JLW is one of the 14 major property agents in Berlin involved in the office market. Its major competitors are shown in the Table 3.2 below:

1	Aengevelt Immobilien KG
2	Angermann GmbH
3	DB Immobilien
4	Dr Lübke Immobilien GmbH
5	DTZ Zadelhoff GmbH
6	Engel & Völkers
7	Eureal
8	Healey and Baker
9	Herring Baker Harris GmbH
10	Jones Lang Wootton GmbH
11	Liljeberg
12	Müller International GmbH
13	Völkers King & Co.
14	Wetherall Green & Smith

Table 3.2: Major Commercial Estate Agents in Berlin (alphabetical)

There are no official or established standard measures of the size of the office market with which the JLW sample size can be compared. Some agents produce estimates of the size of the office market in terms of number of square metres let per year in total, shown in Figure 3.4.

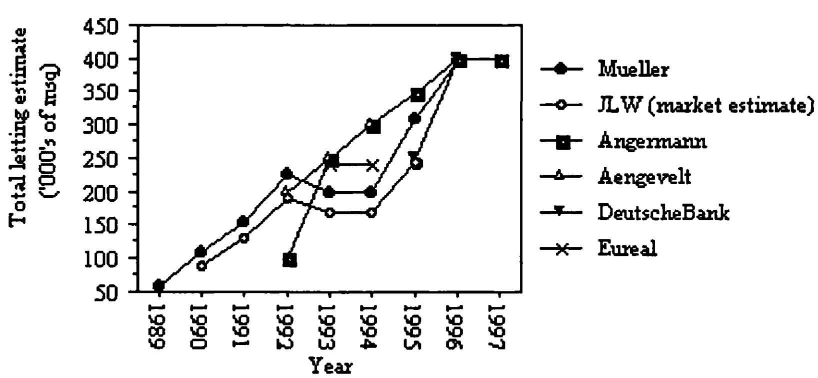


Figure 3.4: Agents Estimates of Berlin's Office Market Size

Source: (Eureal 1994; Jones Lang Wootton 1995; Aengevelt Research 1996; Angermann 1997; Deutsche Bank Research 1997; Müller 1997)

To assess the size of the sample used in this study, the mean of these agents' estimates has been taken as a 'most plausible' estimate of market size. The size of the sample of contract data obtained from JLW is plotted alongside this estimate in Figure 3.5 below:

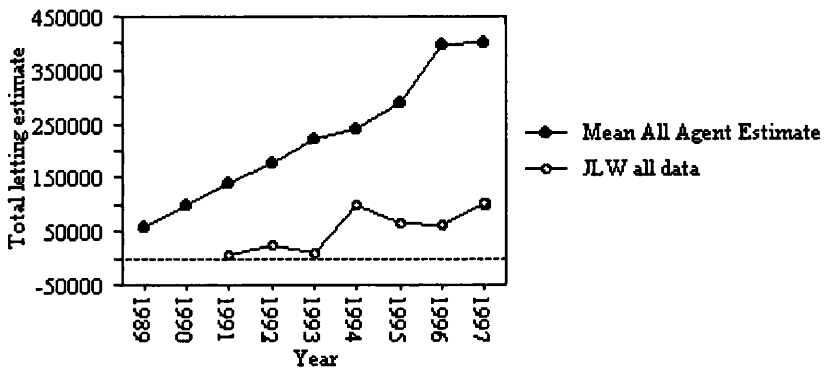


Figure 3.5: Estimated Size of market compared to study sample

At discussions organised by the Immobilienakademie (EBS 1997) in 1996, more detailed estimates were attempted by the 14 main agents shown in Table 3.2 above at the size of the market and their position in it. It was estimated that lettings by commercial agents in 1996 totalled approximately 360,000 square metres. Direct lettings by landlords were estimated to total 100,000 giving an estimate of total market size of around 460,000 (The mean agent estimate from market reports shown above was 50,000 square metres lower). It must also be noted that the owner-occupier sector was not accounted for at all in these estimates. Agents could not agree on a size for the owner occupier sector for the Immobilienakademie report but discussion was of figures in the region of 100,000 in 1996.

When placed against these estimates, the sample of data provided by JLW looks like a very significant proportion of the market. Even without the contracts provided by developers, the percentage of the whole market in the JLW figures is between 5 to 10% of the market for most years. In the early year 1992 a share of 15% was reached (JLW was one of the first international firms to establish an office in Berlin after reunification). When the lease information provided by developers is included, as in Figure 3.6 below, the size of the sample seems implausibly large relative to the market estimates as a whole.

This may indicate that the agents themselves are being too conservative in their estimates. Unfortunately no other figures of market size exist against which to make a comparison.

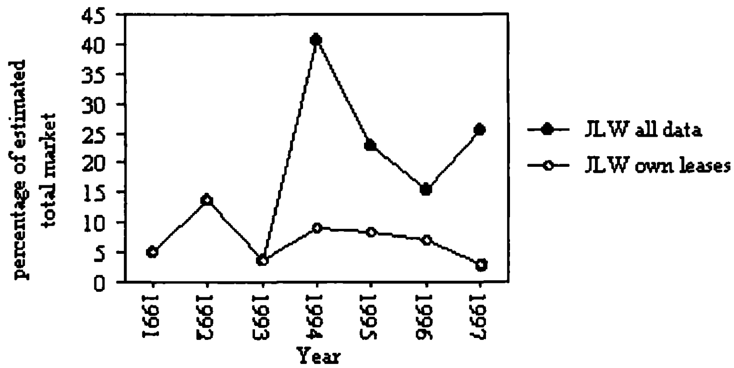


Figure 3.6: Sample as percentage of total Market Estimate

3.3.2 Geographical Distribution of the Sample

Another way in which the JLW sample may differ from the market as a whole is in its geographical distribution and in the segment of the market that is represented. JLW is an internationally renown firm and although there is not a policy to turn down peripheral or cheaper office floorspace, there may be a focus on the inner city in JLW's own lettings and perhaps even in the lettings that they obtained information for from landlords.

This can be tested to some extent by comparing the JLW sample with the Immobilienakademie estimates for the location of floorspace. The agents estimated that the total floorspace let in 1996 were distributed by region as:

- City West 9%
- City East 20%
- Peripheral 43%

(EBS 1997)

The city centre JLW data compares well with this distribution: City West has 9.3% of floorspace in 1996, City East is slightly underrepresented relative to the agents estimates with 16% of total floorspace. The 'peripheral' leases are more difficult to define as a clear indication of where the periphery begins was not provided, however, counting all projects that are on or outside the 'S-Bahn Ring', 39% of all space in 1996 was leased in the periphery of the JLW sample. This also seems representative, although the percentage would be much lower (perhaps as low as 18%) if only projects well outside the S-Bahn ring were included owing to the large number of relatively large contracts in close proximity to the ring. Thus the sample has good coverage for the inner city but is probably much less representative of the periphery.

3.3.3 Building Type Composition of Sample

It is not possible to test whether or not the sample reflects the ratio of new to old office buildings as there are no reliable estimates of this ratio in the lettings market at present. The Immobilienakademie report was not able to provide reliable data on this owing to the fact that too few agents provided such information.

The question of representativeness depends on the intended use of the data. For the purposes of this study, the data is being used to show how rents on average vary in different locations in the city and at different times. The sample is reliable for these purposes in the extent that it conforms to main trends in the market as far as these are known. It is a surprisingly large fraction of the estimated total market size, although available estimates of the total market size are suspect. It also comprises controlled, disaggregated data at individual contract level.

3.3.4 Using the JLW sample to view the market

The use of a single company as the data source may raise the question as to what influence on the rent data JLW may have had and therefore how this might be considered to influence the reliability of the sample. Could JLW have reason and means to influence tenants in specific properties to pay more than they otherwise would with other agents?

The first answer is simply that half the total data is not from JLW leases- it is information provided by landlords for JLW building management services and no major differences in tendency have been seen with the JLW agency data. Thus half the prices used in the study were not from leases which JLW was involved in negotiating.

However, for the detailed study of lease incentives presented in chapter 6, this question does remain pertinent because JLW is the only source. Yet it seems unlikely that JLW as a company can have much impact on the sample for a number of reasons. In a tenants market (as Berlin has been for most of this period), there is quite a clear process whereby an equilibrium between the competing interests of those involved in a transaction is reached- and therefore why JLW is unlikely to have major impact on the sample.

JLW may market certain properties harder with tenants if they have an exclusive marketing contract because there is therefore least risk of time wasting and more potential to close a deal (no other agent is also marketing the space). They may also have certain bonuses for letting a whole property, as other agents do with other properties. There will also be less incentive to 'push' a building if many agents are involved in the letting of it, as the chance of being the one to secure the fee for this letting are much less.

However, pushing one's own buildings must be balanced against the pressure of competition, as potential tenants will be speaking to other agents. JLW is under pressure to provide the tenant with as many alternative lettings as required to minimise the risk of loosing them to another agent. The letting of buildings tends typically to be undertaken by 2 agencies. These factors would mitigate against JLW influencing the prices of lettings very much over the sample as a whole[11].

The tactics used by agents to maximise lettings were discussed in interviews undertaken by the author with JLW agents in Berlin during September 1997. In general the approach is to provide a tenant with as much information as requested. Thus if a tenant requests information on lettings in all central districts then no attempt would be made to limit their search. However, if the tenant has little clear idea of what they want, the search process begins with buildings for which JLW has an exclusive leasing agreement with the landlord. In the period until the end of 1992 it was possible for agents to dictate both choice of unit and terms of leases relatively easily as the restricted supply forced tenants to take whatever was available. After 1992 the move to a tenants market prevented this from taking place and agents were required to work within the context of competitive bidding from landlords and other agents. This exerted a pressure to provide as much information as necessary in order to secure a letting.

3.4 Variables

The rent leases contain numerous different kinds of information that has been stored by JLW but in various forms: either digitally in spreadsheets, or stored in notes or stored only in the original paper contracts. In order to properly analyse the data, a database was created with each type of information categorised as a separate field below are

---

[11] In a landlord driven market, as the Berlin office market was in 1990 to 1992, the ability of an agent to influence demand would be greater than in a tenant driven market. But even under these conditions the best strategy for the agent would be to ensure that buildings with an exclusive marketing contract are suggested (perhaps first) but to give the potential tenant as much choice as they seem to want.

descriptions of the fields of the database. These fields are also summarised in Table 11.1 of Appendix B: Definition of Lease variables. . For a more detailed discussion of the terminology and concepts used in these variables, the reader may also consult the Glossary in Appendix F.

3.4.1.1 Building Quality

The definition of building quality is a very complex problem for property market analysis, as was seen in the various attempts of previous studies outlined in section 2.5.2 of the literature review. In the Berlin market there is a common distinction made by agents in market reports between 'new' and 'old' build. The building quality classification used in this study was undertaken with the assistance of agents at JLW and conforms to this categorisation used by the agents to describe their market. The category 'old' is used for office space leased in a building built before the fall of the wall (either an older purpose built office or a converted building) and 'new' for purpose built office space built since 1990. This reflects the common distinction made in market reports, as will be shown in the market reports in chapter 5 (for example the figures by Blumenauer reproduced as Table 5.2 on page 169 below). The category distinction was also used as a dummy (binary) variable in the MRA, as described in chapters 6 and 9, whereby 0 represents old and 1 represents new.

3.4.1.2 Lease start date

The lease start date has been taken as the month and year date of the start of occupancy. This is not the start of payment, which may be affected by rent-free months given as incentives. The date of lease commencement has been converted into a continuous variable for the purposes of the MRA and is referred to in the models as the *leasebeginmonthcode*. This is the month from January 1991.

3.4.1.3 Pre-letting time

A precise measure of pre-letting time in months was calculated by comparing the date of the lease signature with the start date of occupancy. As with the lease start date, this was the start of occupation and not the start of payment, which may be affected by a rent-free period. It was only possible to generate this measure for JLW's own leases, as an inspection of the paper contract itself was required. This variable has been given the name *monthsprelet* in the database.

3.4.1.4 Obligatory lease term

The obligatory lease term is the length of time in years until the first point at which the tenant can leave the contract. This is effectively the period until the first break clause, rather than the maximum period that a tenant could choose to stay. This variable has been given the name *leaselength* in the database.

3.4.1.5 Optional renewal time

Optional renewal time has been calculated as the total period that a tenant may choose to remain under the same lease conditions after the obligatory lease term. First and subsequent renewal periods have been summed. For example, a lease with two renewal periods of 5 years would have an optional renewal time of 10 years. This variable has been given the name *optiontotal* in the database.

3.4.1.6 Unit floorspace size

Unit floorspace size is the amount of office space in square metres taken by the tenant (excluding garage or other use space). This was considered a closer test of a potential economy of scale effect for tenants than floorspace of the entire building, as tenants let a unit and not a whole building. There were also no reliable records of total building floorspace and to survey this data for all buildings containing leases would be beyond the scope of this study. However, it was also considered that the problems of multicolinearity that had been found with the building size variable (section 2.8.3 on page 72 above) would be less likely to occur for *unit* size. This variable has been given the name *floorspacem2* in the database.

3.4.1.7 Tenant name

The name of tenants was used to clarify some of the addresses that were not complete. Owing to the need to retain anonymity of the tenants and partly for reasons of focus, the study has not attempted to make in-depth categorisations of tenant types, such as SIC categories. This would be an interesting study in its own right but is beyond the scope of this work.

3.4.1.8 Address

This field was split it into sub-fields of building number, street number and postcode in order to allow accurate data linkage to spatial measures within a GIS system. This has allowed the representation of the spatial distribution of rent levels that can be seen in Chapter 7.

3.4.1.9 Total lease value

For reasons of confidentiality, it is not possible to present the sum of total lease values for JLW leases, as this relates to the confidential business information of the data source provider (the fee of agents is based on a percentage of total lease value and this is therefore an index of the agency revenue). However, it is possible to present averages for both JLW and landlord leases together and these are calculated as the mean rent per metre multiplied by floorspace size.

3.4.2 Incentives

There are four provisions in the contracts studied that can be classified as incentives because they reduce the effective cost of rent in favour of the tenant. These are the rent free time, cash incentives, step increases and index or fixed rate multipliers. Incentives have increased to the advantage of the tenant over the study period.

3.4.2.1 Indexes and multipliers

Indexes and other multipliers are clauses that allow for an appreciation over the length of the lease to offset the depreciation that comes from inflation. The *Lebenshaltungskostenindex* used in German office leases is a consumer inflation index, not a property market index. There are variations as to when the rent is first adjusted and how often, the most common being in year 2 and every year afterwards. The cost of living index (or any variable index) must be used both upwards and downwards in adjusting rents according to German law. A fixed percentage multiplier can also be used, and this can be upwards only. This would be a clause stating that the rent should be raised by x% per annum, normally commencing in the second year of the lease. This variable has been given the name *appreciation%* in the database.

3.4.2.2 Cash incentives

Direct cash incentives have played a very small role in the Berlin leases of the sample and are practically insignificant compared to other incentives. Only two cases of cash incentives were recorded, the effects of the incentives in these cases were included in the calculation of incentive adjusted rents.

3.4.2.3 Step additions

Step additions are yearly additions to the rent over the course of the lease. The simplest example would be an increase of x DM per square metre per year. More complex might be a varying amount added to the price per square metre each year or an amount added once only or at arbitrary times during the lease. In some cases a fixed decrease takes place in the first year and in very few cases a fixed decrease is specified for later years. The value of each addition as a percentage of lease value has been calculated and this variable has been given the name *addition%* in the database.

3.4.3 Incentive adjusted rents

As was seen in section 2.5.1.1 of the literature review, the valuation of incentives depends on whose interests or costs are relevant. For the purposes of this study, it is the effective cost-benefit to the tenant that is of interest, rather than the effective cost-benefit to landlords, because the purpose is to find a basis for comparing the cost of lettings on a single price measure. From the lease data used in this study, two kinds of effective rents have been calculated:

3.4.3.1 Consideration rent

The consideration rent represents the most basic adjustment for the effect of incentives on the cost to the tenant. This was type 3 rent as defined in Table 2.1 of the literature review (see page 34). It is the average rent price per annum of the jagged income flow of a lease with its incentives. Wheaton has referred to this as the '*consideration rent*' in his study of a huge database of 60,000 leases from the property company CB commercial (Wheaton and Torto 1994).

3.4.3.1.1 Effective rent

The term *effective rent* will be reserved for the purposes of this study to refer to rent that is both adjusted for incentives and treated as a discounted cash flow, regardless of the rate chosen. It is important to know whether discounting the rent significantly alters the trends shown in the consideration rent. The method used was to discount the cashflow calculated for the consideration rent and take the average net present value of each year of the lease. A discount rate of 6% was used, which was the average German interest rate for the period under consideration (Deutsche Bundesbank 1998).

3.5 Methodology of Rent Data Representation

The literature review showed that the urban rent theory and econometric studies of rent have placed very little emphasis on the representation of real rent values. However, the empirical representation of rents is one of the central aims of the thesis (as set out on page 18 of the introduction). The representation of location rent patterns is considered necessary in order to provide a sound empirical basis against which any investigation of the relationship between urban spatial structure and rents can be conducted.

A methodological solution is required that overcomes the lack of clarity about what data is being represented (section 2.7.2 on page 60 above). The solution adopted in the thesis is to attempt to control the rent values as much as possible for non-spatial influences in order to represent a value that can be attributed to location alone: an hedonic *location rent* price. The thesis applies the same approach to the Berlin office lease data of that Gallimore et al. undertook with house values (Gallimore, Fletcher et al. 1996). A location-blind Multiple Regression Analysis is used in order to derive location rents that can be represented, in a similar approach to that used by Gallimore outlined in section 2.7.2 on page 60 above). The process for the construction of a location blind MRA is described in section 6.5 on page 217 below.

3.5.1 Use of GIS data visualisation techniques

In order to be able to represent as detailed and accurate a visualisation of the rent data as possible, the representation tools of a Geographic Information System (GIS) were used. The desktop GIS application 'MapInfo' was used in this study. In order to represent the spatial patterns of rent data, it was necessary to find the geographic location of each building of the leases in the sample and attribute the lease data to the geographical objects. A relational database was used to link address fields by house number, street number and postcode. The level of aggregation was kept at the lowest possible for representation purposes, the individual building. In total, the 435 leases are distributed in 187 buildings, giving an average of 2.3 leases per building. Map 7.1 on page 231 shows a simplified map of the street network of Berlin with the location of all the buildings with leases in the sample.

The buildings have been represented as circles of a uniform size. Most of the representations of interest in this thesis are at a very global scale, where the pattern of rents is shown over a large area. Differences in building footprint shapes are very difficult to represent clearly at this scale, because building plots are fairly uniform in size. The average address plot is approximately 25m by 50m. The settled area of Berlin is approximately 35km by 30km at its greatest extent and at least 15km by 10km just for the dense inner S-Bahn ring area. Consequently the difference between a $35m^2$ building plot and a $50m^2$ building plot will not be of significance in a representation of the global pattern of rents, although it would of course be more significant at the very local detailed scale of representation.

The use of equal circular units for building representation also has the benefit of making the data anonymous- it is impossible to tell the exact street address of each building unless a section of the map is displayed in extreme close up.

3.5.2 Isoplethic mapping of rent data

The most common representation technique used in previous studies of rent has been the isopleth analysis technique. Although some theoretical problems with this technique have been raised in the literature review, it will also be used to represent rent data in order to allow comparison with previous empirical studies. A surface representation was generated using the GIS application ArcView created by ESRI (ESRI 1998). This is the same software used by Gallimore et al in their surface representation of location values (Gallimore, Fletcher et al. 1996). Map 7.10 shows an isoplethic map of location rents for Berlin. This representation uses a similar spectral colour range to that of the rent maps but it presents a continuous surface of colour rather than at points where empirical data were available.

To create this kind of representation a number of parameters needed to be set:

- The spatial extent of the grid surface to be interpolated must be set. This can be to the extent of an arbitrary area or to the data extent itself. For this case the extent of the data was chosen.
- The cell size or resolution must be defined for the surface. For Map 7.10 to Map 7.12, a resolution of 140m was taken.
- The kind of surface interpolation can be either Spline or IDW (Inverse Distance Weighted). Spline interpolation may be considered less appropriate for rent in cities given that it is a technique designed for gently changing surfaces (ESRI 1998).
- The method of surface interpolation is either nearest neighbour or fixed radius. Both these techniques were tested and a comparison is provided in Map 7.12 in chapter 7 below.
- The power value must be set for the distance weighting. In the case of Map 7.10 a power of 2 was chosen.

- Barrier objects can be identified if there are any, although the complexity of barrier objects is limited by the currently available computing power. None were chosen in the case of Map 7.10.

Theoretical problems with this technique's application to rent data were outlined in the literature review (chiefly, the assumption of isotropicity). There are also a number of methodological questions raised by the use of this technique. Chiefly these concern the many further assumptions necessary to generate a surface for which little theoretical guidance is available. Although there are some general guidelines (such as that the spline technique is more appropriate for cases of smooth change) it is not clear what setting the other parameters ought to have for rent data. The choice of contour model in rent representations has been largely left unexplained in previous studies and the potential for different contours is ignored within the literature. Where differences in parameter settings have a large effect, their use is explored in the representations of chapter 7.

3.5.3 Choroplethic mapping of rent data

Whereas the thesis adopts a similar approach to define *what* rent values are being represented as that used by Gallimore et al. (the location blind MRA), the methodology of *how* rent values are displayed is not the same.

The main technique for representation of location rents used in this study is choroplethic mapping. The method of choroplethic mapping is to use colour shading to represent the attribute values of a phenomenon. This has a major advantage for the representation of spatial patterns because the use of colour does not distort the spatial pattern of the phenomenon in the way that isopleth representations can. This allows as detailed a spatial map as possible while simultaneously displaying the attribute values in their original location.

As Van Hove has noted in his survey of representation methods for use in GIS, the disadvantage of the choropleth method is that the area size has an undue influence on the importance given to a certain phenomenon (Van Hove and Loots 1988). Larger areas of colour may cause one to see more significance in a single case than it necessarily has. However, if the unit areas are relatively equal in size and similar in shape then this disadvantage does not apply (Robinson 1995). This means that for the representation of office rents with choropleth maps, the level of aggregation is important because unequal unit sizes may have a misleading visual effect on the representation. This problem was avoided for rent maps as equal circular units were used to represent buildings.

There are a number of other parameters involved in a colour representation of numeric values, particularly the colours used and the kind of scale. This study uses a full spectrum scale from red (highest average rent level above trend) down to dark blue (lowest average rent below trend). It is also necessary to choose how to link the numeric data to the scale- i.e. at what points in the range of data is each colour to be used. This can be done in four ways:

- equal range- the scale is invariant and the data fits to it
- equal count- the same number of data points are attributed to each colour
- natural break- the characteristics of the distribution itself are mapped onto the colour range
- arbitrary- the user sets up each range boundary

Table 3.3 shows an example of these kinds of ranges for the location rents. The number of cases in each range is shown in brackets. Because the values are positively skewed, the equal range scale has very few cases in the higher ranges. The equal count has the opposite character, that the higher colours are over-represented. The graphics used in this study have taken the natural-break scale, which is useful as it accounts for logarithmically distributed variables, of which floorspace size and rent are two.

Sample	Colour	Equal Range Scale	Equal Count Scale	Natural Break Scale
	red	22.4 to 27 (3)	8.8 to 27 (22)	14 to 27 (12)
	orange	17.6 to 22.4 (2)	4.6 to 8.8 (17)	6.1 to 14 (22)
	yellow	12.8 to 17.6 (7)	2.1 to 4.6 (21)	2.9 to 6.1 (19)
	light green	8 to 12.8 (11)	-0.6 to 2.1 (20)	0.5 to 2.9 (16)
	dark green	3.2 to 8 (26)	-2.8 to -0.6 (22)	-2 to 0.5 (27)
	cyan	-1.6 to 3.2 (43)	-4.3 to -2.8 (22)	-3.8 to -2 (23)
	light blue	-6.4 to -1.6 (62)	-5.5 to -4.3 (21)	-5.5 to -3.8 (26)
	mid blue	-11.2 to -6.4 (26)	-7.8 to -5.5 (20)	-8.2 to -5.5 (22)
	dark blue	-16 to -11.2 (7)	-16 to -7.8 (22)	-16 to -8.2 (20)

Table 3.3: Scale comparison for choropleth representation

This use of choroplethic mapping is distinct from the majority of previous rent representations, which have used the isopleth technique to visualise rent patterns (shown in section 2.7.3 of the literature review). Section 7.3 of the thesis on page 241 presents isopleth representations for the Berlin lease data along with a critique of the technique. The methodology used to create the isopleths is described in detail in this section.

3.6 Methodology of Spatial Analysis

A number of non-spatial variables that have been derived from the lease data have already been outlined in section 3.3 above. However, the difficult problem in rent studies has always been the selection of appropriate independent variables to represent location. As was seen in section 2.6 of the literature review, this requires a measure of location to be derived from the spatial structure of the city. In this study, the space syntax technique of axial mapping will be used to represent the network of streets in Berlin and measures of spatial 'integration' will be used to provide independent location variables . This technique is used to fulfil a number of criteria for the use of a location variable within the MRA model. The criteria for the selection of independent spatial variables are summarised in Table 3.4 below:

Criteria	Description
Independent spatial variable	The measure must be a variable that is independent of rent values themselves.
Applicable	It must be possible to apply the measure to the Berlin case
disaggregation	The measure must work at the same spatial resolution as the phenomena it seeks to explain (buildings on streets)
methodological individualism	At least in principle, the measure must be linkable to individual peoples actions

Table 3.4: Criteria for the selection of spatial measures as the location variable

The use of a measure of location requires both a methodology for its selection as a test of hypotheses and an evaluation of its performance in capturing something meaningful about the empirical data. This section tackles the methodological questions. The evaluation of the space syntax measures' performance will be undertaken in the later chapters (especially chapter 9 where a detailed statistical analysis of the relationship between these measures and the empirical data is presented). As was described in chapter 1, the hypothesis is that changes in the spatial configuration of the street system have had an effect on the pattern of rents in Berlin. In order to test this hypothesis, a measure of spatial structure is required that fulfils a number of criteria.

The measure must be independent of rent values themselves. This is because the aim of the third question raised in the introduction (page 18) is to test what spatial explanatory variable might account for the pattern of rents and in particular, *changes* to the pattern. Any regression model that correlates the pattern of rents with itself must be tautological, excluding the possibility of an explanation of *change* in rents by the model. As has been discussed in section 2.6.1 on page 44 above, the methodology of isopleth analysis to generate a surface model of location value (Gallimore, Fletcher et al. 1996) is problematic because of the lack of distinction between the independent explanatory variable and the phenomenon that is being explained. This problem will be demonstrated with reference to Berlin data in section 7.3 (page 241) below.

The spatial measure must be available for the whole area of Berlin before and after reunification for which rent data is available. If it is not applicable to Berlin, it cannot be used to say anything meaningful about the case study. This effectively rules out the use of accessibility measures derived from LSUMs as no LSUM exists in Berlin. It would also not be possible to apply another LSUM to Berlin or create one from scratch because of the huge requirements of LSUMs outlined by Lee (section 2.6.3.1 on page 53 above).

The measure of location must be at the resolution of individual buildings on streets in order to investigate such street level differences as those that were shown in the literature review (section 2.7.4.1 on page 68). In order to capture anything meaningful about street level differences in rent, any measure must function at this level, otherwise it commits the 'ecological fallacy' of imputing lower level relationships from aggregate data (Lee 1973).

Lastly, if the measure of spatial structure is to play a part in a social theory of rent determination, it must be possible to link the measure to the actions and interactions of *individual* humans in order to explain something about social actions. In the Berlin case in question this means that the spatial measures must in principle be linkable to *individual companies* renting spaces in Berlin. This is in order to fulfil what the philosopher Karl Popper refers to as the *methodological individualism* of the social sciences. Social theory may involve complex and emergent phenomena but the role of people in those phenomena must be explicit in order for it to be an ultimately testable *social* theory:

> The task of social theory is to construct and to analyse our sociological models carefully in descriptive or nominalist terms, that is to say in terms of individuals, of their attitudes, expectations, relations
>
> (Popper 1957, pg. 136)

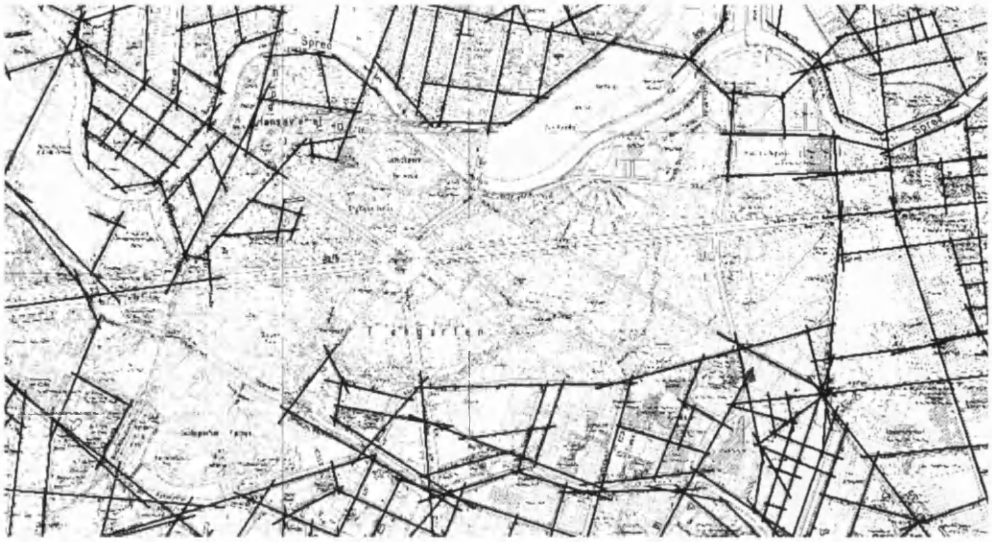
The role of the spatial measures in a social theory of rent determination is explored in depth in the conclusions of chapter 9.

In short, from the criteria above, the measure chosen must reflect something about the morphology of the street grid itself in order to test its importance as a variable. The axial map analysis (outlined in the literature review on page 55) fits all of the above criteria, although there is an important weakness of the measure in the level of aggregation. A single value is provided for an entire axial line (effectively an entire street) rather than at the individual block or building. The measure does differentiate between main streets and side streets and there is good evidence of such differences in the rent data itself (shown in section 2.7.4.1 on page 68 above). However, it cannot measure the differentiation along a street- from ends to centre and between major intersections. Although the differentiation along a street does not seem to be as pronounced as that between main and side streets, this difference may also be significant. However, the measure has been chosen as the best available for all the criteria.

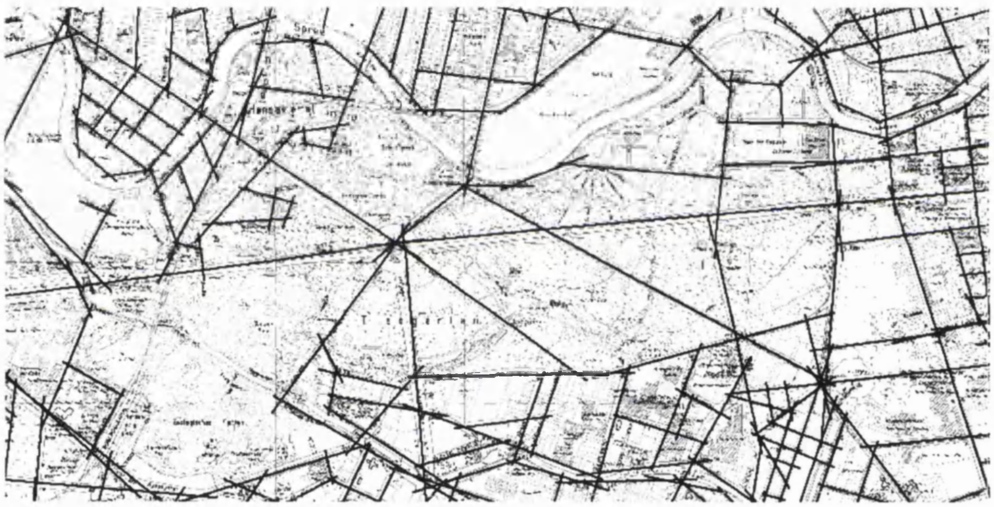
3.6.1 *What spatial system is being measured?*

The measure of location used in this study is purely of the physical layout of the street system. It does not contain any public transport infrastructure such as the subterranean *U-Bahn* metro system or the *S-Bahn* surface light rail system. These systems form an obvious addition to the street level system of public space and provide transport for both pedestrians and cyclists. Although the importance of such systems is undoubtedly great, it is not at all obvious that the axial map is an appropriate tool to capture a whole range of transport systems. There is not a supporting body of evidence to show that the analysis actually can capture space use characteristics of other transport systems such as the urban rail network. This study has therefore confined the axial map to the physical street system for which it has been shown to correlate well with space use. The role of other movement systems in rent patterns is discussed further in the conclusions, but for the purposes of the study it may be noted that only the role of street configuration is being tested by the regression models.

The axial map was created as a representation of the street-based movement system linking all possible origins and destinations, in accordance with the principle outlined in section 2.6.4 above (page 55 above). There was a methodological issue of whether lines that did not have any addresses on them but did form part of the public space system should be included. The most prominent example of this is the large urban park in central Berlin called Tiergarten. Axial Map 3.1 below shows what the model would look like if the routes in Tiergarten were excluded. Despite the lack of destinations on such routes, it was not deemed viable to exclude them as many of them form major links in the city. Consequently all clear public routes were included, as in Axial Map 3.2 below:



Axial Map 3.1: Section of Berlin excluding routes in Tiergarten



Axial Map 3.2: Section of Berlin including routes in Tiergarten

The existence of a large number of building sites in Berlin also raised the methodological issue of how to map such streets within the axial analysis. In cases where the future street layout of an existing building site was clear, the axial lines of streets were included (as in the Debis site at Potsdamer Platz to the bottom right of Axial Map 3.2 above). Where the planning was not clear and building had not commenced, the streets were mapped as in their present state.

The base maps used for the creation of the axial map were 1:5,000 and 1:10,000 raster maps of Berlin (Landeskartenwerk Berlin 1996; Landeskartenwerk Berlin 1996). These were geo-registered in the MapInfo GIS application using the Soldner co-ordinate system specific to Berlin. A series of historical maps produced by the Berlin Senate (Aust and

Stark 1987) were used as the base maps create the historical axial analysis in chapter 4 below (pages 125 to 164 below).

3.6.2 Methodology of axial map construction

The procedure for axial map construction in this thesis follows that outlined by Hillier and Hanson (see chapter 3 of Hillier and Hanson 1984, esp. pg.s 97-104). In brief, the fewest number of longest axial lines have been drawn along all public routes through which people can see and move. The longest possible lines of sight have been used to define the axes. Enough axial lines have been used to link all maximal convex public spaces in the city in a network that is as *shallow* (in graph terms) as is physically possible[12].

However, there are aspects of the methodology of map construction that are different in the Berlin case. Hillier and Hanson outline the special morphological characteristics that dead end streets have in graph models of street systems (Hillier and Hanson 1984, pg. 94). They refer to dead-ends as *non-distributed* lines and experiment with their removal or inclusion in spatial models of a street systems extensively (Hillier and Hanson 1984, pg. 118). This began a tradition of experimentation with the removal or inclusion of dead ends in axial maps and the diverse range of studies since then have sometimes included dead ends and sometimes not. The purpose of the analysis in this thesis is to measure the spatial properties of streets in order to test some relationship to rent patterns. Given that dead end streets contain addresses just like any other street, the measure cannot justifiably exclude them if it supposed to be a street level model of spatial configuration. Therefore all dead ends have been included in the model.

3.7 Measures of the Spatial Analysis

Using the axial map representation of the street system, a number of measures of the network properties of this system can be calculated. These measures will all be tested for significance against the empirical data in the thesis and are described below from the simplest to the more complex.

---

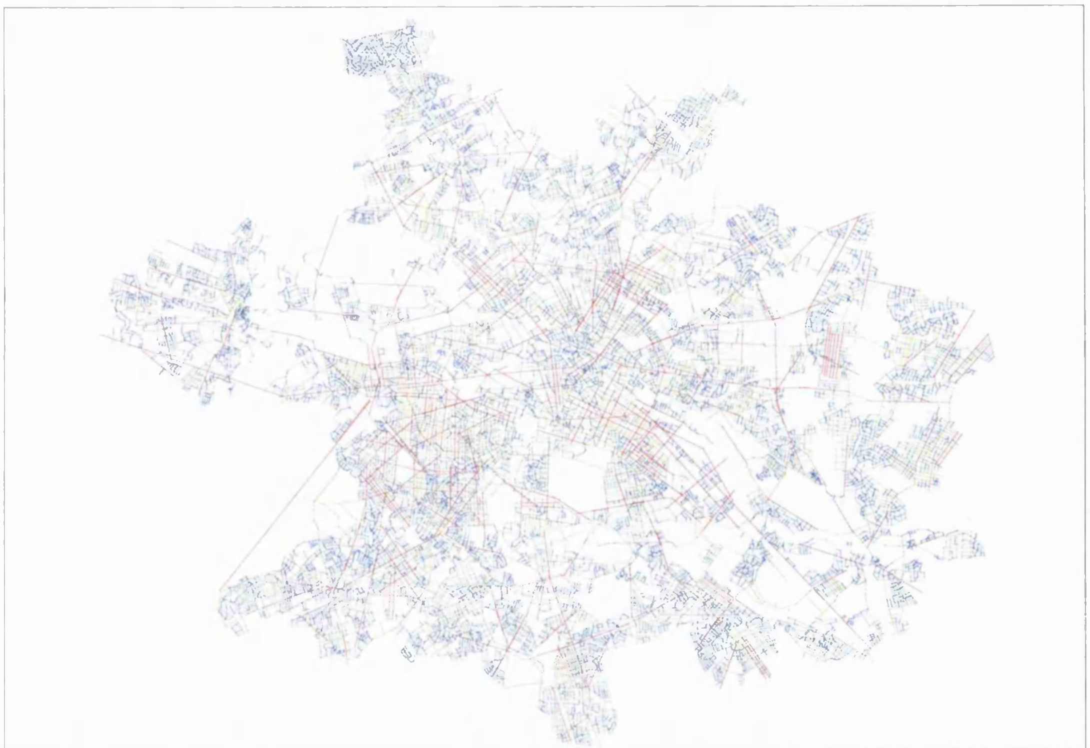
[12] This simplification known as the fewest line axial map is based on the 'all line axial map'. For depth calculations (not for the number of lines) there is a great deal of redundancy in the all line axial map. There is a subset of lines in the all line axial map that link all possible maximal convex spaces in a city and do not increase the depth of any to each other(see Penn, Desyllas et al. 1999).

3.7.1 *Length of Axial Line*

The simplest of all morphological measures that can be derived from the axial map is the length of the longest possible axis along any street or space. This is effectively the length of each named street, as by convention the vast majority of streets in Berlin are straight lines with a single name and the name changes if the street bends significantly[13]. The total length of all lines in the Berlin axial map is around 5300km.

When the street system is represented as a set of longest axes, the pattern that emerges is very hierarchical, with a small number of very long lines. Axial Map 3.3 shows the length of lines coloured according to a spectral range, using the same convention as the rent maps as described in section 3.5.3 above. The average length of axial lines in Berlin is 533 metres but the longest is over 12.5km. This difference is because the length of streets in Berlin is logarithmically distributed with a positive skew (skewness =5.42) as can be seen in the box plot of Figure 3.7 below. 95% of lines are within the bottom decile of the range (from 62m to 1.3 km). The distribution of street lengths is not a normal distribution, it is hierarchical one reflecting the importance of a very small number of key streets within the network as a whole.

[13] This appears to be a widespread convention, at least in the Western world. There is an apparently good correlation between axiality and the naming of streets, which might reflect something about the use of axes for navigation by people.



Axial Map 3.3: Length of axial lines in Berlin (colour spectrum)

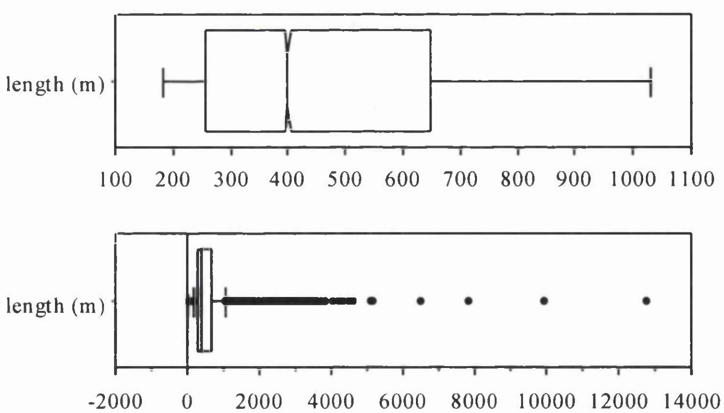


Figure 3.7 : Box Plots of Axial Line Length in Berlin

The longest streets are the main arterial exit routes out of the city. These are either motorways or highly dominated by cars. These are the routes that carry interregional traffic in and out of Berlin. The longest is the Adlergestell, a 12.5 km long car dominated route that can be seen in Axial Map 3.3 stretching Southeast from the Treptow area. The second longest is the Avus motorway that stretches towards the Southwest through the Grünewald and the third is the extension of Falkenseer Chausee leading west out of the city from Spandau. The second tier of long lines are the long radial streets of the

Hobrecht plan (Map 4.8 on page 140 below), particularly the local shopping streets of Frankfurter Allee, Prenzlauer Allee, Mueller Straße. These are the routes that carry commuter traffic in and out of the central area and form the main roads of the intra-urban network. Within the centre of town the main streets of Friedrichstraße and Kurfürstendamm are also within the small group of longer, important lines.

This fundamental difference is shown in Table 3.5 below, where the mean length of different road types is compared:

	all lines	normal roads	dead ends	urban motorways
Mean	532.502	528.547	236.534	1518.571
Std. Dev.	468.514	455.375	115.949	1525.666
Std. Error	4.682	4.560	8.138	241.229
Count	10013	9973	203	40
Minimum	62.018	62.018	88.111	207.543
Maximum	12783.680	12783.680	736.626	9962.110
Range	12721.662	12721.662	648.515	9754.567
Sum	5331939.151	5271196.323	48016.353	60742.828
Median	399.610	398.392	206.736	1169.560

Table 3.5: Length of axial lines split by road type

3.7.2 Connectivity

The second most local spatial measure of axial lines is the number of connections or intersections with other lines. Whereas the length of each axial line is independent of other lines, the connectivity of each line depends on how it relates to the others. The connectivity is a property of each line within the network of interconnected lines. It is therefore less local than the length of lines, but it is still a property that would be more or less visible to anyone standing on a street without further knowledge of the system as a whole.

Axial Map 3.4 on page 108 shows the connectivity of Berlin lines as a colour spectrum. The Adlergestell is the most highly connected of all lines. This is to be expected from the strong relationship between the length of lines and their connectivity. As can be seen in Figure 3.8 below, there is a correlation of r^2= .582 between line length and connectivity. However, there is a much greater variance in connectivity for shorter lines, but the longest follow the trend much more closely. The extreme exception to the trend at the higher end of the length range is the Avus motorway, which is nearly 10km in length but has only 5 connections.

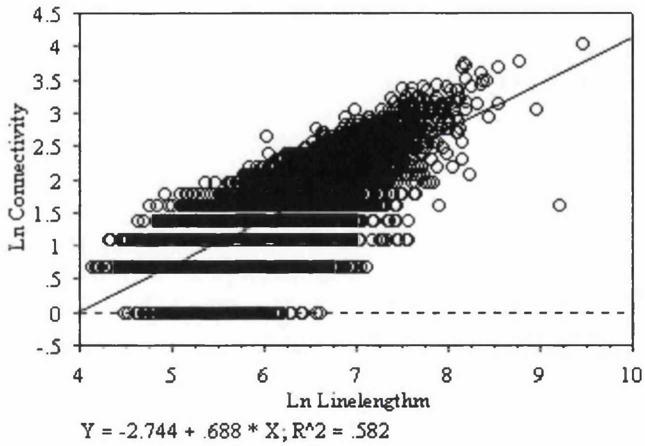
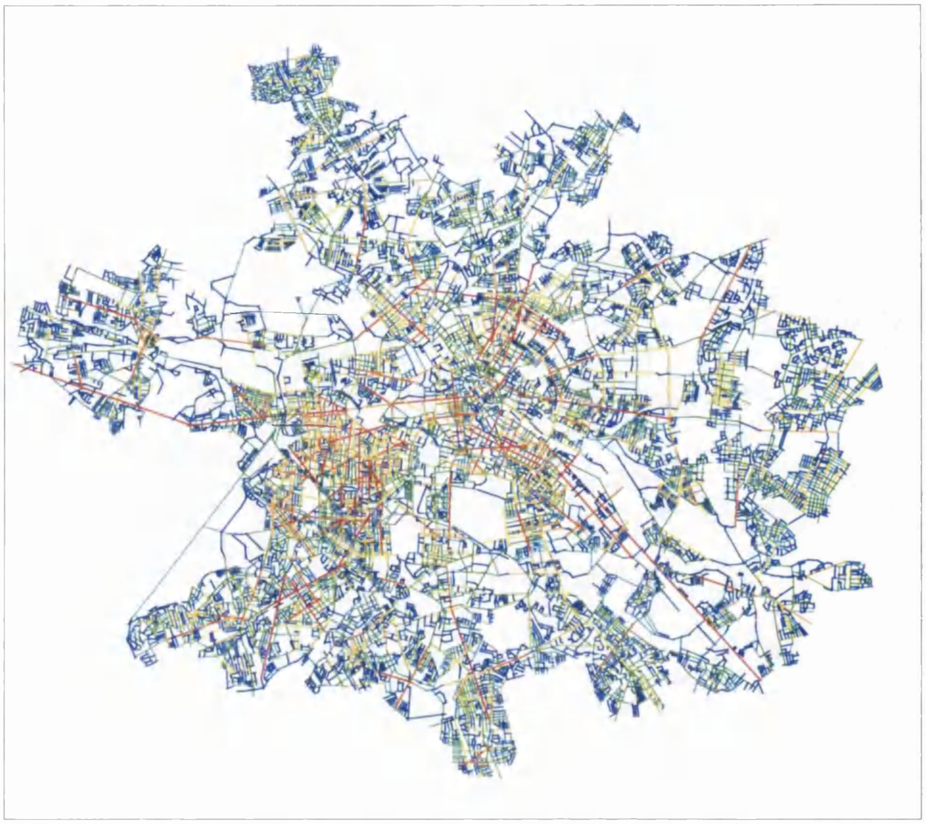


Figure 3.8: Correlation between Ln line length and Ln connectivity

Table 3.6 below summarises the descriptive statistics for local spatial measures applied to the Berlin map.

Measure	length in metres	Connectivity
Mean	533	5
Median	400	4
Mode	.	3
Std. Dev.	468.51	3.65
Std. Error	4.682	.036
Minimum	62	1
Maximum	12784	57
Range	12722	56
Sum	5331939	49646

Table 3.6: Local Spatial Measures



Axial Map 3.4: Ln Connectivity of axial lines in Berlin (colour spectrum)

3.7.3 Local Spatial Measures and Types of Roads

Once the two basic spatial differences of a street's length and its connectivity have been established, their relationship can be investigated by creating compound measures such as the connections per metre. Axial Map 3.5 shows this measure coloured according to a spectral range. This map highlights small clusters of lines that have a high number of connections per metre. The clusters are comprised mostly of short lines (not longer than about 300m in length). Two distinct kinds of area exhibit such clusters of short, well-connected lines. Firstly, many of the much older mediaeval town centres are highlighted. Spandau and Köpenick town centres are particularly clearly delineated as clusters, as is shown on Axial Map 3.5, but other old, unplanned areas such as the villages of Dahlem and Zehlendorf show up too. The other kind of area that is highlighted by this measure is the small masterplanned areas of the twentieth century. The Papestraße area built in the 1930s in Tempelhof is one example and the new Daimler Benz centre on Potsdamer Platz is another.

The two local measures can also be used to approximate the average length of block faces on each street. If L is line length and C is connectivity then the average block face F can be approximated by Equation 3.1 below:

$$F = \frac{L}{C-1}$$

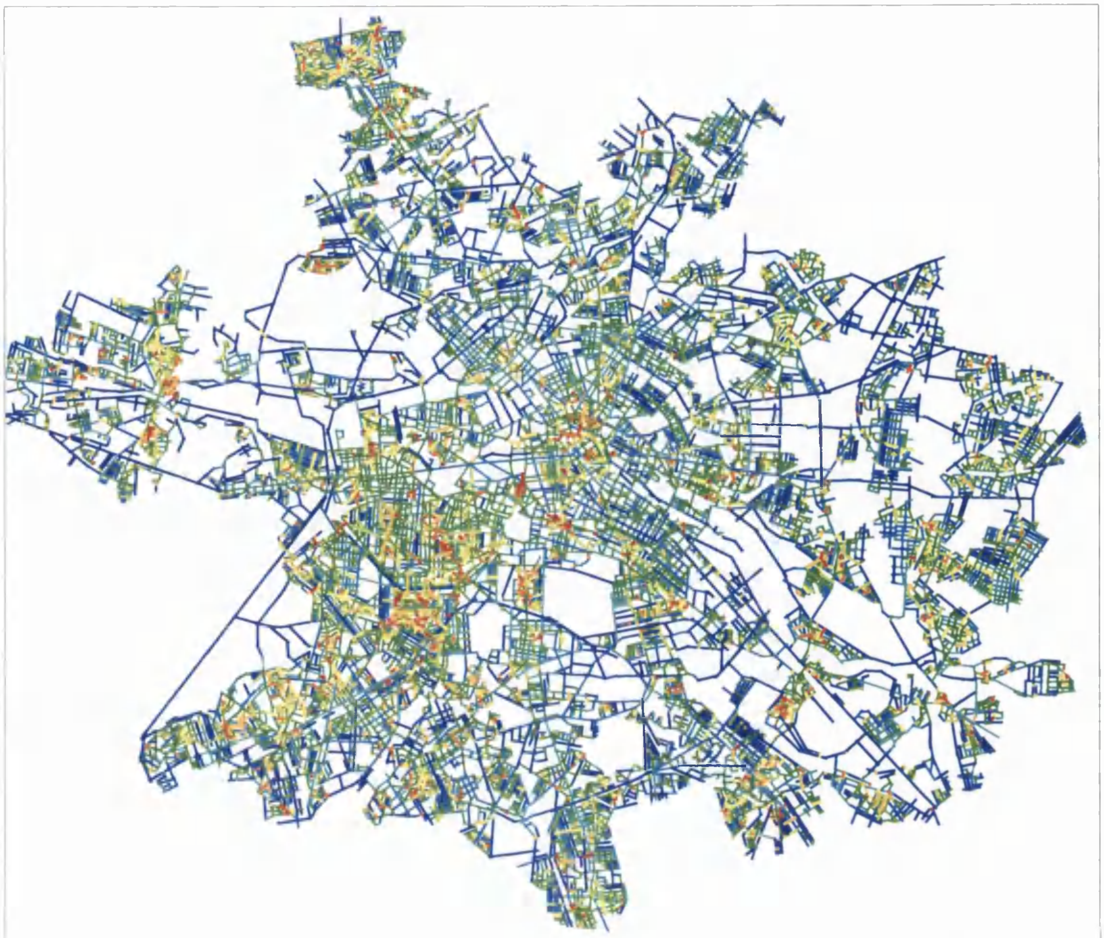
Equation 3.1: Approximation of mean block-face length

For the 203 lines in Berlin where C=1, the length itself (L) can be used. This measure gives an approximate length of street frontage between major intersections, although there will be some errors, such as when lines have a connection breaking the block wall on one side and not the other. Information about whether a connection is off a street in one direction (as in a T-junction) or a full cross street is not possible to calculate within the GIS or proprietary space syntax software. Table 3.7 provides a summary of these measures:

Measure	connections per km	average segment length (m)
Mean	10.73	165
Std. Dev.	4.747	104.437
Std. Error	.047	1.044
Minimum	.502	27.463
Maximum	43.695	2490.528
Range	43.193	2463.064
Median	9.941	137.562

Table 3.7: Measures of block-face length

The mean length of segments between street junctions in Berlin is 165m, although the median is considerably lower at 138m. Axial Map 3.6 shows the average length of street segments coloured according to a spectral range. This map brings out a particular morphological characteristic of the urban motorways: they are comprised of long axial lines with very few connections. Whereas the high connectivity, short line clusters of Axial Map 3.5 showed neighbourhood centres, the low connectivity long lines brought out by Axial Map 3.6 are characteristic of automobile routes. This is even clearer when the averages are compared, as in Table 3.8 and Table 3.9 below. On average, motorway axes are almost three times as long as normal roads and have less than half the connections per kilometre.



Axial Map 3.5: An example of the connections per metre of axial lines in an area of Berlin

Axial Map 3.6: An example of the average Block-face length in an area of Western Berlin

	all lines	normal roads	dead ends	urban motorways
Mean	10.732	10.755	5.060	5.133
Std. Dev.	4.747	4.741	1.971	2.595
Std. Error	.047	.047	.138	.410
Count	10013	9973	203	40
Minimum	.502	1.358	1.358	.502
Maximum	43.695	43.695	11.349	11.001
Range	43.193	42.337	9.992	10.499
Sum	107463.477	107258.169	1027.263	205.307
Median	9.941	9.969	4.837	4.502

Table 3.8: Connections per kilometre split by road type

	All lines	normal roads	dead ends	urban motorways
Mean	164.946	164.121	236.534	370.754
Std. Dev.	104.437	100.943	115.949	388.639
Std. Error	1.044	1.011	8.138	61.449
Count	10013	9973	203	40
Minimum	27.463	27.463	88.111	102.264
Maximum	2490.528	1212.070	736.626	2490.528
Range	2463.064	1184.607	648.515	2388.263
Sum	1651608.373	1636778.224	48016.353	14830.149
Median	137.562	137.309	206.736	271.920

Table 3.9: Average segment length split by road type

There are 203 axial lines in Berlin that have a connectivity of 1 and are hence dead ends. It must be noted that some lines may be dead ends but have a connectivity of 2, because they can contain connections of overlapping lines that do not create sections of distributed road. Of the 10,003 axial lines in the axial map of Berlin, 40 are on car only routes.

3.7.4 Depth of Lines

For the connectivity measure, the number of intersections between each street and its neighbours was counted within the matrix of all streets. This enables the calculation of measures that capture properties of the line that are not local to the line but depend on its position within a network. Let us call a specified line under investigation the root line, for which we will consider the location to be called step 1. The set of lines that are connected to this root line can be termed those at step 2 from the root (their count is the connectivity of the root line). The set of lines that are connected to lines at step 2 will be the root line and a further set of lines at step 3 from the root. This begins to form a graph of depths from the matrix of lines. Axial Map 4.7 and Axial Map 4.8 on page 134 below shows two examples of depth from a line. The root line is shown in red. Lines at step 2 are shown in orange and those at step 3 are in yellow.

3.7.5 The measure K

The measure *K* for any line is derived from the depth calculation described above. This measure is used in the calculation of integration values using space syntax software but has not been previously treated as an independent value of interest, possibly because the software has not been available to calculate it. The development of the software used for this study has made this possible. Whereas connectivity showed the number of lines that intersect a given line, *K* is the number of lines within a specified number of intersection steps from a line. This means that K_3 is the sum of the root line (R1) plus all those to which it connects (its connectivity value) plus all lines connected to those lines.

K_x is therefore a value of the number of axial lines reachable within x-1 changes of direction from a root line. The measure can be visualised by comparing the orange and yellow lines of Axial Map 4.7 with those of Axial Map 4.8 on page 134 below. The larger number of orange and yellow lines in Axial Map 4.8 shows the larger K_3 value for Friedrichstraße (the red line) compared to that of Rathausstrasse in Axial Map 4.7. In Berlin the value K_x can only reach 10,003 because that is the count of all lines. Consequently we can describe the number K_n as the radius of K necessary to reach all lines within the system. Table 3.10 below shows a series of K values for lines in Berlin. The mean value of K_3 is around 27 which means that on average, approximately 26 axial lines can be reached within two changes of direction from any given line.

	K3	K5	K7	K9	K11
Mean	25.747	180.562	591.814	1316.762	2359.748
Std. Dev.	20.153	143.942	438.451	888.507	1427.904
Std. Error	.201	1.438	4.382	8.879	14.270
Minimum	3	5	9	34	94
Maximum	205	1058	2833	4827	6883
Median	20	133	441	1097	2074
Mode	12	59	268	1769	2495

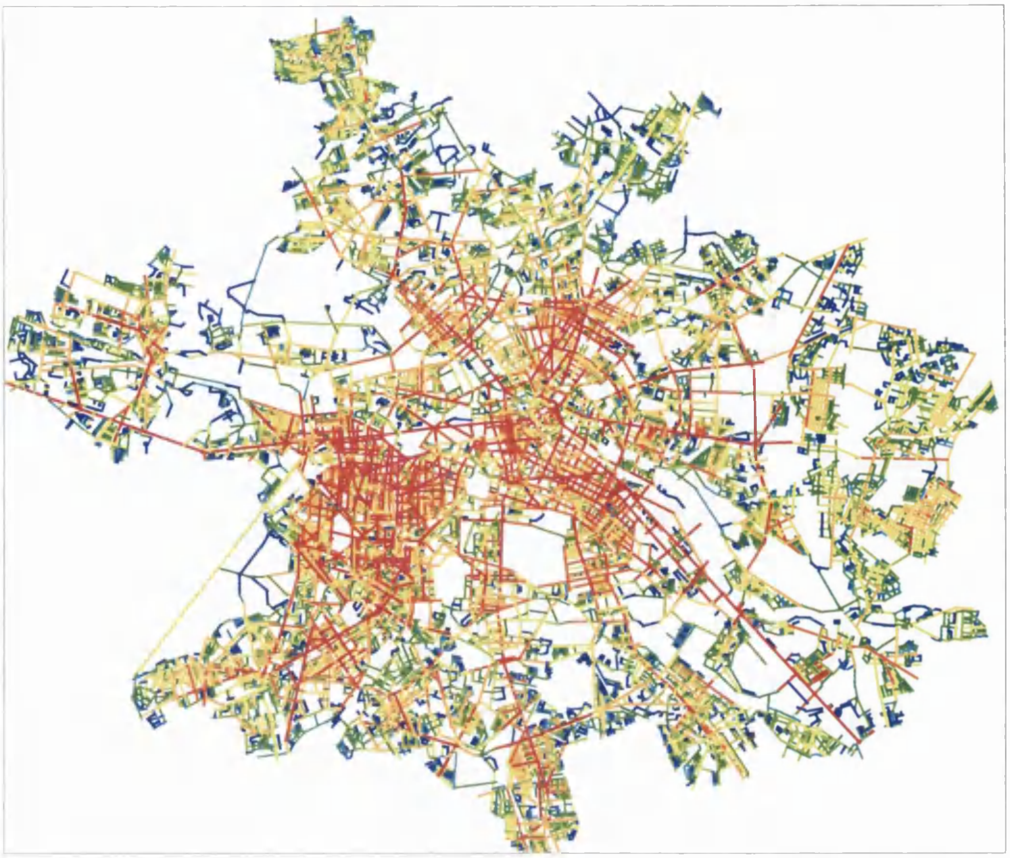
Table 3.10: K values for Berlin axial map

It is possible to describe a new measure from these values, which we can term the *reach* of an axial line at any K_x. This measure describes the percentage of the city that is reachable from any street within a specified number of changes of direction. The reach for a line at K_x can be termed R_x and is given by Equation 3.2 below:

$$R_x = \frac{K_x}{K_n} * 100$$

Equation 3.2: reach of axial lines

The pattern of K_3 values can be seen in Axial Map 3.7 below. This simple morphological measure captures almost all the main roads of the street network in Berlin in a continuous *supergrid* structure. As with the length and connectivity measures, the long radial traffic routes such as Mehringdamm, Frankfurter Allee and Landsberger Allee are almost all visible. More surprisingly, all the developed local district centres appear to be visible as clusters of red lines. The central area inside the S-Bahn ring is also visible as the concentration of red lines within the map as a whole. The average reach at K_3 is just 0.27% of the whole city but the maximum reach at K_3 is 2%, which is achieved by the Kaiserdamm/Bismarkstraße axis in West Berlin. Within 4 changes of direction from the root line (K_5) the average reach is 1.8% of Berlin. At K_{11} almost 24% of the city is reached on average (the increase is logarithmic).



Axial Map 3.7: An example of K_3 Values in Berlin

3.7.6 Integration

Finally, the most global measure that will be applied to Berlin is the integration of each axial line (representing a street) within the network of all lines. The measure of integration is useful in showing the global structure of the whole network as a system. It is also the measure that has been found to correlate best with movement patterns, as discussed in section 2.6.4.1 of the literature review (page 56 above).

Integration is a normalised measure of graph depth. It is based on the measure of 'relative asymmetry' given by Equation 3.3 below, where RA is the 'relative asymmetry' or integration of a line, d-bar is the mean depth in graph terms to all other lines and k is the number of lines in the system.

$$RA = \frac{2(\bar{d} - 1)}{k - 2}$$

Equation 3.3: Relative Asymmetry

A further adjustment is made to allow for scale differences between axial maps by Equation 3.4 below, where D is the RA value for the root of a diamond shaped system. This gives a scale adjustment for spatial systems of different sizes. It produces a measure known as real relative asymmetry or '*integration'*. The reciprocal of RRA is termed *integration* or *global integration* and is higher for *shallower* lines.

$$RRA = \frac{RA}{D_k}$$

Equation 3.4: Real Relative Asymmetry

This measure allows the differences in the mean depths of each line in the system to be viewed in one analysis, giving a picture of the relative accessibility of the whole network from each line in graph terms.

Measures of integration can be calculated either with respect to the system as a whole or for a more limited set of axes from each line, such as K_3. Integration at K_3 is commonly termed 'local integration'. Both local and global measures of integration will be explored extensively for the Berlin axial map in chapters 3 and 4 below.

3.7.7 Comparison of Spatial Measures

In the two tables below, the relationships between the spatial measures are explored. The integration values for both divided and reunified Berlin have been included. These two measures are strongly correlated (r squared .790). This is because, despite the dramatic shift in the centre of the city, the global relationship between peripheral streets and central streets is strong in both measures and therefore they co-vary. It should be noted that the 51 missing cases are the lines that crossed the wall for which it is not possible to compare divided and reunified values.

	Ln Length	Ln Connectivity	Control	Integration	K radius 3	Integration Radius 3	Divided Integration	Divided Local Integration	K9	Integration Radius 9
Ln Length	1.000	.762	-.012	.029	.005	.004	.071	.005	.031	.034
Ln Connectivity	.762	1.000	-.005	.150	.052	.041	-.013	.037	.157	.151
Control	-.012	-.005	1.000	.104	.520	.639	.100	.639	.135	.199
Integration	.029	.150	.104	1.000	.509	.428	.790	.396	.953	.801
K radius 3	.005	.052	.520	.509	1.000	.878	.458	.860	.597	.686
Integration Radius3	.004	.041	.639	.428	.878	1.000	.404	.992	.509	.651
Divided Integration	.071	-.013	.100	.790	.458	.404	1.000	.401	.789	.704
Divided Local Integration	.005	.037	.639	.396	.860	.992	.401	1.000	.476	.630
K9	.031	.157	.135	.953	.597	.509	.789	.476	1.000	.879
Integration Radius 9	.034	.151	.199	.801	.686	.651	.704	.630	.879	1.000

Table 3.11: Correlation Matrix for Axial map variables

9962 observations were used in this computation. 51 cases were omitted due to missing values.

Table 3.12 below showing the correlation analysis for space syntax variables has been sorted in descending order according to the strength of the correlation. The correlation analysis shows that there is a very strong relationship between almost all the significant variables, which means that they cannot be included in an MRA together owing to multi-colinearity. This has been overcome in later chapters by testing the measures against the data in individual regression models whenever major colinearity was detected.

	Correlation	P-Value	95% Lower	95% Upper
IntegrationRadius3, Divided Local Integration	.992	<.0001	.991	.992
Integration, K9	.953	<.0001	.951	.954
K9, IntegrationRadius9	.879	<.0001	.875	.883
K radius 3, IntegrationRadius3	.878	<.0001	.874	.883
K radius 3, Divided Local Integration	.860	<.0001	.855	.865
Integration, IntegrationRadius9	.801	<.0001	.794	.808
Integration, Divided Integration	.790	<.0001	.782	.797
Divided Integration, K9	.789	<.0001	.781	.796
Ln Length, Ln Connectivity	.762	<.0001	.754	.770
Divided Integration, IntegrationRadius9	.704	<.0001	.694	.714
K radius 3, IntegrationRadius9	.686	<.0001	.676	.697
IntegrationRadius3, IntegrationRadius9	.651	<.0001	.640	.662
Control, IntegrationRadius3	.639	<.0001	.627	.650
Control, Divided Local Integration	.639	<.0001	.627	.650
Divided Local Integration, IntegrationRadius9	.630	<.0001	.618	.642
K radius 3, K9	.597	<.0001	.584	.610
Control, K radius 3	.520	<.0001	.506	.534
Integration, K radius 3	.509	<.0001	.494	.523
IntegrationRadius3, K9	.509	<.0001	.494	.523
Divided Local Integration, K9	.476	<.0001	.461	.491
K radius 3, Divided Integration	.458	<.0001	.442	.473
Integration, IntegrationRadius3	.428	<.0001	.412	.444
IntegrationRadius3, Divided Integration	.404	<.0001	.388	.421
Divided Integration, Divided Local Integration	.401	<.0001	.384	.417
Integration, Divided Local Integration	.396	<.0001	.379	.413
Control, IntegrationRadius9	.199	<.0001	.180	.218
Ln Connectivity, K9	.157	<.0001	.138	.176
Ln Connectivity, IntegrationRadius9	.151	<.0001	.132	.170
Ln Connectivity, Integration	.150	<.0001	.131	.169
Control, K9	.135	<.0001	.116	.154
Control, Integration	.104	<.0001	.085	.124
Control, Divided Integration	.100	<.0001	.081	.120
Ln Length, Divided Integration	.071	<.0001	.051	.090
Ln Connectivity, K radius 3	.052	<.0001	.032	.072
Ln Connectivity, IntegrationRadius3	.041	<.0001	.022	.061
Ln Connectivity, Divided Local Integration	.037	.0002	.018	.057
Ln Length, IntegrationRadius9	.034	.0008	.014	.053
Ln Length, K9	.031	.0018	.012	.051
Ln Length, Integration	.029	.0042	.009	.048

Table 3.12: Correlation Analysis for Spatial Measures

9962 observations were used in this computation. 51 cases were omitted due to missing values.

3.7.8 The Attribution problem

In order to test the relationship between the spatial measures pertaining to street axes and the rent data pertaining to units within buildings, it was necessary to link the two within a common database. GIS offers the most practical solution to this problem and was chosen as the platform for data overlay, linking and display. Unfortunately the existing proprietary space syntax software created at the Bartlett School of Architecture and Planning at UCL was not capable of importing or exporting both attribute and spatial data together in any format other than the proprietary one of the 'Axman' software. The author had the opportunity to write the brief for a software application that would process axial maps in a format compatible with GIS platforms[14].

Having placed the axial map and the rent data into a common database system, the methodological question of how to link the two remained. Lease data was represented in individual buildings but these had to be linked to the axial map representation, which is a simplification of the street system. If a building is on a corner or has an overlap of more than one axial line on its adjacent street then an ambiguity exists as to how the data should be linked. The solution adopted was to link each lease to the street according to its entrance address, regardless of whether or not it was on a corner. In case of any overlap, the line adopted was the longest one. Once this link was created, the spatial variables of the axial analysis can be used in an MRA for rent determination along with lease variables and unit or building characteristics.

Before this linking between the spatial analysis and the rent data is presented, a spatial analysis of Berlin will be provided both historically and with the recent reunification of the city.

3.8 Summary

This chapter has presented the methodology of the empirical study that forms the core of the thesis. The methodological problems relating to sample selection have been evaluated and the solutions adopted in this thesis have been explained. Given the doubts about asking rents outlined in the literature review, a sample of real headline rents has been sought for this study. In view of the problems caused by aggregation at building level in previous studies, the rents have been analysed at a disaggregated level in order to capture

---

[14] The software was commissioned by the author in the course of a research project for an Australian local council (Desyllas, Duxbury et al. 1999)

the influence of variables such as lease provisions. The definition of different rent measures used (headline, consideration and effective rents) is clarified with reference to those used in other studies as discussed in the literature review.

A study of the representativness of the sample has been undertaken as far as possible within data constraints. It is argued that the sample is broadly representative of the market as a whole with the proviso that there is a bias towards more expensive central areas and fewer leases in peripheral locations than would be expected from a random sample. Certain other constraints of the sample are noted and it is recognised that the data provides a robust picture of the activities of one agent within the market but can only be used to tentatively confirm hypotheses about the market as a whole that would benefit from further testing.

The importance of the representation of location rents has been emphasised and the methodology of a location blind MRA to derive location rents has been outlined. The use of GIS as a tool for systematic data visualisation has been introduced.

A number of independent variables are enumerated in order to evaluate the implicit price of various spatial and non-spatial characteristics in rent transactions. The most problematic variable to quantify in previous studies has always been location itself. The criteria for the selection of a measure that provides this spatial variable have been explained. The set of measures adopted is the space syntax measures of the graph properties of the street network represented as axial lines. A methodology for linking the axial analysis to large urban databases such as the rent values used in this thesis has been presented. This set of measures is used because it fits all of the criteria with the proviso that it does not allow for as detailed a representation of space as would ideally be sought. The simplifying assumptions used in this spatial analysis have been explained: it is a measure of the graph properties of the street grid as a physical system and does not account for public transport or any weighting according to economic and social data. The methodology used to link these measures to the rent data has been explained.

In the next two chapters, this spatial analysis will be applied to Berlin to highlight the changing configuration of the street grid, firstly as the city developed and then with the recent reunification of the city.

4 Historical Development Of Urban Morphology And Land Use In Berlin

4.1 Introduction

In order to test the role of street morphology in the determination of office rent patterns, some way of quantifying the location variable for each building within the urban morphology is required. As has been described in the previous chapter, this thesis uses space syntax techniques to provide an analysis of the urban morphology and calculate a measure for location that can be tested against rent.

The purpose of this chapter, is to use the spatial analysis techniques in order to measure and investigate the historical evolution of Berlin's urban morphology. The way in which the global spatial structure of Berlin changed as the city grew and the development of local areas within the city will be evaluated using the measures of global and local integration described in section 3.7.6 of the previous chapter. This will allow the complex urban morphology of Berlin at the point of reunification to be understood within the context of its previous development over centuries.

If historical data on rent patterns were available, then the evolution of their spatial patterns could be viewed alongside the morphological evolution of Berlin, and this would allow for a detailed study of their relationship over time. As the urban structure changed with growth, the concomitant changes (or lack of change) in the pattern of rents would elucidate much about the relationship between the two. Unfortunately this is not possible, as a study of historical rent patterns in Berlin is hindered by the lack of available historical data[15].

Although it is not possible to view the historical evolution of rent patterns, it is possible to trace the evolution of Berlin's land use pattern. The second purpose of this chapter is to describe the unusual pattern of land uses within which the office market in reunified Berlin has developed. In Chapter 2 it was shown that the main spatial variable used to represent 'location' in previous studies of the spatial characteristics of rent has been distance to the CBD. This is essentially a measure that concerns the pattern of land uses,

[15] Before the historical evolution of rent patterns in Berlin can be directly investigated, a major task of research in the field of economic history is required. Not only are the collection of accurate historical records of office leases a prerequisite, but the kind of analysis of contemporary rent data presented in the later chapters of this thesis would have to be undertaken on the historical data.

as the CBD is defined as the main concentration of non-residential land uses. Berlin provides a particularly difficult case for such modelling, as the city has been characterised by many authors as the archetypal polycentric city with at least two centres of significance (Elkins and Hofmeister 1988; Kraetke 1992; Newman and Thornley 1994). In this chapter, empirical evidence on the evolution of Berlin's CBD will be reviewed to come to a more precise understanding of the extent to which Berlin is polycentral in terms of both its spatial structure and land use. This will allow the use of the distance to the CBD variable to be evaluated with reference to the Berlin case.

The historical evidence on the evolution of a land use pattern also provides indirect evidence that is of significance to any understanding of rents. This is because the land use pattern shows the concentration of offices and this effectively represents the supply side in the commercial office market. If rent is a value mechanism linking supply and demand, then any understanding of the rent pattern in Berlin must be able to account for the pattern of land uses as it emerged. Consequently, the chapter will finish with a discussion on what the relationship between urban morphology and land use patterns can allow us to deduce about the relationship between urban morphology and rent values.

4.2 Evolution of Urban Morphology and Land Use Pattern

4.2.1 Historical Maps of Land Use

Although historical rent or land value data for Berlin are not available, a remarkably good dataset of historical land use maps is available from which both the morphology of the street network and the pattern of land use can be traced as far back as 1650. The historical maps of land use were created by researchers in the planning department of the Berlin senate and published in 1987 to mark the 750th anniversary of the founding of the city (Aust and Stark 1987). Surviving historical maps of Berlin were cartographically corrected as far as possible with reference to the archaeological record and other available sources. Historical maps from 1650, 1690 1750, 1800, 1850, 1910 and 1940 were redrawn on a 1:10 000 basis and overlaid on the map of the contemporary city to allow for scaled comparisons. In this chapter, these maps of land use are used along with a number of other primary map sources.

A common land use classification system was applied to all the maps. Basic land uses such as residential, industrial, commercial (office and retail) uses, continuous shop-front and public buildings as defined in the German building use code called the

Baunutzungsverordnung (BauNVO) were used and represented in colour using the mapping convention of the *Planzeichenverordnung* (PlanzVO). Table 13.1 in the Appendix D: Key to the Planzeichenverordnung, which shows the colour coding for land use categories.

The categorisation for the 1986 map of land use is based on planning department surveys for land use plans during the 1980s. Further back in the historical record, more obscure sources are used such as address books and original maps in an attempt to find evidence of buildings conforming to one of the modern categories (Aust and Stark 1987). This common categorisation is particularly useful as it allows for a comparison of land use and morphology through time. A universal land use categorisation system has been applied to the city before and after major interventions of the twentieth century such as the building of the wall.

There are limitations in applying current land use categories to historical maps. Modern land use categories are much less relevant for the description of the pre-industrial city. The maps before the mid-nineteenth century tend to describe most of the city as 'mixed area'. This partly reflects the lack of more clearly specialised building structures in the archaeological record before industrial urbanism- most buildings were not specific enough to categorise with modern use labels or it is not possible to reconstruct specific uses confidently owing to lack of data. The categorisation also reflects the research problem that the older maps are based on very fragmentary evidence before more detailed surveying and address book data began to be collected in the nineteenth century.

4.2.1.1 Overview of the city's growth

The development of Berlin's population over the time frame of the land use maps is shown in Figure 4.1 below which gives an overview of the growth of the city. Berlin's rapid growth with industrialisation began in the late nineteenth century, reaching a peak in 1940 before the destruction of the war. The unusual interruption to development caused by division in the post-war period is in stark contrast to the other cities of Europe. Reunification led to the initial massive increase in population by bringing the two halves together and Berlin has grown slightly in recent years.

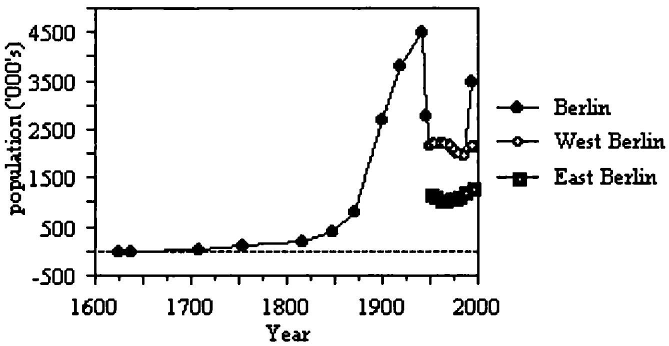


Figure 4.1: Population Growth of Berlin

For comparative purposes, the development of two other cities (London and Santiago de Chile) are also shown in Figure 4.2. Berlin belonged to the second wave of rapid urbanisation in Europe. As can be seen, London was already a very large city in 1900 and its growth as the centre of world trade during British industrialisation accelerated from 1800. Berlin was part of the continental industrialisation of the late nineteenth century in the second wave of rapid industrial urbanisation. Santiago is an example of the wave of rapid urbanisation in the developing world that is taking place in the late twentieth century.

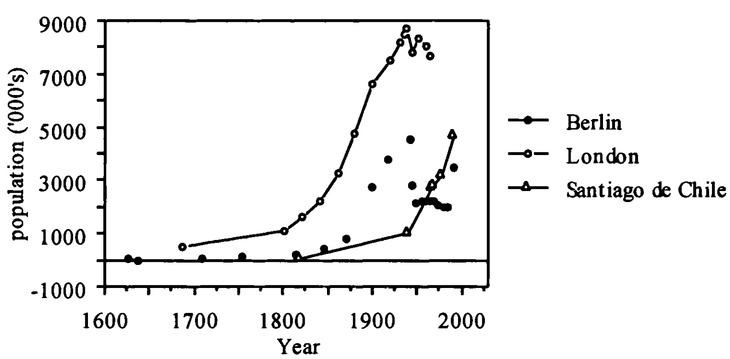
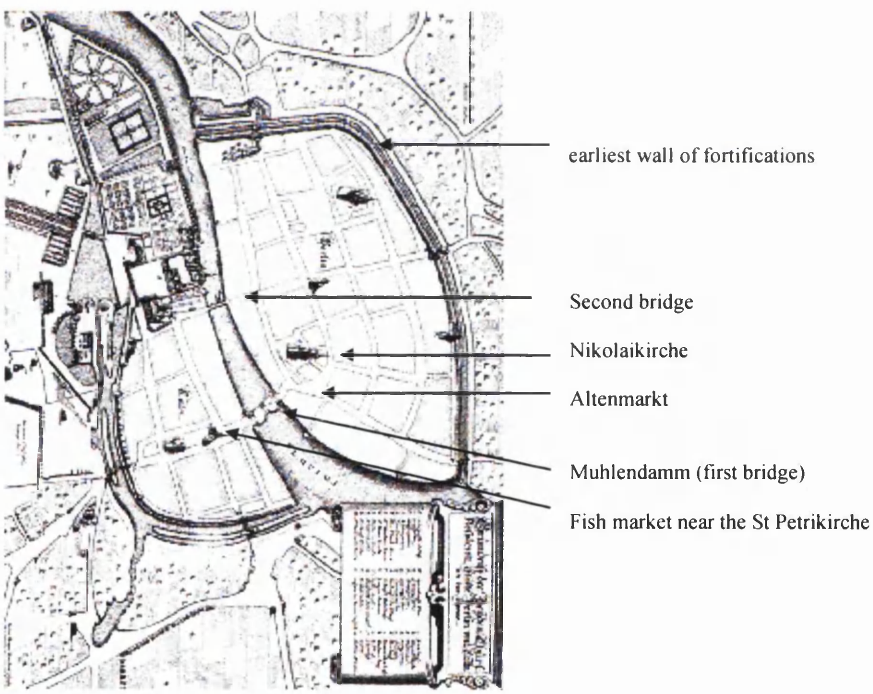


Figure 4.2: Population Growth London, Berlin and Santiago de Chile

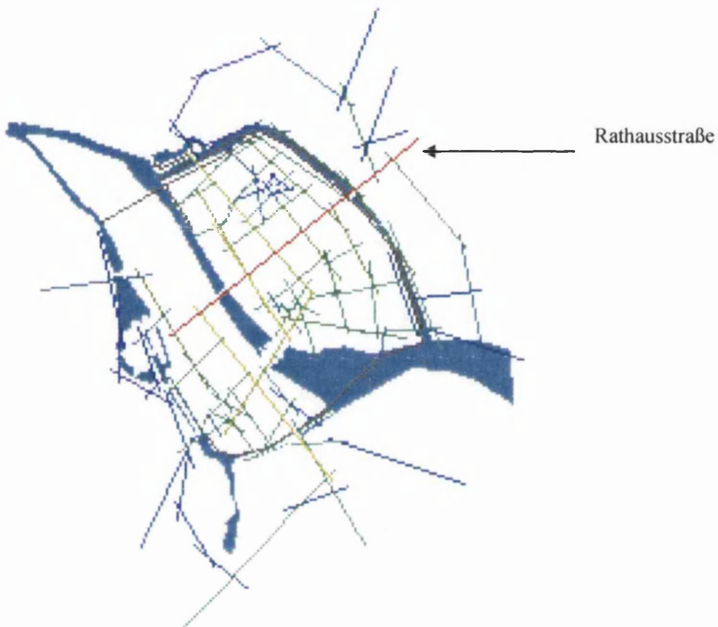
4.3 The Historic Centre of Berlin

The earliest settlement in the Berlin area was founded in 1237 by Teutonic knights in the Germanic expansion eastwards, although older Slavic forts existed at the nearby settlements of Köpenick and Spandau (Ribbe 1987). Map 4.1 shows the oldest surviving historical map of Berlin in 1652 (Memhard 1652). Early Berlin was made of the twin cities of Cölln (on the island Southwest) and Berlin (to the Northeast) at a crossing of the river Spree. The Berlin settlement began around the Nikolaikirche and the Alten or Molkenmarkt (the St Nicholas Church and the old market) and on the island of Kolln settlement began around the Petrikirche and the fish market. The Muhlendamm bridge was the first river crossing point and it existed from the beginning of the settlement between these two original markets. The second bridge followed in 1300. The first Schloß or palace was built around 1450 for the Kurfürst or Great Elector.



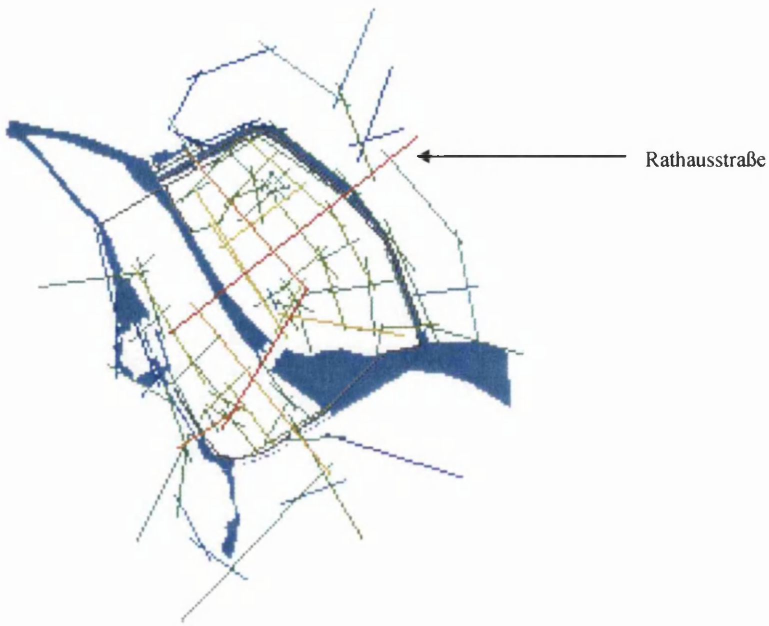
Map 4.1: Memhard's 1652 Map of Berlin
(Memhard 1652)

The two-town structure of early Berlin is clearly visible in Axial Map 4.1 below, which shows the pattern of global integration of Berlin in 1650. The most globally integrated line in Axial Map 4.1 (the most spatially strategic shown in red) is the Rathausstraße (formerly Köningsstraße)- the second bridge that formed a continuous axis through Berlin and across the river to the Schloß in Kolln. Areas outside the first wall (to the West of the island and to the East of the moat) are coloured blue, showing that they are relatively segregated within the global structure.



Axial Map 4.1: Global Integration of Berlin in 1650

The pattern of local integration shown in Axial Map 4.2 picks out both the Rathausstraße and the older Muhlendamm Bridge. The axial analysis shows that the bridges linking the twin cities were the key functional links in the morphology of the city. Although the importance of the first (southern) bridge in the local structure of Berlin is brought out by the pattern of local integration, the second bridge to the north is far more dominant in the global pattern.

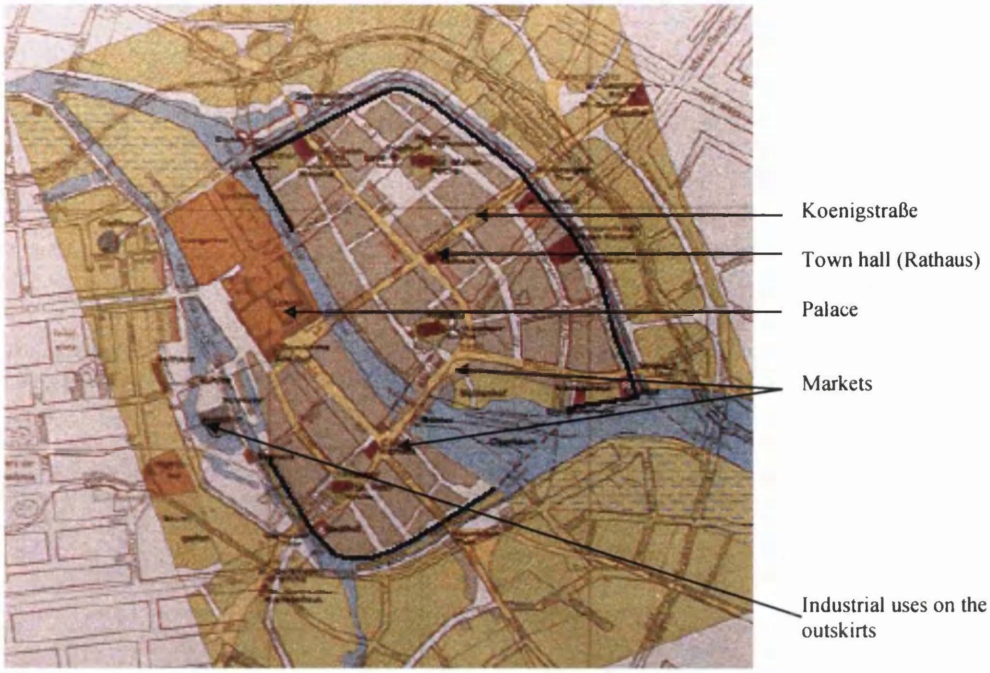


Axial Map 4.2: Local Integration of Berlin in 1650

Map 4.2 shows the land use map for 1650 (Aust and Stark 1987). There is only limited evidence on the commercial areas of early Berlin and consequently most of the map is coloured with the light brown 'mixed use' designation. However, the locations of the main markets are shown at either end of the first (southern) bridge. As well as being one of the key morphological links within the local structure of the city, the southern bridges also acted as a focus for the market activities.

The Rathausstraße, which was shown to be the most globally integrated line in the analysis of Axial Map 4.1, is shown in the land use map as the main street that linked the two cities together and provided the principal bridge across the river. It passed the Berlin town hall and the Schloß (castle). Evidence on its role as a commercial street is unavailable but it clearly has a role linking the major institutions and is marked as a key traffic route.

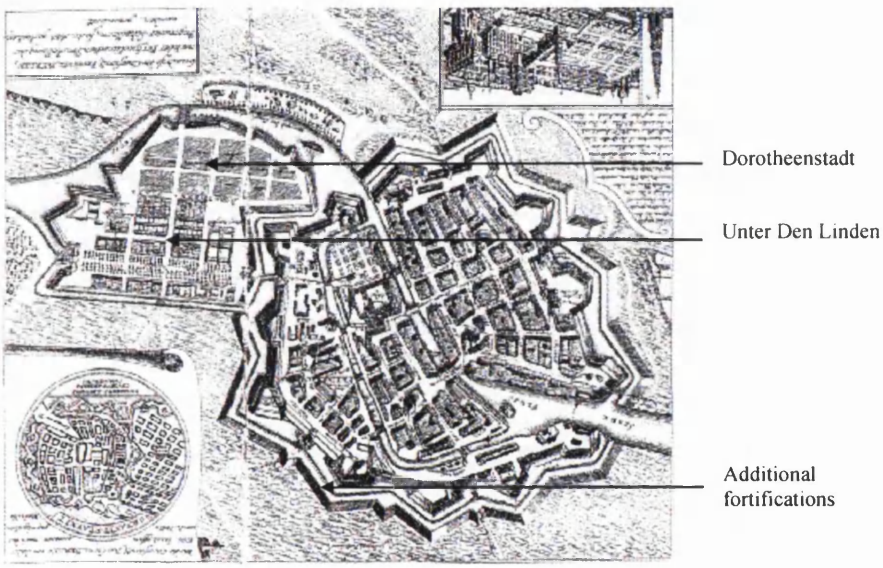
Industrial land uses are marked on the outskirts of the settlement- related to the woodcrafting and other primary industries. These are the peripheral, more segregated locations in the Axial Map 4.1 of global integration above. The defensive wall and use of the river as a moat are clear morphological boundaries at this stage, with only four entrances to the West of the city and three to the East.



Map 4.2: Land Use 1650 Berlin

(Aust and Stark 1987) For Legend see Table 13.1 in Appendix D.

Map 4.3 of Berlin in 1690 shows the new expansion of the city to the west (Schultz and Schleuen 1688). The urban extension of Dorotheenstadt was planned for the royal court as a residential area (Elkins and Hofmeister 1988). Unter Den Linden was extended as a ceremonial axis leading out from the palace. The medieval wall was replaced by new larger fortifications further out, including extensions of the river to form a proper moat on all sides. There is also clear evidence of settlement extending beyond the wall, particularly to the East where buildings on the other side of the river are clustered near the entrances. The settlement Eastwards was much less planned and most was outside the outer-fortifications. There are now only three entrances to the city on the west side and three on the East.

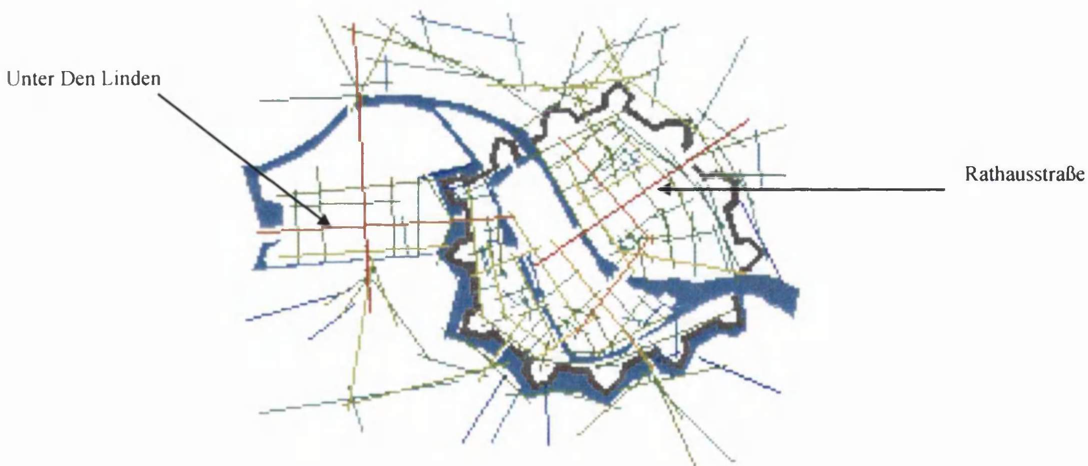


Map 4.3: Schultz and Schleuen's 1688 Map of Berlin
(Schultz and Schleuen 1688)

Axial Map 4.3 of global integration in 1690 shows the effect of the expansion of the city on the structure of global integration. The most globally integrated line is still Rathausstraße but there are now strategic lines moving Westwards that extend the core of the city around the Schloß to Unter Den Linden- shown in the axial map as the orange horizontal line to the West. The more segregated areas shown in deep blue are the parts of the settlement outside the fortifications to the North of the city, also segregated by the river itself as a natural barrier. The principal route structure of this area north of the river (that was not planned by the court) formed the basis of the 'Scheunenviertel' district of concentrated Jewish settlement.

Axial Map 4.3: Global Integration of Berlin in 1690

The pattern of local integration in 1690 shown in Axial Map 4.4 below brings out the local importance of Friedrichstraße and Unter Den Linden within the new area of Dorotheenstadt outside the historic core.

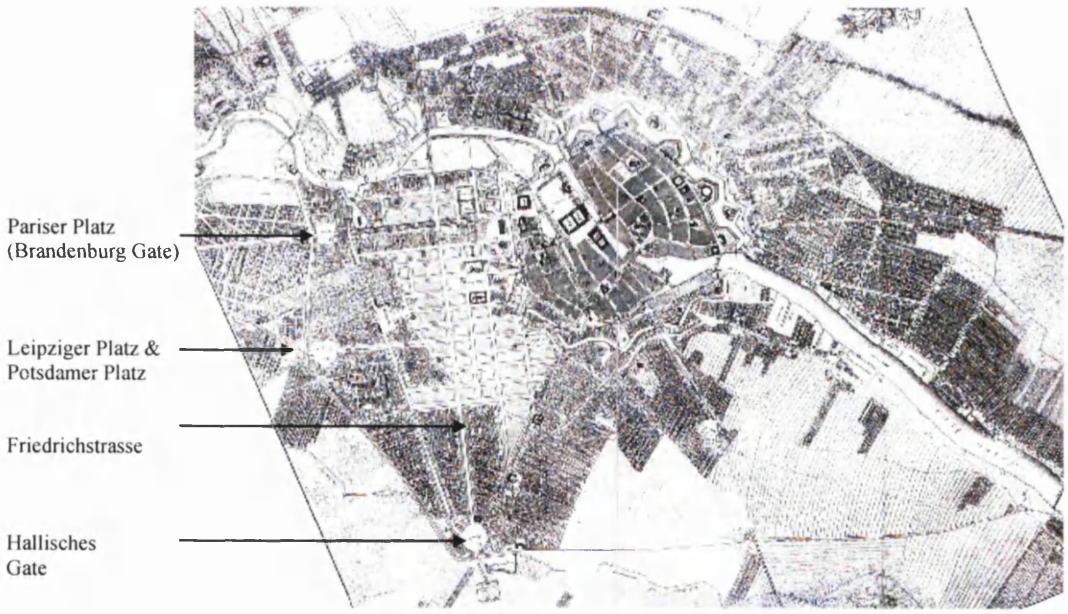


Axial Map 4.4: Local Integration of Berlin in 1690

4.4 Pre-industrial Expansion of Berlin

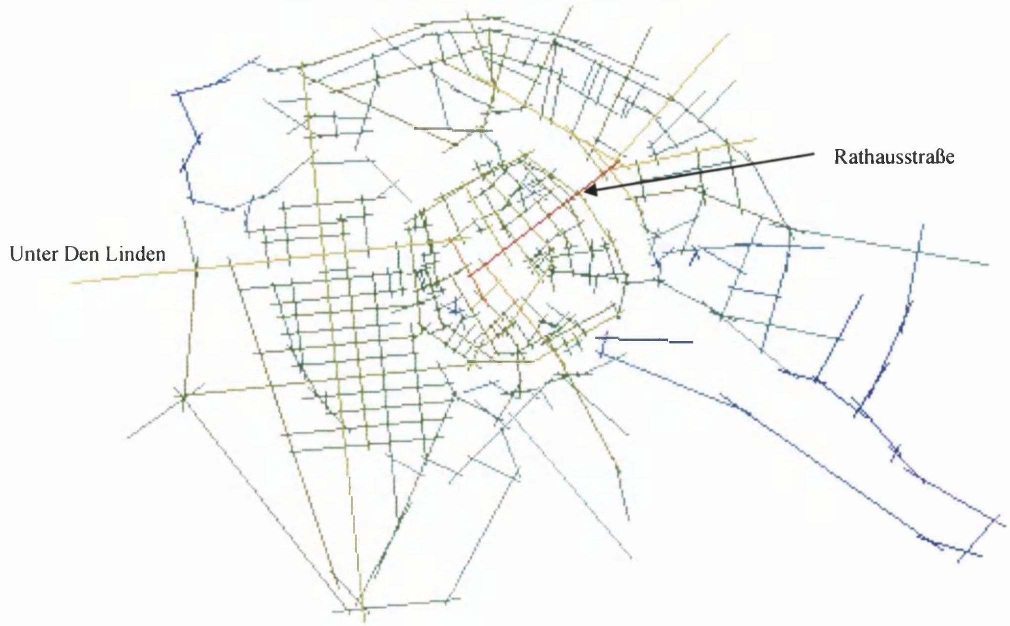
Map 4.4 shows the expansion of Berlin that had taken place by mid-eighteenth century (Schmettau 1748). The expansion of the city was primarily Westwards into a new grid-like area of Friedrichstadt. This area was planned under by the royal court under the influence of enlightenment ideas of urban design. This area was outside the mediaeval fortifications and a new customs wall was built further out, which is highlighted on Map 4.5 below of land uses. The customs wall was set some distance further than the settlement extent to the East in order to allow a large agricultural area inside the wall and to provide room for expansion of the city.

The customs wall was bounded on the Western side by the key gates at Pariser Platz (the Brandeburg Gate), and Leipziger Platz (the Potsdam gate and Potsdamer Platz). The southern gate was the Hallisches Gate (for the trade route to Halle). These gates formed the entrances to the city from the important trade routes to the West.



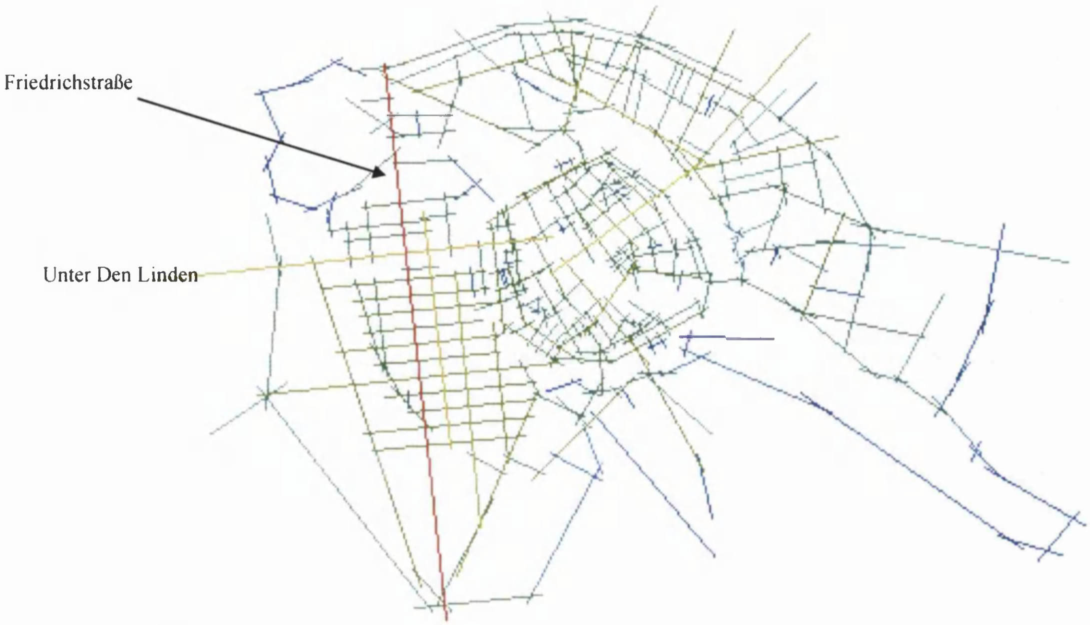
Map 4.4: Schmettau's 1748 Map of Berlin
(Schmettau 1748)

The global integration analysis of Berlin in 1750 (Axial Map 4.5 below) shows that Rathausstraße, in the core of the old city, is still the most globally integrated line. The darker, more segregated lines stretching south east are in the areas of expansion along the riverside.



Axial Map 4.5: Global Integration of Berlin 1750

The difference between global and local integration in 1750 is however, quite unlike the earlier plans. The city of 1650 and 1690 showed a concentrated integration core on Rathausstraße and a more dispersed pattern of locally important lines that were connected to it. The expansion of the grid to the West of the city by 1750 led to a break in the geography of local and global cores, with Friedrichstraße (a full four steps of depth from the integration core) as the most locally integrated line, as can be seen in Axial Map 4.6 below:



Axial Map 4.6: Local Integration of Berlin 1750

This shift in the relation of local and global can be seen in the correlation of these values. There is a strong relationship between the local integration of a line and its global integration (for example the correlations for Berlin in 1650 and 1690 in Figure 4.3 and Figure 4.4 below). However the relationship between these values for the model of Berlin in 1750 shows an extreme outlier, highlighted with a circle on Figure 4.5 below. This outlier is the highly locally integrated Friedrichstraße.

Figure 4.3: Correlation of local and global integration for Berlin Axial Map in 1650

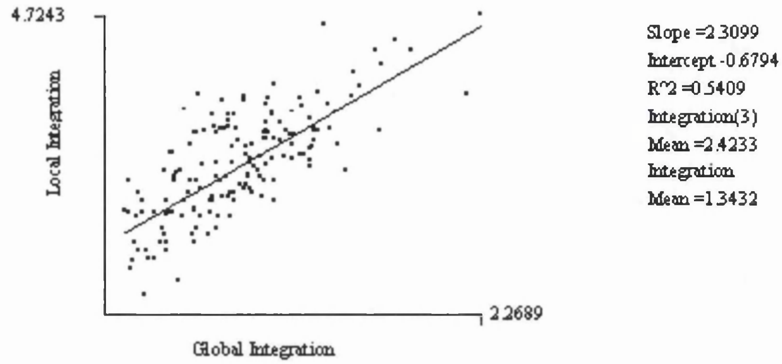


Figure 4.4: Correlation of local and global integration for Berlin Axial Map in 1690

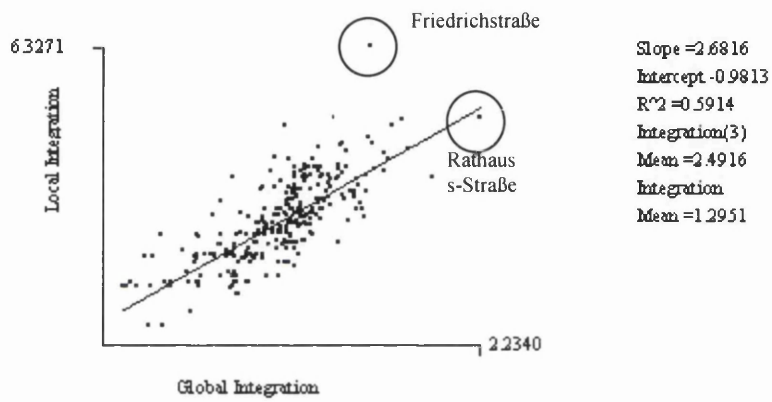
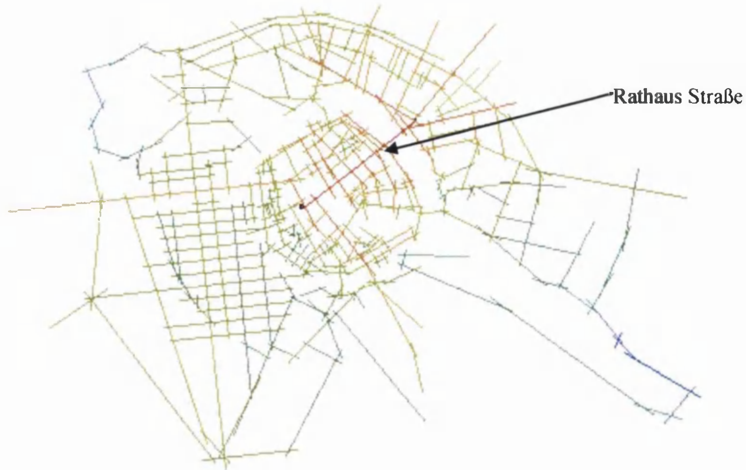
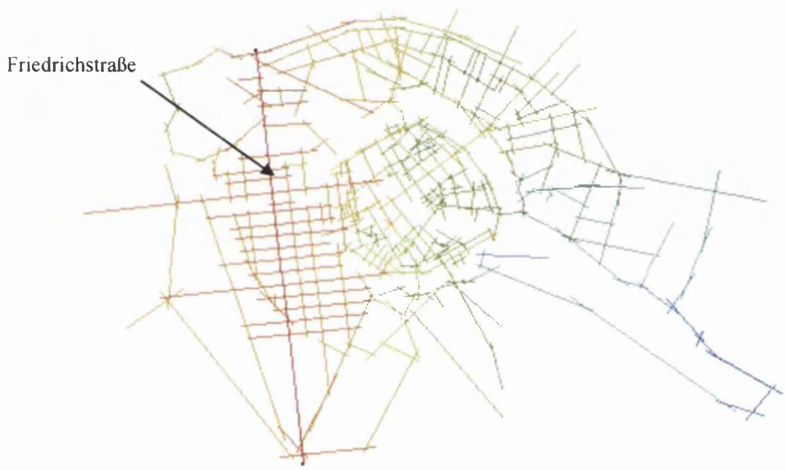


Figure 4.5: Correlation of local and global integration for Berlin Axial Map in 1750

This distinction between Friedrichstraße as the most locally integrated line and Rathausstraße as the most globally integrated marks one of the first major morphological shifts in the structure of the city caused by the form of expansion. Axial Map 4.7 and Axial Map 4.8 below highlight this difference in the structure by showing the step depth of the rest of the settlement from the local focus of Friedrichstraße and the global focus of Rathausstraße. From Friedrichstraße the whole of the new Friedrichstadt area is highlighted (owing to its very high connectivity and the fact that it transverses the whole grid). Whereas depth from Rathausstraße highlights the geographically much smaller area of the original settlement inside the old wall. Rathhausstraße's global importance came from its bridging role across the river, but ceased to be so significant as the morphology grew westwards without prioritising this link.



Axial Map 4.7: Step Depth from Rathausstraße in 1750



Axial Map 4.8: Step Depth from Friedrichstraße in 1750

By 1750 a clearer spatial differentiation in land uses is visible, as shown in Map 4.5 below. The area of urban expansion to the West (Friedrichstadt) is shown as a mixed use area. However, a large border of pink coloured residential areas on the Western side can be seen within the customs wall that replaced the older fortifications close to the main entrances of Potsdamer Platz and the Brandenburg Gate. Within the larger agricultural areas left inside the customs wall to the East, the settlement can be seen to have expanded in a very linear way, along the roads that lead to the other gates. These are also the trade routes to other settlements Eastwards, such as Frankfurt am Oder. Industrial expansion extended along the Spree river to the East, reflecting the importance of the river for freight haulage. This industrial area to the south east is in the most segregated part of the axial analysis of Axial Map 4.5 above.

Map 4.5: Land Use 1750 Berlin

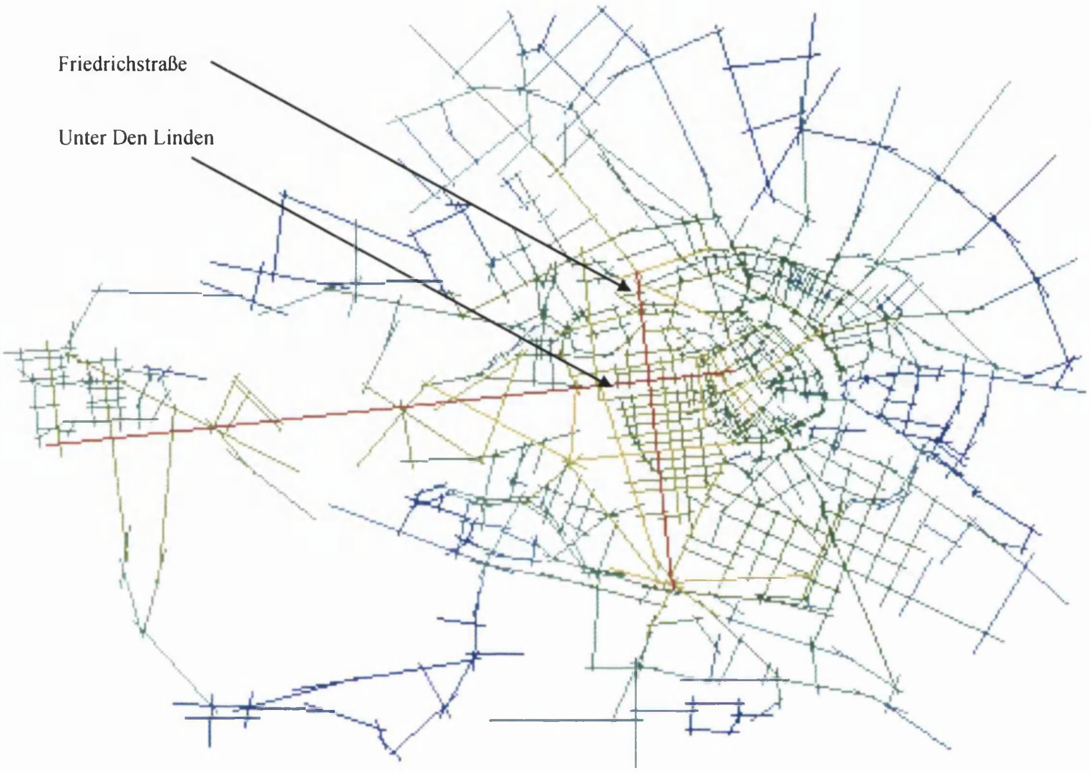
(Aust 1986) For Legend see Table 13.1 in Appendix D.

Map 4.6 of Berlin in 1850 (Sineck 1856) shows the pattern urban settlement on the verge of the rapid industrial expansion that was to create the metropolis. With the Zollvereinigung (Customs Union) of German provinces in 1848 the customs wall was no longer necessary. This political change was part of the nascent industrialisation of Germany that led to rapid urbanisation, particularly of the main centres such as Berlin. It also facilitated the first phase of urban growth unhindered by an outer wall. The extension of the settlement around Potsdamer Platz and along the Potsdamer Straße is highlighted. Settlement also continued westwards, beyond the Tiergarten park, around the Charlottenburg castle.

The Leipziger Platz Octagon was conceived as a market area to move trade in agricultural goods out of the inner city (Balfour 1990). This function never took hold in the Octagon, although the Potsdamer Platz, just outside the wall did have a market function even from early times as the point where the various trade routes to the South West met at the boundary between city and countryside.

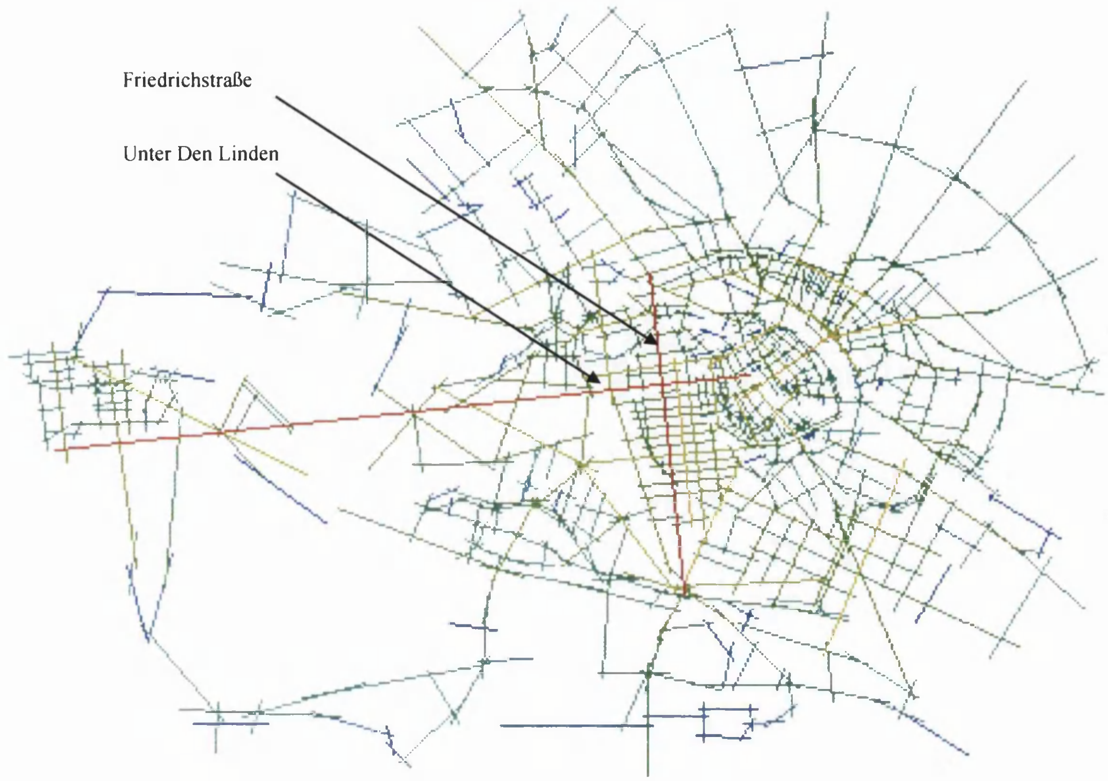
Map 4.6: Sineck's 1856 Map of Berlin
(Sineck 1856)

The axial analysis of the 1850 settlement pattern shows that the relation of global to local has again changed. The expansion of the city Westwards has shifted the core out of the old town completely, as can be seen by Axial Map 4.9 below of global integration in 1850. Rathausstraße was no longer the most globally integrated link by this point. Friedrichstraße and the Unter den Linden axis had become by far the most globally and locally integrated lines.



Axial Map 4.9: Global integration of Berlin in 1850

The large gaps in the settlement morphology are between the outlying villages and settlements that were just becoming unified in a continuous urban system. At this early stage the outer settlements were highly segregated within the overall system. Indeed it seems a character of the 1850 analysis that the disparate individual settlements brought together as one has prioritised Friedrichstraße and Unter den Linden as the only main routes that hold the whole together. Axial Map 4.10 below of local integration shows the predominance of the two main axes within the local structure of the city. In the correlation of the local and global integration values shown in Figure 4.6 below, the difference between the rest of the city and these two highly integrated lines has been highlighted.



Axial Map 4.10: Local integration of Berlin in 1850

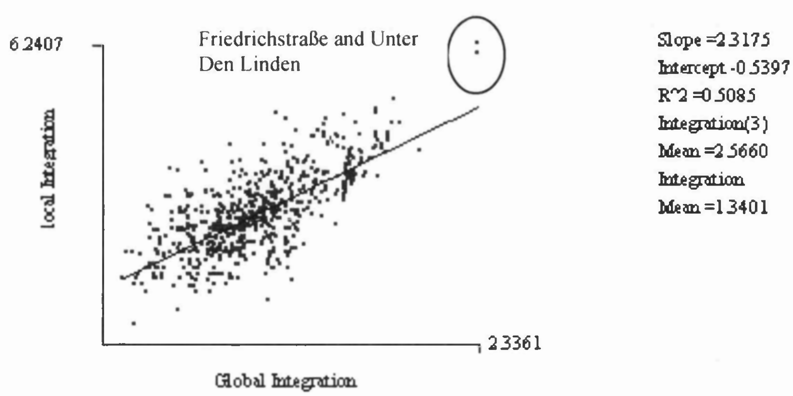


Figure 4.6: Correlation of local and global integration for Berlin Axial Map in 1850

Map 4.7 shows the pattern of land uses in 1850. The pink expansion of residential uses outside the former customs wall at Potsdamer Platz is highlighted. The maps shows that riverbank sites continued to provide the location for heavy industry as the city expanded, for example Borsig began building steam locomotives on a riverbank site in 1841, replacing the British imports. Berlin was a key engine for this kind of import replacing industrialisation in Germany and this is reflected in the presence of major industrial firms in Berlin such as Borsig.

Growth of Berlin by 1850 had extended far enough to reach a critical turning point in the morphology of the city- the inclusion of formerly independent outer settlements. Although the earlier growth had accommodated small settlements outside the city walls, by 1850 growth has extended the urban fabric more or less continuously to the royal town of Charlottenburg and the old villages such as Kreuzberg, and Schöneberg. The outer settlements are highlighted in Map 4.7. Charlottenburg had grown around the other palace of the Hohenzollern and was the most significant of these outlying settlements. The two palaces had always been linked to the city through the royal hunting grounds of the Tiergarten, although this park area formed a block between the two settlements. By 1850 the park was still a barrier but the 'royal axis' of Unter den Linden extended through the park providing a direct route through the park. Settlement to the North also linked the built form of the two towns.

Map 4.7: Land Use 1850 Berlin

(Aust 1986) For Legend see Table 13.1 in Appendix D.

4.5 Industrialisation and the First Central Business District

In order to govern the rapid expansion of Berlin with industrialisation during the second half of the nineteenth century an extensive plan for spatial growth was created by Hobrecht (Hobrecht 1862). Map 4.8 below shows the Hobrecht Plan overlaid on the modern city as it developed. This was very clearly a plan for growth, extending the major route structure by creating long radial streets out from the centre and semi-regular small grids to fill in areas between the peripheral settlements. New streets were planned for a much larger capacity than in the old city (25-39m wide). The block structure was unusually large with dimensions of 200 by 300 or 400m and around 100m to 200m deep plots (Newman and Thornley 1994). The plan remained in force until 1919 and had a tremendous influence on the urban form.

Map 4.8: Hobrecht Plan
(Aust and Stark 1987)

Map 4.9 shows the expansion of the city in 1880 under the influence of the Hobrecht plan. Despite some key differences (such as the breaking of a major planned East-West axis South of Tiergarten) the city expanded largely within the constraints of Hobrecht's main route structure. However, although expansion did not violate Hobrecht's route structure, the order in which plots were filled and the land uses that became attributed took on a pattern that was not uniform and did not progress radially out from the existing settlement. The built form extended first between Berlin and Charlottenburg, as shown in the pink areas of residential expansion south of the Tiergarten around Potsdamer Platz in Map 4.9.

Map 4.9: Land Use 1880 Berlin

(Aust 1986) For Legend see Table 13.1 in Appendix D.

The land use map of 1910 (Map 4.10 below) shows a significant change in the land use classification. By 1910 the land use pattern shows the emergence of what could be called a 'Central Business District' where a clearly visible core of commercial buildings are clustered. This area, which came to be known as Mitte, was concentrated on the grid of Friedrichstadt but also extended linearly out along important routes such as the Potsdamer Straße West of Potsdamer Platz and encompassed Alexanderplatz to the East of the historic centre.

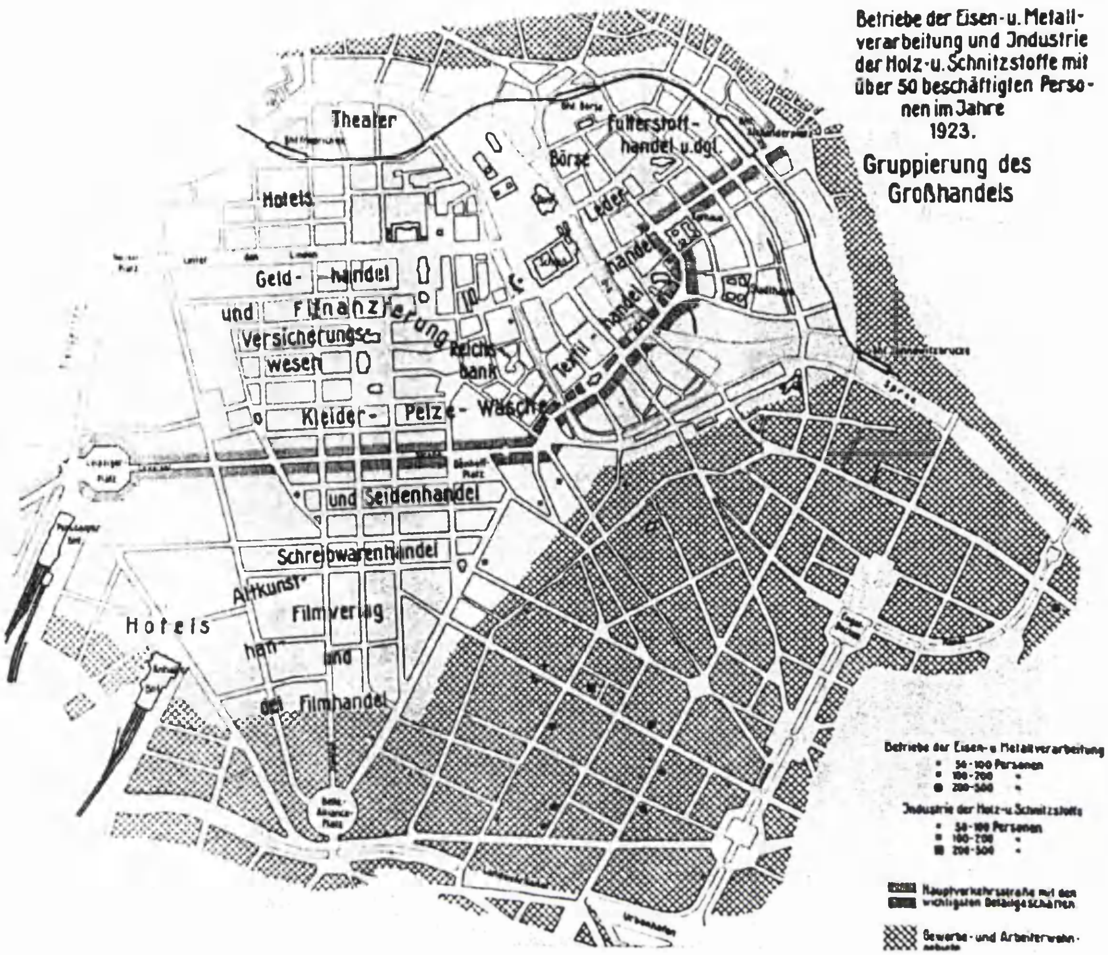
Map 4.10: Land Use 1910 Berlin

(Aust 1986) For Legend see Table 13.1 in Appendix D.

The development of a central business district in Mitte involved not only the change in primary users with the expansion of the city around this core but also the changes in building type with redevelopment. The German geographer Louis described this process in the 1930s:

> (Mitte) had long been abandoned as a place of residence by members of the official caste, who had moved westwards, and since about 1860 it had also been loosing its characteristic lower-middle class inhabitants through transformation into part of Berlin's urban core. Only a few fringe areas were still essentially residential; otherwise the inner city had been invaded by uses such as shops, offices, warehouses, and workshops, as well as by the characteristic small cafes serving the workers. The process was reflected in urban morphology; the two or three storey houses built in the seventeenth, eighteenth and early nineteenth centuries...had been partially replaced by purpose built commercial buildings.
>
> (Louis 1936) translated by (Elkins and Hofmeister 1988, pg. 158)

Within the CBD, particular agglomerations of more specific functions came into being. These were not actually mono-functional areas, they were clusters of certain types of commerce or office uses along particular streets. Map 4.11 from 1923 shows street clusters such as the money and finance institutions along Behren Straße and the film industry in the southern Friedrichstadt. Retail is shown to have concentrated linearly along the 'main traffic route with the most important detailed (sic) shops' (quoted in Helmer 1985) leading East from Potsdamer Platz along the Leipziger Straße and up to Alexanderplatz. Large department stores developed along this main route, the most famous of which were the Wertheim stores on Potsdamer Platz and Leipziger Platz.



Map 4.11: Commercial land uses within the Mitte District in 1923

(Helmer 1985)

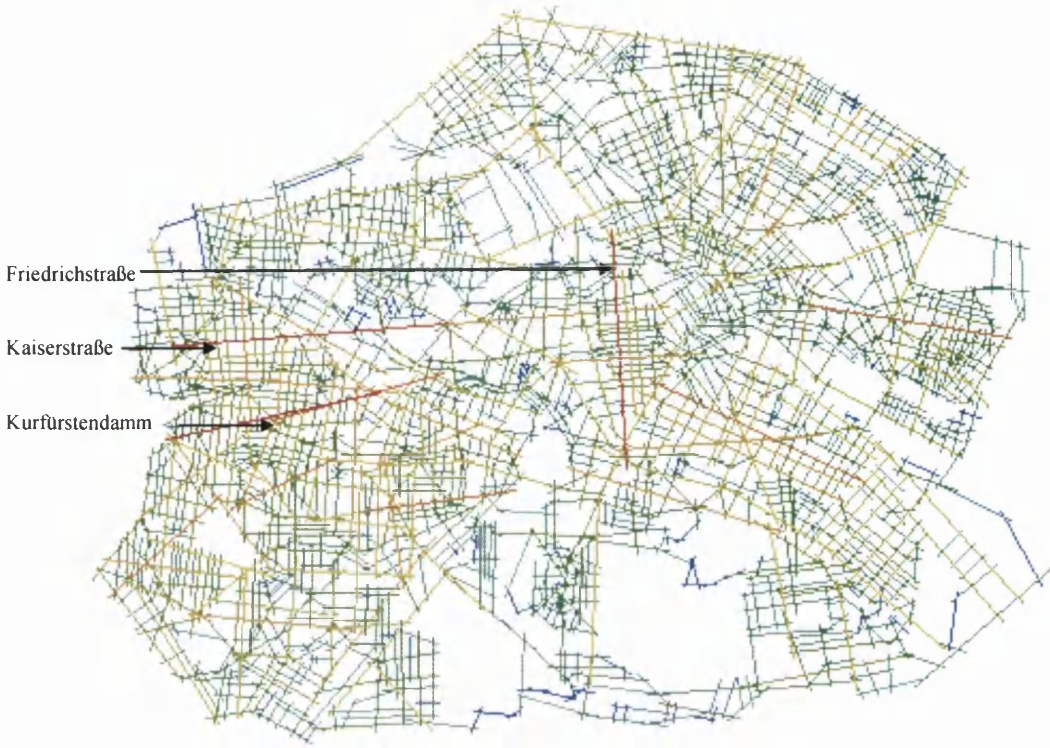
Axial Map 4.11 of global integration in 1940 shows the integration structure of the city as it had filled the area of the Hobrecht Plan[16]. The global integration core of the city is very clearly in the Stadtmitte area with the three lines of Friedrichstraße, Unter Den Linden and Leipzigerstraße as the most important routes. This clearly mirrors the area that had become the CBD: the pattern of global integration picks out exactly the concentration of commercial uses.

Axial Map 4.11: Global Integration of Central Berlin in 1940 (originally from Walter 1993)

Axial Map 4.12 of local integration in 1940 shows the predominance of a number of locally important lines in sub-areas of the city. The scale of the city in 1940 has led to the development of a much larger number of local integration hotspots that are both geographically disparate from one another and lie outside the global core. Friedrichstraße is still the most integrated on this measure, but it is notable that Kurfürstendamm is very important in the local sense as are the other radial axes of the Hobrecht plan. These radial axes form the key lines in the local district centres in Berlin and share a morphological characteristic that the axial analysis highlights: they provide the links across the spatial barrier of the S-Bahn ring. Like the bridges across the river in early Berlin and the gates

[16] This axial map was drawn by Ralf Walter for an MSc thesis (Walter 1993). All other axial maps were created by the author.

to the customs wall, these radial lines are almost without exception the only lines that link inner Berlin to the settlement outside the S-Bahn ring.



Axial Map 4.12: Local Integration of Central Berlin in 1940 (Walter 1993)

Figure 4.7 below shows the correlation between local and global integration for the axial map of Berlin in 1940. The most integrated lines (Friedrichstraße, Unter Den Linden and Leipzigerstraße) are no longer major outliers as they were in Figure 4.6 of the relationship in 1850. Interstitial axes have filled in the empty spaces between the settlements that these major lines connected and created a more even transition between the most integrated spaces to the lesser ones.

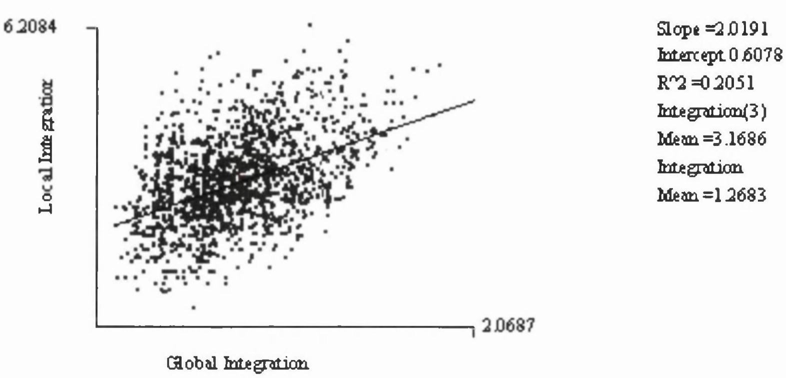


Figure 4.7: Correlation of local and global integration for Berlin Axial Map in 1940

Map 4.12 of Berlin in 1940 shows the pattern of land use at the high point of the city's population. The Central Business District of concentrated core functions that had developed since the late nineteenth century stabilised in the area of 'Stadtmitte' (also known as 'Mitte'). This area extended from the old historic centre in the East to the Potsdamer Platz and was concentrated around Friedrichstraße in the Friedrichstadt area. There is a clear correspondence between the concentration of core uses in this area and the most integrated area of global integration that was shown in Axial Map 4.11 above.

Map 4.12: Land Use 1940 Berlin

(Aust 1986) For Legend see Table 13.1 in Appendix D.

The most notable development of commercial land uses outside this CBD is the extension of retail in the West of the city. Whereas office concentrations seem to have been confined to the main streets of the CBD, the concentration of retail uses occurred on main streets far outside the central business district. These streets upon which continuous shop frontage developed are also those that were shown to be highly locally integrated in the analysis of Axial Map 4.12 above. The Kurfürstendamm is particularly notable as both an highly locally integrated line and a main shopping street[17].

The Kurfürstendamm was a focus for a concentration of retail, especially at its western end around the Gedächniskirche church. More exclusive retail such as the Kaufhaus Des Westens on Joachimstaler Straße developed in this western area. It was the area of shops, fashionable cafes and entertainment facilities that catered for the higher class housing West of the Tiergarten. Whereas Potsdamer Platz was infamous as the area of illicit clubs typified by the image of Berlin in the Weimar years, the Gedächniskirche area was seen more as the place for respectable nightlife:

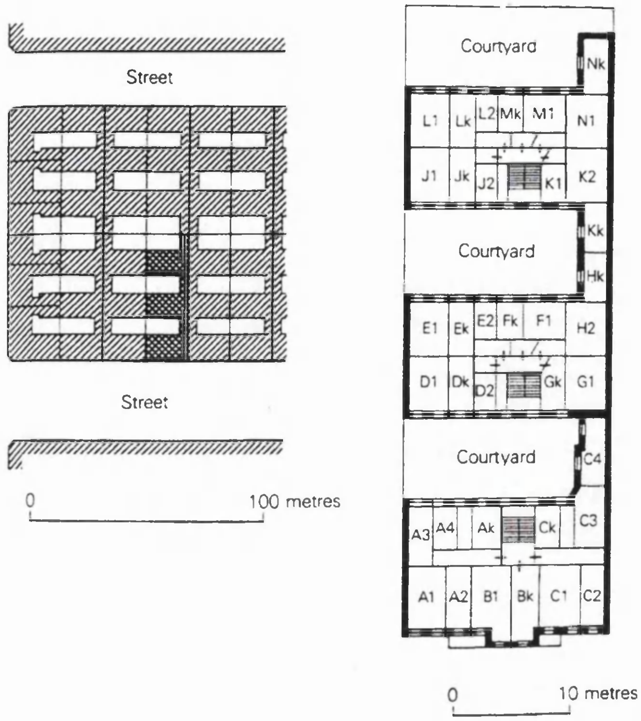
> Its silhouette is lit up at night by the glare of the illuminated advertising signs. From the late afternoon until long after midnight it is encircled by an unbroken stream of traffic. Cinemas, dance halls, cabarets, restaurants, smart shops, and miscellaneous places of entertainment are grouped round the church and have overflowed into the neighbouring streets, notably the wide Kurfürsten-Damm.
>
> (Bädecker 1936:16, translated by Elkins and Hofmeister 1988, pg. 28)

4.5.1 Building Design, Rent and Mixed Use in Berlin

Along with the development of the CBD, the expansion of Berlin from the late nineteenth century shows a massive surrounding belt of pink residential areas- the new housing of the 'Grunderzeit' (the foundation years) built by speculative developers. These blocks were built to a much higher density than originally foreseen by the Hobrecht plan. The Hobrecht streets were only supposed to form the main route structure with local internal routes inside the main blocks. However, the blocks were developed to the maximum density allowed by the Bau-Polizei Ordnung- which ruled that 2/3 (in central area3/4) of plot could be built up. The size of interior court was kept as small as regulations would allow (28.5m^2 upto 1865 and 80m^2 by 1897) and eaves heights were determined by the capabilities of fire engines (5 floors). This was the development of the characteristic Berlin blocks known as the 'Mietskasernen' ('rent barracks'), an example of which is shown in Map 4.13 below. During the peak years of growth in the early twentieth century residential densities in excess of 1000 per hectare were recorded in such blocks (Leyden 1933).

---

[17] So whereas the concentration of commerical uses is in the core of global integration, retail is visible both on the streets of the most globally integrated lines but also on locally integrated lines outside the CBD, such as Kurfürstendamm.



Map 4.13: Typical 'Mietskaserne' Block Structure
(Elkins and Hofmeister 1988)

Yet the classification of the blocks as 'residential' hides the well-known mixture of uses typical of these areas in Berlin. Along with very dense residential use, there were a large variety of other uses in the blocks. The so called 'Hinterhof Industrie' (back courtyard industry) in Berlin was based in these blocks of the Wilhemenian expansion, where deep internal courtyards offered low rent space for small scale manufacturing. Along the street frontage there were also typically a large number of shops and cafes, to some extent reflected in the designation of continuous shop frontage along the main radial streets shown in the land use maps (see the area highlighted on Map 4.10 above).

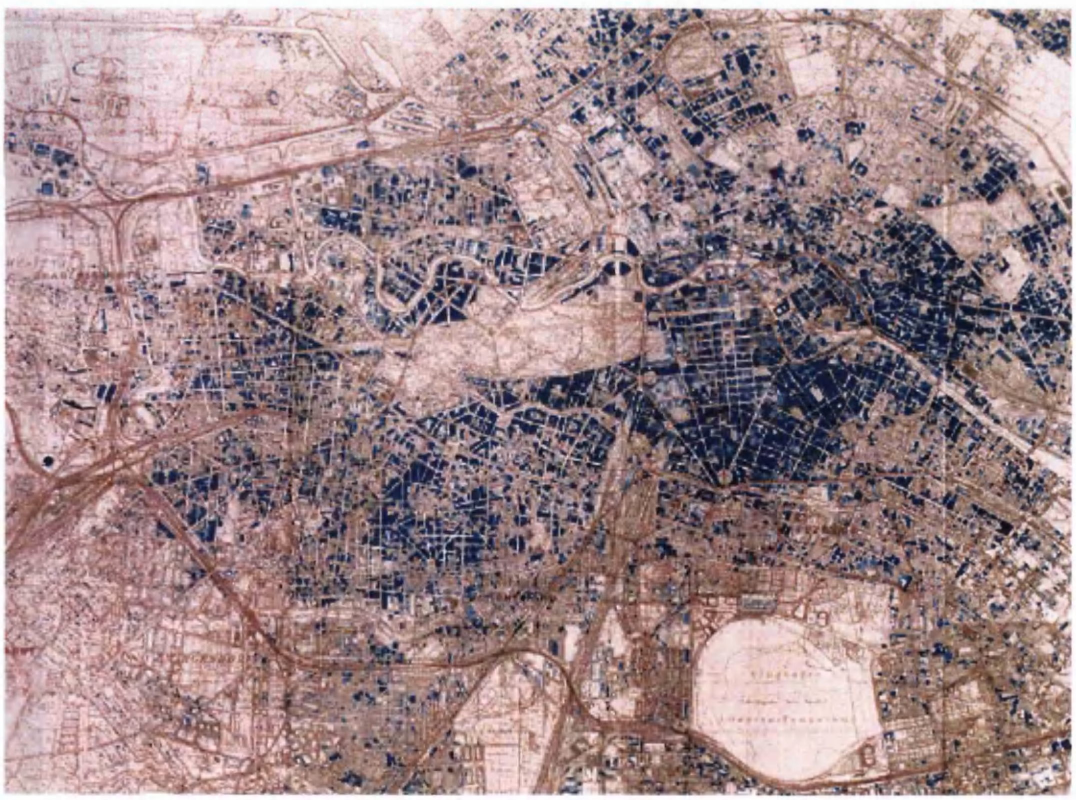
There is evidence that the deep blocks in Berlin with multiple internal courtyards led to large differentials in rents within very close proximity. These rent differentials were spatially organised by the distance of the unit from the street. They were significant because they led to a wide variety of land uses within single plots that was to be a lasting characteristic of the city:

> A survey of thirty-five blocks in Kreuzberg, carried out in the early 1960s in advance of urban renewal revealed that on an area of 107 hectares there were, in addition to 37,000 inhabitants, no fewer than 2,714 distinct places of employment, with 19,400 employees occupied in hundreds of different trades. Small firms were attracted by the low rents charged in these interior courts, while 60 per cent of their employees lived close enough to walk to work ... from about 1890 this location of manufacturing had come to be accepted as normal to the extent that purpose-built 'rent factories' were established in the inner courts
>
> (Elkins and Hofmeister 1988, pg. 126)

Thus the rent barracks actually had a significant interior structure that differentiated rent values and therefore land uses relative to the street, all within a single building plot.

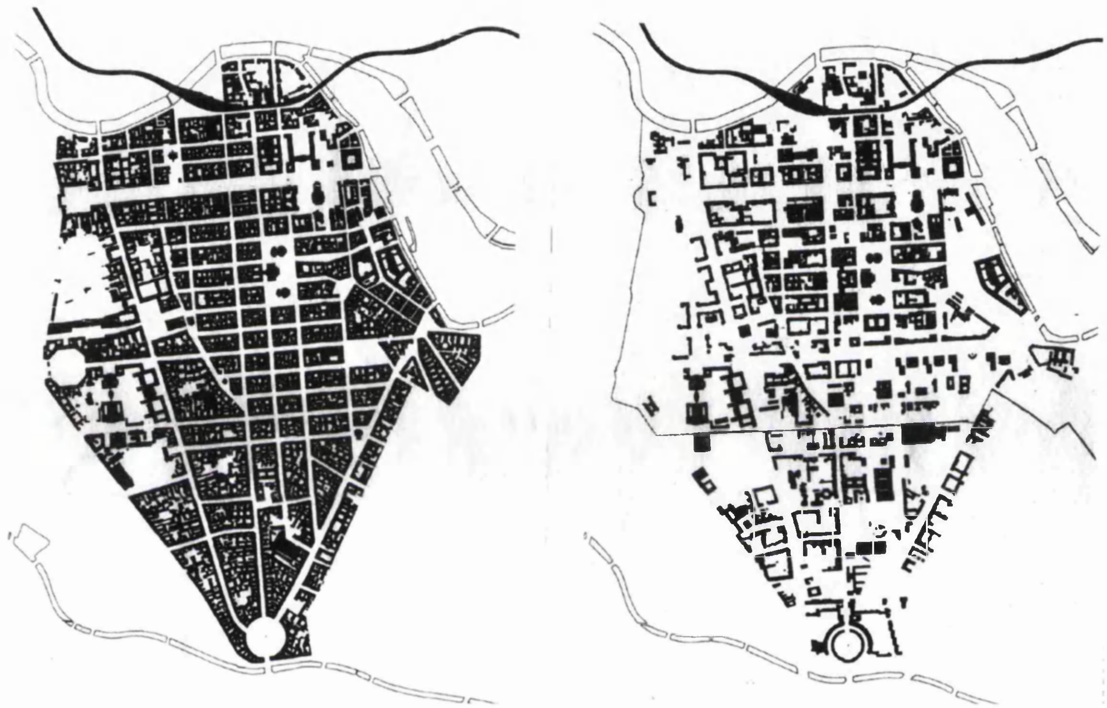
4.6 Divided Berlin

The complex pattern of commercial land uses that had evolved in the centre of the city by 1940 was more or less completely destroyed by the war, as can be seen by the destruction of buildings shown in Map 4.14 below. The effect of heavy bombing combined with the street fighting of the final battles led to very severe damages to the built form. The concentration of destroyed buildings in the centre resulted in what was known as the "dead eye of city". West Berlin's industry, which had already lost about 23% of its pre-war capacity through wartime destruction, lost a further 53% (or 70% of what remained) through Soviet dismantling in 1945 (Elkins and Hofmeister 1988). During the following blockade, West Berlin industry almost ceased to function, and emerged economically crippled as the Western island cut off from former markets and suppliers in its surrounding areas that were the Eastern Zone. By 1989, only 7 of the top 500 German industrial and service sector firms had their headquarters in Berlin (Ring 1992).



Map 4.14: Damaged and Destroyed Buildings 1945 Berlin
(Aust 1986)

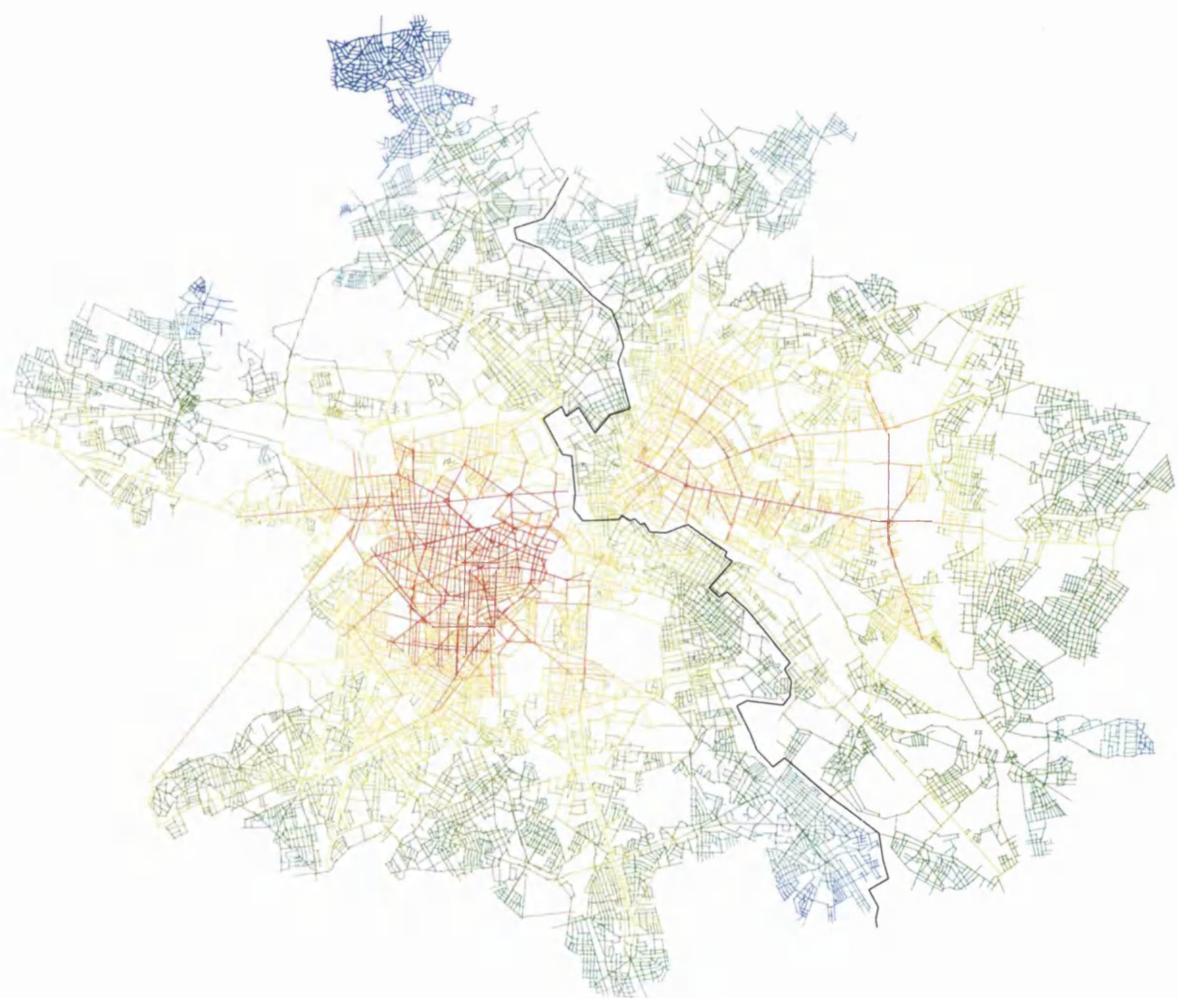
The effect of the war on the former CBD in Mitte is clearly visible in the comparison of built area in 1940 and 1989 shown in Map 4.15. Many buildings in Mitte destroyed during the war were left empty throughout the entire period of division. Some of these lots had been redesignated as green spaces by the East German planning authorities, partly a consequence of lack of resources but also legitimised as planning policy. On the West Berlin side of the wall in Kreuzberg densities were similarly low.



Map 4.15: Built form in Mitte in 1940 (left) and 1989 (right)
(Bauwelt 1991)

The radical spatial effect that the building of the wall had on the structure of the city can be seen in Axial Map 4.13 below of global integration in 1986. This analysis shows the unusual phenomenon of two cities (West and East Berlin) adjacent to each other but operating as two separate systems. The core of the city has shifted out of Stadtmitte to two new centres: one in the West around the Bahnhof Zoo/ Kurfürstendamm area and the other in the East on radial lines to the East of the historic core, especially the Frankfurter Allee.

The analysis also shows that areas along the wall are highly segregated despite their geographical centrality. This is particularly clear for the West Berlin areas of Kreuzberg and Wedding because the '*C*' shape of the wall created areas bounded on three sides and thus broke the majority of global links to the city that these areas had. These areas were locally integrated but had become very segregated globally, as can be seen by their blue colour in Axial Map 4.13 below.



Axial Map 4.13: Global Integration of Divided Berlin in 1986

Map 4.16 shows the land use structure in 1986, as it developed after the building of the wall in 1961. A new concentration of core uses is shown in West Berlin around the Gedächniskirche and Kurfürstendamm. The move of the central business district of Berlin from Stadtmitte to the Bahnhof Zoo area of West Berlin during division very clearly mirrors the shift in global integration that occurred with the division of the city, as was shown in Axial Map 4.13 above.

Map 4.16: Land Use 1986 Berlin (wall highlighted)
(Aust 1986) For Legend see Table 13.1 in Appendix D.

This West Berlin CBD developed relatively quickly after the Second World War. In the turbulent period of the 1950s there were little resources for major planning strategy and apart from some intervention later in the 1970s (pedestrianisation and traffic re-routing) the centre had developed in a relatively unplanned fashion. Map 4.17 shows the extent of the CBD, which formed a triangle shape around Bahnhof Zoo. This triangular area is the same as the concentration of red, globally integrated lines that form the global integration core of West Berlin in Axial Map 4.13 above.

Map 4.17: West Berlin CBD in 1986

(Aust 1986) For Legend see Table 13.1 in Appendix D.

As well as the new commercial centre, West Berlin had the extraordinary phenomenon of the 'Inner city fringe' area along the wall. These were areas of previously very commercial land uses that were now far from the CBD. In residential areas near the wall the huge drop in housing rents led to a very different population mix- typified by groups that were socially excluded. Kreuzberg became the centre for German 'alternative' culture- famous for anarchist groups and the squatter movement that filled the empty flats of the *Mietskaserne*. Neukolln and Wedding became areas of concentrated 'Gastarbeiter' (Turkish 'Guest workers' who were not given German citizenship and their immediate families). The main commercial streets near the wall fell into disrepair. Potsdamerstraße, which used to be the main route into Potsdamer Platz now led only to the edge of the wall and became notorious for prostitution and narcotics. These West Berlin areas of 'inner city fringe' uses correspond very closely to the central areas that had been segregated by the wall, as was shown in Axial Map 4.13 above.

The development of land uses in East Berlin where no commercial market in property existed was quite different, as market forces did not determine new building function. The effects of central planning are discernible in the land use pattern of East Berlin shown in Map 4.18. A huge decrease in core uses in Stadtmitte is visible. This was partly a legacy of the loss of building stock in the war (resources were not available to rebuild much of the empty plots). It was also partly a result of the loss of land to the wall itself and of the deliberate policy to prioritise housing over other uses. The reappearance of housing in Stadtmitte is seen in the pink blocks especially along Leipzigerstraße. The major redevelopment of a retail and entertainment 'civic centre' was at the Alexanderplatz, completed in the 1970s.

The location of the Alexanderplatz civic centre is notable within the pattern of global integration shown on Axial Map 4.13 as the intersection of the main radial lines East (Frankfurter Allee and Greifswalder Straße). These had become two of the main globally integrated lines in the spatial structure of East Berlin.

Map 4.18: Mitte in 1986

(Aust 1986) For Legend see Table 13.1 in Appendix D.

4.7 Main Findings of the Historical Analysis

The spatial analysis of Berlin's development has shown that the spatial structure of the street system changed significantly as the city grew. Rather than just adding to an existing structure, the physical growth of the city repeatedly led to a shift in the location of the *spatial core* of the most integrated lines. This changed the whole global structure of the system, effectively moving the centre of town in morphological terms. The first major global shift occurred when the core moved West out of the historic town into the Friedrichstadt area during the nineteenth century. This was seen in the difference between Axial Map 4.5 of the global structure in 1750 (on page 131 above) and Axial Map 4.9 of the global structure in 1850 (on page 137 above). The second major change occurred with the division of the city, where the core of Berlin in Mitte (shown in Axial Map 4.11 of the global integration of 1940 on page 145) shifted out to two new centres in West and East Berlin (Axial Map 4.13 on page 153).

As the spatial structure of the city changed, the pattern of land uses *reorganised* around the changed structure. This can be seen repeatedly in the move from residential uses to commercial uses of buildings in areas that became more spatially strategic over time. The residential buildings that were the basis of the Dorotheenstadt and Friedrichstadt areas of urban expansion were replaced by commercial uses when these areas coalesced as the Mitte area upon which the Central Business District was built. The residential areas in Charlottenburg were converted first into the entertainment and retail functions of a local centre and then into the office functions of a CBD with the major spatial change that occurred with the division of Berlin.

The reorganisation of land uses shown in the historical development is evidence of a long-term relationship between the pattern of global integration and the pattern of land uses. In particular, there appears to be a strong match between the global integration of the urban street network and the location of the CBD. Office uses are concentrated in the most globally integrated lines. Retail uses on the other hand, developed on those streets that were shown to be important within the pattern of local integration. This is particularly the case for the most important retail street of Kurfürstendamm.

4.8 Discussion

The findings of the historical development of Berlin's urban morphology presented in this chapter point to a relationship over time between the spatial structure of the city as a whole (measured by global integration) and the concentration of commercial land uses. What can this evidence lend to an understanding of rent?

The literature review showed that there is a well established relationship between the location of the CBD and the point of highest land values. Indeed this relationship is the basis for the use of distance to the CBD as a spatial variable in previous studies of rent. Insofar as property development takes place within a capitalist market this relationship should hold true, as any concentration of land uses within the city should be a reflection of the market mechanism whereby the higher rent price attainable at certain locations attracts development preferentially over other locations, leading to concentration. According to secondary sources, this was also empirically the case over Berlin's historical development. During the period of division, office rent values were highest within the CBD where the concentration of office land use was most pronounced (Elkins and Hofmeister 1988). This relationship between rent and land use concentration means that any understanding of rent patterns ought to be able to account for the pattern of land uses that emerged in Berlin.

The key finding of this chapter is that not only is there is a relationship between the spatial structure of the city and the pattern of land uses over time, but morphological change actually *predates* changes in the pattern of land uses. This has a number of consequences for the understanding of rents. The reorganisation of land use patterns around a changed spatial structure implies that there is something in the *potential* of locations given by the spatial structure of the city itself that can lead to advantage to certain land uses. What is the potential that comes from the spatial structure and how does this relate to rent? This is a phenomenon that can be tested in other cities, and the evidence of this finding can be used as the basis for a theoretical debate about the role of location in cities (see the discussed in section 2.9 of the literature review). A process has been isolated in the relationship between land use and spatial structure. The historical development of other cities can now be tested to see if the same process is found.

For the pattern of retail uses, the movement economy theory outlined in section 2.6.4.2 of the literature review would appear to provide a very satisfactory framework for understanding the potential of locally integrated streets that led to a concentration of retail uses on them. Previous research has found that the pattern of local integration is a good predictor of pedestrian movement in a number of cities (see page 15 above). Assuming this were also the case in Berlin, then streets that became locally integrated as the city developed offered a large pedestrian flow of potential customers for retail. This would increase the potential rental value of buildings on those streets for retail use because there is a higher potential return to retail from locations with more pedestrian flow. This in turn would act as a price incentive for owners or developers to convert buildings on those streets to retail, regardless of their previous use. This would lead to just such a concentration of retail uses on locally integrated lines found in Berlin and predicted by the theory of the movement economy.

However, for office uses, the pattern of concentration is related much more to the global structure of the city than to local streets with a high potential flow of pedestrians. Offices have concentrated in the most globally integrated area of the city and when the integration core has changed, the location of the CBD has changed too. This relationship is not as easy to explain with the mechanism posited by the existing theory of the movement economy. Given that the global integration core is the most accessible area of the entire street grid, it might be reasonable to argue that this area is where more movement from all origins to all other destinations in the city may take pass through. This suggests that the location of offices is more linked to the location of everything else: the city as a whole rather than local movement routes[18]. At this juncture, the important point is the isolation of a process: the concentration of commercial land uses follows urban spatial structure as the morphology of the city changes, rather than leading it. This has not previously been explicitly stated in previous studies, although it does explain why the distance from the CBD can be used as a proxy for a generalised location measure, as it has been in previous studies.

However, the case of Berlin shows that the location of the CBD can change radically even over relatively short periods of time, as it did after the division of the city. This provides a difficult problem for rent theory, as distance from the CBD has been the most frequently used proxy for the pattern of office rents. If distance from the CBD is a good proxy for office rents in Berlin, and the CBD is itself organised around global integration, then it follows that the pattern of rents should be organised around the pattern of global integration. Indeed, insofar as the development of land uses in Berlin took place within a market economy, office rent values would have to be highest in CBD because rent value

[18] The discussion of this result is picked up and expanded substantially in the concluding chapter.

is the market mechanism that allocates office uses towards any particular concentration, just as it does for retail.

The historical evidence from Berlin has shown that it is not tenable to assume a constant position of the Central Business District as the city grew and changed. The location of the CBD is actually *dependent* on the changing pattern of global integration of the city. The consequence of this for rent theory is that distance from the CBD cannot be treated as an *independent* spatial variable to explain rent patterns. If the relationship between the location of the CBD and rental patterns holds in Berlin, then the pattern of global integration can be assumed to determine both these spatial patterns (the pattern of office rents and the concentration of office locations). In order to investigate this idea, the next chapter looks at contemporary rent patterns within a spatial analysis of the new city of reunified Berlin after the wall fell.

4.9 Summary

This chapter has undertaken a spatial analysis of Berlin's development for the period from 1650 until 1989. As the city grew, its morphology was shown to have changed. Changes in the pattern of global integration showed a shifting of the spatial core of the city with key phases of urban growth. The two main changes were the shift of the core of Berlin westwards to Friedrichstadt in the nineteenth century and the shift of the spatial core out to two new centres during division, in the West around Bahnhof Zoo and in the East on the radial lines such as Frankfurter Allee.

A relationship between spatial measures of integration and the location of land uses has been observed. The concentration of office uses that formed the CBD was shown to have evolved and reorganised around the changing pattern of integration as the city grew. Whereas the Friedrichstadt area began as a residential extension of the city in eighteenth century, it developed into the core of commercial uses by the late nineteenth century after the core of global integration had shifted to this area. The area around the Gedaechniskirche developed first as a residential area, then an entertainment and retail centre in the early twentieth century. It then became the CBD after the building of the wall shifted the pattern of global integration around this area. The main concentrations of retail are also shown to have coalesced on the most locally integrated streets of the spatial structure.

It has been argued that the changing location of the CBD in Berlin, following changes in global integration, makes the use of distance from the CBD as an *independent* spatial variable in rent studies very problematic. This measure itself is determined by the changing spatial structure of Berlin and, consequently, it is the spatial structure that may be assumed to underlie rent patterns themselves.

In the next chapter the analysis of urban morphology moves from historical development to the contemporary city after the wall. For this period rent data is available and the first stage of analysis of the relationship between the spatial structure of Berlin and the pattern of rents will be presented.

5 URBAN SPATIAL STRUCTURE AND THE PROPERTY MARKET IN REUNIFIED BERLIN

5.1 Introduction

This chapter has two main purposes. The first is to provide a configurational analysis of the spatial change to Berlin that occurred with reunification, through the use of axial maps. The Berlin wall was opened for East Germans in September 1989 and Germany was officially unified in 1990. The spatial analysis will show how the fall of the wall altered the structure of divided Berlin creating a new configuration of the street system in the reunified city.

The other purpose of this chapter is to investigate whether there are characteristics of the property market in Berlin after the wall that could explain a particular pattern of office rental values. Although the rebuilding of particular sites in Berlin is still taking place, the fundamental spatial change of reunification happened effectively within a period of a few months. In this chapter, the effect that this spatial change had on the organisation of the property market in the years after reunification will be evaluated using available property market data. The analysis of the property market will focus on the office sector to show how the pattern of office rents and the pattern of supply developed within this new urban morphology. As recession had hit the construction industry in London and Paris, Berlin was seen as a honey pot for European developers who rushed to fill the huge deficit of modern office and retail space in the first three years after reunification. The recession and restructuring of the office market that followed this short-lived reunification boom will be evaluated from published evidence. In particular, the spatial reorganisation of the property market that took place after the wall will be presented. This will provide the context for the more detailed statistical analysis of the sample of office leases that is the subject of chapters 6 to 9.

Firstly, the morphological change that occurred with the removal of the wall will be presented. Then the development of the property market from the demand and supply side will be outlined. This will show the non-spatial characteristics of the market but will also focus on how the market developed *spatially* within the new geography of reunified Berlin. The relationship between the spatial structure of Berlin, the pattern of rents and the location of office development will be discussed.

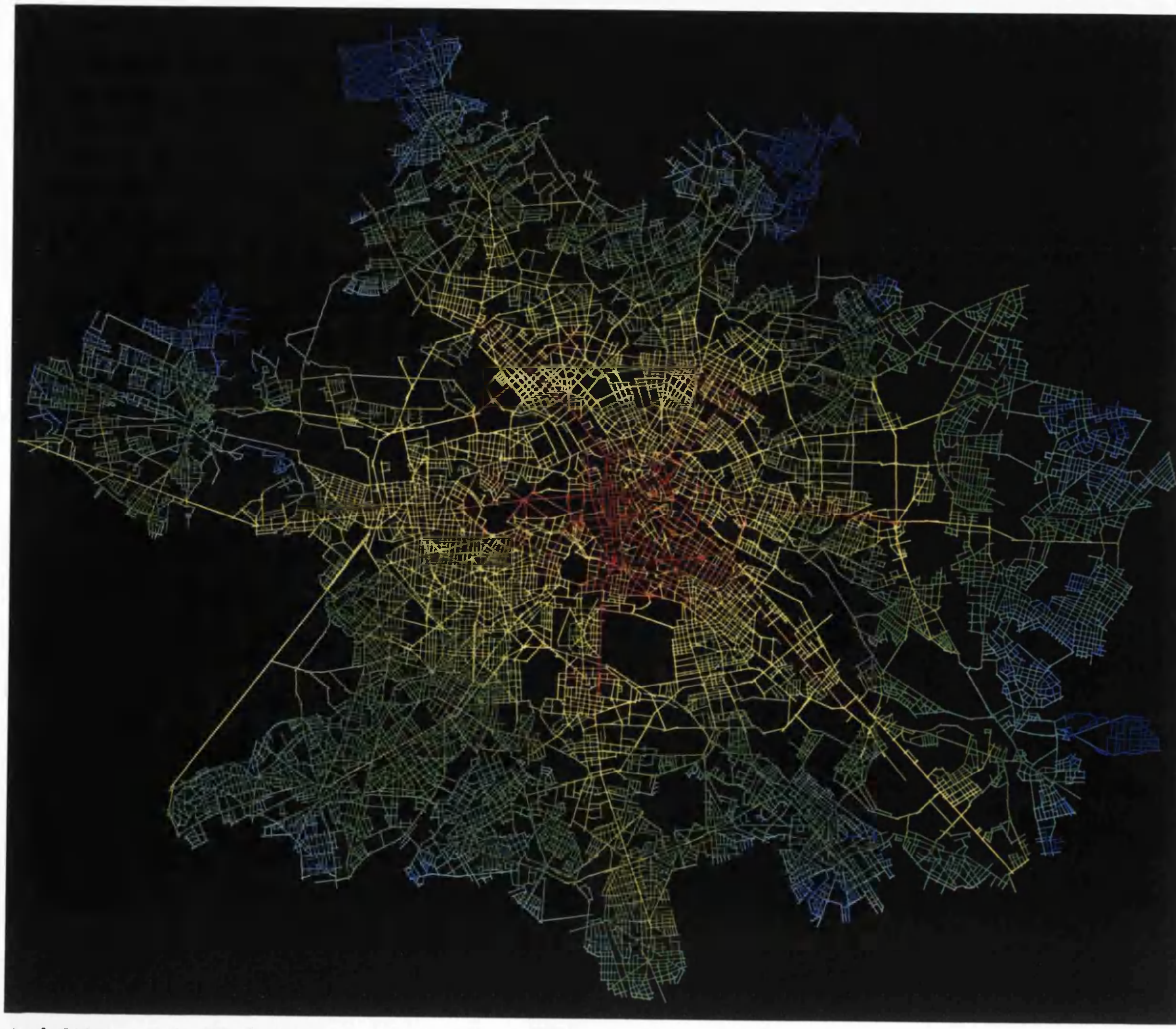
5.2 Spatial Analysis of Reunification

As might be expected from such a fundamental spatial change as the removal of the wall, the space syntax analysis of the reunification of the two halves of Berlin shows a dramatic restructuring of the pattern of global integration. This can be seen in the difference between Axial Map 5.1 overleaf, which shows the global integration of divided Berlin and Axial Map 5.2 which shows the pattern of reunified Berlin. With reunification, global integration shifted to a new core in Mitte, replacing the two global cores of Divided Berlin. Friedrichstraße, Unter den Linden and Leipzigerstraße became the most important lines in the spatial structure.

In a general sense, the shift of global integration to Mitte with reunification is a move back to the structure of Berlin as it had been before the intervention of the wall with division. If Axial Map 5.2 of reunified Berlin below is compared with Axial Map 4.11 of the pattern of global integration in 1940 (on page 146 above), the main characteristics of the pattern of integration centred around Mitte can be seen to have been recreated in the period after the wall. However, some significant changes are visible owing to the urban planning interventions that occurred during the period of division. Alexanderplatz is more integrated relative to the whole city in the analysis of Berlin after the wall than it was in the 1940s, owing to the direct axes from Unter Den Linden and Leipzigerstraße that were created by the East German planning authorities. There are some other important changes to the street layout, especially where rebuilding during division made the recreation of the pre-1945 street grid impossible. The most important example is the Potsdamer Platz.

The shift of the core of global integration back to Mitte in reunified Berlin changed the spatial importance of the West Berlin CBD relative to the city as a whole. In the previous chapter it was shown that the CBD of West Berlin had developed around the most globally integrated streets in the network: around Bahnhof Zoo. In the analysis of reunified Berlin (Axial Map 5.2 below) the spatial core of reunified global integration of lies well outside the West Berlin CBD.

Axial Map 5.1: Global integration of Divided Berlin in 1989



Axial Map 5.2: Global integration of Reunified Berlin in 1999

5.3 Economic Restructuring and the office Market

Having seen the major spatial change that occurred with reunification, we now come to look at how the pattern of rents developed within the new geography of Berlin. In order to understand the development of the property market, it is necessary first to provide an overview of the economic context of its development.

The rise of the office market in Berlin takes place within the context of regional economic restructuring forced by reunification. The Berlin economy has had to move away from a highly subsidised industrial base and a large state sector share of employment that characterised both East and West Berlin during division. Both halves of Berlin were heavily over-industrialised at reunification owing to the sheltering of manufacturing in the East from international competition and the heavy subsidisation of industry in the island economy of West Berlin. Berlin during the study period had above average social security claimants active in the industrial sector (27,5%), above average percentage in the public sector (10,6%) and very few employees in financial services (3,4%) compared to other German cities (Deutsche Bank Research 1997).

Restructuring of the Berlin economy also had to take place within the context of the German economy as a whole. In 1992-1993, the property market was hit by the worst recession since the Second World War. West German output contracted by as much as 2% p.a. depending on which measure was used (Economist Intelligence Unit 1994).

The main characteristic of Berlin's economic restructuring has been the decline of manufacturing and state sector jobs and the rise of services. After reunification, industry in Berlin was affected both by the end of the West Berlin Subvention and the migration of industry to the regained hinterland of Brandenburg. The decline in East Berlin manufacturing employment after reunification was an enormous 77%: from 180,000 in 1989 to 40,000 in 1994. West Berlin manufacturing employment fell 16% from 172,000 in 1990 to 144,000 in 1994 (Ellger 1994). The service sector has grown, increasing demand for offices, but growth in services has not been fast enough to offset the huge loss of jobs in industry. These trends can be seen in Figure 5.1, which shows employment in West Berlin[19]. In 1997 West Berlin unemployment was 15,5% and East Berlin 14.6% (Deutsche Bank Research 1997).

[19] Office employment may have shrunk a little into 1996 according to some sources (Westrup 1998)

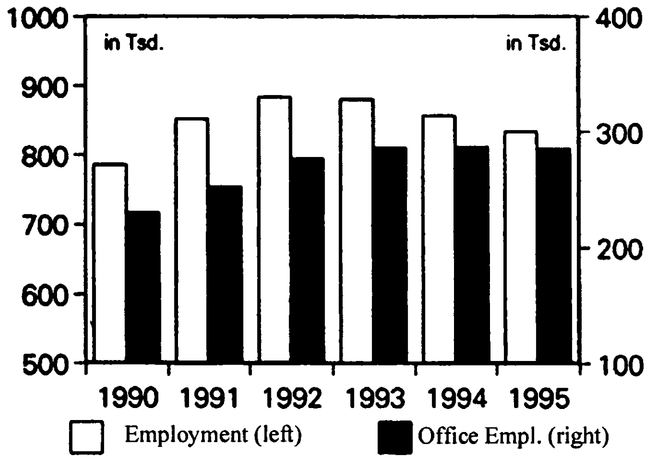


Figure 5.1: Office Employment in West Berlin
(Deutsche Bank Research 1997)

The Eastern half of the city benefited more from investment than the West. Whereas West Berlin 1980-92 growth in gross regional product was 2.7% p.a. (which was better than the West German average), the 1997 West Berlin growth rate was negative (a recession) but East Berlin growth was 6 to7%. Growth in Berlin as a whole is expected at around 2.7% until 2001, slowly catching up with the average for Germany (Deutsche Bank Research 1997).

5.3.1 Suburbanisation and central redevelopment

The regaining of a hinterland has had further effects on the economy of Berlin. As well as loosing industrial employment, the residential market has been affected by a huge development of suburban housing projects, on the cheap land of (formerly East German) Brandenburg around Berlin. The kind of suburban residential development typical of Western European cities in the postwar period was not possible in divided Berlin owing to the Wall. Spatial restructuring has led to a sharp growth in commuting as workers commute out of Berlin to the industrial jobs that have moved to Brandenburg and others commute into Berlin from the new suburban housing (Geppert 1996).

5.4 office Demand Development

Berlin in the 1990s has experienced a short 'boom' and prolonged 'bust' pattern of office rents. The almost complete lack of modern office stock in Berlin combined with a huge interest from German and European companies to establish some presence in the city led to a rapid inflation of rental values directly after reunification. This increased top rents from around the 20 DM/ m^2/ month in 1989 to a peak of around 95 in 1992. This was soon followed by a deep recession. Figure 5.2 shows the average reported top rent (in

DM/m²/month) from a number of Berlin agents reports (Eureal 1994; Jones Lang Wootton 1995; Aengevelt Research 1996; Angermann 1997; Deutsche Bank Research 1997; Müller 1997). The period corresponds well to the points from boom to hesitant recovery in Bond's model of the office market cycle, shown in Figure 2.3 on page 43.

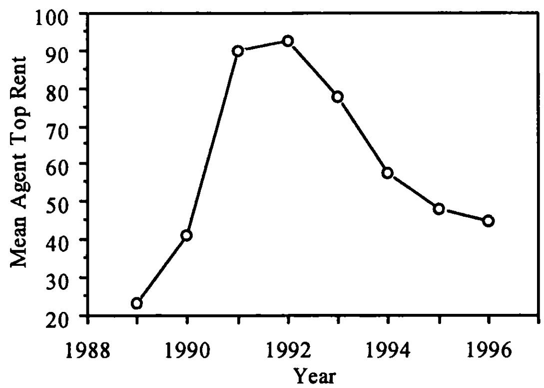


Figure 5.2: Berlin's Post-reunification boom and bust in office rents

Large differences can be seen between the agents' estimates. Engel & Völkers mean rent estimates are especially higher than others. Although the report states mean rents, the levels quoted are similar to top rents. However, for both top rents and mean rents, there is broad agreement that 1992 marked the peak in values and that they fell quite rapidly since that point. Table 5.1 below shows only one exception to this assessment; the agents Engel & Völkers put the peak at a year later in 1993.

Year	Aengevelt Top Rent	Müller Top Rent	Aengevelt Mean Rent	Engel & Völkers Mean Rent
1988		20		
1989		23		21
1990	32	50	20	23
1991	80	100	40	50
1992	100	85	40	60
1993	90	65	34	80
1994	60	55	30	50
1995	46	50	27	50
1996	45		26	38
1997				

Table 5.1: Top and mean rent estimates

Sources: (Aengevelt Research 1996; Engel & Völkers 1996; Müller GmbH 1996)

Far fewer figures on mean rents have been published, but those of Aengevelt shown in Figure 5.3 below puts the peak in mean rents at 39 DM/m²/month in 1991-1992.

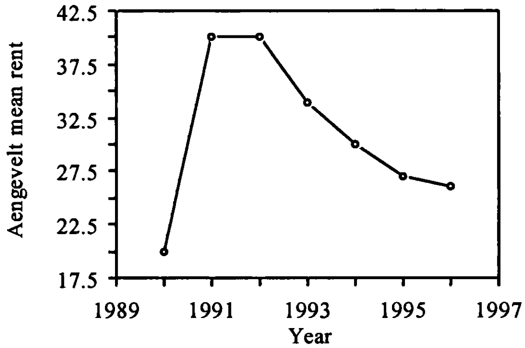


Figure 5.3: Aengevelt mean rents (Aengevelt Research 1996)

5.4.1 Demand Composition

Much of the letting activity after 1993 was the result of market *churn*, whereby demand was composed mostly of Berlin companies relocating rather than new companies taking space. Especially after 1996, when 5 year leases signed near the peak of the cycle came up for renewal, many companies took the opportunity to relocate under more favourable conditions (Westrup 1998). According to agents, tenants took advantage of the lower rents to move both from poorer locations into central ones, and to move from old buildings to new buildings (Sands 1996). Europroperty estimated the percentage of churn at 90% of total demand in 1996 (Westrup 1996).

The most discussed potential for new tenants seeking space in Berlin (as opposed to existing Berlin companies) has been companies who may relocate to Berlin in response to the move of Germany's federal government. On 20th June 1991, the Bundestag voted to move the federal capital of Germany to Berlin but the actual move of the Bundestag was not to take place until 1999. There was great scepticism in the earlier part of the 1990s about whether the Government would make good on its commitment to move to Berlin and if so, how soon (Dempsey 1993).

Some agents, such as Müller, argue that the move of the federal government has a knock on effect on the rest of the market:

> Although parliament and government are not acting mainly as tenants, they are indirectly contributing quite substantially to demand for office space to let, as their previous tenants have been forced to look for new premises (as in the case of the Federal Ministry of the Interior accounting for approx. 30,000 m^2).
>
> (Müller GmbH 1996)

Positive ideas about the role that the move of government can play in stimulating demand are echoed by other agents (Blumenauer Immobilien 1997). However, any gains in demand for office space from central government are partially offset by job losses at city government level that result in a shedding of office space. Perhaps 70,000 office jobs could be created by 2001 especially with the move of Government (Deutsche Bank Research 1997) but the Senate plans to shed at least 20,000 jobs by the same date owing to its dire financial circumstances after losing subsidies (Bittner 1997). Whatever effect the move of Government may have in the longer term, its influence during the period under consideration has been limited.

5.4.2 Demand for new and old build

Relatively little information has been reported on the price differentials based on the quality of the office building. The common distinction made in Berlin is simply between 'new-build' for the post-reunification buildings and 'old-build' for everything else. This is quite an easy distinction to make given that so little office development occurred in Berlin before the wall fell[20]. The only available estimates come from the agency Blumenauer (Table 5.2 below) which put quite a major premium on new-build. For very central locations Blumenauer cites a premium of differences of up to 60% for new-build in 1995. The premium decreases in more peripheral locations to a maximum of 40% (Blumenauer Immobilien 1997). There are also changes over time, with the difference narrowing slightly in 1996 for both central and peripheral locations.

MIETEN BÜROFLÄCHEN	1995	1996	AUSBLICK
Neubau, City, Toplage	40 - 50 DM/m²	38 - 48 DM/m²	→
Altbau, City, Toplage	30 - 40 DM/m²	28 - 36 DM/m²	→
Neubau, City, Mittellage	25 - 35 DM/m²	20 - 30 DM/m²	→
Altbau, City, Mittellage	20 - 28 DM/m²	20 - 26 DM/m²	→
Spitzenmiete	65 DM/m²	50 DM/m²	→
Neubau, Top-Randlage	22 - 28 DM/m²	15 - 25 DM/m²	→
Altbau, Top-Randlage	22 - 28 DM/m²	18 - 26 DM/m²	→
Neubau, Mittel-Randlage	20 - 25 DM/m²	12 - 20 DM/m²	→
Altbau, Mittel-Randlage	10 - 18 DM/m²	10 - 15 DM/m²	→

Table 5.2: Rents for new and old buildings in 1995 and 1996 (Blumenauer Immobilien 1997)

5.4.3 Lease provisions in the Berlin market

It has been widely reported that the oversupply in the Berlin office market has led to a high level of incentives in lease provisions. Not only have achieved rents been much lower than asking rents, but the use of incentives has also lowered the effective value

---

[20] The few buildings that were completed in the late 1980s typically would also be classified as 'new-build' by agents.

further (Cash 1995). The effect of incentives is very difficult to assess because there have been practically no published figures on the average incentive values for leases in the market. Comments in the property agents' reports imply that incentives have been concomitant with the fall in rents from 1993 on. By 1998 property market observers were reporting that tenants were seeking fewer incentives but expecting headline rents at lower levels in their leases (Westrup 1998).

Other major characteristics of the leases are also omitted from the property agents' reports. In the literature review it was shown that both lease length and the unit size have been considered as potential influences on rent, especially in the literature from the surveying profession (section 2.5.1.2 on page 39 above). But little information on these in the Berlin market has been published.

5.5 The Spatial Pattern of office Demand

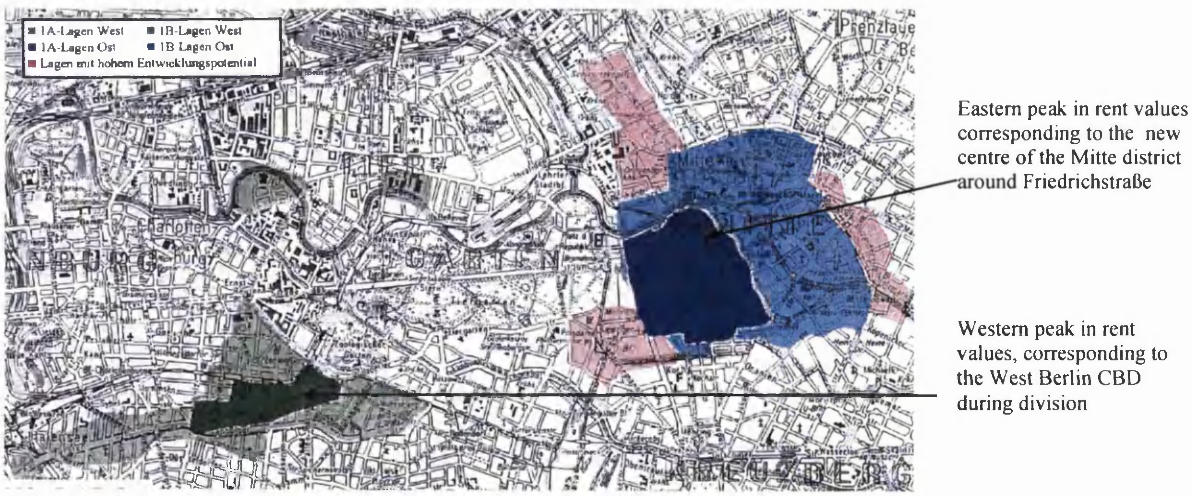
As well as the evidence on the main non-spatial characteristics of demand for office space in reunified Berlin provided in the reports, the maps of rent patterns in the reports also provide evidence on the spatial characteristics of rent. These can be seen in Map 5.1 to Map 5.6 by a number of the main property agents in Berlin (Eureal 1994; Jones Lang Wootton 1995; Engel & Völkers 1996; Müller GmbH 1996). All the maps reproduced in this chapter have been produced using the dasymetric technique[21], whereby the pattern of location rents is split into a number of idiosyncratic areas rather than either a continuous surface or points with a scale of values.

Some of the maps are specific about the rent that can be expected in each area by providing figures on the map, such as Müller and Eureal. Others are more general, such as JLW and Engel & Völkers, showing only location categories like 1A and City Centre-with data on the rents achievable in these locations in separate graphs or tables. Colour is used in all maps but not in any clear scale, it typically varies in intensity with a deeper colour in the areas of higher rent but there is no defined relationship between the colour and the numeric values it represents. Although both the quality and level of detail on the maps differ, there is a fairly good correspondence between each of them on the geographical location and extent of prime values. The borders of the prime areas do not differ significantly.

[21] As was noted in chapter 2, each step of the dasymetric technique can add error to the map because almost every step requires some subjective decision (Robinson 1995). However, despite their limitations, the maps are primary evidence of how agents view the market.

The pattern of office rents in Berlin shown by the agents reports is a very global one, with rents higher in the centre of the city than at the edge (see especially Map 5.6 below). This is what might have been expected from the representations of office rents of previous studies reproduced in section 2.7 on page 59 of the literature review above. However, the most prominent feature of the agents' rent maps is the existence of two centres, one in the West and one in the East, as highlighted on Map 5.1 below.

The Western peak of rent is shown in all the maps to correspond with the West Berlin CBD as it had developed during division. This area is focussed around the Bahnhof Zoo train station and forms a triangle from Ernst Reuter Platz taking in the Kurfürstendamm and extending eastwards to Wittenbergplatz (its development is described in section 4.6 on page 151 above). The maps show the 1A prime space of the western centre as an elongated area along the Kurfürstendamm, which can be seen both in Map 5.1 and Map 5.3. This linear extension of prime values corresponds to the concentration of core commercial uses that had developed along the Kurfürstendamm after the Second World War, as was seen in chapter 4. This is also the area that was most globally integrated in West Berlin during the period of division, as was seen on Axial Map 4.13 on page 153.

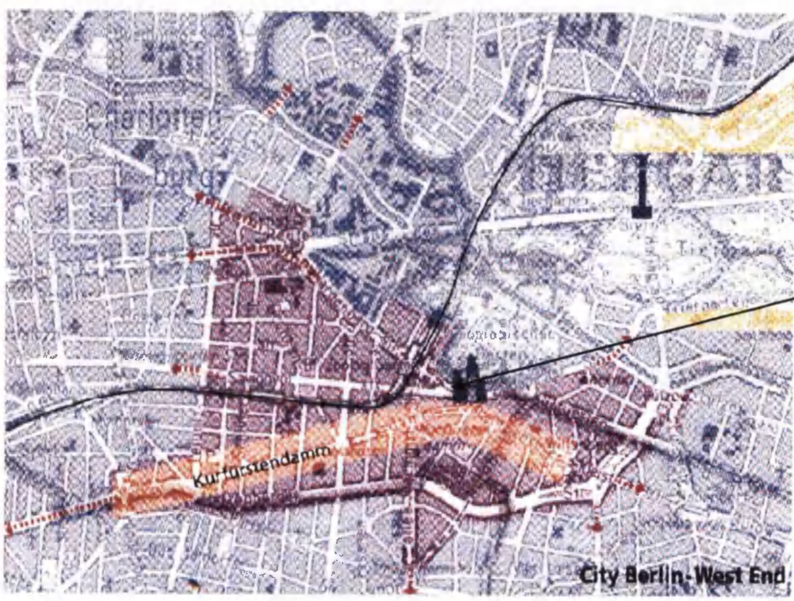


Map 5.1: Engel & Völkers Office Rent Patterns

(Engel & Völkers 1996)

Map 5.2: Jones Lang Wootton Office Rent Patterns

(Jones Lang Wootton 1995)



1A prime location for office rents in the Western centre are located in a linear strip along the Kurfürstendamm

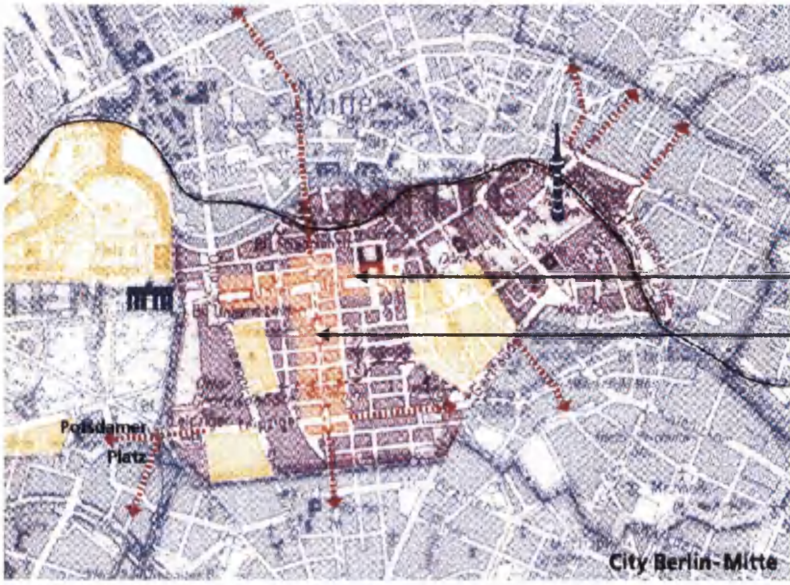
Map 5.3: Jones Lang Wootton Western Centre

(Jones Lang Wootton 1995)

As well as the Western peak of values, agents' maps show a new area of peak values in the former East Berlin. This eastern peak in rent values is shown within the centre of Friedrichstadt up to the former line of the wall along the border between the districts of Mitte and Tiergarten. Although Alexanderplatz, the former civic centre of East Berlin, is included in the Eastern peak of values, it is not shown as the 1A area in any of the maps. Agents' maps that do attribute 1A values within the Eastern centre show them on Friedrichstraße and Unter Den Linden, as in Map 5.4 by Jones Lang Wootton below. The prime area in Map 5.5 by Eureal also shows a pattern corresponding to the linear extensions of Friedrichstraße and Unter Den Linden. This was the area that suffered worst from the massive destruction of the Second World War and was left in relatively poor repair during the period of division, as was seen in Map 4.15 and Map 4.18 on pages 152 and 156 above.

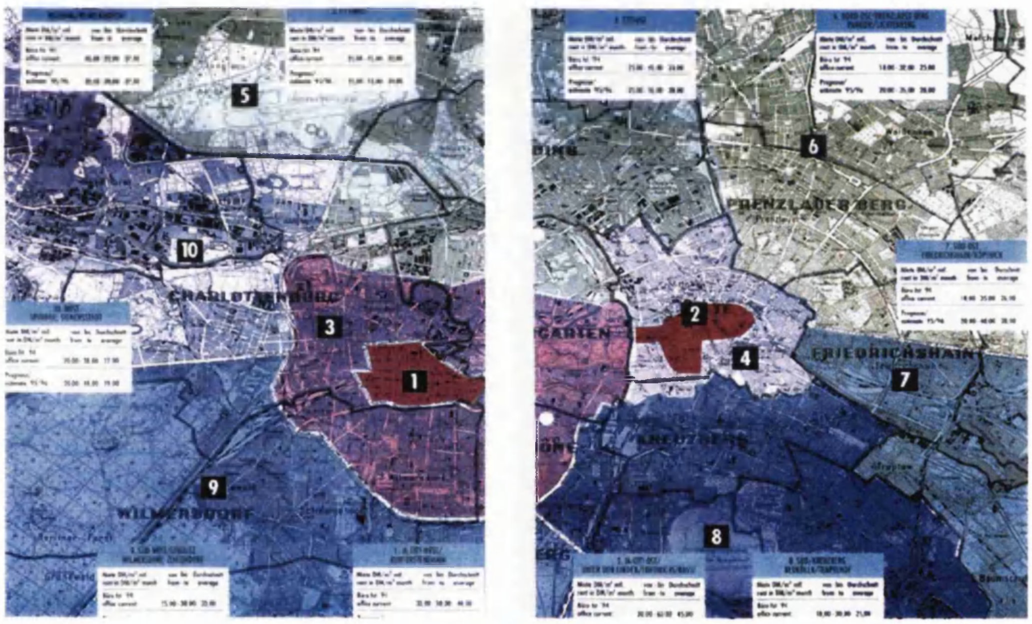
This Eastern peak in values has occurred in the area that became the most globally integrated core of the street system with the reunification of the city, as was seen in Axial Map 5.2 on page 164 above. Friedrichstraße, Unter den Linden and Leipzigerstraße were shown to be the most integrated lines in the pattern of global integration shown in Axial Map 5.2 above. Friedrichstraße and Unter Den Linden are also identified as the key A1 streets[22] for office rents by the property agents' maps (see especially Map 5.4 below). The third most globally integrated street in the axial analysis of reunified Berlin is the Leipziger Straße. Although this street is shown as one of the streets with development potential (signified by red arrows in Map 5.4), it was much slower to develop as an office location in reunified Berlin. This may be partly a result of the planning uncertainties about its future that marred the first five years after the wall (it had been widened during division and it was unclear whether the original plot structure would be reinstated). The fact that the Leipzierstraße had been almost wholly rebuilt as a residential street during division (see Map 4.18 on page 156 above) also precluded its rapid redevelopment as an office location.

[22] There are no definitions for the A1 areas in any of the agents reports that use the term, but the normal use of the term is to describe a small number of streets within a city that command a higher rent than any other locations.



Map 5.4: Jones Lang Wootton Office Rent in Mitte

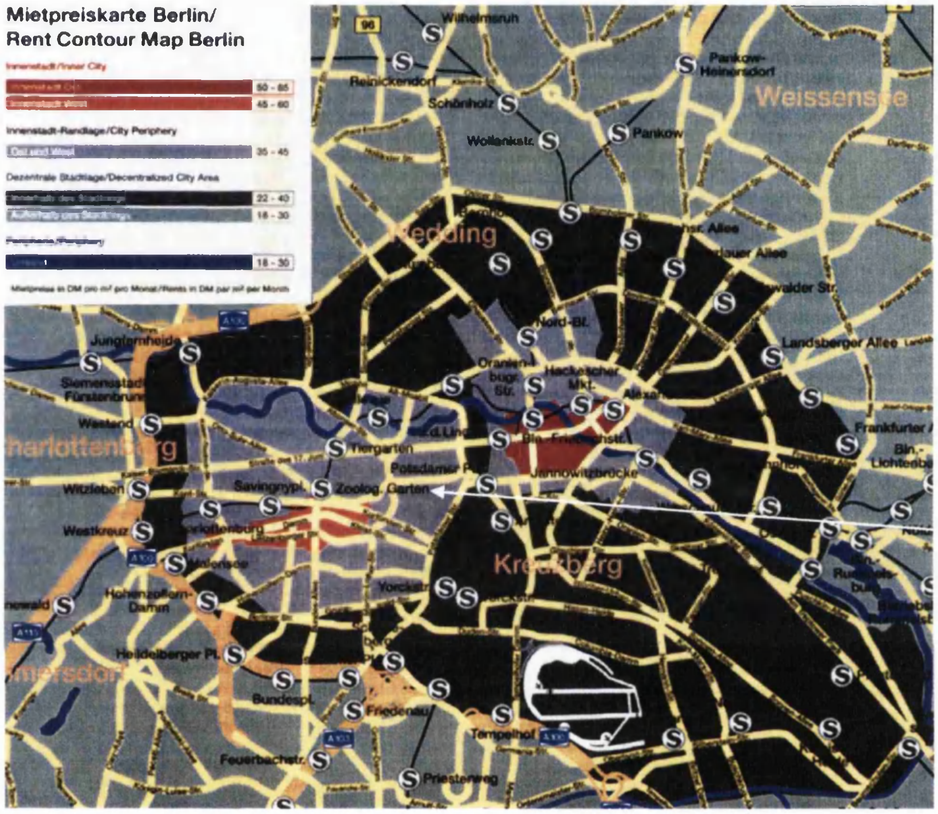
(Jones Lang Wootton 1995)



Map 5.5: Eureal Office Rent Patterns

(Eureal 1994)

A number of other characteristics of the spatial pattern of rents can be seen from the property agents' reports. Firstly, the reports show abrupt changes in rent level from street to street. Only one or two primary 1A streets are shown and values around the corner from them are much lower. Although areas or relative homogeneity are shown (within the broader centres or surrounding areas) there does seem to be a relatively good correspondence at individual street level between the various property agents' reports, especially where abrupt changes are noted. For example, the agents reports all show a clear distinction between the two peak areas, with the area between them (where Schoeneberg borders the Tiergarten) as a break in the location of prime values. This area is highlighted on Map 5.6 below. These fine scale spatial distinctions are similar to the large differentials at street scale that were found in previous studies of other cities shown in section 2.7.4.1 of the literature review (page 68 above).



The area south of Tiergarten between the two peaks of rent value is shown on all the maps to command a much lower rent.

Map 5.6: Müller Office Rent Contour Map (Müller GmbH 1996)

5.5.1 The two peak areas of rent and Berlin's spatial structure

The rent maps have shown two peaks in value and a relationship has been noted between their location and the pattern of global integration. Whereas the Western peak in value corresponds with the core of integration in West Berlin as it was during division, the East Berlin peak in rental values corresponds to the pattern of integration in reunified Berlin.

However, a closer inspection of the property agents' reports also shows that the relationship between these two peaks of rent value changed over the years after reunification. Prime values *shifted* from the Western centre to the new centre in East Berlin. Engel and Völkers provided estimates of top and bottom rents for the prime and secondary office space in both West and East Berlin in a 1996 report (Engel & Völkers

1996). Figure 5.4 shows the mean of these top and bottom figures, from which the shift in trend towards the East is visible. By around 1995, the eastern centre had overtaken the West. Other agents confirmed this shift. According to Müller, rents continued to decline in all office market locations in 1995, particularly in the western centre, where the top rent fell from DM55 per m^2 in 1994 to DM 40 per m^2 in 1995. The highest rents were achieved in the Eastern centre (approximately DM 50 per m^2). Müller quotes top rents for the Eastern centre at the beginning of 1996 at 50 DM/m^2 and the West at 40, with average rents at 40 DM/ m^2 and 33 DM/ m^2 respectively (Müller GmbH 1996). According to a meeting of the major property consultants in Berlin, the average rent levels for 1996 were DM 26,20, with the Western centre achieving DM 30,80 and the Eastern centre DM 32,90. Prices in peripheral locations were around DM 23,75. (EBS 1997).

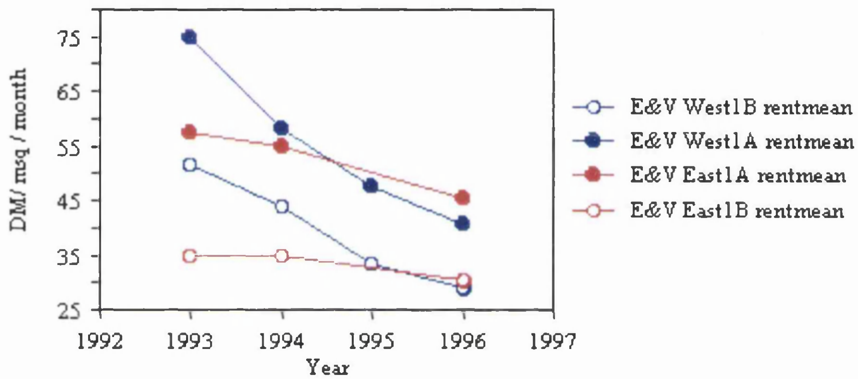


Figure 5.4: The shift in rent price towards the East according to Engel and Völkers

The demand profile between the Western and Eastern centre is also different. In 1996 the German property agents Engel & Völkers described the demand profile of the Western centre as comprising of smaller service sector firms such as lawyers and architects, who typically require only 100-400 square metres of office space. The profile in the Eastern centre of Mitte is oriented towards bigger firms such as telecommunications, big public companies and publishers. These are the kinds of firms that might want a presence near Government (Engel & Völkers 1996).

5.5.2 Spatial analysis of the two prime areas of office rent

The morphological difference between the two peak areas of value within the spatial structure of Berlin can be explored by investigating the relationship between local and global measures of integration. The scatter in Figure 5.5 below shows the relationship between local and global integration during division with the West Berlin CBD highlighted. The Western CBD forms a very tight scatter of its own crossing the regression line at the highly globally integrated end of the scatter for the city as a whole. The same are within reunified Berlin has a very different pattern, as can be seen in Figure 5.6. It is now globally more layered, no longer at the most integrated end of the scatter and no longer such a tight correlation of its own.

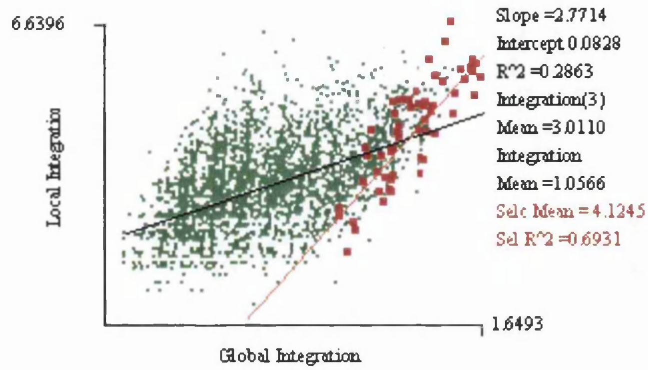


Figure 5.5: Integration of West Berlin CBD (Highlighted) in Divided Berlin

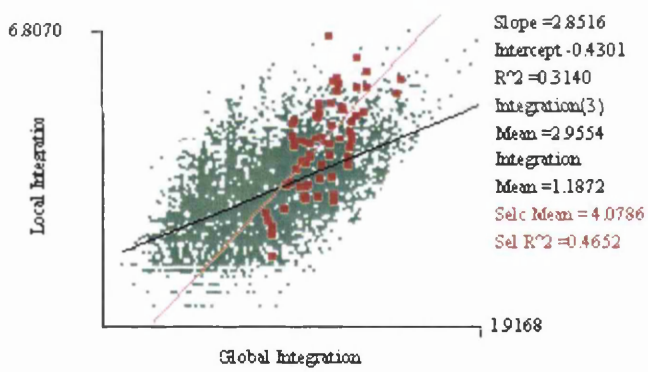


Figure 5.6: Integration of West Berlin CBD (Highlighted) in Reunified Berlin

The same comparison for the Mitte area shows almost the exact opposite effect from reunification. Within the correlation of local and global integration for East Berlin during division (Figure 5.7), the points for Mitte are not exceptional. The regression line is very close to that of the city as a whole. However, the Mitte area in reunified Berlin exhibits a very similar pattern to the position that the Western CBD had before reunification- it forms a tight scatter at the most integrated end of the spectrum crossing the regression line steeply (Figure 5.8). Relative to the rest of the city, Mitte has gained the kind of prime spatial position that the West Berlin CBD had during division.

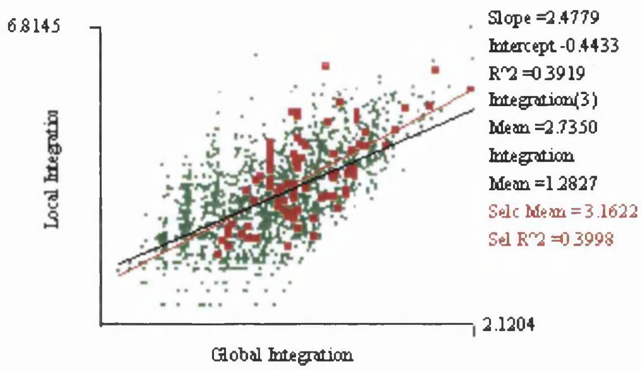


Figure 5.7: Integration of Mitte (Highlighted) in Divided Berlin

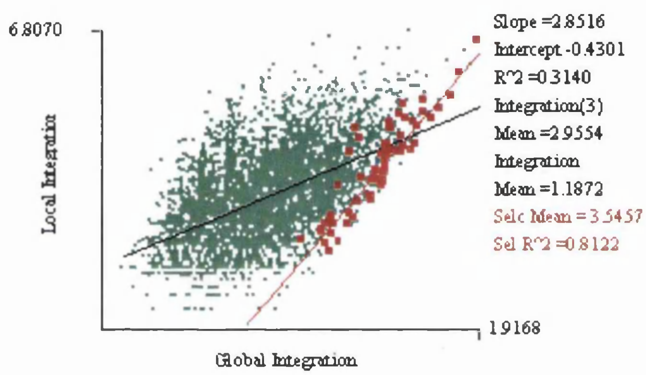


Figure 5.8: Integration of Mitte (highlighted) in Reunified Berlin

The spatial analysis shows that the location of both the West Berlin CBD area of high rents and the Mitte area of high rents reflect the importance of these areas within the underlying structure of global integration for the whole city. However, the prime position within the global pattern of integration that the West Berlin CBD had during division was lost when the global core shifted to Mitte with reunification. There is also evidence of a shift in the pattern of rental values from the Western centre to the Eastern one in the first 5 years after reunification. This shift corresponds to the changing global integration of the Mitte relative to the Western CBD.

Despite some evidence of a shift in values from the West to the East over time in agents' reports, there is relatively little change in the pattern of rents shown in agents' maps. Within the Western centre the earlier representations had 1A values extending beyond Kurfürstendamm onto Tauenziehenstraße (for example Map 5.3). In later representations the 1A area is shown only on the Kurfürstendamm and stops at the Gedächniskirche (as can be seen in Map 5.1). The only real change in the later representations of the eastern centre is that the Potsdamer Platz began to be highlighted more as an area of potentially high rents from around 1996 (see for example Map 5.1). This reflects the fact that the Potsdamer Platz development site was taking shape and agents were perhaps expecting a high demand from the market. The earlier maps do not represent this potential as the site was completely empty (for example Map 5.5 or Map 5.6). However, the shape of rent patterns as a whole, with a peak in the western CBD and in Mitte, does not appear to have changed greatly according to the property agents' reports.

5.6 Office Supply Development

Fraser posited that rising demand for office space induces an increase in supply after a typical time lag of around five years for major city-centre commercial developments (Fraser 1993). This estimate applies very well to the Berlin market, with the first wave of office completions hitting the market in 1995.

Although estimates vary considerably, it is clear that a substantial boom in property development has occurred in Berlin since reunification. The boom in the supply of office space after reunification was fuelled by three factors. Firstly, there was very little space for a city of Berlin's size compared to other German centres: as late as 1995 Greater Berlin had an average of $4m^2$ of office space per inhabitant, compared to 6.6 in Hamburg, 8.8 in Munich and over 13 in Frankfurt (Engel & Völkers 1996). This was perceived by developers as a deficit in supply that could lead to increased prices as the reunified city re-established itself economically within Germany.

The second factor fuelling the supply boom was the sharp rise in rents that immediately followed the fall of the wall, as described earlier. These gave many investors the impression that Berlin was the 'honey pot' of development opportunities whilst the other main property markets of Europe were in a deep recession (Economist 1993). Investments were made in this early period before 1993 on the basis that rents would continue to rise, especially with the move of the capital to Berlin.

The third factor fuelling development in Berlin was a complex series of tax breaks on investments in the former East Germany (for which both halves of Berlin were eligible). These encouraged speculative office development until they ran out at the end of 1996 (Sands 1996).

Estimates vary considerably about the amount of office space built in Berlin during the first wave of development after the wall, as can be seen from Table 5.3 below. The Senate of Berlin estimated that between 1991 and 1997/98 around 660 projects comprising 9.47 million m^2 gross floorspace were completed (SenStadtUm and IHK 1995). According to Aengevelt research, around 475 large investment projects with major office use were finished or on site by 1996, bringing around 5.2 million square metres of gross new floorspace between 1992 and 1998 (Aengevelt Research 1996). Whereas in 1997 Aengevelt estimated a figure of 1.3 million gross square metres of new floorspace, Deutsche Bank's estimate for the same year was 750,000 (Deutsche Bank Research 1997). Aengevelt's estimates are graphed in Figure 5.9 below, showing the peak of the first wave of office construction after the wall during the study period.

Year	Aengevelt	Deutsche Bank	Jones Lang Wootton
1990	80		
1991	110		
1992	360		
1993	550		
1994	780		
1995	1300	750	
1996	1000	750	
1997	1000		250

Table 5.3: New Office Completion Estimates ('000's m^2 gross floorspace)

Source: (Aengevelt Research 1996; Deutsche Bank Research 1997; Jones Lang Wootton 1997)

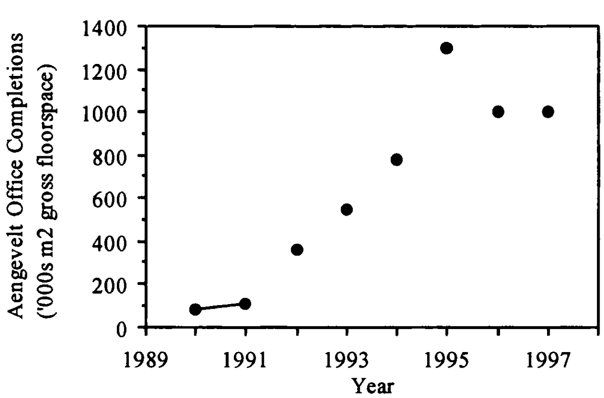


Figure 5.9: Aengevelt Office Completions estimates

5.6.1 Office stock in Berlin

The boom in office building since reunification has increased the stock of office space in Berlin considerably, although estimates of the size of stock are again divergent. Aengevelt estimated that the effective increase in stock from the new supply was approximately 3,4 million, or 66% of new-build. The stock of office floorspace was therefore predicted to increase further from 12 million in 1991 to around 16 million by the year 2000. The trend until 1997 can be seen in Figure 5.10 below (Aengevelt Research 1996). The Engel & Völkers estimates are also shown in Figure 5.10, which only rise to 13 million by 1995 and are about 2 million lower than Aengevelt's (Engel & Völkers 1996).

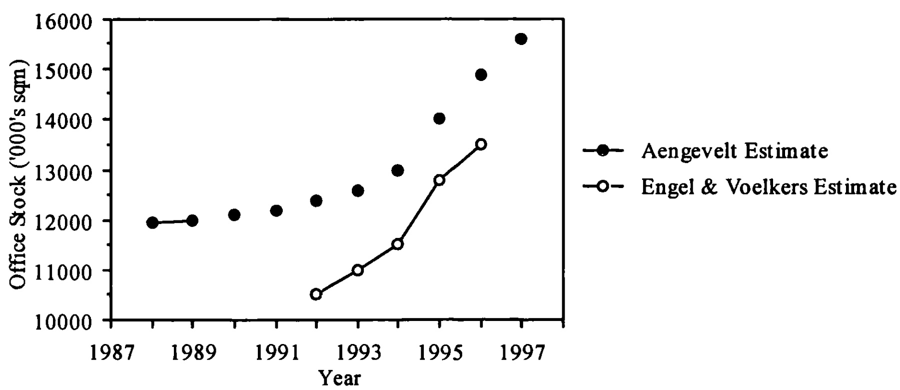


Figure 5.10: Office Stock Estimates in Berlin

5.6.2 The composition of office space on the market

Unlike many cities, commercial buildings in Berlin are rarely single use such as office, but rather have other uses such as retail at ground floor and housing at the top. The office buildings of the recent wave are on average 71% office, 12% housing, 10% retail, 3% Hotel/cultural uses and 4% industrial (SenStadtUm and IHK 1995). This shows the continuation in contemporary Berlin of a historic tendency for mixed uses within a block through marginal separation from the street, as has been outlined in section 4.5.1 of the previous chapter (see page 148).

The reaction of developers to the collapse in office market rents was to sink the office percentage of buildings when possible and increase the mixture of other uses (Volger 1994). Between the 1992-93 and 1994-95 surveys of the Senate, the office percentage of new buildings sank from 83% to 73% with housing rising from 5 to 10% and retail from 7 to 10%. The office percentage is also much lower in the project proposals that had not yet passed planning (SenStadtUm and IHK 1995). The mean size of new projects is 31,000 m^2 gross floorspace, but this is influenced by the 10% of very large projects, which account for 67% of the total gross floorspace (SenStadtUm and IHK 1995).

5.7 The Spatial Distribution of office Supply

Figure 5.11 below is taken from a 1995 survey of office projects by the senate (SenStadtUm and IHK 1995). It shows a distinction in the spatial pattern of supply between East and West Berlin. The first two columns on the left represent completed space in 1995 ('fertigstellung'). The amount of floorspace can be seen to be relatively equal in East and West Berlin, both at around 2.7 million square metres of gross floorspace. However, the other columns reveal marked difference in the projects not completed by 1995 but in planning. The more long term the phase of planning, the more that projects are concentrated in the East and not the West. At the competition stage of planning in 1995, over 5.8 million square metres were proposed for East Berlin but only 2.9 million for West Berlin:

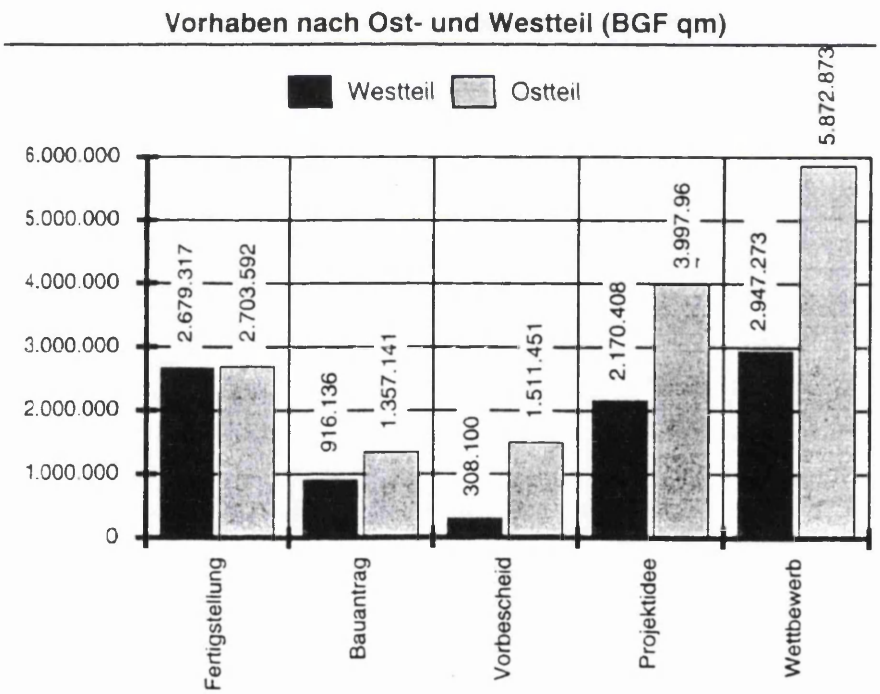
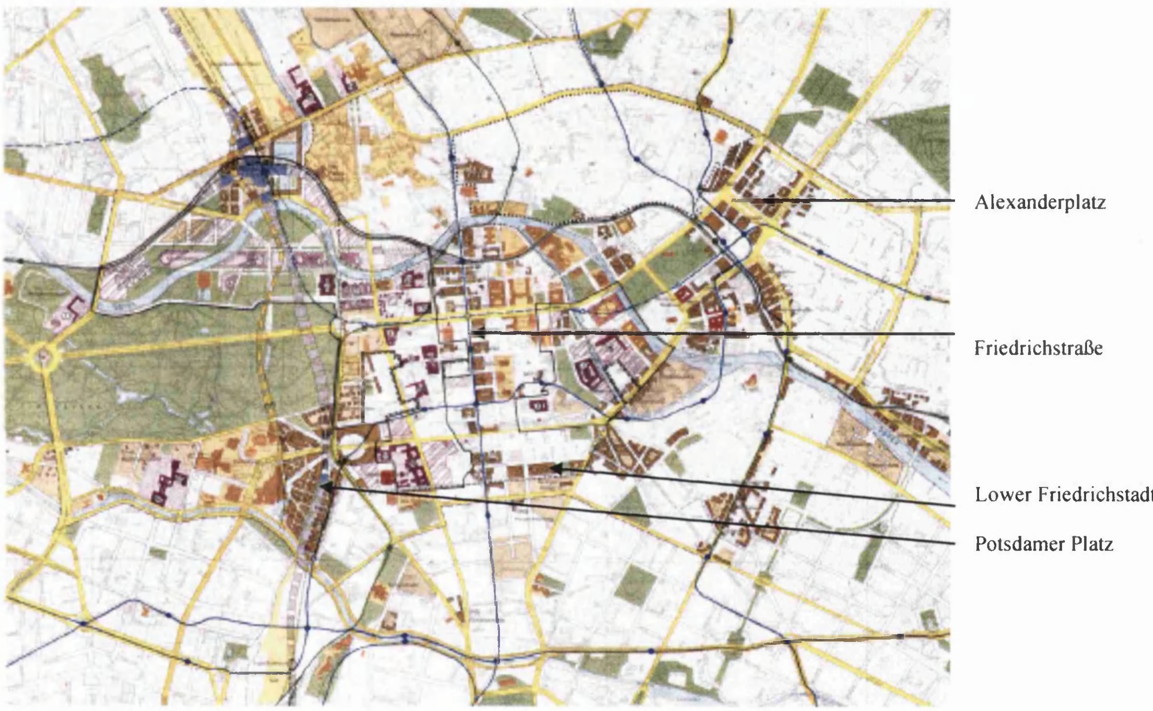


Figure 5.11: Distribution of Supply in East and West Berlin (SenStadtUm and IHK 1995)

The largest area of concentration in new supply has been in Mitte. The major redevelopments in this area are shown in Map 5.7 below. Development has been most intense along the Friedrichstraße, where approximately 30 commercial buildings were developed in the first wave. Friedrichstraße is also the most globally integrated line in the pattern of integration for reunified Berlin shown by the analysis of Axial Map 5.2 above.

Whereas Friedrichstraße was typified by a large number of independent developments, a major redevelopment has also taken place at Potsdamer Platz, but this has been undertaken under the direction of just 3 major investors. The largest development at Potsdamer Platz is the Daimler Benz Inter Services (DEBIS) project. North of DEBIS is the Sony site and Southeast of it is the ABB site. Major redevelopment at Alexanderplatz is also planned but had not begun at time of writing. Potsdamer Platz



Map 5.7: Major Projects in Berlin Mitte
(Aust 1994)

As well as the supply within Berlin there was also a lot of development in office parks outside the city. Aengevelt quotes 330,000 m^2 gross office floorspace finished in the surrounding Brandenburg countryside by 1996 (Aengevelt Research 1996).

5.7.1 Planning influences on Supply

There have been a wide variety of complex inducement programmes to develop in certain locations in Berlin. The Senate at first tried to shift supply away from the two central areas and develop entirely new centres outside the downtown areas at rail intersections. The senator for urban development stated that the senate 'wished to concentrate most of the office projects in Berlin along the inner railway ring, specifically where it is intersected by railway lines from the suburbs and outlying areas' (Branoner 1994). This policy did not succeed in attracting a great deal of investment except for some redevelopment at Ostkreuz (the eastern rail crossing).

Another policy of the Senate was to support self-build rather than speculative development. The Senate provided cheap land for organisations such as the Deutsche Industrie und Handelstag (28000 m^2) the Ostdeutsche Sparkassen und Giroverband (26500 m^2) the SPD party headquarters (15000 m^2) the Industrie und Handelskammer of Berlin and the Konrad Adenauer Stiftung (Cash 1995). However, it is often particularly difficult to separate speculative from self-build in Berlin because many of the large companies developing headquarters are also developing speculative office space. The magazine *Cash* cites typical examples of this as the Daimler Benz and Sony developments at Potsdamer Platz and the 'Treptowers' development by Allianz in Treptow (Cash 1995). For these projects it is not clear how much space the company will use and how much will be put on the market.

The third influence has been the complex system of tax breaks and incentives that encouraged a level of speculation that paid less attention to site selection. Bittner argued that much of the current supply is in poorly integrated locations in the East with poor links to infrastructure and amenities and that such projects owe their existence to the special tax breaks and support programmes (Bittner 1997).

5.7.2 The Shift in Integration and the supply side

The concentration of new office development projects in the Eastern centre of Mitte shown in Map 5.7 above corresponds to both the new core of global integration in reunified Berlin (see Axial Map 5.2) and the Eastern peak of rent values shown in the agents maps. There appears to be a strong relationship between the pattern of global integration, the peak in rent values and the development of new office projects.

Given the strong resemblance of both rent patterns and the clustering of new office projects to the pattern of reunified global integration centred around Mitte, it might be expected that the amount of floorspace in individual buildings would also be related to the integration of their location. Would developers not wish to realise more floorspace on a more prime site? But the indications from a pilot study of 250 buildings in 1994 suggest that this is not the case (Desyllas 1994). There was no relationship between building size and integration. This was also the case with other measures of integration and with the total or mean floorspace per street. Thus small and large buildings were being developed in prime locations and, more ominously, both small *and large* buildings were also being developed in the more segregated locations that are shown to have lower rent values by the agents maps. This could be the result of many factors such as speculation, site availability and planning restrictions. As has been seen, the landlords market in the boom years after the wall led many to believe that anything could be let in Berlin and thus little concern was paid to the choice of site location in some cases. The availability of developable plots combined with planning restrictions like the 5 floor eaves height in Berlin must also have an impact on the pattern of realised floorspace: it may just not be possible to build larger buildings on better integrated sites.

5.8 Vacancy

The falling rents combined with the increases in supply led to a huge increase in vacancy rates for office space. Although estimates differ on the amount of space, there is agreement that 1995 marked the biggest increase, reflecting the increases in supply that occurred in that year as the first wave of development was finished. Table 5.4 shows estimates that were provided in agents' reports of the amount of vacant space per year. These are graphed in Figure 5.12 below:

Year	Müller	Bavaria	Engel & Völkers
1986	175		
1987	145		
1988	110		
1989	100		
1990	55		
1991	65		
1992	155		
1993	215		200
1994	350	600	300
1995	815	1,100	900
1996	1,098	1,400	1,100
1997		1,600	

Table 5.4: Vacant Office Space Estimates ('000's m^2)

(Engel & Völkers 1996; Müller GmbH 1996; Bittner 1997)

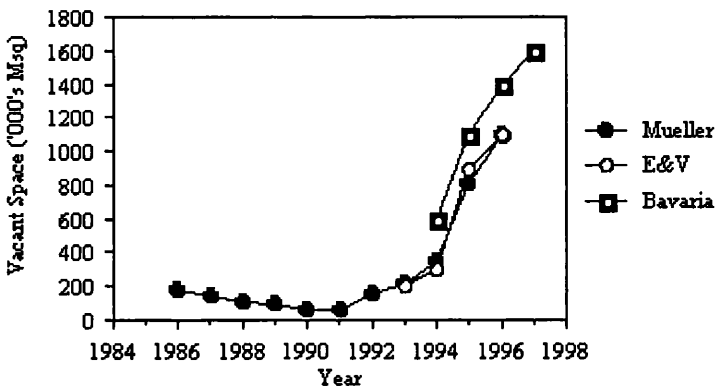


Figure 5.12: Vacant space estimates

Forecasts for when the vacant space will be absorbed differ. Angermann assume that the vacancy in the inner ring will be more or less absorbed by 2000 (Angermann 1997). Deutsche Bank expected an office completion volume of 3,300,000 m^2 until end 2001 with demand predicted for 2,200,000 m^2 (Deutsche Bank Research 1997). Estimates of vacancy as a percentage of available space are shown in Table 5.5 below:

Year	Eureal	Deutsche Bank	Blumenauer Immobilien	Bavaria Immobilien
1993	2.3			
1994	3.1			4.2
1995	3.5			7
1996				9
1997		8%	7.1%	10.5
1998				10.5

Table 5.5: Vacancy rate estimates (percentage of available space not let)

(Eureal 1994; Bittner 1997; Blumenauer Immobilien 1997; Deutsche Bank Research 1997)

The move into recession has affected vacancy rates in peripheral office locations much more than in central ones. The general agreement between agents is that the lower prices in the centre made it particularly difficult to let space in more peripheral buildings and therefore exerted more pressure on peripheral rents. Companies have used the opportunity of low rents in the centre to take 'better equipped and more central buildings' (Brockhoff 1997). According to Müller, premises in top city centre locations and the central belt area (defined as the dark green area in Map 5.6) accounted for 70% of all lease agreements in 1996. Demand stagnated at comparatively low levels in both subcentres and peripheral locations (Müller GmbH 1996).

5.9 The Turn From a Landlords to Tenants Market

The falling rent prices, rising supply of office space and rising vacancy rates have had the effect of making Berlin in the 1990s a classic example of a move from a landlords to a tenants market. An interview with one of the agents at Jones Lang Wootton provided the author with a first hand account of how the market had changed. The agent described how during the years 1991 and 1992 when Jones Lang Wootton had just established an office in Berlin, there were tenants 'queuing up' to let office space. If a tenant would balk at the conditions on offer in negotiations they could simply be told 'ah well, leave it if you wish, but if you change your mind and come back later this afternoon I will raise the price by 5 DM/ m^2'. Within a few years the tables had been reversed. In 1997 the agent described how tenants were shopping around quite easily and demanding that landlords provide a better offer than one of the near competitors otherwise they would just walk out. David Savinson, of Healy & Baker estate agents, described the situation in 1997 succinctly:

> It is desperate. If developers know an agent is looking on behalf of a tenant, the red carpet comes out all over the place.
>
> (Europroperty 1997)

Tenants became more selective with the falling rents. This involved moving out of old premises (which can then no longer find a tenant) and into new premises with high furnishing standards (Müller GmbH 1996). By the end of 1994 agents such as Eureal were already reporting that prospective tenants were much more price conscious and were seeking to obtain better locations for their money (Eureal 1994). Blumenauer also suggests that tenants were demanding higher quality space once rents started to fall and that new space was mainly taken by Berlin firms taking advantage of market conditions to secure better premises (Blumenauer Immobilien 1997).

5.9.1 'Talking up' of the market by property agents

Many agents could either not believe that the market would continue to fall as long as it had done, or indulged in an attempt to *'talk up the market'*. As early as 1994, one of the managers of a major property company was quoted in the Immobilien Manager magazine as estimating the fall in rents in the inner city to have more or less stopped (Koch 1994). In 1996 Engel & Völkers were advising that the low point of rents had been reached in autumn 1995 and that a pick up could be expected from 1996. They also predicted that tenants were recognising that it would be futile to hold out for better offers any more as the offer would not get any better (Engel & Völkers 1996). More cautiously, Bittner of

Bavaria Immobilien said in 1997 that 'at least for the top locations, the fall in rent seems to have levelled out' (Bittner 1997).

5.10 Discussion

This chapter set out to explore the pattern of rent values in reunified Berlin and test whether or not the property market has structural characteristics that might explain this pattern. Certain factors have been identified that can be seen to have influenced the supply side in Berlin, in particular the availability of land in East Berlin and certain planning incentives.

However, for the demand side (the rent values paid by tenants), the review of the market does not lead to obvious structural reasons for the shift in the value of locations, where buildings of comparable quality are concerned. East Berlin at the point of reunification was seen to have been in fairly poor condition as a whole, which cannot explain the willingness of tenants to move there. The relocation of government was shown to be unlikely to have much significance for the period under which these leases were made.

The factor that seems most important in the rise of rent values in East Berlin is the change in accessibility that has been identified by the axial map analysis. The main finding of the historical analysis was that the *move* of the CBD over time followed the development of the spatial structure of the city.

In this chapter, the spatial pattern of rents in reunified Berlin has been investigated directly using the maps from property market agents' reports. This investigation has shown a distinctive pattern of two peaks in rent value, one in the West Berlin CBD and one in Mitte. There is a relationship between the pattern of global integration and this pattern of rents. The spatial analysis of reunification showed that a new centre in the historic core of Mitte replaced the two centres of divided Berlin (The Western CBD around Kurfürstendamm and the Eastern core out on the radial Boulevard of Frankfurter Allee) when the Wall was removed. The western peak in office rent values corresponds to the spatial structure of divided Berlin and the Eastern peak to the new pattern of global integration in reunified Berlin.

These findings suggest that the pattern of rent *is* related to global integration, as was hypothesised by the relationship between the pattern of land use and global integration seen in the historical development of Berlin. Yet the relationship between integration and office rent in reunified Berlin is not a simple one. Rather than the two peaks in rent value reflecting a polycentral characteristic of the spatial structure of Berlin, they actually reflect the location of the global core of Berlin *before* and *after* the major event of reunification. The Western peak in values corresponds to global integration as it was in divided Berlin, whereas the Eastern peak corresponds to the contemporary (reunified) pattern of integration. The axial analysis shows that the western CBD is clearly less globally integrated in the new geography of the city, yet it remains important in the agents' representations of rent value.

Do the agents' representations of office rent constitute evidence of a polycentral pattern to rent values in Berlin? If they do reflect a genuine polycentrality in rent patterns, then the relationship between global integration and the concentration of offices in the CBD does not appear to hold for office rent. However, there is evidence of a shift over time in rent values from the western to the eastern centre shown in the tables within the property agents' reports, although no major spatial changes are discernible in the rent maps. The spatial representations of rent in the property agents' reports are relatively static and having identified the geographical boundaries of two centres, the reports do not show how these have developed over the period since reunification. Yet the evidence on the shift in rents (see for example Figure 5.4 on page 176 above) would tend to support a similar change in the pattern of rents that was seen in the pattern of reunification: a move to Mitte rather than two centres.

There are problems with the agents' reports that limit their usefulness as evidence of rents. At the simplest level, discrepancies between the market estimates of the different agents reports have been noted. For average rents, vacancy levels and the supply of new floorspace, there are significant differences in the agents figures. There are also problems with the objectivity of the agents representations of rent. In section 2.7 of the literature review, a number of methodological issues in the representation of rent data in previous studies were outlined which apply to the agents' reports. There is a lack of information about the sample of rents upon which the maps are based along with the lack of a clear objective methodology for their construction. This makes it difficult to assess the extent to which the evidence provided in the reports does in fact represent objective characteristics of the market or is more a reflection of the opinions, expectations or hopes of the property market agents.

This means that the agents' reports are of limited use as evidence against which the hypothesis of this study can be tested. They do constitute evidence of what agents thought about the pattern of rents during the study period (or at least what they were prepared to say that they thought). However, their use as objective evidence of the market is limited because of the inconsistencies and lack of methodological clarity discussed above.

In order to overcome the limits of this published data, the study now moves on to the primary lease data gathered from the Berlin market. This lease data will allow the relationship between Berlin's changing spatial structure and the pattern of rent to be investigated with a sample of empirical data rather than secondary sources. The analysis of this lease data is the subject of the next three chapters.

5.11 Summary

This chapter has shown how the spatial change that occurred with reunification can be measured using the space syntax method of analysis. The results of the analysis show that the removal of the wall transformed the pattern of integration from two centres in divided Berlin to a single core in the area of Mitte.

The property market in the period under study was characterised as one in recession and with rapidly falling rents after the short-lived reunification boom of 1989-1992. This has led to a shift from a landlords' to a tenants' market. The wave of new buildings that started reaching completion in 1995 led to a severe oversupply of office space and increased the downward pressure on rents. There has been a dramatic halving of rents in real terms over just 6 years (1992-1997).

Property agents reports were analysed and a common spatial pattern has been found in their representations of office rents. A peak in office values in West Berlin has been found in the area of the West Berlin CBD that evolved during division as outlined in chapter 4. A new peak in values has been shown to have emerged in the Eastern district of Mitte that chapter 4 had shown to have been in decline during the period of division. This is also the area that has become the new global integration core of reunified Berlin according to the space syntax analysis of the street network. Property agents' reports have shown a shift in rent values from the Western CBD to the new Eastern centre of Mitte, yet this shift has not been represented visually in rent maps.

The need to obtain more accurate data on rents than that provided in the agents reports has been discussed. The analysis of a more accurate sample of rents is the subject of the next section of the thesis.

6 NON-SPATIAL CHARACTERISTICS OF THE LEASE SAMPLE

6.1 Introduction

The purpose of this chapter is to review the main empirical source of rent data used in the thesis (the sample of leases) in order to see whether the effect of non-spatial characteristics of the sample could rule out any explanation of the spatial pattern of rents in terms of their location. In other words, before using the empirical data to investigate the main problem of this thesis, which is the relationship between the spatial pattern of rent and the layout of the built environment, this chapter reviews the available lease data for other non-spatial factors that might influence the spatial pattern of rent.

In the previous chapter, a distinctive pattern of two peak areas of office rent was shown in agents' reports. One of these appeared to correspond to the West Berlin core of global integration as it was before reunification and the other corresponded to the core of the reunified city *after* the wall. But the evidence of the agents' reports is limited both in terms of the unclear methodology, the lack of reliability and the level of detail[23]. A visual similarity between rent and the pattern of global integration was found, but in order to analyse this relationship properly it is necessary to move on from the evidence of published sources to the study of a sample of real lease transactions.

6.2 The Lease Sample

As was explained in the methodology chapter, this thesis uses real lease transactions rather than asking rents as the sample of rent data for analysis. The complex relationship between a tenant and a landlord is documented in the rental contract. When large numbers of contracts are analysed, general regularities in landlord tenant relations can be seen. Previous research has shown that in a recession, negotiating power shifts from the landlords to the tenants and this shift in market power allows tenants to push for changes in lease provisions to their own advantage (section 2.5.1.1 on page 36 above). This makes the comparability of leases suspect and it is therefore important to investigate lease provisions if the sample is to be used to compare location rents. In this chapter the investigation of the non-spatial characteristics of the lease sample is undertaken in order to control for three issues:

---

[23] As has been stressed in the literature review, the methodology chapter and the previous chapter, this is not a criticism of agents' reports, it is simply a consequence of the fact that the reports were not produced for academic research purposes.

6.2.1 *What are the non-spatial characteristics of the lease sample?*

In this chapter, the analysis of the lease data will begin by looking at the non-spatial characteristics of the leases. The property agents' reports analysed in the previous chapter provided general information about the Berlin market in the period under discussion. In particular, all the agents' reports presented evidence that the office rental market has undergone a recession after the short lived reunification boom. However, very little detailed evidence on such fundamental market characteristics as building quality or lease provisions was available in the market reports. Section 6.3 below will provide a description of the main non-spatial characteristics of both the detailed JLW sample of leases and the larger sample of headline rents.

6.2.2 *How comparable are the leases?*

As well as the lease provisions that show differences in the kind within the sample, there are also a number of provisions can be seen to influence the effective cost of the lease to a tenant. Effective rent is an elusive term and it has already been seen in the literature review that there is no agreed definition. Epstein and others have argued that the nature of rent data makes a proper accounting for such differences in provisions impossible and that effective rents must be *indeterminate* (see section 2.5.1.1 on page 36 above). However, the lack of any accounting for those lease variables that may influence the value of the lease to the tenant is one of the weaknesses of published rent values and the study of actual leases will allow for this issue to be tackled.

Despite the uncertainties involved in calculating effective rents, chapter three introduced two kinds of adjusted rent values that could be calculated for the smaller sample of Berlin leases where all lease provision data was available. In section 6.4 below the difference between these adjusted rents and the headline rent value is analysed for the study sample to see how important these other provisions are.

6.2.3 *How can an objective value for 'location rent' be created?*

In the previous chapter, the limitations of rent maps from agents' reports were outlined. The first problem was that it was unclear exactly what values are being represented. In this chapter a control of non-spatial variables will be undertaken in order to allow for a more objective representation of the residual difference that remains. The influence of the non-spatial variables alone will be tested in a Multiple Regression Analysis in section 6.5. This 'location-blind MRA' is the same technique as that used by Gallimore (see section 2.7.3 of the literature review) to provide an objective 'location rent' value that can be used in representations of rent patterns. The process of representation that will be used for this sample of rents is however different to that of Gallimore's, and that will be the subject of the next chapter.

6.3 Analysis of Non-Spatial Variables and the Lease Sample

Table 6.1 to Table 6.3 below provide the summary statistics for the lease and other non-spatial variables used in this study. The methodology used to calculate each variable was provided in section 3.3 of the methodology chapter above. A quick reference guide to the definition of each variable can be found in Table 11.1 in Appendix B: Definition of Lease variables.

	Lease begin month code	Months pre-let	Floor space m2	Obligatory lease term	Option total	Option/ contract	Headline Rent (91prices)	Build Quality Dummy
Mean	53.966	1.592	616	5.189	3.153	.720	30.991	.602
Median	59	1	313	5	3	.750	28.815	1
Mode	64	1	182	5	0	0	39.890	1
Std. Dev.	21.828	1.702	1413.908	2.531	3.078	.803	12.637	.491
Std. Error	1.521	.119	98.512	.176	.214	.056	.880	.034
Minimum	1	0	21.85	1	0	0	15.640	0
Maximum	84	14	12943	10	12	4.500	85.630	1
Variance	476.443	2.896	1999136	6.408	9.475	.644	159.695	.241
Range	83	14	12921	9	12	4.500	69.990	1
Skewness	-.822	3.365	6.648	.823	.583	1.596	1.804	-.417
Kurtosis	-.193	18.889	48.298	-.084	-.432	3.659	4.163	-1.827

Table 6.1: Summary Statistics of the Leases in the Jones Lang Wootton Sample (n=206)

	rent free months	free time fraction	addition	Appreciation
Mean	1.323	.022	.255	.024
Median	0	0	0	.031
Mode	0	0	0	.031
Std. Dev.	2.461	.040	.843	.016
Std. Error	.171	.003	.059	.001
Count	206	206	206	206
Minimum	0	0	0	0
Maximum	15	.200	6.438	.103
Variance	6.055	.002	.711	2.541E-4
Range	15	.200	6.438	.103
Skewness	2.354	2.057	4.878	-.044
Kurtosis	6.497	3.876	27.592	1.769

Table 6.2: Summary Statistics of the Lease Incentives in the Jones Lang Wootton Sample (n=206)

	Floor space m^2	Obligatory lease term	Headline Rent (91prices)	Lease begin month code	Build Quality Dummy
Mean	846	5.120	29.127	58.597	.659
Median	353	5	26.600	64	1
Mode	200	5	39.890	70	1
Std. Dev.	2448.875	2.291	10.427	18.620	.475
Std. Error	117.146	.129	.499	.891	.023
Minimum	21.85	1	13.940	1	0
Maximum	40000	12	85.630	84	1
# Missing	0	120	0	0	0
Variance	5996989	5.250	108.720	346.723	.225
Range	39978	11	71.690	83	1
Skewness	10.834	.983	1.902	-.989	-.671
Kurtosis	153.484	.784	5.805	.660	-1.550

Table 6.3: Summary Statistics for the landlords sample (n=437)

6.3.1 Rent Levels of the sample compared to market

In chapter 5, rent levels from agents' reports were quoted to show how rents have developed over time. The most often cited rent levels in agents' reports are so-called 'top rents'. Figure 6.1 below shows two examples of top rent time-series and their mean:

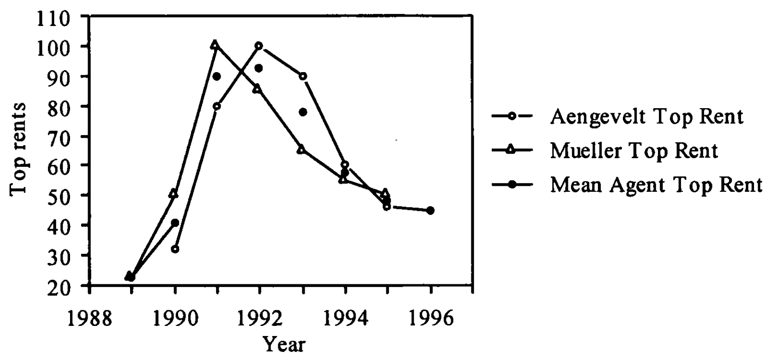


Figure 6.1: Agents Stated Top Office Rents (Aengevelt Research 1996; Müller GmbH 1996)

Top rent is an ambiguous term and less reliable than mean rents as a variable for comparison between the sample and the market as a whole[24]. The disadvantage of top rents is that single outliers may have a great effect on the series. This is shown in the box plot[25] of the JLW rent series in Figure 6.2 below:

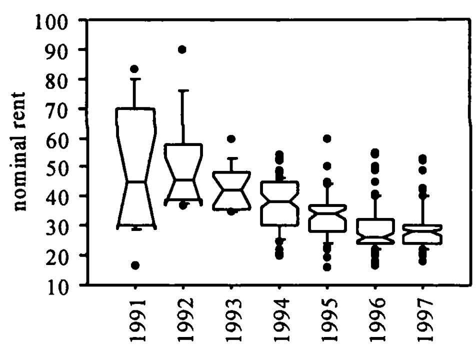


Figure 6.2: Box plot of nominal rent values

In Figure 6.3 below, the sample data is compared to the mean of agents top rents both by using the top number and the 90th percentile. There is no explanation of an adjustment for inflation in the other agents' reports and so the assumption must be that they are using unadjusted, nominal prices. When displaying any kind of monetary data that varies over time it is necessary to adjust for inflation in order to represent the real price movements (Tufte 1983; Wheaton and Torto 1994). The rents of the sample used in this study have

---

[24] Agents may use top rents because they vary more clearly over time than mean rents, or in order to 'boost' perceptions of the market, or perhaps because the agents are keen to attract a higher segment of customers.

[25] The box plot uses the normal convention of representing the 90th and 10th percentiles in the whiskers, the 25th and 75th as the box boundary and the median as the line in the box. The outliers are values outside 2 standard deviations.

been adjusted to constant ('real') prices, but for the comparison with agents' reports the nominal values from the JLW sample have been used.

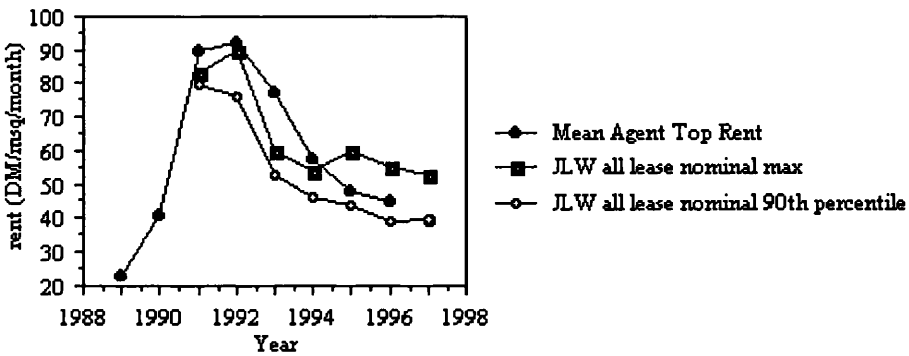


Figure 6.3: Comparison of Top Rents

The JLW sample can be seen to follow the trend over time shown by other agents. The sample is lower than the agents' estimate in the earlier period but higher in recent years. Although the 90th percentile is lower than the absolute JLW top figure (for obvious reasons), it fits the curve of the other market estimates better because the outliers have been removed, so the trend is much smoother. As a result of this study, a suggestion for a useful standard to construct indices of top rents is to use the 90th percentile, thus removing some of the erratic behaviour at the very end of the rent scale but maintaining the more marked changes that the top rent shows.

The falling trend in mean real rent prices with the recession is shown in Figure 6.4. The trend for the sample reflects the market trend shown in the property agents' reports of chapter 5 closely. The 95% confidence intervals show that the range was greater in the earlier years of the sample and narrowed as the market slumped (the earlier years also have smaller sample sizes).

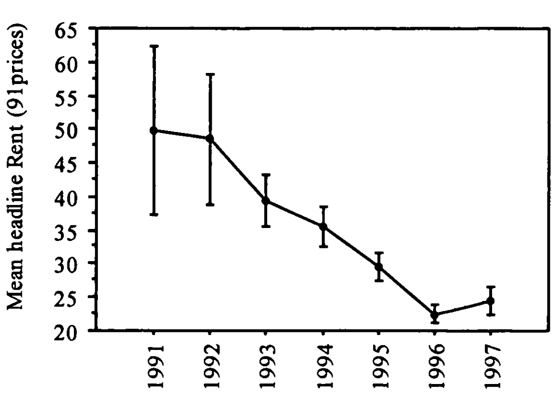


Figure 6.4: Berlin's Falling Office Rents

6.3.2 *Building Quality*

As was seen in chapter 5, very little information about differences in Berlin rents between new and old buildings has been published, but there is a general view that new buildings should command a premium. This was seen in the comments of the property agents' reports analysed in chapter 5 and the few price estimates reproduced in Table 5.2 (page 169). However, no statistically significant premium for new buildings is detectable in the lease data.

A possible explanation for this may be that location is acting as an intervening variable in the relationship of building type to rent. Perhaps rents were slightly higher in old buildings during the earlier years because there were fewer new buildings in the prime locations, whereas it may have been easier to renovate older buildings for office use quickly. On this basis, the narrowing of this differential after 1995 would be explained by the increase in supply of new buildings in central locations. The role of location in the sample is explored in chapters 7 and 8. At this stage, it is of interest to note that a direct premium for new-build is *not* detectable in the sample.

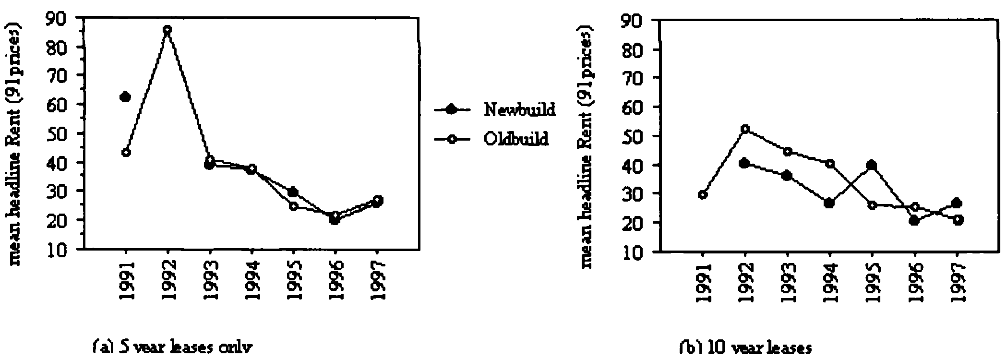


Figure 6.5: Headline rents in new and old buildings for the JLW sample

The proportion of new buildings in the sample rises through time, as can be seen in Figure 6.6 below. This pattern may reflect a more general rise within the office market as new buildings were completed, as has been shown in chapter 5. Indeed the dominance of lettings in new buildings in the sample after 1995 coincides with the completion of many new buildings in the first wave of development. A similar pattern emerges when the sample is analysed according to the total floorspace let in old and new buildings, as can be seen in the right hand graphic of Figure 6.6. From a total of 437 leases (including the landlords leases) 288 are in new buildings (66%).

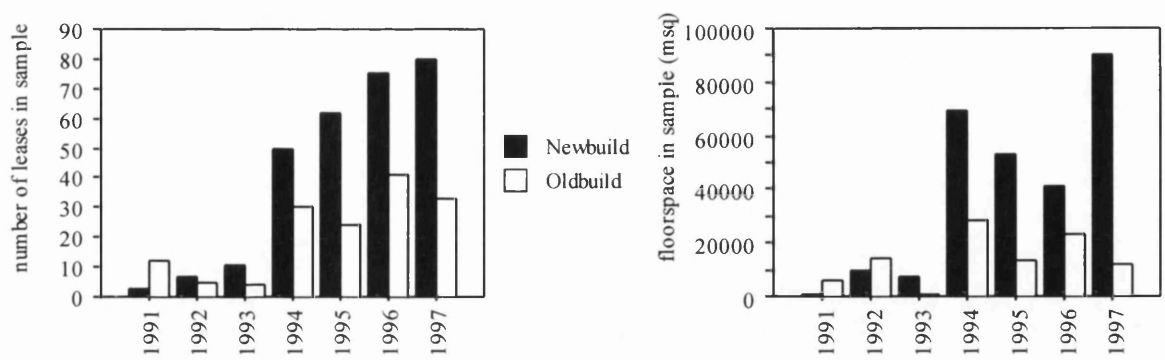
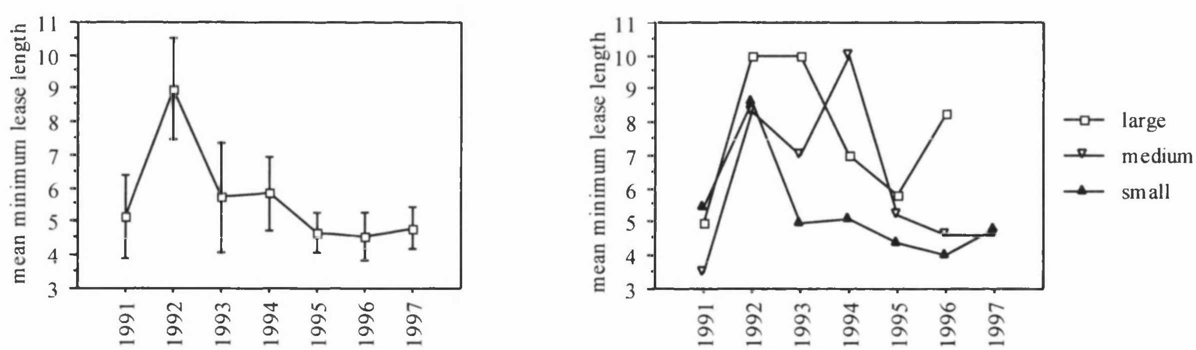


Figure 6.6: Leases in new and old buildings per year by number (left) and floorspace (right)

6.3.3 *Obligatory lease term*

Research in the UK reviewed in chapter 2 showed that one of the most prominent characteristics of the last office recession was the shortening of average lease terms and a greater diversity of lease lengths (section 2.5.1.2 on page 39 above). The recession in Berlin has also led to a reduction in the average length of leases in the sample, with a much shorter minimum term in the later period compared to the boom peak of 1992, as can be seen in Figure 6.7(a) below. This reflects a shift in favour of the tenants given a continued expectation of falling rents, as the tenants are left with an opportunity to seek a better rent price elsewhere or renegotiate.



(a) whole JLL sample
Error bars show 95% confidence intervals

(b) split by floorspace size

Figure 6.7: Average obligatory lease length

As was noted in section 2.5.1.2 (page 39 above), Brennan found that lease length was highly positively correlated with the size of the unit. There is also a broad relationship between lease length and floorspace size for the lease sample. The longer 10-year leases are more likely to be in larger units of over 1000 m2. This is to be expected if larger firms are less mobile and therefore more likely to trade off flexibility against their high moving costs. This can be seen in Figure 6.7(b) above, which shows the average obligatory lease term split by floorspace size category. Small units (less than 500m2) were on average leased for less than 5 years during the recession.

For the Jones Lang Wootton sample, the most common length was 5 years and accounted for 50% of the leases. The second most common length of 10 years accounted for a further 18%, as can be seen on the right hand distribution of Figure 6.8 below. The obligatory lease length for the larger sample of landlords leases compares well with the JLW sample. As can be seen in Table 6.3 on page 195 above, the mean for the landlord sample is 5.21 months compared with the JLW sample of 5.189. The larger landlord sample has a lower standard deviation at 2.291 compared to 2.531.

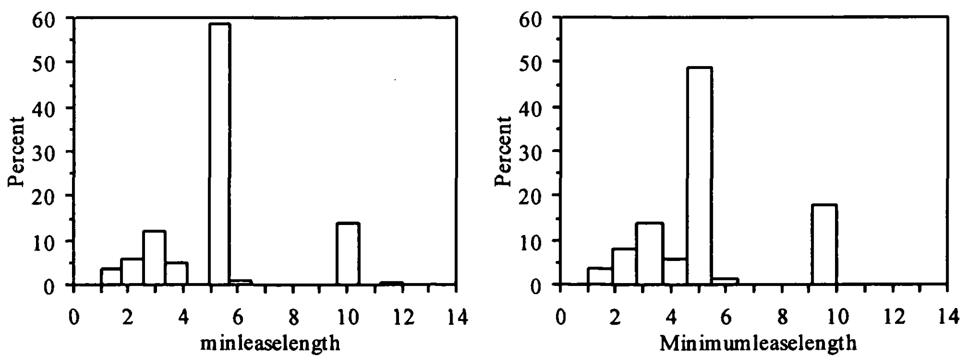


Figure 6.8: Frequency distribution of obligatory lease terms in all leases (left) and JLW leases (right)

Apart from some insignificant differences in the earlier years of the sample, there are no clear differences in rent between them, as can be seen in Figure 6.9 below. This finding is similar to the results of Brennan's study of Chicago office rents (Brennan, Cannaday et al. 1984) which also showed no clear relationship between lease length and rent (as discussed on page 39)[26].

[26] It may be noted that the lease lengths in Germany are much shorter than those in the UK (although these have been falling since the early 1990s too). Consequently the issue of lease length is not quite as important in the German market.

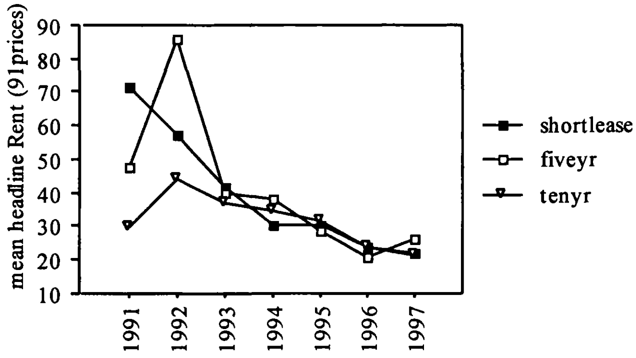


Figure 6.9: Rent in leases of different lengths

6.3.4 *Optional renewal time*

Evidence on optional renewal times from other studies of office markets is patchier than that for lease terms. As was seen in section 2.5.1.2 of the literature review (see page 39), Lizieri et al concluded from their study of the UK office market during recession that the short lease and long option would be optimal for tenants. They suggested that this would therefore be the favoured lease form in a tenants market (Lizieri, Crosby et al. 1997). This is exactly the pattern that development has taken in the Berlin market, which has been a tenants' market. As well as securing shorter obligatory lease terms, the recession in Berlin has also given tenants the power to demand longer periods of optional renewal time. The rising trend in optional renewal times is shown in Figure 6.10 below.

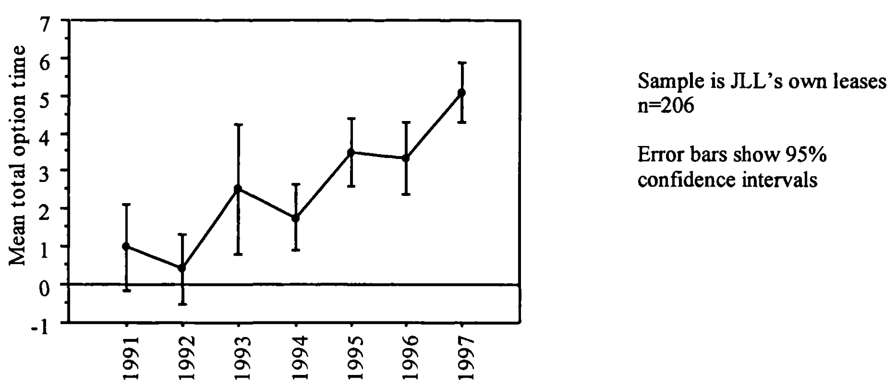


Figure 6.10: Mean total optional renewal period in years (95% confidence intervals)

The frequency distribution for optional renewal time is shown in Figure 6.11 below. Over 70% of the sample had either no renewal period or 5 years, with other periods much less frequent. This means that optional renewal times are not normally distributed- landlords and tenants tended to either agree them at a fixed 5 year period or not at all. As the proportion of landlords allowing optional renewal times increased with the recession, the mean period per year crept upwards. The high error bars of Figure 6.10 reflect that the sample is mostly composed of either 5 years or no years (as shown in Figure 6.11).

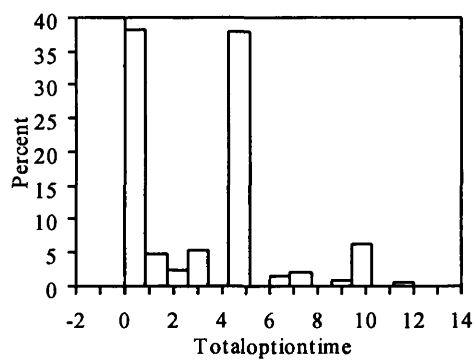


Figure 6.11: Frequency distribution of optional renewal time

6.3.5 Optional renewal fraction

The length of optional renewal time as a fraction of the minimum mandatory lease length is shown in Figure 6.12 below. This fraction has also been growing steadily over the period since 1991, which is symptomatic of the shift to a tenants market as it reflects greater flexibility on behalf of the tenant. In times of a falling market, it is in the interests of the tenant to have a short obligatory lease term (as in Figure 6.7) but a long option. This allows the tenant to get out and seek a better bargain if rents continue to fall as they have been (Figure 6.4), or to remain at a low level (using a long option time at the favourable rent terms defined in the existing lease) if rents begin to rise[27]. The fraction is greater for 5 year leases (shown on the left) than it is for 10 year leases (right) as the differences in absolute free time given are not scaled up for longer leases.

[27] This is not to say that the option will be at the same rent as the initial or headline rent, but the rent for the option period will have been defined by the rent increase terms agreed in the lease under poor market conditions.

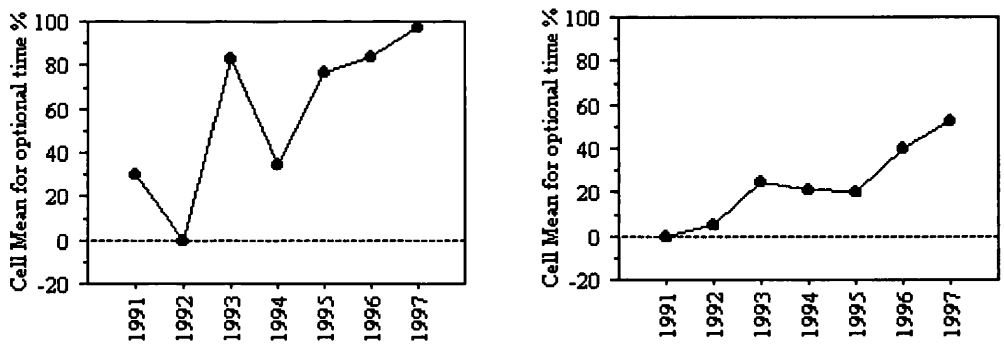


Figure 6.12: Optional renewal time as a fraction of obligatory lease length for 5 year leases (left) and 10 year leases (right)

6.3.6 Leased floorspace area

A factor that might be thought to affect the rent price per square metre would be the size of the letting. This would be a result of the economies of scale involved in letting larger premises: with fewer tenants costs are lower as management is easier. In times of high vacancy such as the period under analysis, the advantages of letting a larger proportion of a building at once may be much greater. It would therefore seem reasonable to expect a lowering of the per square metre price with the size of the letting.

No clear linear relationship between unit size and rent per square metre value could be detected. However, the average value of very small leases (under 500 square metres) was found to be higher for most years, as can be seen in Figure 6.13 below. The difference was between 5 and 10 DM, and was significant in the years 1993 to 1996 at 1 standard error but not 95% confidence intervals. However, no significant savings in unit cost could be detected for the very large leases (over 1000 square metres) compared to the others. Given that the size of units in the sample is logarithmically distributed, it might be expected that savings would be most visible at the extreme end of the scale.

The lack of a clear saving for large units may reflect a shortage of very large units that outweighs the economies of scale effect. As was seen in chapter 2, Wheaton also found little evidence of an economy of scale effect in his study of 5000 US office leases. He suggested that that supply and demand conditions for large blocks of space might actually lead to larger lease premiums in certain cases (Wheaton and Torto 1994).

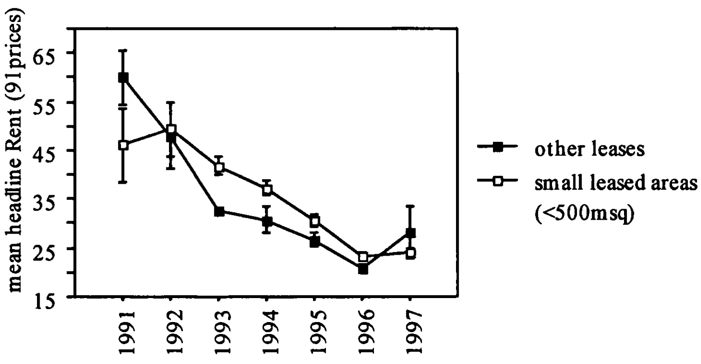


Figure 6.13: average rents in small leased areas compared to larger leased areas

Floorspace sizes are on average smaller in the later period, as can be seen from Figure 6.14 (a) below. The floorspace size is related to the length of the lease, as can be seen from Figure 6.14 (b) which shows the mean unit size split into the main lease lengths of short term (less than 5 years), 5 years and 10 years. The earlier period before the recession is characterised by more leases with large floorspaces (over 1000 m^2) and longer 10-year leases.

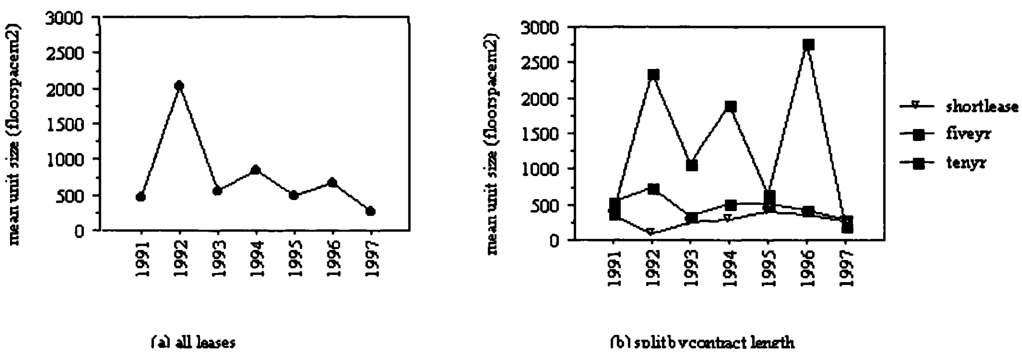


Figure 6.14: Unit floorspace size

As can be seen from Figure 6.15, the distribution of floorspace sizes is highly positively skewed, owing to a few very large lettings.

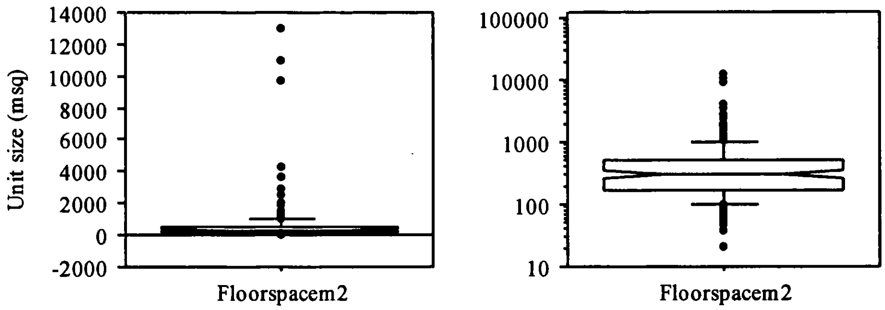


Figure 6.15: Box plot of unit floorspace size: linear scale (left) and log 10 (right)

As has been noted in chapter 3, the landlords' leases are on average larger than the JLW sample. The most plausible explanation for this difference would seem to be that landlords are more likely to have made the effort to tell JLW about larger lettings, whereas for the JLW sample the author recorded all available leases. The skewness of the landlords sample is also greater (10.83 in Table 6.3 compared to 6.65 in Table 6.1), owing to the much larger maximum outlier.

6.3.7 Pre-letting time

The pre-letting time is often discussed as an interesting index of market confidence as tenants are thought to secure space earlier in advance if the market is expected to rise. Yet evidence on pre-letting times is often limited to anecdotal information. Analysing the pre-letting times of leases has shown characteristics of the market that were not visible from the property agents' reports. Firstly, the mean pre-letting time is greatest in the earlier years of 1991 and 1992 before the recession began, as can be seen in Figure 6.16a below. This makes intuitive sense in a market with restricted supply of office space as Figure 6.16b on the right, the main cause of the higher pre-letting times in the earliest years of the sample is shown to be short term leases. This may reflect companies wishing to establish a foothold in Berlin after reunification by reserving some space on a short lease basis. The sample size is so small in the first year for pre-letting that it impossible to draw statistical significance from this finding.

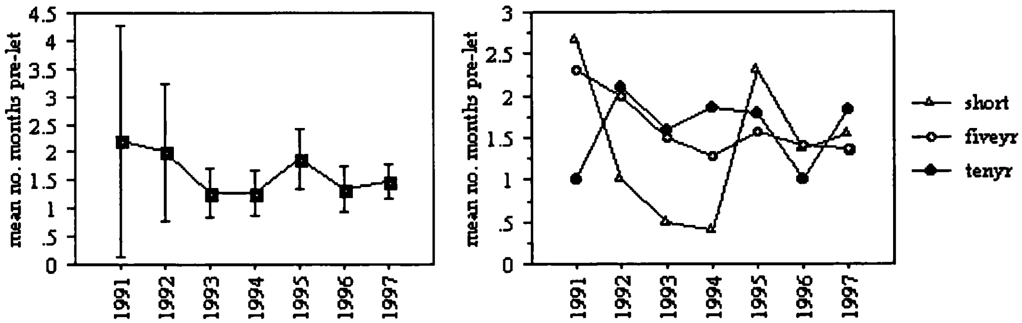


Figure 6.16: Mean Pre-letting times per year in the JLW lease sample

Secondly, there are higher mean pre-letting times for leases in new buildings compared to old buildings. This difference is significant to 1 standard error. The pattern of pre-letting times in new and old buildings also varies in relation to the broader supply and demand conditions of the market. Pre-letting times increased more in new office space after 1994, when the bulk of the first wave of buildings since reunification came onto the market. The difference between new and old is more pronounced for 10-year leases as can be seen in the right hand Figure 6.17b below. This may reflect the a more ready acceptance of pre-letting by larger companies looking for a high quality, longer term unit amongst the new building stock, but it is difficult to generalise from the small sample of JLW leases where this information was available[28].

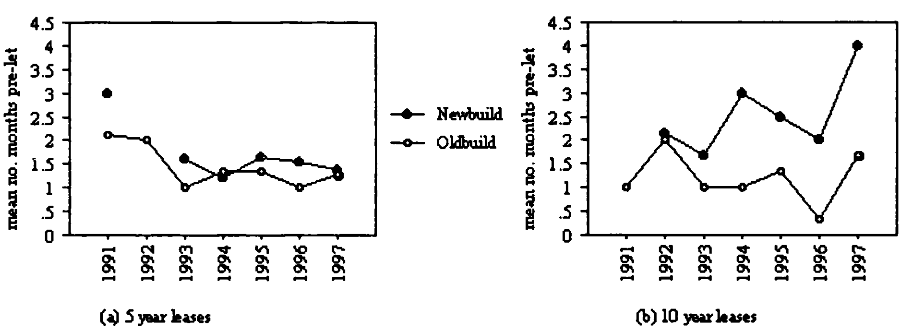


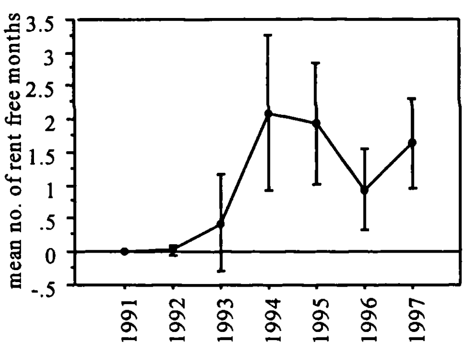
Figure 6.17: Mean pre-letting time in new and old buildings

[28] A thorough examination of the interrelation of these lease characteristics would merit a specific study, which is beyond the scope of this research. For the purposes of this thesis the investigation is limited to the question of whether any market characteristics can be identified that are pertinent to the thesis being tested (that there is a relationship between urban street configuration and location rent).

6.3.8 *Rent-free periods*

The use of lease incentives to attract tenants was a prominent feature of the Berlin office market in the recessionary period of the study years after 1992. 34% of the leases in the JLW sample had rent free months, making this the most prominent direct incentive. This percentage seems lower than some estimates from the British recession of the early 1990s, for example a focus group of investors, occupiers and developers in the UK estimated that 90% of office leases had rent free periods (Lizieri, Crosby et al. 1997). However, the longer average lease terms in the UK would lead to a more important role for some rent free time in leases.

There is also a great degree of variation in the amount of rent-free time given in each lease and this amount has also changed over time. The upward trend in rent-free time for the Berlin sample can be seen in Figure 6.18[29].



Sample is JLL's own leases (n=206)

Error bars show 95% confidence intervals

Figure 6.18: Number of rent-free months per contract

The percentage of the obligatory lease term that this period of rent free time represents is shown in Figure 6.19 below. A difference can be seen between new and old buildings, with a peak in 1994 for old buildings but a steady increase for new buildings.

[29] Crosby noted the same phenomenon of increasing rent free periods in UK office leases during the recession of the early 1990s. Rent free periods peaked at 18 months in the West End of London in 1992 and 36 months in central London in 1993 but the whole market average peak in 1993 at 12 months(Crosby and Murdoch 1998). These periods are much longer than those shown in Figure 6.18 are. However, UK lease terms are also much longer on average. Assuming a standard UK office lease to be 15 years after 1990, a very rough estimate of UK rent free period percentages for comparative purposes would imply peaks in the West End office market of perhaps 10%, in Central London at 20% and for the market as a whole at 6%. These are significantly higher than the averages shown for Berlin.

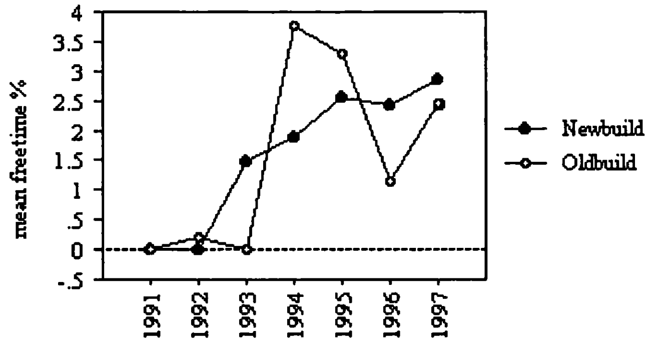


Figure 6.19: Percentage of rent-free time in new and old buildings

6.3.9 Increase Clauses

Approximately half of the leases were adjusted automatically to the *Lebenshaltungskostenindex,* a German consumer price index that averaged 3.1% p.a. during the study period (Bundesanstalt für Statistik 1998). 11% of the leases had an adjustment percentage clause above this average rate of inflation and 38% were below the rate. Of those below the rate, 26% had no multiplier adjustment clause at all. Appreciation multipliers have been decreasing slightly on average over the period, reflecting the more favourable terms being won by tenants, as can be seen in Figure 6.20 below.

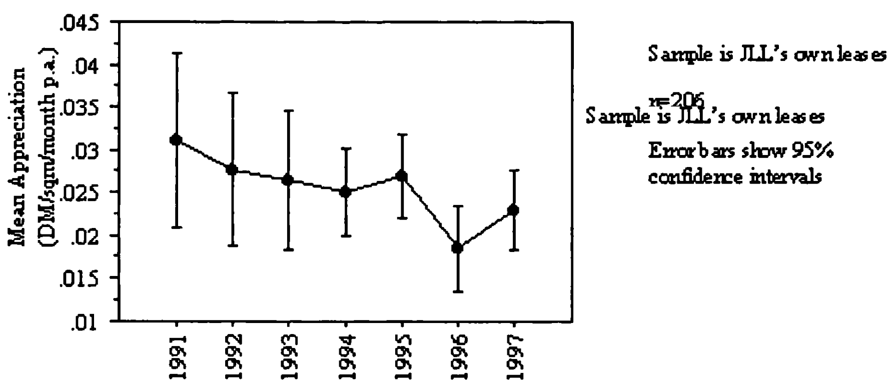


Figure 6.20: Mean rent appreciation multiplier per year

Another form of rent increase over the course of the lease is the step addition, but this was much less frequently used in Berlin. Over 80% of the sample had no yearly step addition.

6.4 Incentive Adjusted Rents

The lease provisions that can be quantified as incentives described above all show a trend in favour of the tenant for the period after 1992. When these incentives are taken together they have an influence on the effective price to the tenant of the lease. Incentives are very common in a recession because landlords attempt to conceal the fall in the *effective* value of their rental income in order to protect expected capital values. From the lease data used in this study, two kinds of incentive-adjusted rents have been calculated. Owing to the differences in incentive levels that arise with leases of different lengths it was necessary to control the sample for length. As the largest group of leases was that of 5-years in length, this group was chosen.

6.4.1 Consideration Rent

The first adjusted rent represents the most basic calculation for the effect of incentives on the cost to the tenant. It is the average rent price per annum of the jagged income flow of a lease with all its incentives (section 3.4.3.1 on page 93). The nominal consideration percentage shown in Table 6.4 below is a calculation of the average price per year set out in the lease without an adjustment for inflation. As can be seen, this leads to a nominal median value of almost 105% of headline rent. The mean value of 103.9% is just above the average rate of inflation during the years under consideration. This shows that on average, leases contained clauses to increase the consideration rent enough to offset inflation.

	Headline Rent (91prices)	nominal consideration rent %	effective rent %(5yr)
Mean	30.878	103.692	86.540
Std. Dev.	13.456	6.881	5.863
Std. Error	1.339	.685	.583
Minimum	16.660	83.804	68.336
Maximum	85.630	131.698	109.580
Range	68.970	47.894	41.244
Median	27.870	104.727	87.728

Table 6.4: Consideration and effective rent percentages

Figure 6.21 shows the average percentage of the headline rent that tenants paid in each year of their lease for five-year leases. The pattern conforms to the *front-loading* of lease incentives within the whole term of the lease described in Davidsons' model of incentives

(Figure 2.2 on page 37). Tenants were on average paying around 85% of the headline rent in their first year for 5-year leases[30]. This means that although a certain 'start price' was agreed for a lease, tenants are actually paying much less than the start price in the first year because they are receiving incentives like rent free time. Landlords were using incentives at the beginning of a lease rather than lower rents to attract tenants. They then increased the rent incrementally until the end of the lease. As Davidson et al noted, this is a rational policy for landlords: as well as supporting the appearance of higher capital values somewhat, it means that rent review negotiations at the end of the contract begin from a higher starting point (Davidson and Darlow 1993). After the first year, the consideration rent is higher than the headline rent and continues to rise to the end of the lease, where it averaged over 10% more than the headline rent.

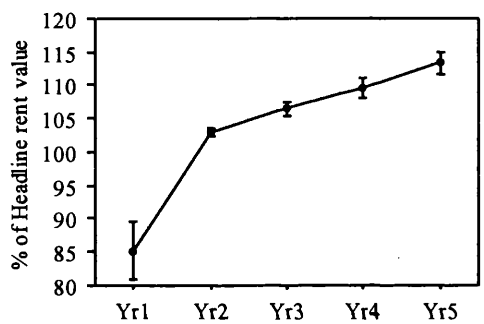


Figure 6.21: Consideration rent value as a percentage of headline rent for each year of the lease life

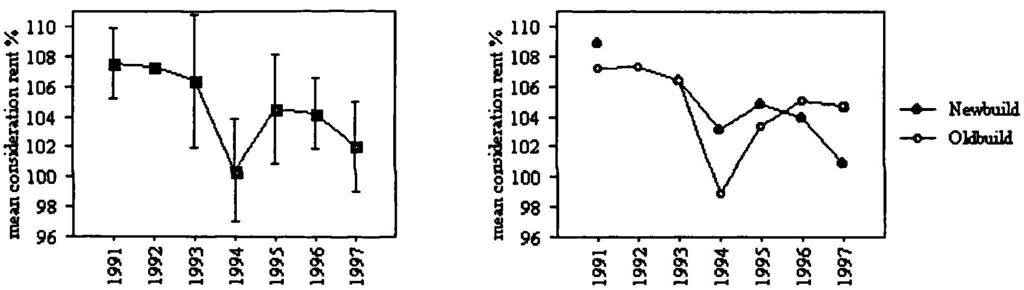
A slight positive trend is detectable in the relationship between the headline rent value and the percentage of consideration rent for 10 year leases but the relationship does not reach statistical significance (r squared=.069 p=.117). The coefficient is also positive for 5 year leases but the relationship cannot be considered to be significant (r squared= .005, p=.4873).

The trend in the consideration percentage of headline rents over the period can be seen in Figure 6.22. The 5-year leases show two drops in consideration rent percentage. The first

[30] It may be noted that in Germany, headline rent is always quoted as the start rent, regardless of adjustments that will take place over the life of a lease. This is the case in market reports and in the landlords sample of prices used in this study. This headline rent is not defined in the same way as Davidson's 'Target rent', which is the rent price at the end of a lease. Although it would be possible to create an estimate of the target rent (the price per square metre per month in the last year of a lease) for the smaller sample of JLW leases, this would not be comparable with the landlords leases. The definitions of Headline Rent, Consideration Rent and Effective Rent are provided in more detail in the Glossary.

drop was in 1994, when the mean consideration rent percentage fell to almost 100% of the headline rent. After recovering in 1995 and 1996 the rents dropped again in 1997.

An interesting difference in the timing of incentives can be seen between leases in new and old buildings, as in Figure 6.24 (b) below right. The first drop in consideration percentages in 1994 was more pronounced in old buildings whilst the second drop in 1997 was more pronounced in new buildings. At their lowest, average consideration rent percentages in old buildings declined to less than 100% in 1994. This means that even *before any discounting for inflation or a bank interest rate*, they were on average worth less money than they appeared to be from the headline rent, owing to the high incentives. However, they began to recover as a percentage in 1995 and continued to do so until 1997. Although the lease sample is very small and the data has a great deal of noise, this might suggest that leases in new buildings weathered the 1994-drop in consideration rents better than those in old buildings did, but declined further afterwards.



(a) All 5 year leases
error bars show 95% confidence intervals

(b) 5 year leases split by building quality

Figure 6.24: consideration rent percentages over time

6.4.2 Effective rents

The consideration rent shown above does not take into account depreciation to reflect the time aspect of money. Incentives have a differing impact dependent on the year that they are implemented: rent-free months at the beginning of a contract are worth significantly more, especially in terms of the cash-flow advantage to the tenant. As was explained in chapter 3, a discounted cash flow technique has been applied to the consideration rents to calculate an *effective rent.*

The trend in effective rent percentages shown in Figure 6.25 is very similar to the consideration rent trend shown in Figure 6.24. The two drops at 1994 and in 1997 are still featured with the discounted rent. The difference between new and old buildings is also shown.

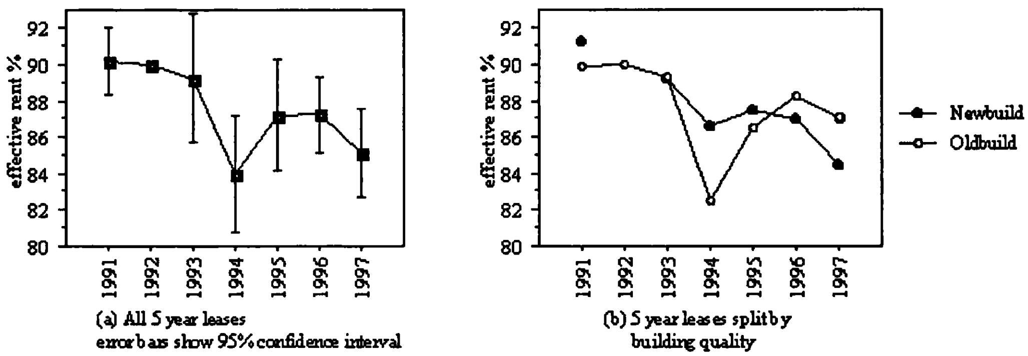


Figure 6.23: Effective rent percentages for 5-year leases

The effective rent is on average around 87% of the headline rent. At the extremes, it varies from 68% to 109%: a full 41% range. Table 6.5 below shows examples of the lease provisions for the 10 most extreme differences between headline and effective rent (the 5 lowest and 5 highest):

Year	Area	Pre-letting time (months)	Unit floorspace size (m^2)	obligatory lease term (years)	Total optional renewal time (years)	Headline Rent in 1991 prices (DM)	Rent-free period (months)	Build Quality	Step addition per month (DM)	Appreciation %	consideration rent %	effect[illegible] rent[illegible]
1994	West inner	0	406	5	5	42.55	12	Old-build	none	index	84	6[illegible]
1997	East core	1	252	5	5	43.84	7	New-build	none	none	88	7[illegible]
1995	West inner	2	1566	5	5	28.75	6	New-build	none	none	90	7[illegible]
1995	West inner	0	356	5	5	36.59	10	New-build	none	4%	92	7[illegible]
1996	Outer	1	352	5	5	20.60	9	New-build	none	index	91	7[illegible]
1996	Outer	3	607	5	0	18.88	0.5	New-build	.86	index	115	9[illegible]
1997	Outer	0	527	5	5	16.86	0	New-build	1.26	none	115	9[illegible]
1995	East core	4	119	5	5	51.50	0	New-build	4.29	index	119	9[illegible]
1995	West inner	1	138	5	0	30.49	0	New-build	2.61	index	121	10[illegible]
1995	East core	2	123	5	10	43.55	0	New-build	6.10	index	132	10[illegible]

Table 6.5: The 5 lowest and 5 highest effective rent percentages (5 year leases only)

6.4.3 Headline Rents Vs Effective Rents

As has been explained in the methodology chapter, the landlords' sample of rent data cannot be adjusted to an effective rent because the lease documents were not available for inspection and it was therefore not possible to control for incentives. Only the headline rents (but adjusted for inflation as constant 1991 prices) can be used for the landlords sample.

If this larger sample of non-effective rents is to be used as a proxy for the effective rents, the reliability of the sample must be tested. Table 6.5 above showed that at the very extremes of the JLW sample, significant differences can occur between the headline rent and the effective rent. How reliable is the whole sample of headline rents as a proxy for effective rent? This can be tested by looking at the statistical correlation (r-squared) between the headline rent and the effective rent.

However, as was discussed in the literature review, it is not clear what the discount rate used to calculate effective rent should be. This raises the further question of what the effect of discount rate *itself* is on the relationship between headline and effective rent. Figure 6.24 below shows the strength of the correlation between effective and headline rents for different discount rate assumptions. This means that each point in the graph represents the r-squared correlation for the variables of effective and headline rent at a certain discount rate, for all leases where these two rent types are available. The two lines represent the correlations for two different samples of effective rent: leases of a fixed 5 year length and leases of all lengths. For leases of a fixed 5 year length, the predictability of effective rent from headline rent declines only minimally as the discount rate rises for all reasonable rate assumptions. But for the sample of all leases, the correlation worsens logarithmically the higher the discount rate.

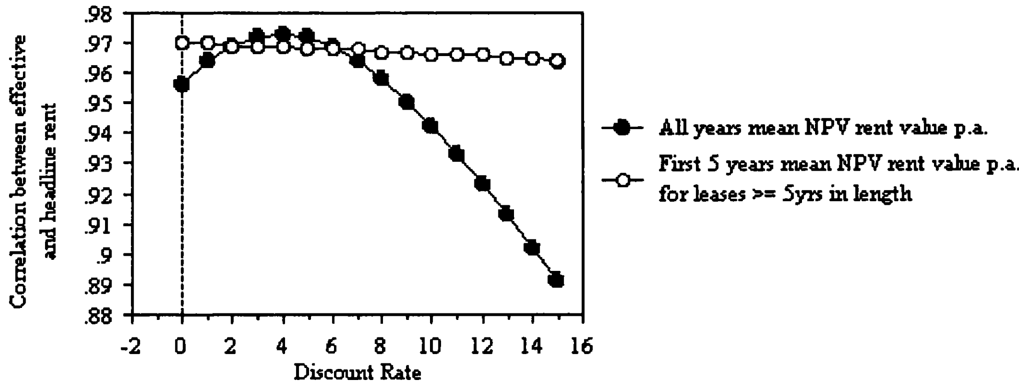
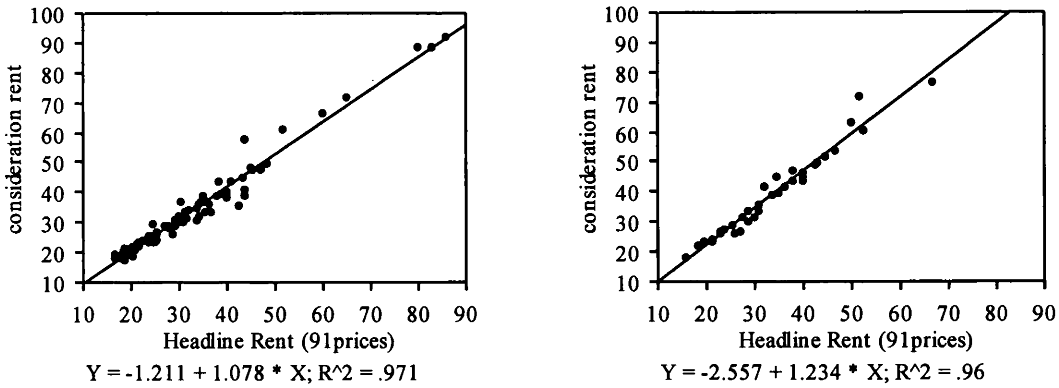


Figure 6.24: Correlation between headline and effective rents for various discount rates

Two conclusions can be drawn from this exercise:

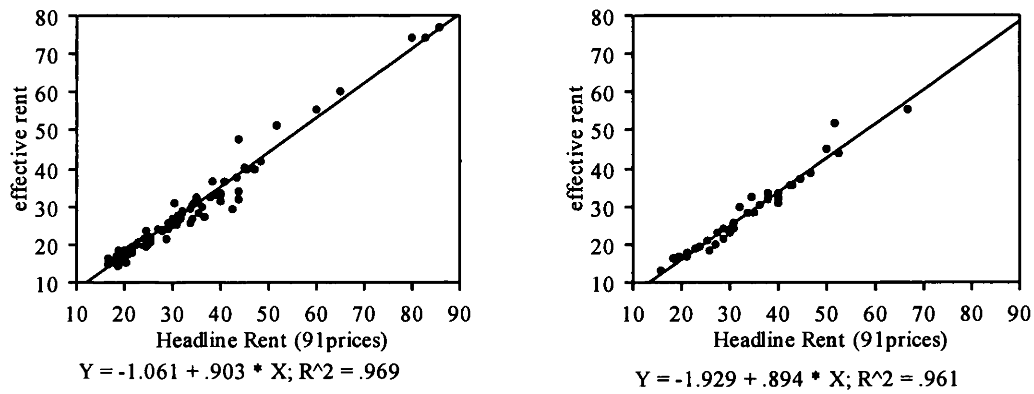
- It is not possible to compare the effective rent of leases that differ in length because the effective rent diverges from headline rents the higher the discount rate simply as an artefact of the different lease lengths.
- Once lease length has been controlled for, the headline rent predicts the effective rent to between 96% and 97% for the sample as a whole. This is true for the whole range of reasonable discount rate assumptions

Figure 6.25 and Figure 6.26 below show the extent to which the headline rent can be used as a proxy for both of the incentive-adjusted rents. Figure 6.25 is the correlation between headline and consideration rent (with incentives but before discounting) for the sample of JLW's own leases. The relationship is extremely strong for both 5 and 10 year leases. Figure 6.26 shows the relationship between the headline rent and the effective rent. The relationship between the two is still very reliable with this discounted version of incentive-adjusted rent. For a small number of individual outliers the non-effective price can hide some differences in the effective value of the rent, as has been documented in Table 6.5 above. But given that the headline rent predicts the effective rent to 97% for the sample as a whole ($p<.0001$), it is justifiable to use the larger sample of non-effective rents bearing this possible error margin in mind. This test was repeated for the sample of 10 year leases, as can be seen in the right hand scatter of Figure 6.26 below. The relationship was very slightly weaker (r squared=.961, $p<.0001$), possibly because the range of values is diminished.



(a) 5-Year Leases only (b) 10-Year Leases only

Figure 6.25: Correlations between consideration rent and headline rent



(a) 5-Year Leases only (b) 10-Year Leases only

Figure 6.26: Correlations between effective rents and headline rents

The debate about effective rents outlined in the literature review centred around how they might be calculated and whether a comparable effective value that takes into account all the different lease terms was possible. In this section it has been shown that it is not possible to compare the effective values of leases that differ in length because of the effect of time in the discounted cash flow calculations that are necessary for effective rents. However, for the small sample of 5-year leases that are comparable, the effective rent has been shown to differ significantly for some cases but to correlate very strongly with headline rent for the sample as a whole. For this reason, the larger headline rent sample is used without any adjustment for real or assumed effective rent differences.

6.5 Isolating Location Rent

In the preceding sections of this chapter, the non-spatial characteristics of the leases have been investigated. This section looks at ways of controlling for these lease variables in order to reach a sample of comparable *location rents*. In order to do this, other variables that systematically affect the rent price will be excluded using a location blind Multiple

Regression Analysis or MRA. This technique has been use by Gallimore et al. for a sample of house prices (Gallimore, Fletcher et al. 1996), as was discussed in section 2.7.2 (page 60).

Many variables might be considered important in determining rent, but it is necessary to detect a systematic effect in the empirical data (albeit a probabilistic effect) to be sure that any theory of rent determination not just a prejudice. MRA provides a method of investigating which variables have a systematic effect, so that the lease variables can be tested to see whether they influence rent in the sample. More importantly, it is possible to derive a residual figure for the amount of rent that is not explained by the systematic effect of lease variables. This figure, the residual that cannot be explained by other variables, can then be used as a 'location rent' because it is the closest we can get to a price that is attributable to the location itself.

Table 6.6 shows the correlation matrix for the main lease variables[31]. By far the strongest correlation is that of the time variable (month of lease begin) determining rent negatively at R=-.561. None of the other correlations are as strong, although the time variable does exert an influence on both obligatory lease term and floorspace, as was shown in the falling yearly averages of these variables in sections 6.3.3 and 6.3.6 above.

	Ln Floorspace	Ln Headline Rent	Contractlength	BuildQualityDummy	Leasebeginmonthcode
Ln Floorspace	1.000	.032	.319	.231	-.190
Ln Headline Rent	.032	1.000	.147	-.158	-.561
Contractlength	.319	.147	1.000	-.006	-.279
BuildQuality Dummy	.231	-.158	-.006	1.000	.079
Leasebeginmonthcode	-.190	-.561	-.279	.079	1.000

Table 6.6: Correlation Matrix for Lease Variables

317 observations were used in this computation.120 cases were omitted due to missing values.

Table 6.7 below shows the correlation analysis, sorted in descending order of the correlation coefficient R.

[31] As can be seen from the note at the bottom of the table, some cases are missing because not all variables were available for these leases. The sample size declines further when the more obscure lease variables are included. For this reason, the less relevant lease variables (such as option time) have not been included.

	Correlation	P-Value	95% Lower	95% Upper
Ln Headline Rent- Leasebeginmonthcode	-.561	<.0001	-.634	-.478
Ln Floorspace- Contractlength	.319	<.0001	.214	.417
Contractlength- Leasebeginmonthcode	-.279	<.0001	-.379	-.171
Ln Floorspace- BuildQualityDummy	.231	<.0001	.122	.336
Ln Floorspace- Leasebeginmonthcode	-.190	.0009	-.296	-.078
Ln Headline Rent- BuildQualityDummy	-.158	.0059	-.266	-.046
Ln Headline Rent- Contractlength	.147	.0104	.035	.256
BuildQualityDummy- Leasebeginmonthcode	.079	.1728	-.035	.190
Ln Floorspace- Ln Headline Rent	.032	.5829	-.081	.144
Contractlength- BuildQualityDummy	-.006	.9120	-.119	.107

Table 6.7: Correlation Analysis for Lease Variables

317 observations were used in this computation.120 cases were omitted due to missing values.

When multiple regression and stepwise regression are used on these variables only the time variable (month and year of lease begin) is shown to be highly significant but the dummy variable for building quality is shown to be *just* significant. This can be seen in the multiple regression of Table 6.8 below[32].

R	.575				
R Squared	.330				
Adjusted R Squared	.321				
RMS Residual	.246				
	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	4.070	.114	4.070	35.790	<.0001
Ln Floorspace	-.016	.016	-.054	-1.026	.3059
BuildQualityDummy	-.063	.031	-.101	-2.052	.0411
Leasebeginmonthcode	-.010	.001	-.561	-11.207	<.0001
Contractlength	.001	.007	.007	.141	.8879

Table 6.8: Location Blind Multiple Regression Analysis for Ln Headline Rent

6.5.1 The factor of time

The result of the MRA shows how fundamental the time factor is in the property market. Before the location variable is considered, the temporal aspect of a lease (the start date) is by far the most critical determinant of price. In this sample it is the only lease variable that has shown a systematic and highly significant influence on price.

[32] This regression can also be seen in Table A of Appendix F, where regressions are summarised.

Price is determined by the interaction of supply and demand within variable market conditions and the point at which a contract comes onto the market within the cycle of boom and recession is critical. To analyse the part of price that can be said to reflect location preference, the rent price relative to the market average at the time a contract was settled is the relevant measure, as opposed to the rent price per-se.

One of the ways of measuring the relative level of rent would be to adjust values with reference to a market index. The most widely used market indices are 'top rents' and a number of these are available for Berlin. However, these indices were investigated in detail in chapter 5 and large discrepancies were found between different agents figures. It was also shown in section 6.3.1 above that the use of 'top rents' as indices is less reliable than mean rents. Top rent indices are very volatile and depend on the exposure of particular agents to highly valued properties. There is no standard market index of rent in Berlin for the study to use as control values against which changes over time can be investigated.

For these reasons, the time factor has not been controlled using indices provided by agents but rather by measuring the time trend within the sample of data itself. There are a number of ways of calculating this, one of which is just to take a simple linear regression of rent against time, shown in Figure 6.27. This is an objective way to create a trend line for rents over time: the residual value shows the level of rent above or below trend for each lease in the sample. Time can be said to explain around 35% of the variability in price on this linear model.

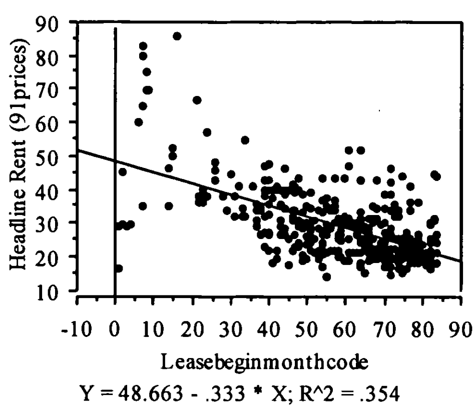


Figure 6.27: Linear regression of rent against time

Another method of creating this trend line would be to capture it by using a curve fitting function rather than a linear regression. There is no need to expect the relationship with time to be linear, in fact a more polynomial relationship could be expected if the market is cyclical. Figure 6.28 shows a 6th degree polynomial regression[33]. This regression fits the rent to time variables even better, accounting for around 48% of the variability in rent.

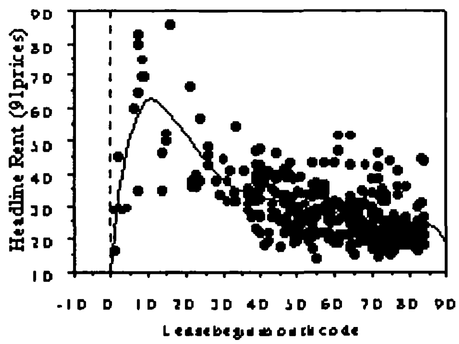


Figure 6.28: Polynomial Regression (6 degrees) of Rent over Time

The main result of taking the polynomial regression is to show a rise during 1991 (until month 12 of the *leasebeginmonthcode* on the x axis). As was seen in Figure 5.2 (page 166) property agents' reported a rise in rents until 1992. The curve in the polynomial from 1991 to 1992 can be explained by the change from rising to falling rents that occurred as the market tipped over into recession. The greater range in rents during the first two years of the sample can also be attributed to the changes occurring as the market rose to its peak and began to fall.

In view of the difference between the rising market before 1992 and the falling one after it, the first year of the sample (1991) has been excluded from the multiple regression models. Figure 6.29 shows the relationship between rent and time for the period 1992 to 1997. The removal of 1991 has not improved the correlation, in fact it is a little worse because the values for 1991 were high anyway. However the removal of 1991 is necessary in order to prevent mis-specification of the regression model. To the right of Figure 6.29 is the log-linear regression for rent, which has been undertaken in view of the positive skew for rent values. This did not make a great deal of difference to the correlation other than to remove one of the early outliers that was responsible for the positive skew of rent values.

The 'wobbles' of the polynomial line for the period after January 1992 cannot be explained by any known market process, and it is not possible to rule out the explanation that they are just an artefact of the individual data from the curve fitting function that

[33] This is a curved best fit line with 6 possible changes of direction

allowed 6 changes of direction. If a polynomial regression is used to fit a curve more precisely to the data without explaining the 'wobbles' in line that this introduces, the model is only reflecting individual data characteristics rather than representing a general influence of the variable.

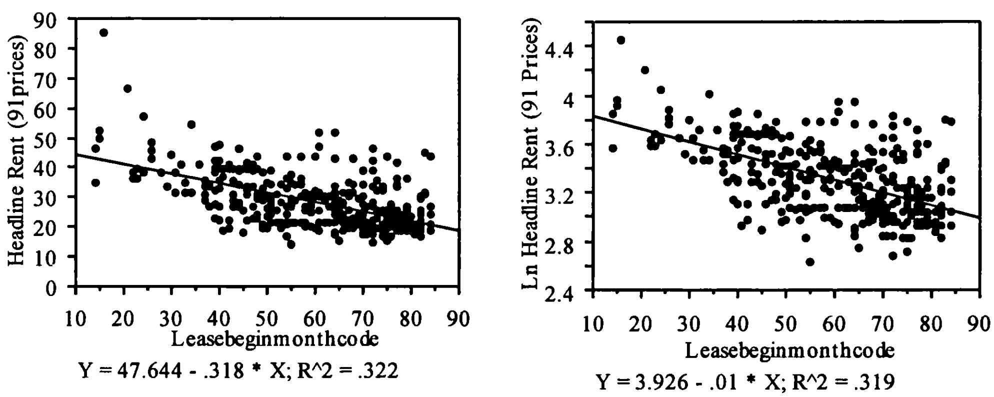


Figure 6.29: Linear (left) and Log-linear (right) regressions for rent against time (1992 to 1997)

A statistical expression of a contract's price relative to the time trend is the residual of the above relationship between rent and time. This has been used as a method of establishing a price relative to the market average, which also takes into account the differences in the number of cases per year. Once a relative price is established, it can be used to display the distribution of rent prices according to location.

6.5.2 Quality of the Premises

This variable was shown to be just significant in the determination of location-blind rent in Table 6.8 above (p=0411). Of more concern was that the sign of the variable in both the correlation matrix and the MRA was *negative* with rent (coefficient=-.063 and the t value=-2.052 in the MRA). Since new-build= 1 in the dummy, this result goes against expectations, as a premium would be expected for new buildings according to both previous research and the property agents reports shown in chapter 4.

The possibility of colinearity with location seems plausible, especially in view of previous studies that showed this problem between indices of building quality and location (section 2.8.3 on page 72 of the literature review). However, unlike previous studies, the fact that the sign is negative implies that new buildings in the sample would be in less prime locations than old buildings. In view of the uncertainties created by this result and given that the statistical effect of the build quality variable is so minor anyway, it has not been included in the value for the representation of location rent. The role of build quality will be re-evaluated with the location model in chapter 9.

6.5.3 Other Variables

6.5.3.1 floorspace size of the unit

As was discussed in chapter 2, the expected sign for floorspace would be negative, as it might seem plausible to assume that an economy of scale effect would show between unit size and rent, but this did not show in previous studies (section 2.5.2.2 on page 41 of the literature review). No such relation has been found in this sample either. The MRA showed that the floorspace size was not a significant variable in the determination of rent.

The only significant (but weak) correlation with floorspace size of letting was that of lease length: the larger the letting, the more likely it is to be a longer lease. This conforms to earlier studies as discussed in section 6.5.3.1 above.

6.5.3.2 Obligatory lease term

No role for lease length was found in rent determination, mirroring the findings of Brennan (section 2.5.1.2 of the literature review). As has been discussed in section 6.3.3, the length of contract has fallen over time and so a weak but significant correlation with time was shown in the analysis of Table 6.7 above.

6.5.4 Untested Variables

The choice of variables tested in previous studies was discussed in section 2.5 of the literature review (a summary can also be seen in Appendix C). All previous studies have used a necessarily limited number of independent variables but (as was discussed in chapter 2) many have also used proxies for the dependent variable of achieved rent that are quite problematic, such as asking rents.

This study has overcome the problems of the use of asking rent as a proxy for the dependent variable by gaining access to real lease data. However, there are still inevitable limitations on the collection of data for independent variables to be tested.

A number of variables that might potentially play a role in determining rent levels that it has not been possible to test because they were not available in the landlords sample of rent information and the cost of collecting such information in a survey is so high that it would require an additional study in its own right. The landlord's sample did not specify information of the availability of parking facilities (although these are usually rented under an additional contract, they may or may not be available at all). This variable has been dealt with in some way by 5 of the 11 previous studies of office rent outlined in Appendix C. Another group of omissions in variables are those relating the state of the interior fit-out, which can differ in many ways, for example:

- air conditioning and climate control
- provision of computer network support infrastructure
- lighting
- availability of support services
- security of the building

Fit-out variables are also dealt with only patchily in previous studies, although a notable exception is Dunse's study of Glasgow asking rents (Dunse 1996).Many of the fit out variables may be correlates of the building quality variable as newer buildings are likely to have better facilities. There has not really been a uniform approach to building quality measurement in previous studies, as was discussed in section 2.5.2. of the literature review

There are other variables that might be significant in rent differences that it has not been possible to test owing to the limits of the landlords sample, such as those relating to micro-scale spatial questions:

- The internal division of space — This variable is the layout of the unit and differences could be the amount of cellular or open plan spaces in a unit. It is reasonable to suggest that it may have an influence on value although no previous studies reviewed in Appendix C have tested it.
- The flexibility of the building — This variable would be the difference in the extent to which the footprint of the building

could be adapted to tenants uses such as changes in structural features like the addition of stairs to link floors more. Again, none of the studies in Appendix C tested this either.

• Scope for expansion	This variable could be measured as floorspace per floor. Hough and Kratz tested this variable explicitly and some other studies tested it with proxies, usually by average floorspace per floor. This information was not available for the lease data used in this study.
• Quality of views of the surroundings from the building	This variable has not been tackled in any of the previous studies of office rents. Some work has been done on the quantification of views in the field of architectural research, using the concept of the isovist originally pioneered by Benedikt (Benedikt 1979). However, this technique has never been applied to the valuation of office spaces and it would require a methodology of its own to be developed specifically to tackle questions such as which views should be measured. This is beyond the scope of this study.
• the floor on which the leased unit is situated	As most other studies in Appendix C did not cover individual leased units, this variable has been tested only patchily in previous studies.
• 'Architectural Quality'.	Whereas some of the above factors might be used to quantify the functional quality of the architecture of a building, there is also the question of the role of aesthetic quality. The influence of this variable on the market as a whole is very difficult to measure because it necessitates some method of valuing aesthetic quality. Hough and Kratz attempted this with the

use of architectural awards as discussed in section 2.5.2.3 of the literature review, but none of the other studies have done so.

In advance of testing any of these variables, it is not possible to tell if they could have an influence on value. However, the research question of this thesis is not to provide a general model of rent but to investigate the role of location in rent determination. Although it can never be ruled out, it is hard to see how these micro-scale variables could have a systematic effect on the spatial differences in rent at the city scale.

6.6 Discussion

This chapter has sought to investigate the characteristics of the lease sample to determine whether there are non-spatial explanations for the spatial pattern of rents in Berlin. In doing so, a number of the non-spatial characteristics of rent have been found in the lease sample that were not available for inspection in the published evidence of agents' reports. Whereas the agents reports showed that the recession has led to a decline in rents, the detailed analysis has revealed that the move from a landlords to a tenant's market has affected not just the rent, but every one of the major lease provisions. Leases have changed to the advantage of the tenant both in terms of provisions that have a monetary value and for those of a more general nature. The result is similar to that found in previous studies of recession in other markets (see section 2.5.1 on page 35 of the literature review).

In this chapter, two kinds of *adjusted* rent values (consideration rent and effective rent) were tested against the headline rents in order to evaluate the impact of the changing lease provisions on effective rent value. This revealed a hidden trend in the market: the peak in lease incentives was found to have occurred in 1994, just before the completion of the first wave of supply, not in 1992 or 1993 when rents began to fall. This supports the finding of Webb's outlined in the literature review (page 36 above), that incentives increase before vacancy rates increase and therefore effective rents are forward looking indications of market conditions (Webb and Fisher 1996).

A difference was also found in the impact of lease changes in old and new buildings. Landlords in older buildings appear to have begun offering larger discounts before the major wave of completions. The leases in the few new buildings completed before 1994 were able to hold out longer. However, as the supply of new office space continued to rise despite inadequate demand in 1995, 1996 and 1997, the effective value of leases in new buildings began to fall.

The move to less standardised lease terms also raises the issue of the extent to which leases are actually comparable as evidence of tenant demand. This issue is critical to the thesis because an analysis of the relationship between urban form and rent values is predicated on a comparable sample of rents. Yet published rent reports from property agents have not even commented on this issue of comparability. The analysis of consideration and effective rent showed that although there is a significant range in the effective percentage of headline rent, the correlation between the two is very good for the sample as a whole. This means that it is possible to use the larger sample of headline rents as an index of the cost of location for tenants.

The analysis of the non-spatial characteristics of leases showed that by far the most important variable in rent determination was time, while it was not possible to isolate a significant role for other non-spatial variables in rent determination. In many senses this result confirmed the analysis provided by the agents reports. Variables such as lease length or unit floorspace size that are not accounted for by the agents in their location rent maps were not found to be statistically significant in location rent determination.

However, this is only the case for the *location rent* measure and it does not preclude the possibility of some of these variables being co-linear with a spatial independent variable. In particular, the fact that building quality was just significant in the MRA and that it had the unexpected negative sign suggests the building quality might be an index of location rather than a truly independent variable. In order to test this, it is necessary to analyse the lease data with independent measures of location. This will be undertaken in Chapter 8.

The result of the investigation into non-spatial characteristics of rent is that it is not possible to rule out a role for the location of a lease in the built environment in rent determination by showing an overwhelming influence of non-spatial variables. This is not to say that lease variables are unimportant and it is of course not possible to make an *induction* from this dataset as to the role of non-spatial variables tested per se. In a real sense, there is no validation of the finding that non-spatial variables tested are not influential in value determination.

Indeed, a deeper understanding of the market has been achieved by looking at lease variables in this study that were previously ignored in published reports. If more transparency and knowledge in the market is desirable, then this evidence calls for more academic studies specifically focussing on the non-spatial variables and more publishing of indices that describe the other characteristics of a lease (not just the headline rent) by those active in the commercial field.

However, for our purposes, the study of non-spatial characteristics is a precursor to the real focus of the thesis, which is to investigate ways of measuring and modelling the spatial characteristics.

6.7 Summary

This chapter analysed the non-spatial characteristics of the office lease dataset. Each of the main lease clauses was analysed and changes were found that provide evidence of a shift from a landlords' to a tenants' market with the recession. Thus, as well as negotiating lower rents with the recession, tenants were also able to negotiate shorter leases and a number of incentives such as rent-free time during the study period.

Incentive-adjusted rents were calculated for the sample according to the methodology developed in the chapter 3. This revealed a hidden trend in the market: the peak in lease incentives was found to have occurred in 1994, just before the completion of the first wave of supply, not in 1992 or 1993 when rents began to fall. This finding supports the finding of Webb's outlined in the literature review (page 36 above), that incentives increase before vacancy rates increase and therefore effective rents are forward looking indications of market conditions (Webb and Fisher 1996).

The evidence showed a differentiation in the market between old and new buildings for lease incentives as these peaked earlier in the old buildings just before new supply came on-line but later in new buildings as competition increased. This differentiation in incentives between new and old buildings has not been investigated in previous studies. It was found that although individual leases may vary greatly, the sample of headline rents as a whole correlate well with effective rents and the larger sample of headline rents can therefore be used as a proxy.

A location blind multiple regression analysis (MRA) was run in order to isolate the residual that can be attributed to location. The result of the MRA shows that the lease start date is by far the most important of all non-spatial variables and that other lease clauses are not found to be statistically significant within the MRA. The potential for covariance with the location variable was discussed particularly with regard to the performance of the building quality variable within the MRA. Build quality was just statistically significant in the location blind MRA but its sign was not as expected.

7 REPRESENTING THE SPATIAL PATTERNS OF OFFICE RENTS

7.1 Introduction

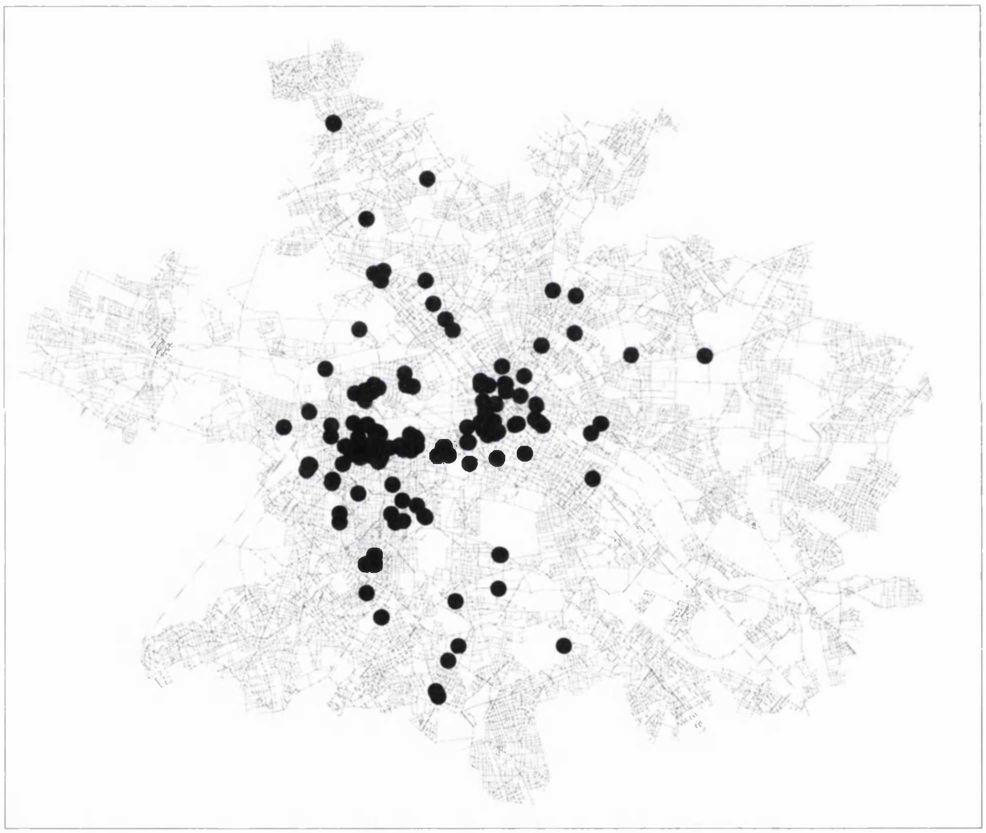
Thus far, available indications of the spatial patterns of rent in Berlin from agents' rent reports have shown interesting relationships with the independent spatial structure of the city and the way in which it changed with reunification. A lease sample has been sought with which to investigate the pattern of rent more accurately. In the previous chapter the non-spatial characteristics of the lease sample were controlled in order to allow for a direct representation of the spatial pattern of rents. The empirical results of that representation are the subject of this chapter.

The American economic geographer Knos, in his influential study of land values in Topeka, Kansas, made a distinction between what he called a 'naïve' spatial description which refers to a single place and time and a more general description that invokes a universal theory. In the first kind of description, 'a presentation is made of the observed occurrence of varying intensities or kinds of things from point to point on the earth's surface...such descriptions are generally a recital of *what* is *where* '. The second kind of description 'involves a statement of the spatial variations of a distribution in terms of its relationship with other features distributed over the area' (Knos 1962).

In Knos' terms, the aim of this chapter is purely a 'naïve' representation of the empirical data- the representation of location rent. The reason that this is undertaken so explicitly is that there has been confusion in much analysis of rent patterns between the data under observation (the spatial distribution of the dependent variable) and the measure used to explain the data (the independent spatial variable). This problem was outlined in the literature review of chapter 2. Knos' second, theoretical kind of representation is actually the representation of the *independent spatial variable* to which a pattern of rents is seen to correlate with. The theoretical question of what this spatial variable is and how it should be measured is approached in the next chapter. Of course, the two spatial patterns of the empirical data and the independent variable should be very similar if the spatial measure chosen influences the pattern of rent in a simple way. However, before such a measure can be tested and validated, it is necessary to obtain as clear a representation as possible of the data in question. This is the aim of this chapter.

7.2 The Pattern of Rent

Map 7.1 shows the location of buildings containing leases within the larger sample of rents (including landlords' data). The geographical spread is much better North-South than East-West, as many of the outer districts of the extreme west and east are not represented in the sample. As was shown in chapter 3, the sample is also highly concentrated inside the central S-Bahn ring area, reflecting both the concentration of office uses in the centre of the city and Jones Lang Wootton's focus on central properties (as discussed in section 3.3.2 on page 87).



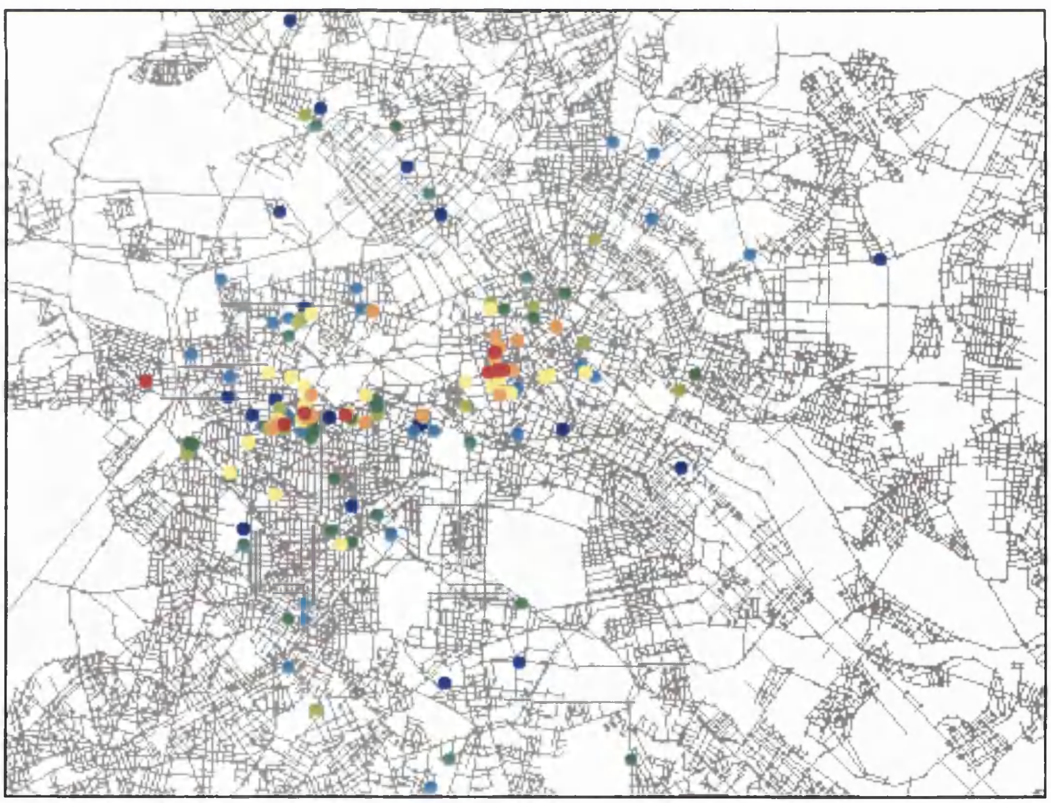
Map 7.1: Buildings Containing Leases in the Study Sample

Map 7.2 shows the pattern of location rent[34] of the entire sample for all years together. The colour scale used is a spectral range (red is highest above average and blue lowest below average rents) with natural break scaling, as explained in chapter 3. There is a notably clear global structure to the spatial pattern of rent data, with bluer points around the periphery of the map rising to red in the two centres. These two peaks of office location rents for the whole period are located in the Western CBD and in Mitte,

[34] This is the residual of the correlation shown on the right of Figure 6.29 on page 222.

reproducing the main feature of the patterns that were shown in the agents' reports (Map 5.1 to Map 5.6 on pages 171 to 175). These are concentrations of red, orange and yellow points on the map. This finding shows that the location of these two rental 'hot spots' in Berlin described by the agents is borne out in the data of actual leases. In other words, the location of prime areas in the property consultants' maps were not attempts to deliberately mislead the market by 'talking up an area' but a fair (if rather crude) representation of the global pattern of location rents as it was evolving at the time.

The lease data might be expected to produce a more chaotic pattern, as there is more random individual variation the more detailed and disaggregated the data. Yet there are very few real outliers to this pattern. The most notable negative outliers are some below average rents in Mitte on Friedrichstraße itself. The most notable positive outlier is in the extreme West of the distribution. The only factor that these outliers shared was that the majority of them occurred in the earlier years of the sample (before 1995). As was shown in section 6.3.1 (page 195), the variability in rent was greater during the earlier years of the sample.



Map 7.2: Location rents in Berlin 1991-1997

7.2.1 Changes in the spatial pattern of rents over time

In chapter 2, it was shown that some research has attempted to represent the change in spatial pattern of rents over time (as discussed in section 2.7.4.2 on page 68). In particular, Antsey and Howes both attempted to plot the changes in the spatial pattern of rents showing that the area of highest values can move over time (Anstey 1965; Howes 1980). According to the statistics in the agents reports, there has been a shift in the location of prime values from West to East in Berlin (for example Figure 5.4 on page 176). However, this spatial shift in values has not been represented in the maps produced by property consultants. One of the findings of the survey of reports in chapter 5 was that no dynamic representation of the spatial pattern of rents has been created for Berlin since reunification.

Having generated a location-rent map for the whole period 1991 to 1997, it is also possible to investigate the spatial changes within the period. Splitting the sample year by year led to a very small number of cases for each year and consequently it was decided to split the sample into two. The year 1995 was taken as the split point because it was a turning point in the market as the wave of new buildings was completed and vacancy levels rose rapidly (as discussed in section 5.8 on page 185). In order to represent the mean building rents in the two periods, the average values of leases per building were recalculated. This led to a new aggregation for the period 1991 to end 1994 of 122 contracts in 80 buildings and for the period 1995 to end 1997 of 313 contracts in 193 buildings[35].

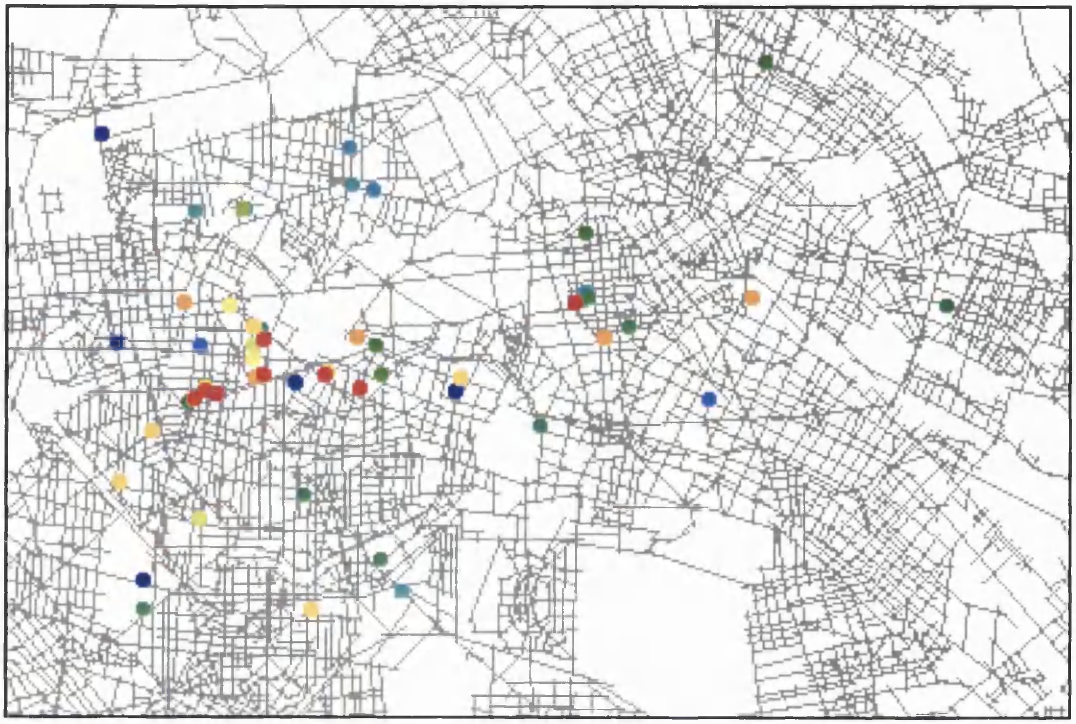
When the sample is split into two periods, the process of change becomes much clearer. In the earlier period (Map 7.3) the Western centre is predominant as the main rent 'hot-spot'. Most of the leases were in West Berlin (reflecting the relative lack of supply in the East during the earlier period). The values of these leases are centred around Kurfürstendamm and the Gedächniskirche, in a very similar pattern to that shown by the property consultants' maps on page 171.

However, the latter period 1995 to 1997 (Map 7.4) has a markedly different pattern of rents: the western peak in values has disappeared almost completely and there is much more of a monocentric pattern focusing on Friedrichstraße and Gendarmenmarkt in the Eastern centre of Mitte. There are significantly more leases in the East during the latter

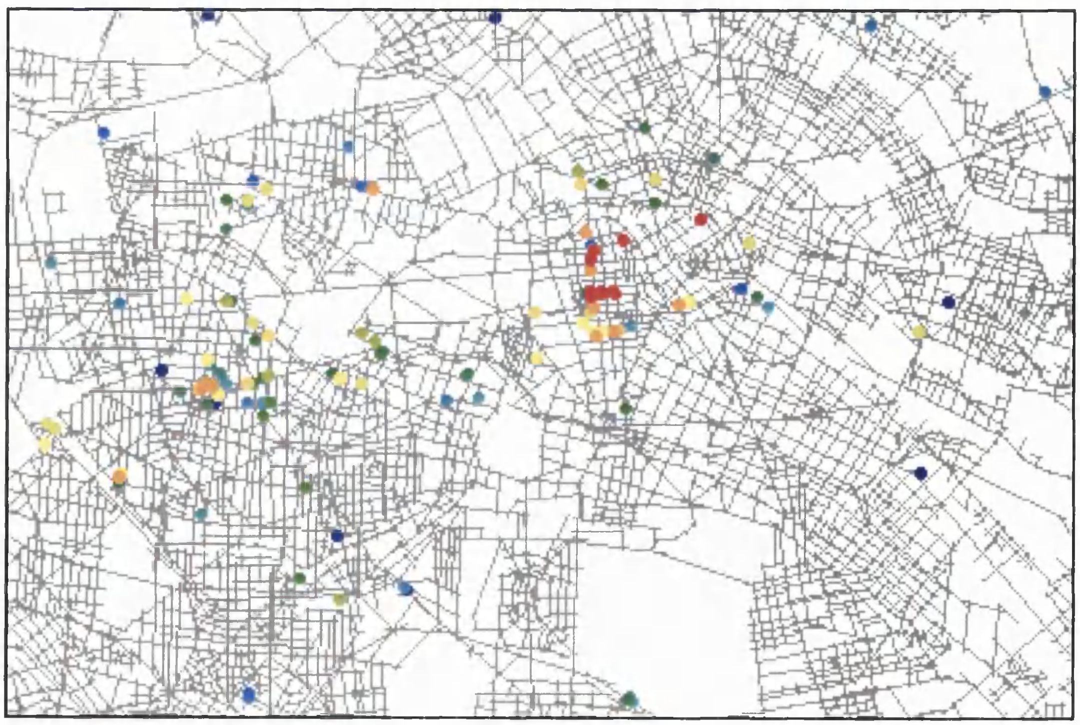
[35] These smaller sub-samples led to smaller average numbers of leases per building: 1.5 and 1.6 compared to 2.3 for the whole sample.

period, reflecting the increase in supply as old buildings were renovated and new buildings were completed.

The use of accurate data has allowed the spatial pattern of rents to be more clearly defined and has made explicit the reorganisation of rent values that has taken place since the fall of the wall: Downtown has moved from West to East Berlin.



Map 7.3: Location rents in Berlin 1991-1994



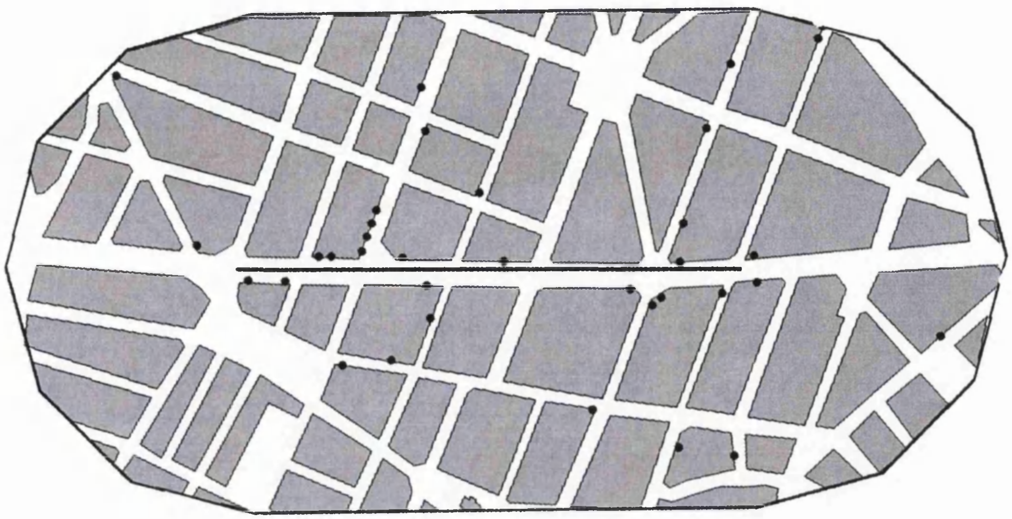
Map 7.4: Location rents in Berlin 1995-1997

7.2.2 *Street scale differences in rent*

As well as the major global shift in values from West to East, the representation of rents using lease data has exposed fine-scale street to street differences in rent values that were not clearly visible from the agents' maps. It has been generally acknowledged that street level differences exist for at least a century. For example, Hurd's rent maps of Minneapolis in 1903 (reproduced above as Map 2.2 on page 62) showed this (Hurd 1903). Brennan's Chicago rent representation (reproduced above as Figure 2.7 on page 66) also showed rents 1.6 times higher on the main street Madison than those found just four blocks away (Brennan, Cannaday et al. 1984).

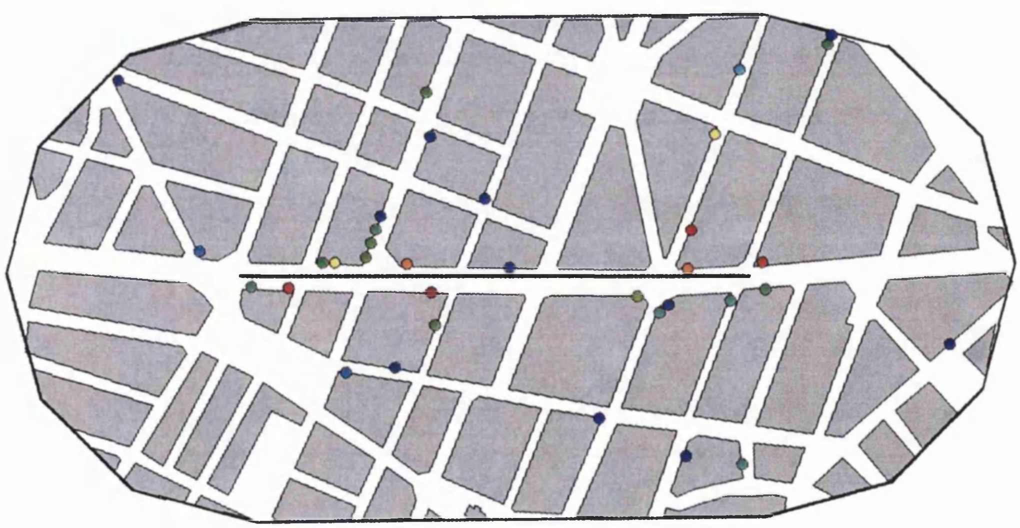
It is possible to demonstrate that the fine scale spatial differences of the kind shown by Hurd and Brennan are also found in the Berlin data. The property agents maps reproduced in chapter 5 indicate a difference between prime streets in Berlin such as Kurfürstendamm or Friedrichstraße and the surrounding areas (for example Map 5.1 to Map 5.6 on pages 171 to 175). However, the representation does not indicate the extent or regularity of differences. The representation at individual building level allows subtle differences between main streets and side streets to be presented.

A part of Kurfürstendamm has been selected to demonstrate this street scale difference. Map 7.5 shows a kilometre section in the middle of the Kurfürstendamm (the black line in the centre) and a surrounding area that has been defined simply by a 500m radius. Buildings containing leases that fall within this study area are shown in black. There are 64 leases on the surrounding streets and 16 leases on Kurfürstendamm. A very detailed examination of street based differences should be undertaken with a much larger sample of points as densely packed as possible, but this was the densest available sub-sample for such a demonstration that could be taken from the data.



Map 7.5: Selected 1000m section of Kurfürstendamm and 500m radius of side streets

Map 7.6 shows the average location rents for all leases within the specified radius of Kurfürstendamm. The colour-scale has been reset to the sample under consideration at equal count, with the red values above the trend with time and the blue values below the average[36]. There is a concentration of reds on Kurfürstendamm, showing that these leases are higher above average than the others. The only other lease reaching similar levels in the surrounding area is a high value lease within 100 metres of Kurfürstendamm in the vicinity of a strategic intersection of two cross streets and the Kurfürstendamm.



Map 7.6: Location rents on Kurfürstendamm and its side streets

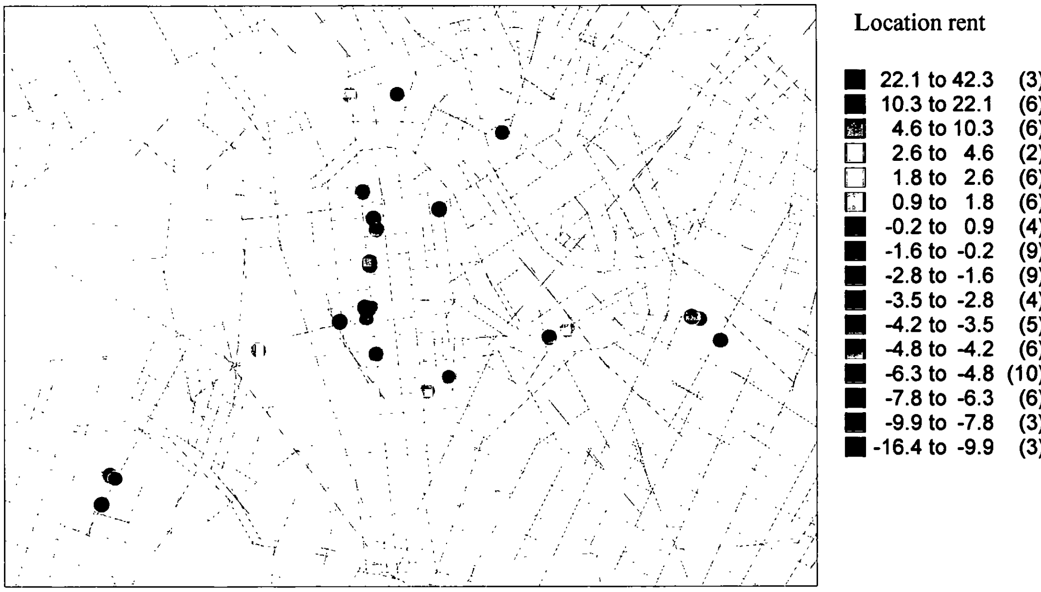
[36] For reasons of confidentiality the legend showing the precise colour scaling has not been reproduced here because it is much easier to attempt identification of individual buildings at this scale.

The mean value for leases on Kurfürstendamm is DM 6.83 above the trend over time, whereas the surrounding side streets have only DM 1.21 above the trend over time. This difference remains when the trend for West Berlin alone is taken, with Kurfürstendamm at DM6.86 above trend and the side streets at DM2.01 above trend.

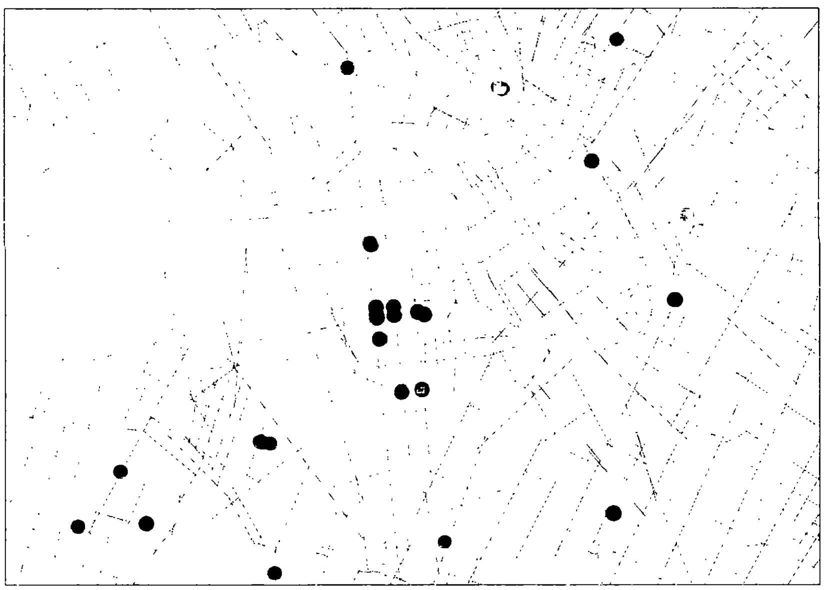
7.2.3 Location rents and new and old buildings

As was seen in chapter 6, it was not possible to find a statistically significant role for build quality in the location blind MRA used to create the location rent values. The hypothesised reason for this was that the distribution of new and old buildings might be independently related to location and therefore it was not possible to detect an influence on rent because of statistical covariance. Having represented the rents for all leases, it is now possible to split the sample into new and old buildings and investigate the difference.

Map 7.7 shows the pattern of location rents in Mitte for old buildings only, for the whole period under study (1991-1997). The colour scale is set to that of the whole city, so it can be seen that the old buildings in the core are high in value, with many oranges and reds above the trend for time. However, there are also some relatively cheap rents to be found in the old buildings even on Friedrichstraße itself. By comparison, the rents for new buildings in Mitte are exclusively very high above the trend for time, as can be seen in Map 7.8. Rents are highest in the middle of Friedrichstraße where the Friedrichstadtpassagen is located and on the Gendarmenmarkt square to the East of Friedrichstraße. These are indeed the two areas that were quoted as prime in the property agents' reports of chapter 4.



Map 7.7: Location rents for old buildings in Mitte1991-1997



Map 7.8: Location rents for new buildings in Mitte 1991-1997

New buildings on Kurfürstendamm in the Western centre have also achieved a premium, as can be seen in Figure 7.1 below which shows the distribution of values in box plots. The highest median rent is in new buildings on Kurfürstendamm, followed by old buildings also on the main street. The median value for old buildings in the surrounding area is actually slightly higher than that for new buildings, which is not the expected result for this difference. A part of the explanation for this must be the very small sample size in this detailed local study.

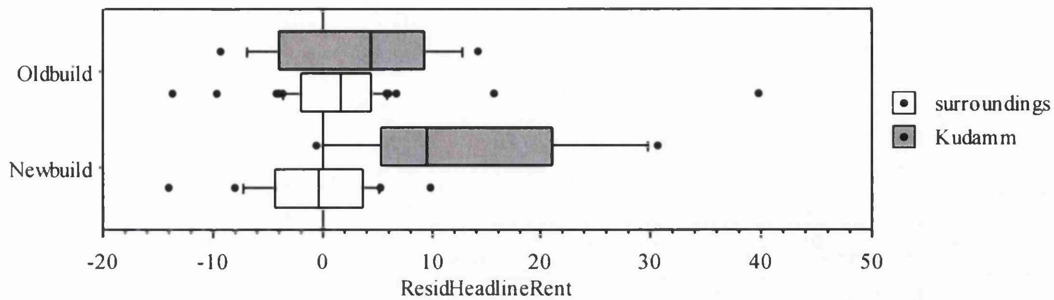
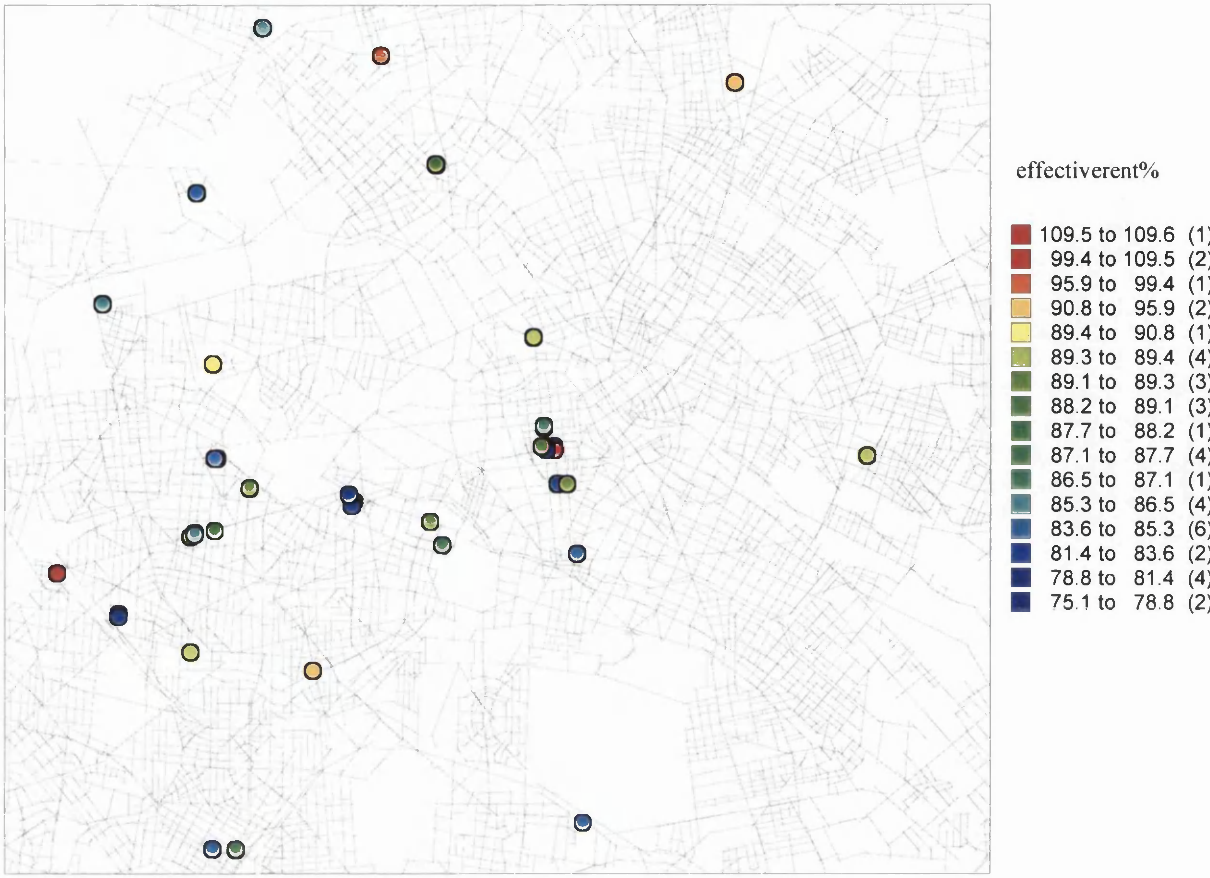


Figure 7.1 Box plots of rents on Kurfürstendamm and within 500m radius

7.2.4 Spatial pattern of effective rents

As was seen in chapter 6, both types of adjusted rent calculated for this thesis (consideration and effective rents) correlate very highly with headline rents. However, the differences in percentage of effective rent may have some spatial pattern. This can be tested by mapping the pattern of effective rents, as has been undertaken in Map 7.9 below. Unfortunately the sample of effective rents is too small to make maps of the whole city, which is limited to only JLW leases of 5 years in length. There are some higher percentages around the edge of the S-Bahn ring compared to the centre, but it is difficult to generalise from this limited sample size.



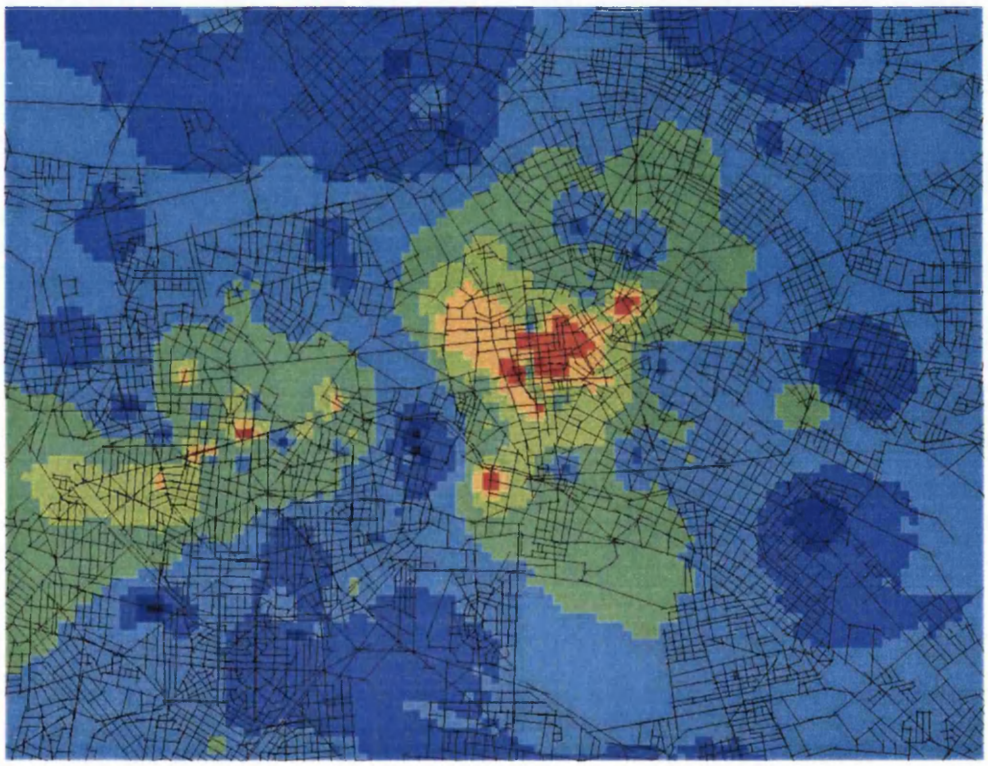
Map 7.9: Effective rent percentages for 5-year leases in Berlin 1991-1997

7.3 Isopleth Analysis

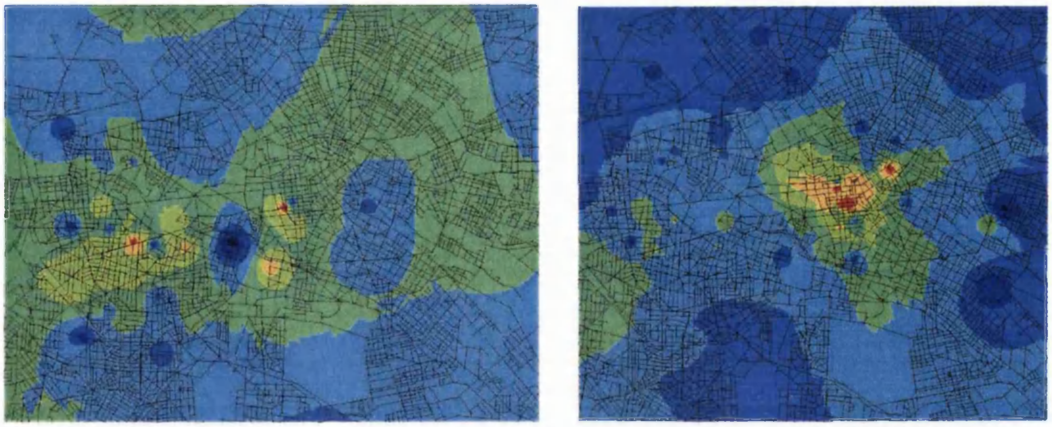
The literature review in chapter 2 showed that the representation of rental values as surfaces has been very popular in the postwar period. Antsey originally advocated the application of contour mapping to land values as a way for planners in the UK to obtain an overview of the value pattern for an entire town. Obtaining an overview was deemed necessary in light of the far-reaching new powers that planners had after the 1947 Town and Country Planning Act (Anstey 1949). The representation technique thus has two purposes, it provides a representation of empirical value data and it provides a *model* of rent values by interpolation where none are available. In this section, the potential of the isopleth representation as a model of rents will be discussed through the practical application of the technique to the Berlin data. This serves as a comparison to the representations of rents in previous studies, which have mostly used this technique.

The pattern of two centres shown in Map 7.2 is reproduced in the isopleth analysis when the whole sample of years is taken, as can be seen in Map 7.8. The low value band between them has been created because of the very low rent values around the Potsdamer Straße, which still retains some of the stigma associated with its role in West Berlin (as discussed in section 4.6 on page 151 of chapter 4).

The surface technique can also be used to show the change over time. Map 7.11 shows the surfaces for the two periods 1991-94 and 1995-97. The shift towards Mitte is also brought out by this representation, with dispersed hot spots focussed on the Western centre in the 1991-1994 representation (the left of Map 7.11) shifting to a clear centre in Mitte for the period 1995-97.



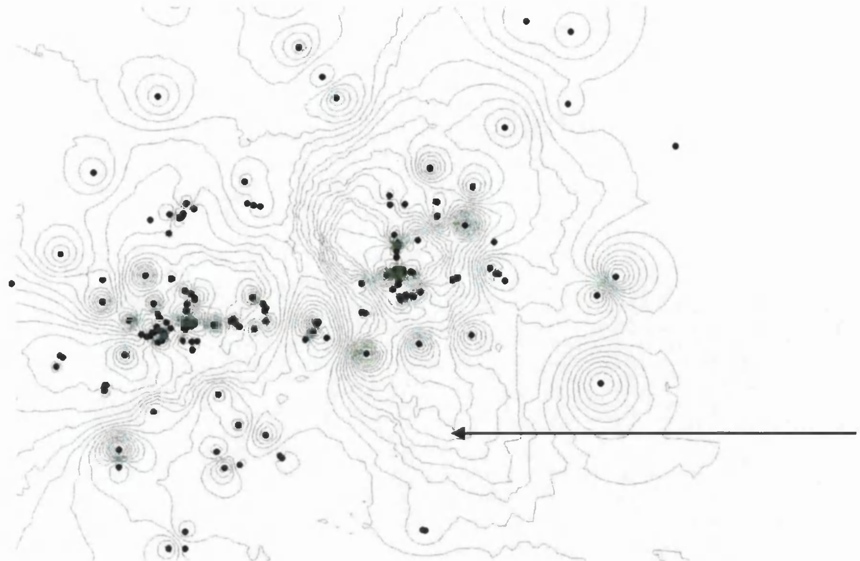
Map 7.10: Location Rent Surface for Berlin Office Rents 1991-1997 (IDW 20 nearest neighbours)



Map 7.11: Location rent surface for Berlin in 1991-1994 (left) and 1995-1997 (right)

7.3.1 Empirical problems with isopleth representations

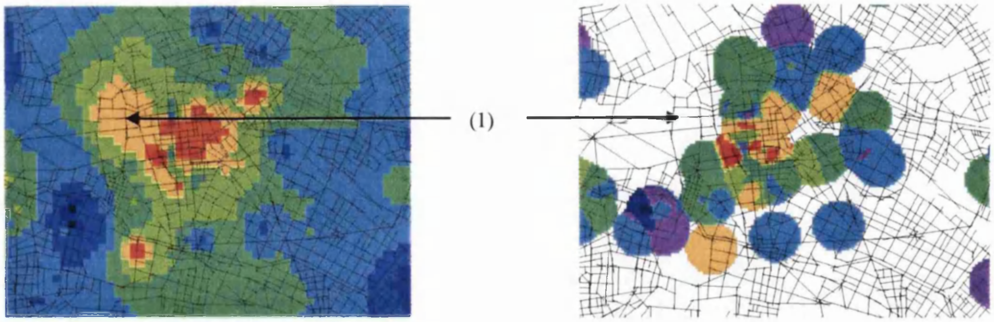
As well as providing methodological and theoretical problems already tackled in the literature review, the isopleth technique also has certain disadvantages as a method of representing the empirical data that can be seen from its use on the Berlin sample. The technique is used to provide rents for buildings where no data was available, but the accuracy of such interpolation is limited by the quality of the empirical data. It is not possible to tell from representations such as Map 7.10 whether the pattern of contours represents a true reflection of underlying empirical data or is simply an artefact of the spacing of available measurements. For example, the green values (representing between DM 1 and DM 2 per m^2 below the trend for time) can be seen to extend into the area to the North of Tempelhof Airport. Unfortunately there are no leases in an area approximately 3.5km North South and 6km East West around Tempelhof marked (A) on Figure 7.2 below. The fact that this effect is due to weaknesses in the empirical data would be hidden and the effect could therefore be mistaken as a characteristic of the data.



(A)

Figure 7.2: Data points and contour lines for the isopleth representation

Another reason for caution when using the technique to represent empirical data is that it is possible to generate quite different patterns from the same empirical data. An example of differences in the representation of the same empirical data owing to contour generation technique is shown in Map 7.12. The map to the left uses the nearest neighbour technique and that to the right uses a fixed radius around each data point to generate the surface. The two techniques represent quite different kinds of rent pattern. For example, the nearest neighbour technique (left) shows an extension of the higher values around Wilhelm Straße and Unter Den Linden into the area around the Reichstag (marked 1 on the map). The fixed radius technique does not, as there are no leases in the area to show the rent. Which is the correct interpolation under the given circumstances? If the whole purpose of rent surfaces is to interpolate and the method of interpolation can significantly alter the output, then the method itself must be supported by a theory that relates the surface to actual market activity. Otherwise the technique is simply a 'smudging' of the empirical data.



Map 7.12: Location rent surfaces in Mitte using the nearest neighbour (left) and fixed radius (right) techniques

7.3.2 The use of three dimensional representations

Map 7.13 shows the three-dimensional representation of the surface generated in Map 7.10, whereby the location rent values is used both to colour the surface and as the value for the z-axis. Three dimensional surfaces have been used by many authors to represent the pattern of location rents (Knos 1962; Brennan, Cannaday et al. 1984; Gallimore, Fletcher et al. 1996). The representation looks interesting but also demonstrates that there is no information added to the representation using this technique.

Because the representation of rent as a three dimensional surface requires the appropriation of at least one spatial dimension (e.g. the geographical z-axis), it makes the representation of spatial data quite difficult to read. When the surface of Map 7.13 is compared with the colour representation of Map 7.10, practically no additional information about the data can be learned. In fact Map 7.13 shows the extent to which the technique distorts the data because less of the surface can be seen in three dimensions than if a plan is used. Whereas very simple patterns over small areas might be clear in a three dimensional surface (for example, Brennan's two street isopleth shown on page 66 in chapter 2), more complex patterns such as the Berlin data shown below in Map 7.13 become very hard to read.

Map 7.13: 3D Location Rent Surface for Berlin office Rents

7.3.3 The Use of Isoplethic Surfaces as a Location Variable

This chapter has discussed the isopleth method of representation extensively because the literature review in chapter 2 showed a number of previous studies that have used the technique as a method of creating a location variable for rent analysis (as discussed in section 2.6.1 on page 44 above). Gallimore summarised the use of the approach:

> It would of course have been possible to adjust [the model] so as to eliminate the prediction errors totally. This could have been achieved by simply adjusting each prediction in accord with its error to actual price ratio. This would have eliminated all errors but would be a pointless exercise, since it adds nothing to an understanding of how location influences the values of those locations in the area (but not in the current dataset). The improvements in the model are achieved by using the surface estimated from error ratios. While it is important that this surface enables better predictions for the data set from which it is created, it is of course crucial that it should result in accurate predictions for new properties whose price is not known.
>
> (Gallimore, Fletcher et al. 1996, pg. 16)

The problem with this statement is that there is nothing more accurate about using a surface- it just means that any remaining error relates to the way in which the surface is created (for which there are a variety of possibilities as seen in the methodology of its application to Berlin).

As has been discussed in section 2.6.1 of the literature review, the isopleth analysis does not provide an independent variable and cannot therefore be said to measure a location variable, only to describe location differences in the rent variable. This chapter has also shown that as a tool for the description of location differences in rent it is also deeply problematic.

The benefit of the isarithmic technique is that it provides a pattern of rents for areas where no observation data is available. A prediction of rents for areas without comparable data is indeed a very useful thing to have. At a very general level, the pattern shown in Map 7.10 is informative as it highlights the global difference between the centre and the periphery for rent values despite the fact that no leases were available in many peripheral areas.

However, the technique also destroys the street to street differences that were demonstrated in previous studies by Hurd and Brennan and in the Berlin case shown in Map 7.6 above. This is because the theoretical assumption of an isotropic plain that is necessary for the creation of a surface tends to get in the way of actually viewing the anti-isotropic differences occurring from street to street.

7.4 Discussion

The maps in section 7.2 of this chapter have attempted to provide a more direct representation of the pattern of location rents than those found in published rent maps of Berlin. The agents' maps reproduced in chapter 5 were of limited use as evidence on rents because of lack of an explicit methodology. The maps used in this chapter took location rent values from the location blind MRA of chapter 6 and represented them with a transparent and repeatable methodology. The result of this exercise has been to reveal a number of characteristics of the pattern of rent that were hidden in the agents' maps. The fine scale representation of leases within individual addresses has shown that the difference in rents between new and old buildings can be seen when location is controlled. The difference is actually as might have been expected, with new buildings commanding a premium over old.

By splitting the representation of rent up into two periods, changes in the pattern over time have been shown, even within the relatively brief study period of 7 years after the wall. These changes show the decline of the West Berlin CBD and the rise of Mitte. In terms of the location of the prime office rent values, *Downtown has moved* to Mitte. This finding points to a more direct relationship with global spatial structure of Berlin than was seen in the agents' maps. The representations that were used by agents tended to emphasise the two centres within Berlin, but the representations of the lease data seem to support much more a case of one centre declining and another growing.

As the spatial restructuring occurred before the changes to the location of prime rents, the shift in the pattern of rent can be seen to *follow* the changes to Berlin's urban morphology that occurred with the fall of the wall. Just as the concentration of office uses in a CBD was seen to follow the global structure of the city as it developed, the move of the prime area of office rents in reunified Berlin also corresponds to the spatial change that occurred with reunification. The Western CBD, having declined in importance spatially relative to the city as a whole, is declining in location rent relative to other locations. The relative ascendancy of Mitte in location rent terms is also occurring on the basis of this areas new strategic position within the spatial structure of the whole city.

The changing pattern of rent revealed by the direct representation of empirical data shows how limited simple interpolation or comparative methods of location rent analysis are in cases of change. The isopleth *analysis* (sic) of rent patterns is essentially just a smudged version of the existing pattern of data in order to interpolate values for locations where no lease data were available. To be valid it must assume equilibrium in that pattern. This means that it is not a technique that is able to cope with cases such as Berlin where that equilibrium has been radically disturbed. It is also not able to cope with the fine scale spatial variations in rent from street to street that were shown by the detailed study of Kurfürstendamm in this chapter.

In the case of change it is necessary to provide a theoretical model of rent determination that can be used to *predict* the effect of changes in those variables that influence rent. The change that occurred in Berlin is fundamentally related to the spatial restructuring of the city with reunification. In chapters 4 and 5 an analysis of that spatial restructuring using axial maps of the city before and after reunification was presented. This analysis of the spatial change in urban configuration appears to provide a very good predictor of the changes that were found to have occurred to the pattern of rents as represented in this chapter. In the next chapter, this promising correspondence between the independent spatial analysis and the rent data will be developed in a model of rent determination. This model will show statistically how far it is possible to use such spatial analyses as predictive tools to help understand location trends such as those that have been presented in this chapter.

7.5 Summary

This chapter has taken the location rent measure calculated in the previous chapter and represented the pattern of these values in Berlin using a GIS. As with the representations of rent by property agents' shown in chapter 5, two peaks in value have been shown in the pattern of office rents for the years 1991-1997 of the sample.

However, a spatial shift of the kind hinted at in some studies of other kinds of rent value (discussed in section 2.7.4.2 on page 68 above) has been demonstrated for the office lease sample by splitting the rent representations into two periods. Whereas the property agents' reports only showed this in the aggregated rent statistics by area, this chapter has represented the shift graphically at the resolution of individual buildings. The representations have shown a dramatic shift: downtown has moved from West to East Berlin.

Fine scale differences have been shown in rent patterns. Differentials between main streets and side streets were found. Within areas, a premium for new-build over old-build has been found. This confirms suspicions about the negative role of build-quality in the location-blind MRA of chapter 6. The use of the isopleth rent surface as a model of rent has been evaluated in detail with reference to the Berlin data and criticised on both methodological and theoretical grounds. The need for a theoretical model of rent determination has been discussed. This model will be the subject of the next chapter.

8 MODELLING THE PATTERN OF RENTS

8.1 Introduction

Thus far, a spatial analysis of Berlin's development has shown how the reunification of the city changed the spatial structure of the street grid. A sample of office leases has been studied and the pattern of location rents has been represented. This has shown a clear change in location rent that relates to the pattern of integration.

In the previous chapter, the spatial pattern of location rents taken from a sample of real leases was represented using objective techniques. This showed that the pattern of rents in Berlin has changed dramatically since the fall of the wall, with the prime area shifting from West Berlin to the East. It was argued that simple interpolation of the dependent variable (isopleth analysis) is not sufficient to model such a change in the spatial pattern of rents as that has occurred in Berlin. Rather, a distinction has been made between the representation of the dependent variable and the *modelling* of its determination. In order to be able model change in rents, an *independent* spatial variable is required that reflects the change in the value of locations that occurred with reunification.

The visual similarity between the pattern of spatial integration in the axial maps and the pattern of rents shown in the previous chapter has already been noted. Axial Map 5.1 and Axial Map 5.2 (on page 164 above) that show the change to Berlin's global integration structure that occurred with reunification appear to predict the rise in the location rent value of Mitte and decline of the Western CBD area with respect to the city as a whole that occurred in the years following reunification. In this chapter, a statistical model of the determination of rents will be presented to show how far the space syntax measures do correlate with location rents and therefore the extent to which it is possible to use such measures to help build an explanatory model of rent patterns in Berlin. The purpose of this model is to explore the relationship between street configuration and rent pattern.

The main tool that will be used to model rent determination in this chapter will be Multiple Regression Analysis (MRA). This tool allows for the creation of a model of the determination of rent prices using both spatial and non-spatial explanatory variables. In chapter 6 it was shown that only time was found to exert a significant effect on rent in the non-spatial MRA (section 6.5 on page 217). However it was also seen that the build quality variable did not have the expected sign and the possibility of colinearity with location was suggested, as had been found in other studies (section 2.8.3 on page 72 of the literature review). In this chapter the role of building quality will be reassessed by looking at this variable in relation to location in a number of ways. The spatial differences in rent and build quality will be investigated on a year by year basis to take out the effect of time. Build quality will also be included in the regression models to see whether the inclusion of a spatial variable shows a different role for build quality that might have been undetectable in the location-blind MRA because of colinearity between build quality and location. Finally, samples of rents in new buildings only will be considered, as will samples of rents in old buildings only. .

Location will also be evaluated in a number of ways. As the representation of location rents in chapter 7 showed such a marked shift from West to East, the distribution of rent values in different areas will be compared. Using a year by year analysis, changes between West and Eastern rents can be traced with some control for the time variable.

MRA will be used both with the non-spatial and spatial variables together. This analysis will be applied to the whole sample and then East and West Berlin separately, in order to evaluate the differences in the importance of both spatial and non-spatial variables in rent determination for these sub-samples. The last stage of the analysis will be to look at the relationship between the spatial model and the 'location rents' variables calculated in chapter 6 in more detail. This will be undertaken firstly by applying regression analysis to the 'location rent' with the spatial variables and then by using location rent to consider the relationship between the spatial core of the city and the more peripheral locations.

8.2 Analysis of rents by Area

Figure 8.1 below show box plots of the distribution of rent both by building quality and by area for the whole sample. The definition of areas has been taken from the agents' dasymetric maps (see page 171 above). East and west cores correspond to the two areas of highest rent (not just the 1A streets). 'East inner' and 'west inner' correspond to the areas outside these cores but inside the S-Bahn ring. 'Outer' denotes all areas outside the S-Bahn ring (East and West). The box plots show the 10^{th}, 25^{th}, 50^{th} 75^{th} and 90^{th} percentiles of the headline rent for the areas in question. The notches show the 95% confidence interval for the median values. The absolute values of rents are shown on the left (Figure 8.1a) and the location rents are shown on the right (Figure 8.1b). These are the residual values from the log-linear regression of headline rents with time of Figure 6.29b on page 222.

When the data is split by area, the role of build quality is shown to be quite different to that found in the location blind MRA of chapter 6. Leases in outer areas have the lowest median values of all kinds and the *old* buildings in the outer areas can be seen to have lower values than *new*. The biggest differential between new and old appears to be in the eastern core. The highest median values overall are for leases in *new* buildings in the eastern core. The difference between the rents in these buildings and the other samples is even greater in the location rent values of Figure 8.2b on the right below. However, the relationship between build quality and price within the Western core is not so clear. The second highest median value for headline rent is the new buildings in the West Berlin core. However, for location rents the second highest median is the old buildings in the western core and the 75th and 95th percentiles of headline rents for this sample are also higher than the other leases. To understand this result, the changing relationship between rents, build quality and location has to be unpacked for the time period studied.

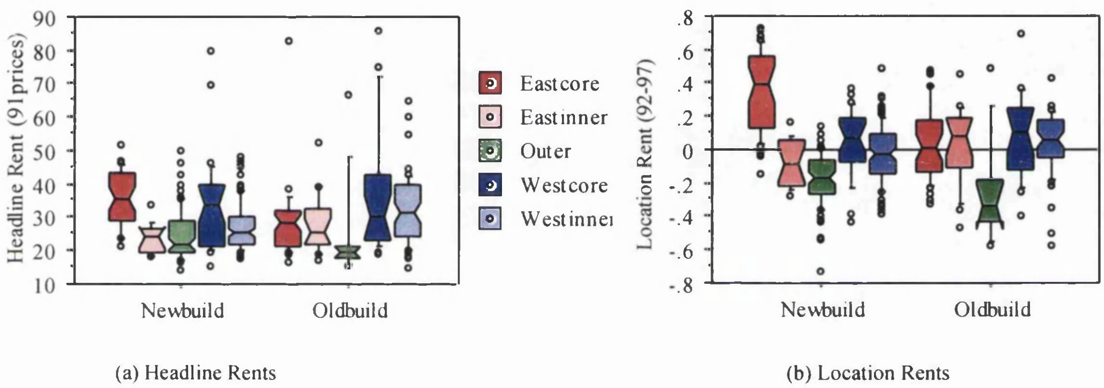


Figure 8.1: box plot of rents by area and build type for all headline rent (left) and residual headline rent (right)

8.3 Analysis of Rents Year By Year

In order to control for the time variable, Figure 8.2 to Figure 8.8 show the rent by area for each of the years 1991 to 1997 separately. Although the samples are not large enough to carry out multiple regressions for in each year, the averages and distribution of values for each area in each year can be examined using these box plots. Figure 8.2 of 1991 below shows the difference between rents in the west core and in the western inner areas for old buildings but the sample is too small to make the box notches (representing 95% confidence intervals) significantly different. The size of the whiskers for old buildings in East Berlin shows the large range in the rents achieved in these buildings. Classifying the data in this way reveals that the extreme variability of the sample rents that had been noted for the early year of 1991 was in renovated buildings in the former east. This may reflect the volatility of the market as rents were just about to peak (as was shown in both the agents reports in section 5.4 on page 166 and in the analysis of the study sample in section 6.5.1 on page 219). It may also reflect the fact that the market did not yet really *know* how to value leases in the East. The *re-valuing* of location after reunification was just getting underway.

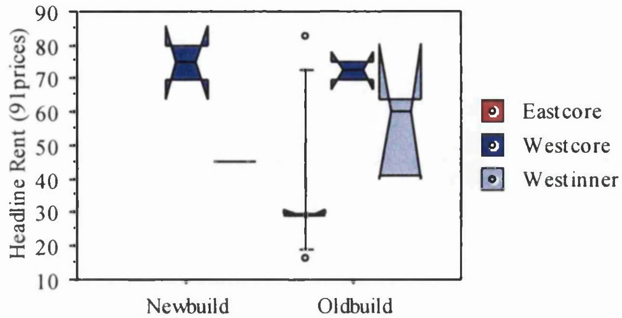
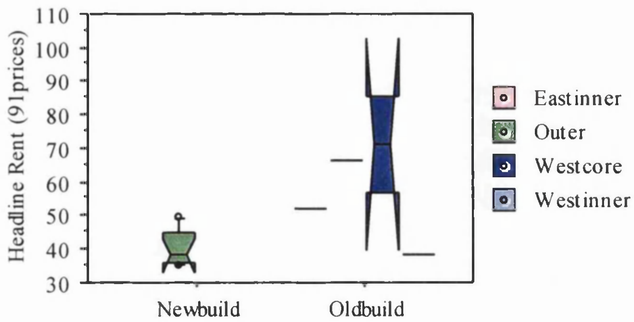


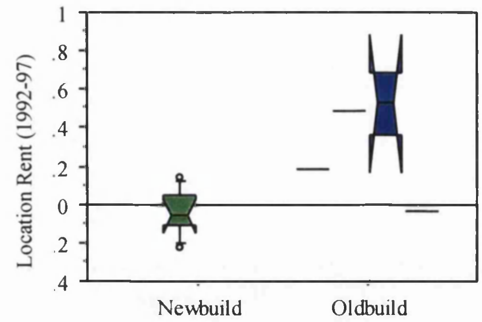
Figure 8.2: 1991 rents by area box plot[37]

Figure 8.3 below shows the pattern for 1992. The median value for old buildings in the western centre is much higher than that for outer areas, but the sample sizes are again too small to make any more significant differences according to area. This is also the case for 1993 (Figure 8.4 below). The range is much smaller and the rents are much lower in this year. These characteristics, as well as the small sample size in 1993 reflects the fact that this was both the first year of declining rents and the worst year of the economic recession in Germany (Economist Intelligence Unit 1994). Most of the leases that were let were in the inner city in West Berlin. It is interesting to note that rents on leases in old buildings in this area were higher than in new buildings. This may reflect more fine scale spatial differences between old and new for these leases but the large error bands again make it difficult to draw conclusions from this sub-sample.

[37] location rents are not available for 1991 because the residual values were not calculated in that year, as was explained in chapter 6.

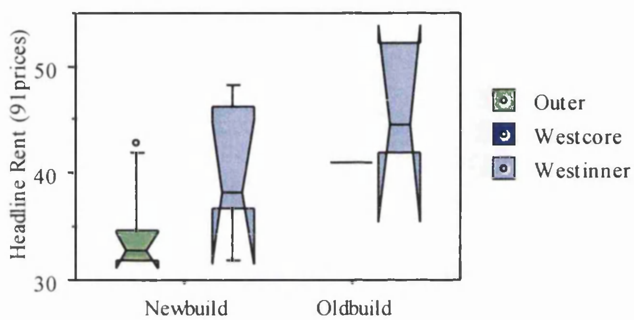


(a) Headline Rents

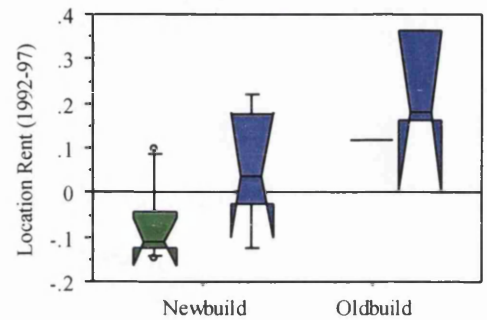


(b) Location Rents

Figure 8.3: 1992 Rents by area box plots



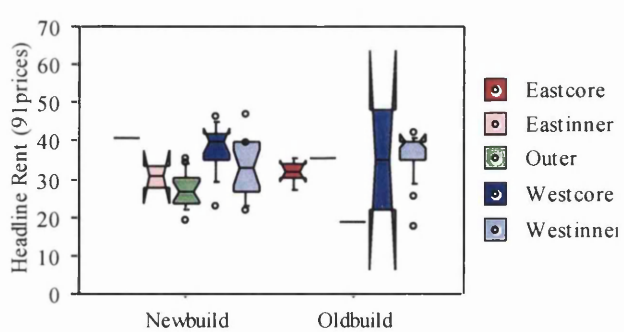
(a) Headline Rents



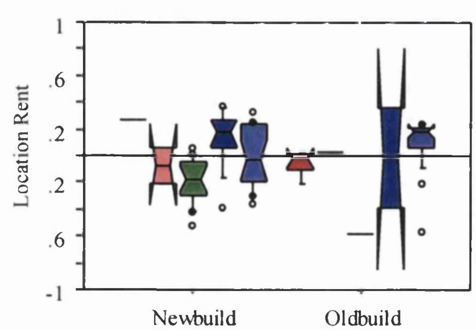
(b) Location Rents

Figure 8.4: 1993 rents by area and build quality

Figure 8.5 below shows the box plots for 1994 rents. During this year, the highest rents in new buildings were still in the Western core, although there were not yet enough leases in new buildings in the East to make a proper comparison. This reflects the fact that the new wave of supply had not yet been completed. Leases in outer areas have the lowest median values of all kinds.



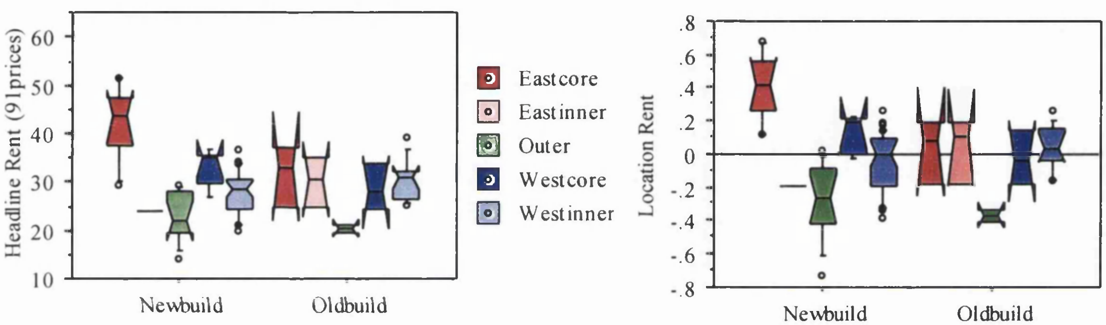
(a) Headline Rents



(b) Location Rents

Figure 8.5: 1994 rent by area and build quality for all leases (left) and JLW leases (right)

In the year 1995 an important change occurred. In this year the new buildings in the East have overtaken those in the West as the highest value leases as can be seen in Figure 8.6 below. This is a statistically significant margin, as can be seen from the 95% confidence bands on Figure 8.6. By 1995 many new buildings in the Eastern core were completed, such as the Friedrichstadtpassagen on Friedrichstraße (Map 5.7 on page 183) and it is buildings such as these that are being reflected in the high values of the leases. The second highest median level of leases is for new buildings in the Western core. The leases in old buildings in the Eastern core also have the highest average (median) rents of all leases in old buildings in the sample for 1995, but the differences among old buildings is not statistically significant. Outer areas again show the lowest median values and there is no significant differentiation between new and old.

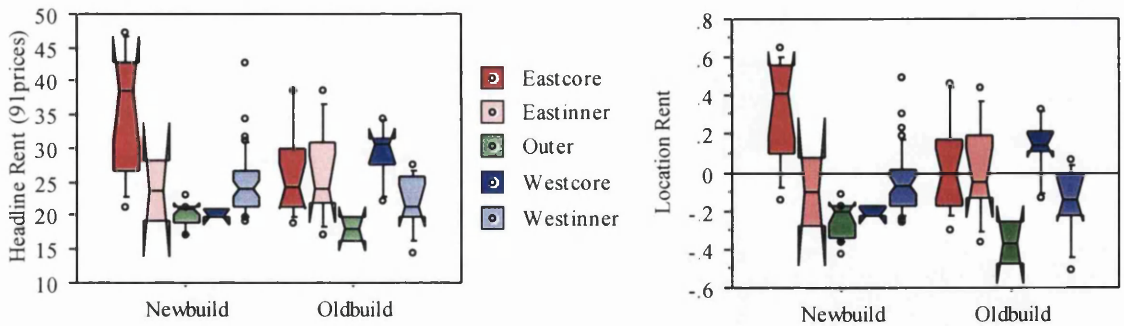


(a) Headline Rents

(b) Location Rents

Figure 8.6: 1995 rent by area and build quality for all leases (left) and JLW leases (right)

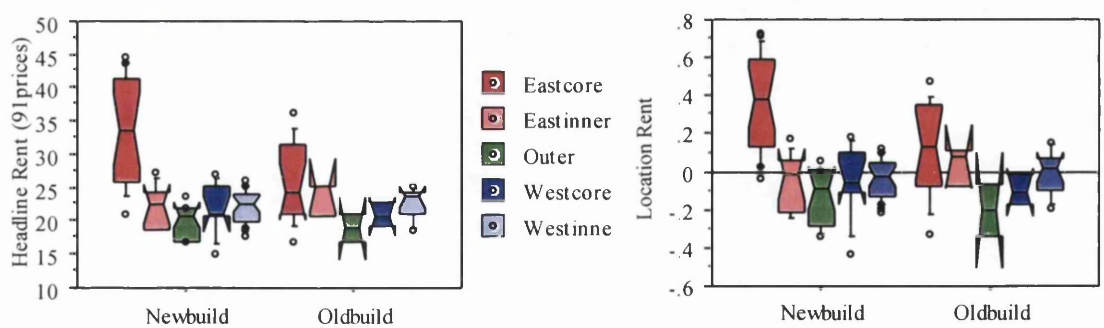
For 1996 the absolute value of new buildings in the Western core has sunk considerably to a median value of DM20, whereas the new buildings of the Eastern core have fallen much less severely to a median value of around DM33, as can be seen in Figure 8.7 below. The new buildings in the Western centre had particularly low levels in this year- lower than old buildings in the *same* area by a statistically significant margin. Indeed old buildings in the Western CBD had relatively high rents compared to the sample as a whole, with the second highest median value after new buildings in the eastern core. It is as if the market did not value new buildings against old buildings in the West in the same way as it did in the East. The differential between rents in the eastern core and the eastern inner area is much greater for leases in new buildings than for those in old ones.



(a) Headline Rents (b) Location Rents

Figure 8.7: 1996 rent by area and build quality for all leases (left) and JLW leases (right)

For the last year of the sample (shown in Figure 8.8 below) the new buildings in the eastern core can again be seen to have a significantly higher median value than any other area. The old buildings in the Eastern core also have a higher 90th percentile than all others and a higher median value than any other except the old buildings in the eastern inner city, although these differences in the median are not statistically significant. For leases in the Western CBD values are particularly low both in new and old buildings. There is no longer a significant difference between the median values of the western core and those in outer areas.



(a) Headline Rents (b) Location Rents

Figure 8.8: 1997 rent by area and build quality box plot for all leases (left) and JLW leases (right)

These year by year statistics using box plots for building types in different areas and over time have shown a number important features:

- There is a relationship between location and rent, even with these crude area splits as a proxy for location. The central areas are consistently higher than the outer area.
- Within central areas, a shift in the location of prime values has taken place over time, with new buildings in the core of East Berlin commanding higher values after 1995.

- There is a statistically significant difference between new and old buildings, but it is only visible when the buildings of different types are compared within small spatial areas (limiting the influence of the location variable). The relationship is positive, with new buildings commanding higher rents, although old buildings in central West Berlin do appear to be exceptional.

8.3.1 The spatial distribution of effective rent percentages

In chapter 7, the percentage of effective rents was mapped for all leases for which this data was available to see if a spatial pattern could be discerned (Map 7.9 on page 241) but none could be found. Figure 8.9 shows the percentage of effective rents split by area. The problem of a much smaller sample size for effective rents is again raised in this analysis. However, some characteristics are notable. The lowest median value as well as the greatest range in effective rent percentages is for new buildings in the eastern core. These reflect the later dip in effective rents for new buildings that was shown in Figure 6.23 of chapter 6. In the later period of 1996 and 1997, more incentives were given in new buildings, and these were particularly concentrated in the eastern centre. When the effective rent percentage in old buildings is compared, the difference between the areas is not significant, as can be seen on the right hand box plot.

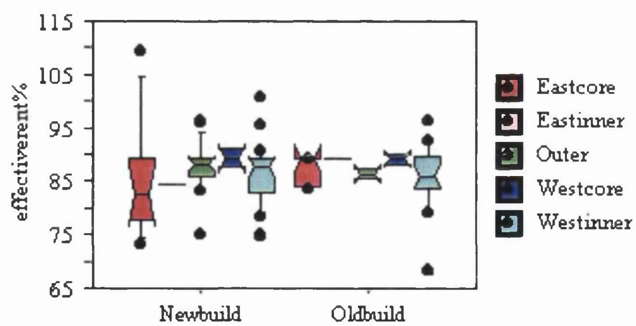


Figure 8.9: Effective rent percentages for 5-year leases in Berlin 1991-1997

8.4 Multiple Regression Analysis

The descriptive statistics in the previous section have confirmed the shift in rents to the East that was found in the rent representations of chapter 7. They have also confirmed the suspicion that the relationship between building quality and rent is a *positive* one, once the influence of location has been controlled by comparing buildings within a limited area[38]. It is now time to test the ability of the independent spatial measures to capture this spatial differentiation of rents. Non-spatial measures were previously excluded in order to produce a location rent for visualisation of rent patterns. These non-spatial measures will now be analysed with the spatial measures together, to evaluate the importance of each factor in determining rent prices.

8.4.1 MRA for All Berlin

Table 8.1 below[39] shows a number of MRA models for leases in the whole Berlin sample. The first model uses the main variables from the leases and global integration of divided Berlin, whilst the second uses reunified integration. The comparison is telling: the only two values to reach statistical significance in terms of the p value in both models are the time of letting (leasebeginmonthcode) and global integration. However, *reunified* integration is more powerful than divided integration (t=9.354 compared to t=2.490 for divided). Reunified integration is the most powerful spatial variable overall, although the second best spatial measure is the local one of K3, probably because it picks up the importance of both the Western centre from the earlier years and Mitte after 1995. It is interesting to note that the new measure K3 is more effective than the more complex measure of local integration used in previous space syntax studies.

Build quality has a negative coefficient in the model with divided integration but a *positive* sign with those for reunified integration and K3 (it is also less significant with their inclusion). This result, along with the role of old buildings in the Western core shown in section 8.2 above, points towards a problem of colinearity of spatial variables with the build

---

[38] When Adair evaluated the use of Multiple Regression Analysis to look at property values, he found that the technique was useful in evaluating the influence of non-spatial variables, but only for small areas(Adair and McGreal 1987). This is because the location variable needs to be controlled, and this can either be done by selecting small areas to analyse, or by quantifying locaiton as an independent variable itself. This thesis is aimed at developing the latter technique with measures of location, but the approach of limiting the area has also been explored in this section.

[39] The reference letter at the left of each regression summary refers to the tables of Appendix E: Summary of Multiple Regression Models, where these results are represented.

quality variable. In fact, the sample of leases in old buildings is slightly more integrated than the sample in old buildings (with a mean global integration of 1.153 compared to 1.076).

Reference	Dependent	Count	Num. Missing	R	R Squared	Adjusted R Squared	RMS Resid		Intercept	Lease begin month code	Ln Floor space	Contract length	Build Quality Dum	Divided Global Integration	Reunif Global Integration	K 3
B	Ln Headline rent 1991-1997	284	138	.610	.372	.361	.239	Coefficient	3.773	-.011	-.013	.002	-.056	.286		
								Std. Error	.173	.001	.016	.007	.032	.115		
								Std. Coeff.	3.773	-.587	-.043	.019	-.088	.126		
								t-Value	21.824	-11.626	-.804	.357	-1.720	2.490		
								P-Value	<.0001	<.0001	.4222	.7213	.0866	.0134		
C	Ln Headline rent 1991-1997	300	122	.694	.481	.473	.216	Coefficient	3.101	-.013	-.011	.006	.012		.921	
								Std. Error	.144	.001	.014	.006	.028		.098	
								Std. Coeff.	3.101	-.699	-.037	.050	.019		.439	
								t-Value	21.551	-14.949	-.809	1.085	.410		9.354	
								P-Value	<.0001	<.0001	.4189	.2789	.6821		<.0001	
D	Ln Headline rent 1991-1997	300	122	.676	.457	.448	.222	Coefficient	3.806	-.011	-.001	2.743E-4	.001			.002
								Std. Error	.107	.001	.015	.006	.029			2.735E-4
								Std. Coeff.	3.806	-.615	-.002	.002	.001			.385
								t-Value	35.422	-13.422	-.042	.045	.026			8.378
								P-Value	<.0001	<.0001	.9669	.9639	.9795			<.0001
E	Ln Headline rent 1991-1997	420	2	.701	.491	.488	.208	Coefficient	3.311	-.012					.574	.001
								Std. Error	.090	.001					.095	2.570E-4
								Std. Coeff.	3.311	-.669					.278	.202
								t-Value	36.889	-18.160					6.035	4.581
								P-Value	<.0001	<.0001					<.0001	<.0001

Table 8.1: MRA models for All Berlin

8.5 West Berlin

In Chapter 7 maps of location rents in Berlin created from the JLW lease data were presented. In Map 7.2 of location rents for the whole period, an interesting pattern of two centres was shown. This pattern was compared with the spatial analysis of Berlin, particularly Axial Map 5.1 of divided Berlin and Axial Map 5.2 of the reunified city. It was suggested that the patterns of rent in West and East Berlin appeared to correspond to different spatial structures: the western peak in rents related to the spatial structure of divided Berlin whereas the Eastern centre related to the spatial structure of reunified Berlin. It is now possible to test whether there is a difference in the determinants of rent patterns in West and East Berlin by looking at which spatial variables are more important in each half.

In light of the problems found with the use of the build quality variable as a dummy in multiple regression described in the previous section, the samples of new and old buildings will also be looked at seperately.

8.5.1 New Buildings in West Berlin

For the sample of new buildings in West Berlin, the strongest MRA for Ln Headline rent has been found with the leasebeginmonthcode (most important) and the *divided* global integration, as can be seen in Table 8.2 on page 263 below. The R squared for this model is .592 (adjusted .587) and the scatterplot of the fitted variable against the dependent variable can be seen in Figure 8.10a below left. Figure 8.10b below right shows the scatterplot for the fitted values against the residuals and no clear pattern can be seen to the values unexplained by the model. No other variables attain statistical significance when included in the same MRA or alternative models.

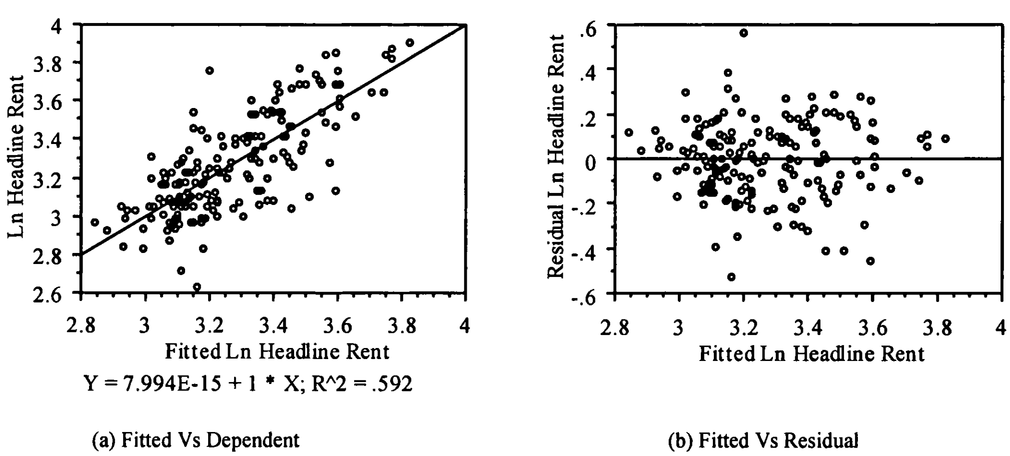
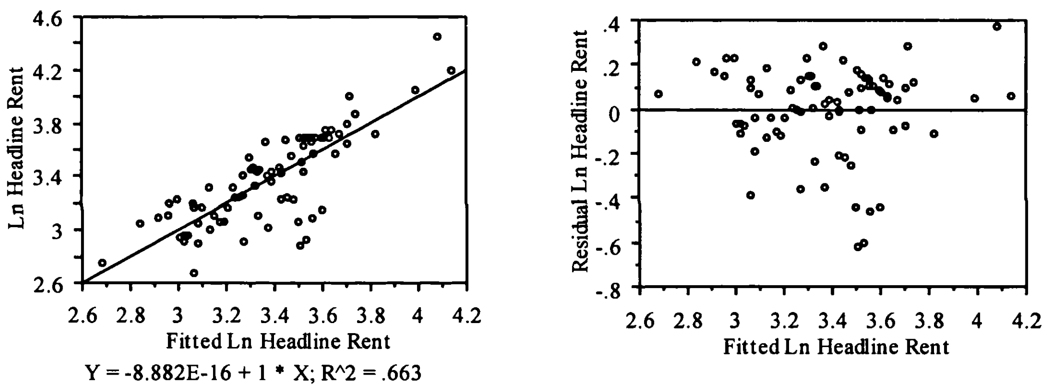


Figure 8.10 (a & b): Scatterplots from the MRA for rent in West Berlin new buildings

As other studies have tested both log and linear models, each MRA was also tested with the linear headline rent as the dependent variable. The MRA for new buildings in West Berlin was slightly stronger in a linear model (when the dependent is not logged). As can be seen in Table 8.2 below, the strongest linear model for new buildings in West Berlin reached an R squared of .603 (adjusted .599). The variables for this linear model were also time and divided integration.

8.5.2 Old Buildings in West Berlin

Although divided global integration also proved more important than reunified integration for old buildings in East Berlin, the strongest MRA was actually found with the more local spatial variable of K3. In this model floorspace was also found to play a statistically significant role, with the expected negative sign. The relationship between the fitted values of the model and rent values are shown in Figure 8.11 below:



(a) Fitted Vs Dependent (b) Fitted Vs Residual

Figure 8.11 (a & b): MRA for Ln Headline Rent in West Berlin old Buildings

Reference	Dependent	Count	Num. Missing	R	R Squared	Adjusted R Squared	RMS Resid		Intercept	Lease begin month code	Divided Global Integration	K3	Ln Floor space
F	West Berlin Old Build Ln Headline Rent	83		.776	.602	.592	.215	Coefficient	3.308	-.015	.824		
								Std. Error	.372	.001	.317		
								Std. Coeff.	3.308	-.710	.189		
								t-Value	8.882	-9.785	2.599		
								P-Value	<.0001	<.0001	.0111		
G	West Berlin Old Build Ln Headline Rent	83	0	.819	.672	.659	.197	Coefficient	4.367	-.015		.003	-.074
								Std. Error	.198	.001		.001	.028
								Std. Coeff.	4.367	-.732		.270	-.169
								t-Value	22.086	-11.276		4.162	-2.615
								P-Value	<.0001	<.0001		<.0001	.0107
H	West Berlin New Build Ln Headline Rent	193		.769	.592	.587	.166	Coefficient	3.373	-.013	.651		
								Std. Error	.100	.001	.095		
								Std. Coeff.	3.373	-.751	.323		
								t-Value	33.845	-16.000	6.872		
								P-Value	<.0001	<.0001	<.0001		
I	West NewBuild Unlogged	193		.777	.603	.599	4.713	Coefficient	31.322	-.370	17.959		
								Std. Error	2.827	.022	2.687		
								Std. Coeff.	31.322	-.763	.309		
								t-Value	11.081	-16.498	6.683		
								P-Value	<.0001	<.0001	<.0001		

Table 8.2: MRA models for West Berlin

8.6 East Berlin

8.6.1 New Buildings in East Berlin

The strongest regression model for headline rents in new buildings in East Berlin was with global integration for *reunified* Berlin and lease commencement date, which has a correlation coefficient of R squared .580 (adjusted .556). In this model the most important variable is reunified integration (t=8.069), the second most important is time (the leasebeginmonthcode with t=-6.119) and there is a small positive role for contract length (t=2.301). The scatterplot in Figure 8.12 below shows the relationship between the fitted values of the model and the dependent variable. If the sample is controlled to remove the first years of market adjustment, the relationship is even stronger. The strongest correlation for East Berlin was to take the sample of new buildings in East Berlin after 1995 alone. This takes out the confusion of the earlier years just after reunification, when the market was just establishing itself. It shows R squared of .605 (adjusted to .576) with the same variables.

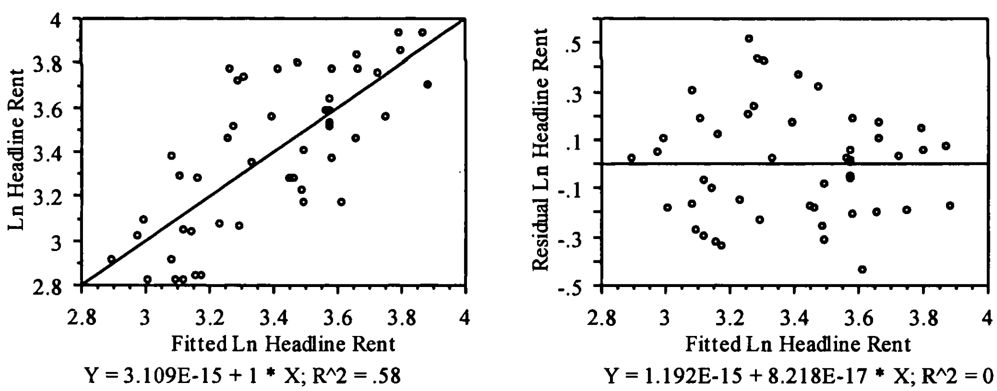


Figure 8.12: MRA for Ln Headline Rent new buildings in East Berlin 1992-1997

Figure 8.13 shows a weakness of the MRA model. The relationship between each of the independents and the residuals of the MRA should not exhibit any pattern, but the relationship between the model shows vertical strips of residual values. This is because the space syntax analysis is not able to provide location measures that are differentiated along an axial line. Rents do differ along lines, as can be seen in the residual, but the location measure does reproduce this level of detail. Consequently a pattern can be seen in the relationship between reunified global integration and the residual value not predicted by the MRA. This suggests that the spatial analysis requires more detail than that provided by axial lines in order to reflect the spatial characteristics of rent.

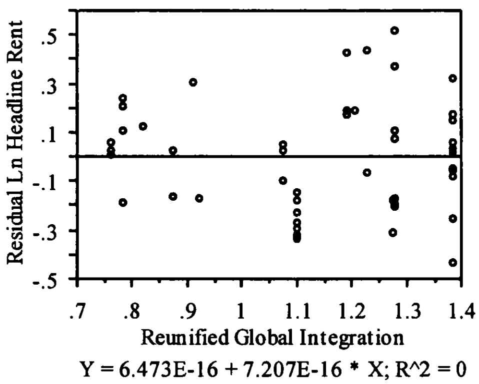


Figure 8.13: Reunified Global integration Vs residual of MRA for Ln Headline Rent new buildings in East Berlin 1992-1997

8.6.2 Old Buildings in East Berlin

The variables that have been found to determine rents in old buildings in East Berlin are the *leasebeginmonthcode* and the reunified global integration, as can be seen in the summary of Table 8.3 below. Unlike new build in East Berlin, time is slightly more important in the rent determination than the spatial integration factor for old buildings (t=-4.7 compared to t=3.794). The regression is slightly improved in a linear model (r squared=.381, adjusted r squared=.356).

There is a major outlier in rent for old buildings in East Berlin, as can be seen in the plot of fitted against dependants in Figure 8.14 below. This case has been investigated. For reasons of confidentiality the address and the rent cannot be specified, but it was a letting from a Government department very early in 1992 (at the peak of the cycle). In one sense, this outlier may represent a category of transactions that are different to normal ones, as the government department may have less knowledge of the market or be acting without the same commercial constraints as other companies. However, it was not excluded because it did not violate any of the criteria for sample selection that were laid out in section 3.2.1.3 (page 81). The criteria for lease selection were designed as a test of the market valuation of locations and to the extent to which state agencies are involved in the market, they also have an influence on the market. But to note the effect, the removal of this outlier decreases the correlation to Rsquared=.345 (adjusted .305).

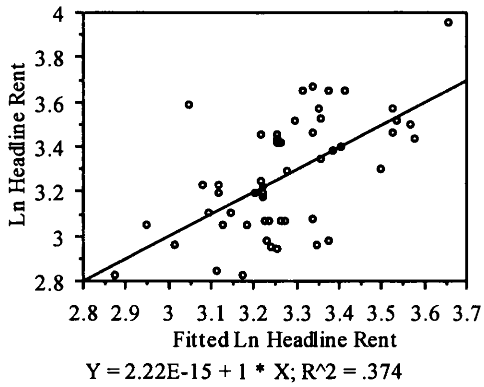


Figure 8.14: MRA for Ln Headline Rent Old buildings in East Berlin 1992-1997

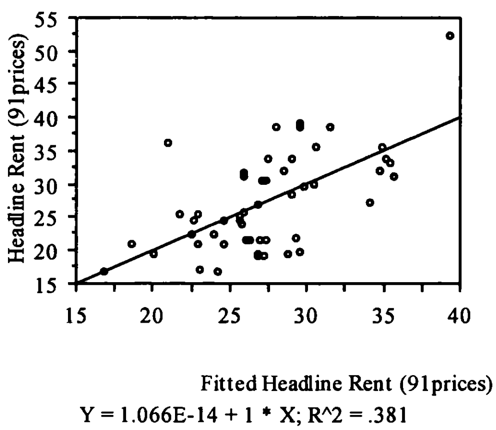


Figure 8.15: MRA for East Berlin old unlogged

Reference	Dependent	Count	Num. Missing	R	R Squared	Adjusted R Squared	RMS Resid		Intercept	Lease begin month code	Reunified Global Integration	Contract length
J	East Berlin Old Build Ln Headline Rent	54	0	.612	.374	.349	.206	Coefficient	2.658	-.009	.984	
								Std. Error	.322	.002	.259	
								Std. Coeff.	2.658	-.532	.429	
								t-Value	8.257	-4.700	3.794	
								P-Value	<.0001	<.0001	.0004	
K	East Berlin Old Build Unlogged Headline Rent	54	0	.617	.381	.356	5.796	Coefficient	15.112	-.280	24.587	
								Std. Error	9.053	.055	7.296	
								Std. Coeff.	15.112	-.570	.379	
								t-Value	1.669	-5.065	3.370	
								P-Value	.1012	<.0001	.0014	
L	East Berlin new build Ln Headline Rent	55	35	.762	.580	.556	.226	Coefficient	2.110	-.017	1.827	.044
								Std. Error	.279	.003	.226	.019
								Std. Coeff.	2.110	-.859	1.101	.262
								t-Value	7.574	-6.119	8.069	2.301
								P-Value	<.0001	<.0001	<.0001	.0255
M	East Berlin new build unlogged Headline Rent	55	35	.754	.568	.543	6.914	Coefficient	-10.061	-.471	55.224	1.434
								Std. Error	8.523	.083	6.927	.586
								Std. Coeff.	-10.061	-.803	1.103	.283
								t-Value	-1.180	-5.640	7.972	2.447
								P-Value	.2433	<.0001	<.0001	.0179

Table 8.3: MRA models for East Berlin

Table 8.4 below shows the residual statistics for each regression model used.

Model	# >= 0	# < 0
All Berlin with Divided Integration	131	153
All Berlin Reunified Integration		
All Berlin K3	156	144
All Berlin Reunified and K3	214	206
West Berlin Old Build Ln Rent	45	38
West Berlin Old Build Ln Rent 2 (K)	48	35
West Berlin Old Build Unlogged Rent	40	43
West Berlin New Build Ln Rent	101	92
West Berlin New Unlog rent	93	100
East Berlin Old Build Ln Rent	24	30
East Berlin Old Build Unlogged Rent	22	32
East Berlin New Build Ln Rent	28	27
East Berlin New Build Unlogged Rent	26	29

Table 8.4: Residual Statistics for all MRA models

8.7 Time and Location in rent determination

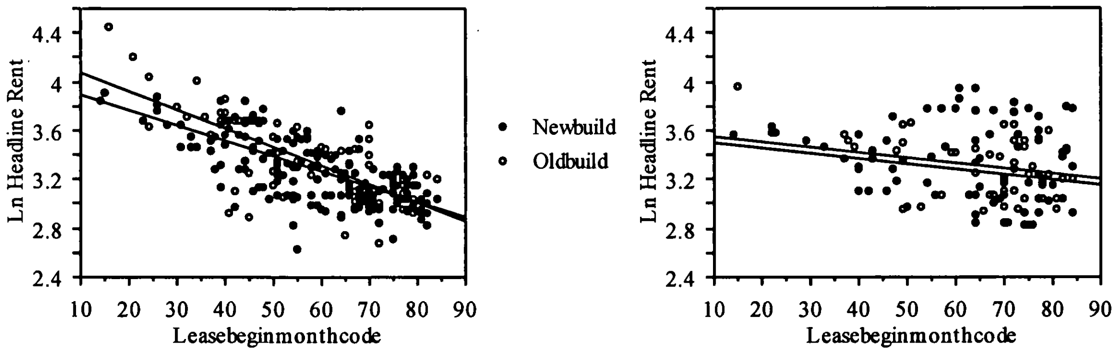
The key results of the Multiple Regression Analyses presented above are that the pattern of rents in Berlin can be modelled with the variables of time and global integration. Only the '*leasebeginmonthcode*' (which represents the point in time at which a lease was agreed relative to the market trend) and the urban morphological variable of *global integration* (that relates to the global structure of the town) that are important. It has not been possible to show a statistically significant influence for the other lease variables in rent determination.

8.7.1 'Bucking' the time trend

In this section, the role of time in rent determination in East and West Berlin is evaluated more closely as the process of market change over time has been so pronounced in Berlin. In Figure 8.16 below, the relationship between time and headline rent (logged) is shown for West Berlin (left) and East Berlin (right) The samples in each are split between new and old buildings. The differences in these regressions reflect the previous findings of the differences in t-values for time within the MRAs. Rents in West Berlin were influenced greatly by time in the period under analysis. Over half the variation in rents for new buildings in West Berlin the period 1992 1997 can be explained by the decline in the market without any reference to location (r squared .548 for the new buildings in black on the left-hand scatter of Figure 8.16).

The trend is even stronger for old buildings in West Berlin, for which over 60% of the variation in rents can be explained by time alone. For the sample of leases in East Berlin, time is a much less important variable. Although the trend in rents downwards over the period studied is still notable in East Berlin, the relationship is much weaker. Time can explain only about 13% of the variation in rents for old buildings and only 5% for new buildings for East Berlin in the same time period.

This result points towards a difference between East and West Berlin that was shown in the shifting pattern of location rents in Map 7.3 and Map 7.4 of the previous chapter. Rents in buildings in East Berlin have been more successful in 'bucking the trend' of rent in recession, with a less marked fall in their average values. This is what underlay the relative shift in value patterns.



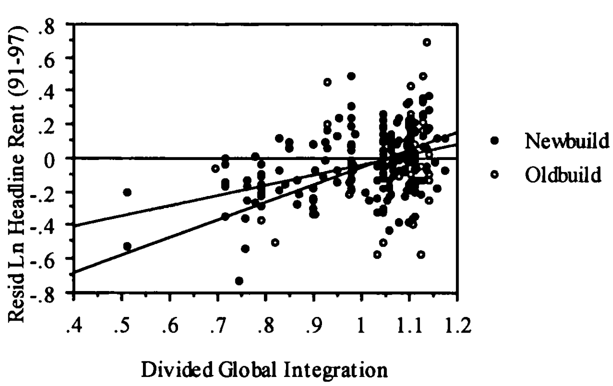
Ln Headline Rent = 4.015 - .012 * Leasebeginmonthcode; R^2 = .548 (Newbuild)
Ln Headline Rent = 4.225 - .015 * Leasebeginmonthcode; R^2 = .631 (Oldbuild)

Ln Headline Rent = 3.594 - .004 * Leasebeginmonthcode; R^2 = .048 (Newbuild)
Ln Headline Rent = 3.543 - .004 * Leasebeginmonthcode; R^2 = .13 (Oldbuild)

Figure 8.16: The relationship between time and Ln headline rent in West Berlin (left) and East Berlin (right) for new and old buildings.

8.7.2 The Location Factor

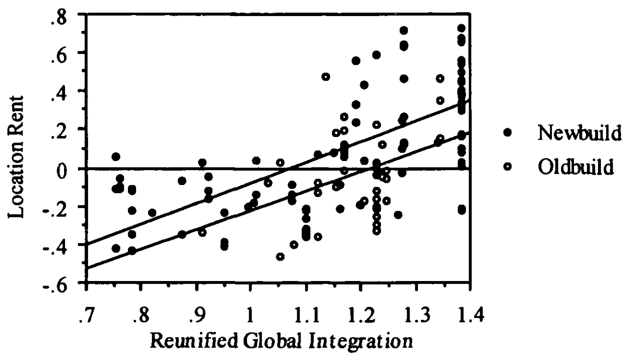
Having looked at the differences in the importance of time for West and East Berlin, the spatial measures of location can be plotted against the variable of location rent. This shows the performance of the spatial analysis presented in chapters 4 and 5 in accounting for the pattern of location rents that was presented in chapters 6 and 7. Figure 8.17 below shows the relationship between the best overall spatial predictor of rents for West Berlin (divided global integration) and the location rents in new and old buildings. For both new and old buildings, the relationship is highly significant (p<.0001) but quite weak. Only 17% of the variation in rents for new buildings can be directly explained with *divided* integration and 11% of the variation for old buildings.



Resid Ln Headline Rent (91-97) = -.649 + .606 * Divided Global Integration; R^2 = .174 (Newbuild)
Resid Ln Headline Rent (91-97) = -1.093 + 1.039 * Divided Global Integration; R^2 = .114 (Oldbuild)

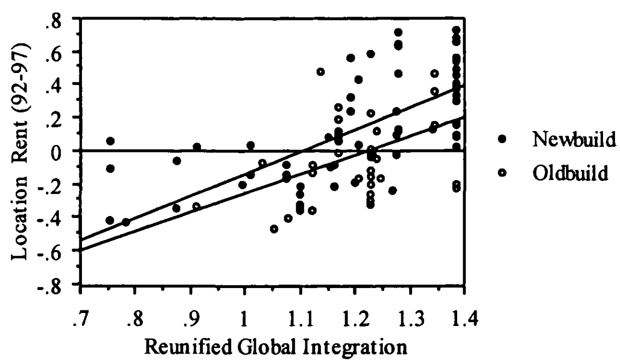
Figure 8.17: Divided Global Integration and Location rents in West Berlin

For East Berlin, rents are much more predictably spatially ordered and the measure of reunified global integration is the most effective predictor. Figure 8.18 below shows the linear regression model for location rents of leases in East Berlin using reunified global integration. For new buildings, around 45% of the variation in location rents can be explained in the simple regression model using the measure of reunified global integration. Location rents in old buildings are less predictable, with only 23.7% of the variation explained by the model. Both the regressions for new and old buildings are highly significant (p<.0001). The relationships are even stronger if the period after 1994 is viewed alone, as in Figure 8.19 below. Excluding the earlier years brings the r-squared correlation co-efficient[40] for new buildings to .451 and for old buildings to .283.



Resid Ln Headline Rent (91-97) = -1.234 + 1.013 * Reunified Global Integration; R^2 = .237 (Oldbuild)
Resid Ln Headline Rent (91-97) = -1.145 + 1.068 * Reunified Global Integration; R^2 = .445 (Newbuild)

Figure 8.18: Reunified Global Integration and Location rents in East Berlin



Resid Ln Headline Rent (92-97) = -1.479 + 1.337 * Reunified Global Integration; R^2 = .451 (Newbuild)
Resid Ln Headline Rent (92-97) = -1.397 + 1.146 * Reunified Global Integration; R^2 = .283 (Oldbuild)

Figure 8.19: Reunified Global integration and Location rents in East Berlin 1994-1997

[40] The improvement in the correlation holds true even if the adjusted r squared values are used. ForFigure 8.18, the adjusted values are .222 for old build and .438 for new build. For Figure 8.19 they are .267 and .443 respectively.

8.8 The Changing Pattern of Location Rents in Berlin

Having shown that the global integration structure of the city appears to provide the best correlate for location rents, it is now possible to use global integration as a tool with which to understand the relationship between rents in the core and the periphery of the city over time. In the literature review chapter, Alonso's representation of rent values in the core and periphery were shown in his discussion of the possibility of multiple peaks in rent (see Figure 2.6 on page 50). However, the Alonso model was limited by the use of distance to the CBD as a spatial determinant as this was the only measure he suggested as an independent spatial variable in the theoretical model of rent and land use determination.

In this section integration will be used as an independent spatial variable to compare geographically disparate locations that have similar characteristics with respect the city as a whole by splitting the sample into 10 percentiles of global integration. Rather than using the dasymetric areas created by the property agents' reports (for which the methodological basis of their definition is unclear) this is a truly independent method of grouping by location that is reproducible for any city. Table 8.5 below shows the count of lines within each 10-percentile range of the frequency distribution for global integration in Berlin. Relatively few of the lines in the city are in the top 10-percentile range (only 3.7% of all lines). The sample size for leases in new and old buildings within each of these percentiles is shown in Figure 8.20 below.

From (>=)	To (<)	Count	Percent
.453	.546	367	3.665
.546	.639	946	9.448
.639	.732	2080	20.773
.732	.826	2204	22.011
.826	.919	1426	14.241
.919	1.012	1488	14.861
1.012	1.106	928	9.268
1.106	1.199	429	4.284
1.199	1.292	132	1.318
1.292	1.386	13	.130
	Total	10013	100

Table 8.5: Frequency Distribution for Reunified Global Integration

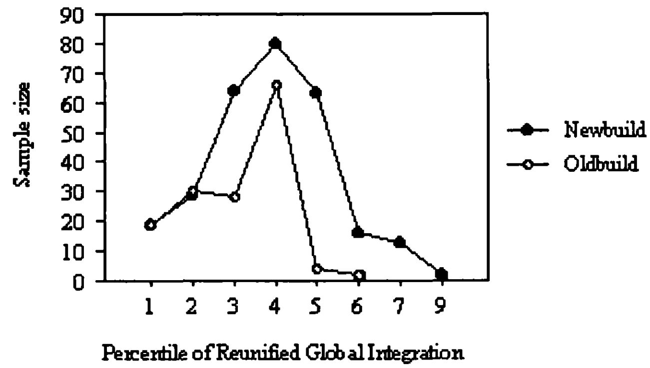


Figure 8.20: sample size in new and old buildings within reunified global integration percentiles

Figure 8.21 below shows the average location rent in each percentile group. As is to be expected from the importance of integration within the MRA, there is a falling away in location rent from the core (global integration band 1) to the periphery.

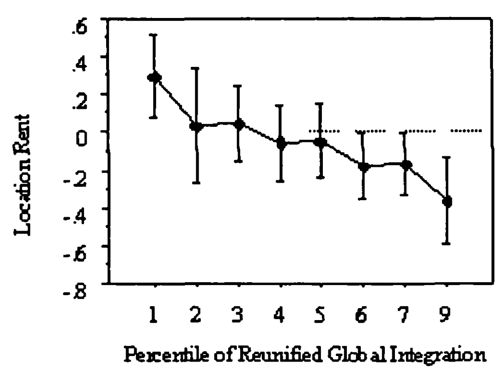


Figure 8.21: location rent split by reunified global integration band

It could be argued that this pattern of location rent is comparable one to the Alonso model of rents falling away from the CBD. After all, rents fall away from the core of global integration in a similar fashion. If a mirror image of Figure 8.21 was placed on the left hand side, it would look similar to the Alonso rent diagrams (see Figure 2.6 on page 50). However, the use of an independent analysis of space to provide the location variable and not the pattern of land uses is fundamentally different to the Alonso model because it allows the changing structure of rents to be evaluated without reference to the land use pattern. The analysis is not restricted by the simplifying assumptions of the distance to CBD view of location.

The importance of this difference between the independent measure of spatial structure and the distance from CBD measure used in previous studies can be demonstrated by looking at the changing pattern of rents over time with the same integration bands, as in Figure 8.22 below. Within the period directly after reunification, the remaining importance of the Western CBD in rent patterns can be seen as a 'bump' at around band 3 of integration. Although it was outside the core of global integration from the moment of reunification, the Western CBD at band 3 was the peak of rent values in Figure 8.22a of rents between 1992 and 1994 (left).

The pattern in Figure 8.22b (right) shows rents from 1995 to 1997. In this figure the peak is at band 1 and the location rent falls more evenly away to the peripheral bands. The Western CBD no longer causes a 'bump' in the pattern of rents from the spatial centre. This is another expression of the shift of rents in line with the spatial reorganisation of the city. The rent pattern has 'normalised' around the new spatial structure.

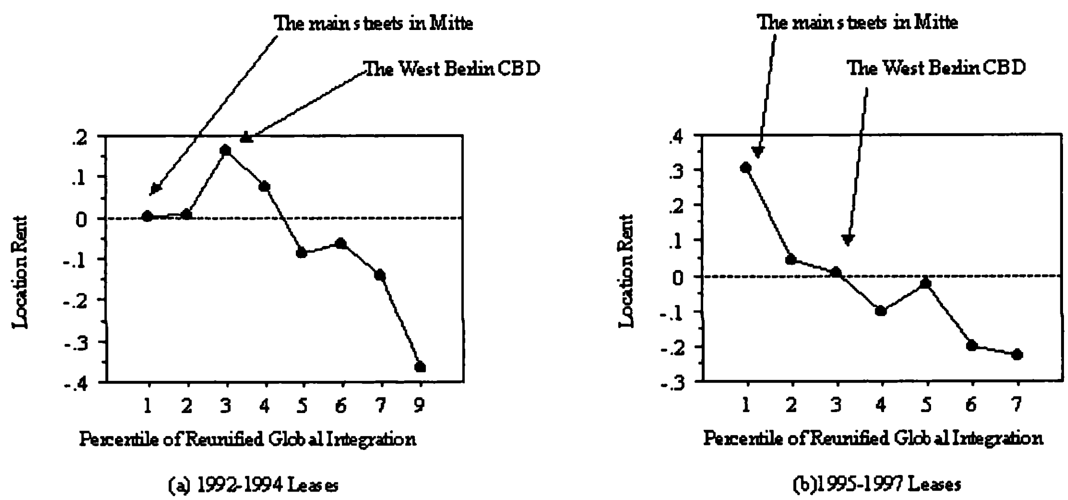


Figure 8.22: Location rent by global integration band for 1992-94 (left) and 1995-97 (right)

The bands can also be further split to show the difference between new and old buildings in East and West Berlin, as was undertaken in the MRA above. The distinction between new and old buildings in West Berlin is complicated by the peculiarities of the sample there, as has been discussed above. However, for East Berlin the build quality variable does capture something structural about the market, as can be seen in Figure 8.23 below. The differentiation between new and old buildings that occurs at the centre can be seen in the divergence of mean location rent values for rents in East Berlin (the left hand graphic of Figure 8.23 below). The kinds of trade-offs between building quality and location centrality that are discussed in general theoretical terms in the Alonso model could be investigated graphically using such techniques. Office space in a new building in East Berlin located in the 3rd percentile of global integration might be comparable on this basis with a space in an old building in the prime first percentile range of integration.

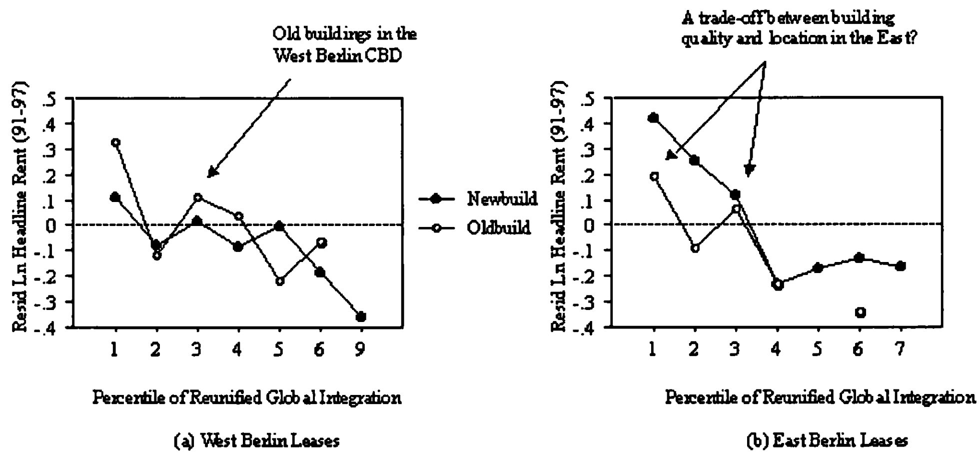


Figure 8.23: location rent in new and old buildings by reunified global integration band for West (left) and East (right)

8.8.1 Spatial Differences in the fluctuation of rents

The integration bands can also be used to examine differences in the fluctuations in rent in the centre of the city compared to the more peripheral locations. This can be seen in the range of location rents shown in Figure 8.24 below. The maximum fluctuation can be seen to occur in the core of the city and ripple out towards the edge. The standard deviation is also greater in the centre, although the results reflect a small number of cases in the sample at global integration band 9 (only 2 cases) which leads to a standard deviation that is actually only the difference between two cases (and is consequently meaningless). A much larger sample size is needed to test these differences. However, a hypothesis from the initial findings is that not only are rents higher in more integrated locations but the range and deviation over the economic cycle may also be greater in the core than it is in the periphery. It seems that there is a 'ripple out' effect in rents.

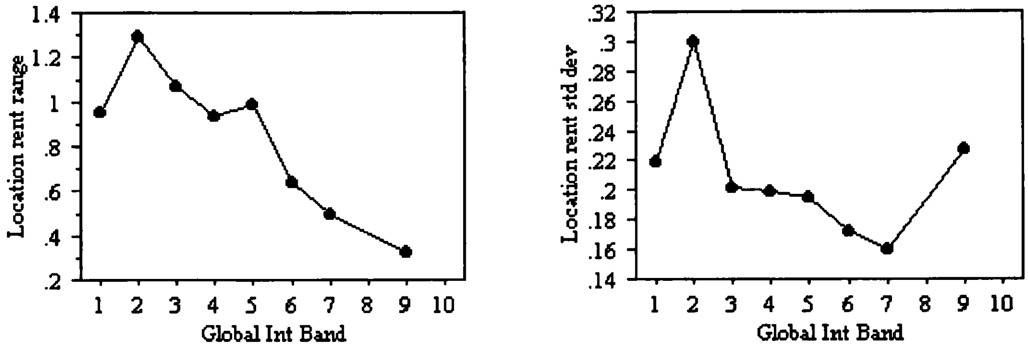


Figure 8.24: Fluctuations in location rent by global integration band

8.9 Discussion: the decline and rise of centres

The statistical analysis has shown that the significant variables in rent determination for Berlin are time and space. In other words, the date that a lease was signed and its location within the city are overwhelmingly important in rent determination, and other variables such as building quality, lease length and unit size do not exert a statistically significant effect. The conclusion to be drawn from this is not that the influence of other variables in rent determination is minor per se, but rather that their influence in Berlin in the period under study cannot be detected outside the effect of location and time. The purpose of testing the other variables with location was to see whether the pattern of rent that seems to be related to the location within the city was actually owing to the hidden influence of other variables. It is never possible to rule out an influence of untested variables on the results, but it is possible to state that those tested in this study cannot be said to account for the spatial pattern of rents.

However, the roles of time and space in the determination of rents in Berlin during the study period are more complex than might be expected, because the models chart the decline of one centre and the rise of another. The strongest variable in the determination of West Berlin rents is time, with a negative relationship. The second strongest variable is the integration values from *divided* Berlin, which correlate with rents positively. Other non-spatial variables and reunified integration are not significant for Western rents. Thus the rents in West Berlin have been falling steadily through time and have been spatially organised around the old pre-unification pattern of integration. The two variables found to determine rents for leases in East Berlin are integration and time, however, it is the *reunified* pattern of integration that is found to be most significant. Reunified integration is actually more important than the time variable. The regression is a messier one but it is still highly significant.

This means that rather than a 'shift' in the location of the CBD gradually Eastwards, what has taken place in Berlin is actually the decline of one centre and the concomitant rise of another. Rents within the West Berlin CBD have remained organised spatially around those streets that were most integrated during division, but have plummeted with the recession. In the East of the city, the new market in office space has evolved a spatial organisation that relates to the new geography of reunified Berlin. This centre has 'bucked' the time trend quite effectively during recession, falling only marginally in absolute average prices and gaining in location rent relative to the rest of the city. The period under investigation is one of a shift from one equilibrium of spatial structure and rent patterns to another and it is the change to the spatial structure that occurred first.

Having completed this more detailed statistical modelling of rent values, the next chapter will summarise the findings of this thesis and draw out the conclusions that result from it.

8.10 Summary

Statistics split by area and year by year were used to explore the shift in rents to the Eastern Mitte area over time that was found in the rent representations of chapter 7. They also confirmed the suspicion that the relationship between building quality and rent is a *positive* one, once location has been controlled for by looking at samples of rent in small areas and by including space syntax measures of location in regression models.

Multiple regression analyses were used to isolate the influence of each variable for rents in East and West Berlin and in new and old buildings. A distinction was found between the determinants of rent in West and East Berlin. Whereas rents in the west were spatially organised towards the pattern of integration for divided Berlin, those in the East were organised around the pattern for reunified Berlin. The relationship between time and location in determining rent was different between West and East. The most important determinants of rents in new buildings in west Berlin is the time, as they fell with the recession. In East Berlin, differences in rents in new buildings are most determined by spatial location, with time of secondary importance.

9 CONCLUSIONS

9.1 Introduction

The aim of this thesis as it was stated at the very beginning of the first chapter, is to contribute to that area of social science that looks at the unintended social consequences of spatial layout: the effect of space onto society. The study of Berlin presented here has provided a series of findings that offer a dramatic example of the effect that a spatial change can have on the organisation of the property market. In this chapter, a summary of findings will be presented to show how this study has formed a contribution to knowledge in this field. The main conclusions from the thesis will be summarised. Some limitations of the study will be evaluated and some suggestions for further research in light of findings will be provided. Lastly, a discussion of the meaning of the findings within a broader theoretical context will be provided.

9.2 Summary of Findings and Conclusions

The hypothesis of the thesis as stated in the introduction was that there is a relationship between the spatial configuration of the street grid and the pattern of office rental values. In order to test this hypothesis, an independent measure of location has been applied to Berlin and a sample of achieved rents has been gathered.

The review of previous research identified three kinds of problem in the study of the spatial pattern of office rents. Firstly, rent data has often been used that may not be a good reflection of the price that a tenant is prepared to pay (most frequently used is the asking price at a high level of aggregation). Secondly, rent studies have been hindered by the lack of an independent measure of location against which to test the pattern of rents. The variety of spatial variables that have been used have not been truly independent and have therefore confused the whole analysis of the role of location in rent determination. Lastly, the spatial representation of office rent patterns has been neglected despite the fact that the few examples of rent maps have been highly informative.

Chapter 3 presented the methodological strategy that has been adopted in this thesis to overcome the problems revealed by previous studies of the spatial pattern of rents. By gathering actual lease data a sample of rent was used that more closely reflects the value that real tenants are prepared to pay. Space syntax analysis of urban morphology was adopted to provide independent measures of location against which the pattern of rents can be compared.

GIS was used as a method to visualise direct representations of rent patterns at the highest level of detail.

In chapters 4 and 5 the findings of the space syntax analysis of Berlin's spatial structure were presented. The spatial analysis of Berlin's historical development revealed that that the pattern of commercial land uses changed over time following changes to the spatial structure of the street grid. The location of the CBD itself was found to be dependent on the layout of the street network. This finding effectively invalidates the use of distance from the CBD as a proxy for rents except in the very short term because it is not static over time. The spatial analysis of reunification showed how this event led to a fundamental spatial restructuring of the city. The pattern of global integration shifted from two centres in the two halves of the city to a new centre in Mitte. Published evidence showed that Mitte has risen as one of the two peaks in office rent and has also been the focus of new building in the post-reunification boom. However, the pattern of rents displayed in agents reports showed two peaks in rent value: the West Berlin CBD and Mitte.

The detailed analysis of the non-spatial characteristics of leases revealed that during the recession in the period under study, all the lease terms changed reflecting a shift from a landlord to a tenants market. The analysis of lease incentives revealed a hidden trend in the market that was not shown in the published agents reports: incentives rose just before the major wave of supply was completed and were given first in older buildings. Potential measures of effective rent were explored on a small sub-sample of leases to test the comparability of the main sample and were found to correlate well with headline rents.

This study has found that it is possible to represent office rent values objectively using GIS visualisation techniques. Location rent values were taken from a location-blind MRA and represented in colour maps. These showed a shift in the pattern of location rent within the short period under analysis. Whereas the Western CBD was the peak area of location rents in 1991-1994, the pattern in 1995-97 had shifted to Mitte. This is direct evidence that prime location rents have reorganised around the new spatial structure of the city revealed by the measure of global integration.

Chapter 9 showed that it was possible to model the determination of rent values in Berlin statistically using MRA. This analysis found that the independent variables of time and space alone were important in rent determination. The statistical model revealed a difference between West and East Berlin, whereby rents in the West were most strongly influenced by time, falling with the recession and secondarily by the spatial variable of global integration of divided Berlin. In the East, the strongest variable was not time but global integration, and it was the reunified pattern of integration that was significant. This is a statistical reflection of the decline of the old centre in the West and the rise of a new one that relates to the potential of Mitte within the new spatial structure of Berlin.

The findings summarised above lead to the conclusion that there is indeed a relationship between the spatial configuration of the street grid and the pattern of office rental values. The fact that changes in the spatial structure of the street network have been followed by changes in the pattern of rents leads to the conclusion that it is a functional relationship and that the pattern of rents is *emergent*. The emergent pattern of location rents relates to an *independent* location variable (the purely spatial characteristics of the street grid). The changes in the spatial structure of the street grid that occurred with reunification were the precursor to the shift in rental value that has occurred since the fall of the wall.

The findings suggest that the pattern of rents depends not on the current local conditions of a location but rather on the *potential* offered by the location relative to the whole city. The fact that the western CBD has declined in location rent and the new centre in the spatial core of reunified Berlin has risen so quickly could be seen as evidence that the agglomeration economies offered by local services are not as important as the relationship between an area and the whole city. Even though the east was an area in very poor condition at reunification without any companies in it, its potential from its position within reunified Berlin has outweighed the existing benefits of being near other companies that the West Berlin Centre could claim.

The reunification of Berlin provides a dramatic example of the influence that the spatial structure of the city can have on rent patterns in the short term. The results of the historical analysis of Berlin's morphological development also point to spatial configuration of the city exerting an influence on the organisation of land uses in the longer, historical term. The traditional approach to studying rent patterns purely within the context of the pattern of land uses (using variables such as distance to the CBD to represent the spatial dimension) would not capture these relationships that both land use and rental value have with the underlying spatial configuration of the city in the Berlin case. The analysis of spatial structure used in this thesis has allowed these relationships to be studied independently of each other, from which a better understanding of how they all relate to each other can be built. Rather than viewing rent patterns through the lens of the land use pattern (where distance to the CBD is the spatial variable), it has been possible to view the spatial structure, the pattern of rent and the pattern of land uses as three distinct, interacting structures.

9.3 Limitations of the Study

As well as summarising the findings about the relationship between the configuration of the street grid and the pattern of rent values, it is also valuable to make clear the limitations of this study.

9.3.1 Building Quality

A limitation of the study is that although building quality has been implicated as an important variable both in rent determination and in broader landlord-tenant relationships, the dummy variable used does not capture the role of building differences adequately. It is clear that the buildings themselves need to play a much more sophisticated role in the explanatory model of rent determination.

The build quality dummy variable used in this study is limited in two respects. Firstly, the difference between new and old buildings may not adequately capture all the structural and fit out differences between buildings. The untested variables relating to this were discussed in section 6.5.4 on page 223. But there is also a level at which the building quality variable does not capture the micro-scale spatial differences between units, such as the flexibility of the floorplate. A much more detailed set of data is necessary in order to begin to tackle the complexity of building stock as part of the rent equation.

9.3.2 Insufficient differentiation in the axial map measures of location

As well as the inability of the build quality variable to capture such micro-spatial differences as the shape of the floorplate, another limit of the study has been the spatial differences between the locations of leases that the axial map analysis has not accommodated. These are of two kinds. Firstly, the single spatial value for an entire street axis does not capture the differentiation in rent values that occurs along the length of an axis. The representations of rent in the literature review showed variation along streets as well as the more pronounced variation between them (see for example Hurd's map reproduced as Map 2.2 on page 62). This lack of spatial differentiation in the axial map prevented the spatial measures from capturing all the spatial differentiation in rent in the statistical analysis of the MRAs. This was shown in Figure 8.13 on page 265, in which a degree of variation left in the residual of the MRA was found to be systematically spatially organised with reference to the axial lines. This demonstrated that the axial map is not sufficiently differentiated to fully capture rent patterns.

The second limitation of the axial map is the inability of the spatial analysis to provide measures of location within a building complex. The location values used in this study have not taken into account the location of a unit within a building (such as the floor it is located on and whether or not it is in the front, side or back wing of the structure). The historical survey in Chapter 4 showed that the internal structure of the typical Berlin 'Mietskaserne' blocks was significant in the pattern of mixed uses that developed. This was because rental value was highly differentiated within the block, and that differentiation was organised by the spatial structure of the block, getting lower the further into the internal courtyards and away from the street (as discussed in section 4.5.1 on page 148 above). Such differences have not been captured with the axial map analysis. Although in principle it would be possible to use the axial map to model not just the external space of streets but also the entire internal configuration of all buildings, this is practically impossible for a spatial object as large and complex as the city of Berlin.

These limitations suggest ways in which further research might be directed, as discussed in the next section below. However, the limitations do not undermine the validity of the main findings of the study about the spatial pattern of rents and its relationship to the configuration of the street grid. The findings are statistically significant in spite of the limitations of available methods outlined above.

9.4 Suggestions for Further Research

A number of avenues for further research are suggested by the findings of this thesis:

9.4.1 A measure of the whole system of public space

The first suggestion for further research follows on directly from the limitations of the axial map analysis highlighted in the previous section. The axial map analysis of the spatial configuration of Berlin has been restricted to the street network in order to undertake a clear comparison of the spatial layout of the city with rent patterns. However, the effective spatial system used by people every day is much bigger than solely the street network. In order to test the theory that the spatial configuration of the city has an influence on space use phenomena such as rent and land use patterns more fully, it would be necessary to construct a measure of location that encompassed the whole physical complexity of the layout of the city. This would include not just streets but the spaces inside buildings and the subterranean movement system. If people use rooms, corridors and streets to move about in and interact with each other, then a true model of the urban grid ought to capture this spatial object at a much greater level of detail. This could provide for a measure of location that was differentiated at a much greater level than the axial map used in this study.

9.4.2 The relationship between street configuration and the supply of office space

The findings of this study suggest that the pattern of land uses can also be viewed as an emergent property of the layout of streets. There is evidence from the study of a spatial feedback mechanism from rent price signals to supply increases: where price signals are higher- (in integrated locations) there is more chance of buildings being renovated or the use being changed to office. The higher average integration of the old office buildings compared to the new buildings found in chapter 9 could just be an artefact of the sample, but it could also represent a response of building owners to the potential of location: if a site will achieve a higher commercial rent then it is worth turning it over to office[41]. This would be the classically expected role of rent as the mechanism for selection of land use, encouraging change of use towards office in more globally integrated locations and away from office in more segregated locations.

In order to test this thesis it is necessary to obtain data on the supply structure as a whole, in order to obtain accurate measures of the distribution of commercial land uses within the pattern of all land uses. A sample of buildings that were not originally offices but were converted to office could be compared with the sample of all buildings that were intended to be offices but were converted to another use to see whether spatial differences could be detected. Then the comparison of their locations could test the hypothesis that the rent pattern arising from the spatial structure was acting as a land use allocation mechanism. In order to fully build a model of land use determination, the role of developers acting on these price signals within constraints would have to be accounted for. This would require other kinds of data to cover their constraints, for example relating to planning procedures and the process of development finance.

9.4.3 The discrepancy between asking rents and headline rents as market information

In chapter 3 it was explained that achieved rents were sought for this study of tenants location preferences because the use of asking rents as a proxy for achieved rents was problematic. This is because of the arguments of Webb and Fischer outlined in the literature review that asking rents are essentially supply side information (Webb and Fisher 1996).

---

[41] The designation 'old-build' includes residential buildings that have been converted to office.

However, precisely because asking rents represent supply side information, it would be extremely useful to be able to test the difference between asking rents and headline rents. This test would be informative not only in order to assess the extent the use of asking rents as a proxy for achieved rents is problematic, but also to see whether there were relationships between the discrepancy of asking to achieved rents and any other variable. For example, does the difference between asking and achieved prices vary with the market cycle? Does it differ with regard to building quality? Most of all, it would be useful to know if there is a clear spatial pattern to the difference and whether it also had a relationship to the street layout that was found with rents. This would tell us something about the variables which lead to a discrepancy between what landlords think they can get and what tenants are prepared to pay.

9.4.4 Vacancy as an index of location preference

This study has used the level or rents that tenant's pay as an index of demand preferences for location within the city. However, demand preferences are also revealed at a more basic level by the choice of tenants to rent or not to rent at different locations. This is reflected in the level of vacant space. A study of vacancy rates in each building might even reveal more about tenant demand in cases of recession where rates are high, as they have been in Berlin (see discussion in section 5.8 on page 185).

Indications from studies of other cities are that vacancy rates are also strongly spatially organised and in a global pattern that is related to that of rents, but with the highest vacancies on the edge and lowest in the middle (as discussed on page 42 of the literature review above). Agents' reports have also suggested that vacancy rates in peripheral areas of Berlin were much higher (see page 185 of chapter 5 above). The pattern of vacancy rates could be tested using similar spatial measures to those used on rents in this study. However it must be recognised that obtaining accurate data on vacancy rates is very difficult. Accurate figures for the office space on the market and for space already let are required and these are very difficult to obtain.

9.4.5 Lease provision instability and market transition

One hypothesis arising from this research is that the market instability of lease provisions other than rent can be used as an indication of transition in the power relations of the market. In Berlin there has been market transition through both recession and spatial restructuring. Tenants took advantage of the upheaval in Berlin that came with the recession to question other aspects of the lease, such as the lease length. It seems that when transition takes place everything about the status quo is disrupted and power relationships have to be re-established within the market.

Previous research has already shown that there is a relationship between some lease provisions, particularly incentives, and the broader market conditions (as discussed in section 2.5.1 on page 35 of the literature review above). The results from the Berlin study suggest that lease incentives may also be differentiated with respect to the quality of buildings in the market because incentives rose first in old buildings. This could be tested in other cities.

9.4.6 The relationship between core and periphery through the property market cycle

The study has shown that the property market cycle has an influence not only on the level of rents but the differentiation of rents between core and peripheral locations. This was shown in the difference of the level, range and standard deviation of rents across global integration bands. Rents do not just all rise and fall with recession, the fluctuation appears to be much greater in the centre than it is on the edge. One explanation for this finding is that the shifting of prime values within the centre that has taken place because of the spatial reorganisation of Berlin has led to a greater level of fluctuation within the centre.

However, it may also be the case that it is a characteristic of property markets cycles to influence the core more strongly than the periphery. This would be to view market change as a '*ripple out*' process that begins in central locations and is felt less strongly at the periphery. If rent values are logarithmically distributed as a sample, then it would be expected that more variation will occur at the high end of the sample. As the rents are organised spatially, this means more extreme fluctuation in the core. Using independent measures of urban spatial structure to provide more objective measures of what is the core and what is the periphery, it is possible to test this hypothesis on other cities.

9.5 Discussion

9.5.1 Why global integration?

This thesis has demonstrated emergent regularities in the pattern of rents and of commercial land uses that relate to the *independent* spatial structure of the city. The analysis of such regularities has only been possible because an independent measure of spatial structure was applied to the city and it was possible to compare rent and land use patterns against it. It was the absence of such an independent spatial variable that hid some of the main features of rent patterns in previous studies. The use of distance to the CBD in the Alonso model necessarily assumed a great deal of spatial equilibrium and prevented Alonso from exploring the changing influence of spatial structure on both rent and land use. This study has shown that it is possible to treat morphological structure as independent and research its role in the emergent patterns of rental value and land use that evolve upon it.

However, although this study has revealed regularities in the pattern of rents and their relation to spatial structure, it has not explored the mechanisms at the individual level of firms that give rise to such patterns. Why should rent patterns relate to this particular property of the spatial layout, the global integration pattern? In order to provide an explanation for this finding, a theory is required that can link the physical environment to the social process of rent determination. It must be possible to show how the actions of real individuals can lead to the emergent patterns observed. In other words it is necessary to show how the 'micro-motives' and actions of tenants in individual rented units give rise to the aggregate 'macro-behaviour' of rent prices in the market as a whole (Schelling 1978). However, there is no existing theory for the location variable in terms of the actions of individuals and their repercussions on the emergent market as a whole.

What is required is a *mechanism* to explicitly link individual actors with the spatial pattern of location advantages required for their social interaction and from this the rent patterns that they give rise to when bidding for office space on the market. Although the patterns of rent that emerge from social interaction are unintended and complex, it is ultimately real individuals that are doing the interacting that gives rise to them.

9.5.2 Towards a social theory of rent

In order to build a proper social theory of rent, a micro-scale study of the activities of individual firms is required as a companion to the macro-scale study presented in this thesis. Such a study would compare the activities of individual firms in more or less integrated locations in order to evaluate which are the salient costs and benefits that lead firms to bid more for more integrated locations.

For the determination of office rents, the costs and benefits to individual companies that are relevant must relate to the potential for *physical co-presence* in some way. This is because the only distinguishing characteristics of spatial locations that remain in the information age are those that relate to actually *being there*. Given the increasing diversity and ease of trans-spatial interaction and information exchange that has come with telecommunications and internet technologies, rents can only reflect something about the potential afforded by face to face contact, as these are the only remaining aspects that distinguish one *place* from another. All that does not require physical co-presence can be obtained by other means and would therefore not be a characteristic of locations that would command a premium in rent.

The hypothesis is then that rents relate to global integration because this value is a proxy for the co-presence potential that is an emergent property of the spatial organisation of the city. The emergent macro-structure of rents in the market is related to the spatial configuration of the street system through the effect that it has on a myriad of specific location criteria for individual firms. When many individual firms make complex location decisions based on accessibility to specific locations important to their business, the pattern of demand that emerges mirrors the general configurational structure of the street grid. This is because the purely configurational properties of the street grid as a spatial system will tend to influence more specific accessibility decisions: a location that is strategic with respect to the whole city is likely to be more strategic to more specific places important to more individual businesses. What has happened in Berlin is that a huge change in the strategic value of the Eastern centre with respect to the whole city has filtered through to affect the complex decisions of more and more individual firms who are prepared to bid higher rents to be there.

A number of immediately obvious conjectures can be made about the specific mechanism of location advantage that leads firms to bid more for integrated locations. From the perspective of the factors of production, a more globally integrated location offers a larger potential pool of labour, as it will be more strategically located relative to all residences in the city. It also offers access to more suppliers of other factors, enabling better prices to be sought. From the perspective of size of market, a globally integrated location offers easier access to the company for more clients and it might therefore be worth paying a premium for.

What is required in order to select among these conjectures are detailed micro-scale studies of the spatial relationships between office firms and their workers, suppliers, clients and competitors. At present it can only be a possible axiom of the explanatory model of rent determination that co-presence has a value. It is, however, a theorem of the model that spatial structure sets up a potential for co-presence within the city that is differentiated.

9.5.3 The Future of Rent

In many developed cities of Western Europe and North America, the relationship between street configuration and rent patterns is fairly stable over time- so much so that it can be taken for granted. After all, the pattern must exhibit a high degree of stability for surveyors to be able to use the comparative method of valuation at all, or for academics to have suggested that distance from the CBD centre is a useful index of rent value. From this viewpoint, the reunification of Berlin appears as a very unusual phenomenon. The scale of spatial restructuring that occurred in Berlin with reunification is very dramatic relative to other cities of the developed world.

However, from the viewpoint of the planet as a whole, the scale of spatial reorganisation in Berlin is not exceptional. Not only is much more of world's population urbanising now but the speed with which cities are growing has been increasing with each wave of urbanisation. This leads to large new areas being added to the spatial structure of the city very rapidly, which changes the emergent pattern of co-presence potential and therefore changes the relative value of locations. Rapid urbanisation poses similar kinds of problems in *revaluing* of location that the reunification of Berlin has done because it also leads to the rapid emergence of a value pattern that is not necessarily as urban planners or anyone else would have expected it to be.

This similarity between the Berlin case and the rapidly changing cities of the developing world points to a wider potential use of measures for urban street configuration in the property market. Change to the configuration of cities take place all the time both in rapidly developing cities and in well established ones. All development projects that affect the infrastructure of a city have an influence on its configuration, whether they are small such as the extension of a residential street or larger such as the building of a bridge or the redevelopment of a train station. Valuers, developers and all others involved in the property market have to make estimates about how important an effect these configurational changes will have on the pattern of location values.

The use of measures such as those presented in this thesis can help this process by providing some independent measure of the potential repercussions of any development on the spatial configuration of the city as a whole. As has been discussed in section 9.3.2, there are limits to the particular methods of analysis used in this thesis. However, the more important point is that the approach of using independent measures of spatial structure to simulate the potential influence of development on the city as a whole is a valuable one. With improvements in the technique, the approach could extend beyond just an evaluation of street configuration and take the whole complex spatial object of the city as a whole, including public transport systems and building interiors.

The relationship between spatial structure and the emergence of location value that has been suggested for Berlin is also one that would apply to any settlement. Wherever humanity chooses to build settlements in the future and with whatever technologies, there will always be an emergent value structure that arises from the co-presence potential created by individuals using the structure in purposive ways. This would be as true for a virtual settlement or an extra-terrestrial settlement as it is for Berlin. Wherever individuals inhabit a spatial system that allows contact with one another, location value is created because the potential for contact is unequal within the system. If a better theoretical understanding of the laws that govern this emergent value can be developed, then measures similar to the one used in this thesis can be used to provide predictive location tools where only intuition and experience currently exist.

10 APPENDIX A: BIBLIOGRAPHY

Adair, A. and S. McGreal (1987). "The Application of Multiple Regression Analysis in Property Valuation." Journal of Valuation **5 (6?)**: 41-47 (57-67?).

Aengevelt Research (1996). City Report Region Berlin Potsdam No VI, Aengevelt.

Alonso, W. (1964). Location and Land Use: Towards a General Theory of Land Rent. Cambridge Mass, Harvard University Press.

Angermann (1997). Angermann Internationale Vermietungs Consultants GmbH.

Anstey, B. (1949). "Value Contour Maps: a new tool for planners." Planning Outlook(2): 22-39.

Anstey, B. (1965). A study of certain changes in land values in the London area in the period 1950-1964. Land Values. P. Hall. London, Sweet and Maxwell: 19-41.

Appraisal Institute (1992). The Appraisal of Real Estate. Chicago, Appraisal Institute.

Aust, B. (1986). "Überblick über den stadtstrukturellen Aufbau Berlins, Dargestellt am Profil von Berlin Mitte nach Lichtenrade." Berliner Geographische Studien: 77 93.

Aust, B. (1994). Hauptstadtplanung Berlin. Berlin, Senatsverwaltung für Stadtentwicklung und Umweltschutz.

Aust, B. and U. Stark (1987). Die Städtebauliche Entwicklung Berlins seit 1650 in Karten. Berlin, Senatsverwaltung für Stadtentwicklung und Umweltschutz.

Aust, B. and U. Stark (1987). Städtebauliche Entwicklung Berlins von 1650 bis heute: beiheft zum Kartenwerk und Ausstellung. Berlin, Senatsverwaltung für Stadtentwicklung und Umweltschutz.

Balfour, A. (1990). Berlin : the politics of order 1737-1989.

Batty, M. (1994). "A Chronicle of Scientific Planning." Journal of the American Planning Association **60**(1): 7-16.

Batty, M. (1995). "New Ways of Looking at Cities." Nature **377**: 574.

Bauwelt (1991). Berlin Mitte, 1928 - Berlin Mitte, 1989. Bauwelt. **82:** 2096-2119.

Benedikt, M. L. (1979). "To Take Hold of Space: Isovists and Isovist Fields." Environment and Planning B: Planning and Design **6**: 47-65.

Bittner (1997). Immobilienmarkt- Research Trendbrief, Bavaria Immobilienconsult und Baurevision GmbH.

Blumenauer Immobilien (1997). Marktbericht 1997. Berlin, Blumenauer Immobilien GmbH,.

Bond, S. (1991). "Rental Valuations with Inducements: An Update." Journal of Property Valuation and Investment **12**.

Branoner, W. (1994). Planning for the future of Berlin. Managing and Marketing of Urban Development and Urban Life. G. Braun. Berlin, Dietrich Reimer Verlag. **52**.

Brennan, T. P., R. E. Cannaday, et al. (1984). "Office Rent In The Chicago CBD." Journal of the American Real Estate & Urban Economics Association **12**(3): 243-260.

Brockhoff (1997). Der Markt für Einzelhandelsimmobilien, Büro- und Hallenflächen, Brockhoff&Partner Immobilien GmbH.

Bundesanstalt für Statistik (1998). Consumer Prices.

Burgess, E. (1925). The Growth of the City. The City. R. E. Park. Chicago, University of Chicago Press.

Cannaday, R. K., H. (1984). "Estimation of Market Rent for Office Space." The Real Estate Appraiser and Analyst **50**(2): 67-72.

Cash (1995). "Der Teuerste Schweinezyklus aller Zeiten." Cash(5).

Christaller, W. (1933). "Central Places in Souther Germany ('Die zentralen Orte in Suddeutschland')." .

Clapp, J. (1980). "The Intrametropolitan Location of Office Activities." Journal of Regional Science **August**: 387-399.

Crosby, N. and S. Murdoch (1991). "Capital Value Implications of Rent-free Periods." Journal of Property Valuation and Investment **12**(2).

Crosby, N. and S. Murdoch (1998). Changing Lease Structures in Commercial Property Markets. London, RICS Books.

Davidson, A. and C. Darlow (1993). Rental Equivalent Tables and Lease Incentives. Estates Gazette, London.

Dempsey, J. (1993). Berliners unimpressed by Kohl plan for 2001, the office space odyssey. Financial Times. London.

Desyllas (1998). The Changing Pattern of Location Rents in the Berlin Office Market. Reading, College of Estate Management.

Desyllas, J. (1994). After the Wall: A Spatial Analysis of Property Development in Reunfied Berlin, University College London.

Desyllas, J. (1997). Berlin in Transition. Proceedings of the First International Space Syntax Symposium, University College London, UCL.

Desyllas, J. (1998). When Downtown Moves. Cutting Edge, Leicester, Royal Institute of Chartered Surveyors.

Desyllas, J. (1999). The Frankfurt Urban Entertainment Centre: Report on Pedestrian Movement Potentials. London, Space Syntax Laboratory.

Desyllas, J. (1999). Why Pay To Be There? Office Rent and the Location Variable. Proceedings of The Second International Space Syntax Symposium, Brasilia, Brasil.

Desyllas, J., E. Duxbury, et al. (1999). The Crime and Urban Design Database: First Report to the City of Gosnells. London, Space Syntax Laboratory.

Desyllas, J., M. Greene, et al. (1998). The Spatial Configuration of a Rapidly Growing City; Implications on the Quality of Urban Life. Computers in Urban Planning and Urban Management. P. Sikdar. New Dehli, Narosa. **1**.

Deutsche Bank Research (1997). Immobilienmarkt Deutschland 1996-2001.

Deutsche Bundesbank (1998). Monthly Report January 1998, Deutsche Bundesbank.

Dunse, N. (1996). The Application of Hedonic Analysis to UK Office Markets: A Case Study of Glasgow. Cutting Edge 1996, Royal Institute of Chartered Surveyors.

Dunse, N. and C. Jones (1997). Identification Of Office Submarkets. Cutting Edge, Royal Institute of Chartered Surveyors.

EBS (1997). gif-Erhebung regionaler Büromarktdaten in Berlin 1997, European Business School Immobilienakademie GmbH.

Economist (1993). Europe's Offices Blocked. The Economist: 124.

Economist Intelligence Unit (1994). Country Report Germany. London, Economist Intelligence Unit.

Elkins, T. and B. Hofmeister (1988). Berlin: The Spatial Structure of a Divided City. London, Methuen.

Ellger, C. (1994). Berlin- Metropolis in Transition: The State of Urban Development in 1994. Managing and Marketing of Urban Development and Urban Life. G. Braun. Berlin, Dietrich Reimer Verlag. **52**.

Engel & Völkers (1996). Büroflächen Berlin: Fakten und Trends.

Epstein, D. (1993). “Effective Rental Values.” Estates Gazette(24th April).

Epstein, D. (1993). “Effective Rents (a Postscript).” Estates Gazette.

ESRI (1998). ArcView User Manual. Los Angeles, Environmental Systems Research Institute Inc.

Estates Gazette (1995). “Rent-free Periods and Valuation.” Estates Gazette.

Eureal (1994). Büromarktbericht 94/95.

Europroperty (1997). “Rents languish as investment sizzles.” Europroperty **March**.

Fraser, W. D. (1993). Principles of Property Invetment and Pricing.

Gallimore, P., M. Fletcher, et al. (1996). “Modelling the influence of location on value.” Journal of Property Valuation and Investment **14**(1): 6-19.

Geppert, K. (1996). Grundlinien der Wirstschaftsentwicklung in Berlin 1995/96, Deutsches Institüt für Wirtschaftsforschung.

Glasscock, J., Jahanian, S and Sirmans, C (1990). “An Analysis of Office Market Rents: Some Empirical Evidence.” Journal of the American Real Estate & Urban Economics Association **18**: 105-119.

Hacking, I. (1983). Representing and Intervening, Cambridge University Press.

Haig, R. M. (1926). “Toward and Understanding of The Metropolis.” Quarterly Journal of Economics **40**(May): 421-423.

Hanink, D. M. (1997). “The integration of intrametropolitan office markets.” Environment and Planning A **29**(3): 391-404.

Heikkila, E., P. Gordon, et al. (1989). "What happened to the CBD-Distance gradient?: land values in a policentric city." Environment and Planning A **21**: 221-232.

Helmer, S. D. (1985). Hitler's Berlin: The Speer Plans for Reshaping the Central City.

Hillier, B. (1996). Space is the Machine. Cambridge, Cambridge University Press.

Hillier, B. (1998). Describing Emergent Structure in Strongly Configurational Systems. Requirements Engineering, Limerick.

Hillier, B. (1999). "The Hidden Geometry of Deformed Grids or Why Space Syntax Works (when it looks as though it shouldn't)." Environment and Planning B: Planning and Design **26**.

Hillier, B., M. Greene, et al. (1998). Self-Generated Neighbourhood Consolidation in Informal Settlements, University College London.

Hillier, B. and J. Hanson (1984). The Social Logic of Space. Cambridge, Cambridge University Press.

Hillier, B. and A. Penn (1992). "Dense Civilisations: the Shape of Cities in the 21st Century." Applied Energy **43**: 41-66.

Hillier Parker (1990). European Atlas of Office Rent Contours. London, Hillier Parker.

Hobrecht (1862). Bebauungsplan der Umgebungen Berlins. Berlin, Abtheilungen I-XIV Genehmigt durch Allerhoechste Cabinets Ordre.

Hough, D. and C. Kratz (1983). "Can 'Good' Architecture Meet the Market Test ?" Journal of Urban Economics: 40-55.

Howes, C. K. (1980). Value maps : aspects of land and property values. Norwich, Geo Books.

Hurd, R. (1903). Principles of City Land Values. New York, The Record and Guide (first published in1903 by Real Estate Record Association).

Isard, W. (1956). Location and space-economy : a general theory relating to industrial location, market areas, land use, trade, and urban structure. New York, Technology Press of Massachusetts Institute of Technology.

Jones Lang Wootton (1995). City Report Berlin, Jones Lang Wootton Research.

Jones Lang Wootton (1996). Company Profile (internal report).

Jones Lang Wootton (1997). City Report Berlin, Jones Lang Wootton Research.

Kishore, R. (1996). "Discounted Cash Flow Analysis in Property Investment Valuations." Journal of Property Valuation and Investment **14**(3): 63-70.

Knos, D. S. (1962). The Distribution of Land Values in Topeka, Kansas. Spatial Analysis. B. J. L. Berry. Englewood Cliffs, New Jersey, Prentice Hall Ltd.

Koch, M. (1994). "Positive Zeichen." Immobilien Manager(5): 28-32.

Kraetke, S. (1992). Berlin: the rise of a new metropolis in a post-Fordist landscape. Cities and Regions in the New Europe. M. Dunford and G. Kafkalas. London, Belhaven.

Krugman, P. (1995). Development, Geography and Economic Theory. London, MIT Press.

Krugman, P. (1996). The Self-Organising Economy, Blackwell.

Landeskartenwerk Berlin (1996). K10 RD CD Karte von Berlin 1:10000 Rasterdaten. Berlin, Senatsverwaltung für Bauen Wohnen und Verkehr Berlin.

Landeskartenwerk Berlin (1996). K15 RD CD Karte von Berlin 1:5000 Rasterdaten. Berlin, Senatsverwaltung für Bauen Wohnen und Verkehr Berlin.

Laurini, R. and D. Thomson (1995). Fundamentals of Spatial Information Systems. San Diego, Academic Press.

Lee, D. B. (1973). "Requiem for Large-Scale Models." Journal of the American Planning Association **39**(163-78).

Lee, D. B. (1994). "Retrospective on Large-Scale Urban Models." Journal of the American Planning Association **60**(1).

Leyden, F. (1933). Gross-Berlin, Geographie der Weltstadt. Breslau, Hirt.

Lizieri, C., N. Crosby, et al. (1997). Right Space Right Price: A Study of the Impact of Changing Business Space Patterns on the Property Market. London, RICS.

Louis, H. (1936). Die Geographische Gliederung von Gross Berlin. Landerkuendliche Forschung: Festschrift zur Vollendung des 60 Lebensyahres Norbert Krebs. H. Louis and W. Panzer. Stuttgart, Engelhorn: 146-71.

Lowry (1964). A Model of Metropolis, Rand Corporation.

Marshall, A. (1890). Principles of Economics.

McCluskey, W., R. Deddis, et al. (1997). "Interactive application of computer assisted mass appraisal and geographic information systems." Journal of Property Valuation and Investment **15**(5).

McDonald, J. F. (1993). "Incidence Of The Property-Tax On Commercial Real-Estate - The Case Of Downtown Chicago." National Tax Journal **46**(2): 109-120.

Memhard, J. G. (1652). Grundriß der Beyden Churfürstlichen Residentz Stätte Berlin und Cölln an der Spree. Berlin.

Mills, E. S. (1992). "Office Rent Determinants In The Chicago Area." Journal of the American Real Estate & Urban Economics Association **20**(2): 273-287.

Müller (1997). Office Market Germany, Müller International Immobilien GmbH.

Müller GmbH (1996). Städte Report Berlin 1996, Müller International Immobilien GmbH.

Murdoch, S. and N. Crosby (1991). "The legal Implications of Rent Free Periods at Rent Review." Journal of Property Valuation and Investment **12**(2): 43-50.

Newman, P. and A. Thornley (1994). Economic and Political Influences on Urban Planning: a comparison of London, Paris and Berlin. Reading, University, Department of Land management and Development.

O'Hara, D. J. (1977). "Location of Firms within a Square Central Business District." Journal of Political Economy **85**(6): 1188-1207.

Park, R. E. (1925). Human Ecology. The City. R. E. Park. Chicago, University of Chicago Press.

Penn, A., J. Desyllas, et al. (1999). "The space of innovation: Interaction and communication in the work environment." Environment and Planning B **26**(2).

Ponsard, C. (1983). History of Spatial Economic Theory. Berlin.

Popper, K. (1957). The Poverty of Historicism. London, Routledge.

Ratcliff, R. U. (1949). Urban Land Economics. New York, McGraw Hill.

Renshaw, E. F. (1958). "Scientific Appraisal." National Tax Journal(December).

Ribbe, W., Ed. (1987). Geschichte Berlins. München.

Ricardo, D. (1817). On the Principles of Political Economy and Taxation.

Ring, P. (1992). Industriestandort Berlin: Wissenschaftliche Analyse, Unternehmerische Bewertung, Politische Initiativen. Industriepolitische Konferenz der Senatsverwaltung für Wirtschaft und Technologie, Regioverlag.

Robinson, A. (1995). Elements of Cartography, Wiley.

Sands, D. (1996). "Tenants retain upper hand in negotiations." Europroperty **August**.

Schelling, T. (1978). Micromotives and Macrobehaviour. New York, W.W. Norton.

Schmettau, M. C. d. (1748). Plan de la Ville de Berlin Levé et dessiné par Ordre et Priviligé privatis du Roy. Berlin, Königlichen Academie der Wissenschaften Berlin.

Schultz and J. D. Schleuen (1688). Grundriß der Churfürstlichen Residentz Berlin nach der Perspektvischen Vorstellung. Berlin.

SenStadtUm and IHK (1995). Bürofächenbericht Berlin 1994/95, Senatsverwaltung für Stadtentwicklung und Umweltschutz.

Sineck (1856). Situationsplan der Haupt- und Residenzstadt Berlin mit nächster Umgebung.

Sivitanidou, R. (1995). "Urban Spatial Variations In Office-Commercial Rents - The Role Of Spatial Amenities And Commercial Zoning." Journal Of Urban Economics **38**(1): 23-49.

Sivitanidou, R. (1997). "Are Center Access Advantages Weakening? The Case of Office-Commercial Markets." Journal Of Urban Economics **42**(1): 79-97.

Smith, A. (1776). The Wealth of Nations. London, Penguin.

Tufte, E. (1983). The Visual Display of quantitative Information. Cheshire, Conn, Graphics Press.

Van Hove, E. and I. Loots (1988). The Structure and use of a city appropriate database. International Conference on Housing, Policy and Urban Innovation, Amsterdam.

Vandell, K. and J. Lane (1989). "The Economics of Architecture and Urban Design." Journal of the American Real Estate & Urban Economics Association **16**: 235-20.

Volger, G. (1994). Fundamentales Ungleichgewicht. Immobilien Manager. **November:** 18-24.

Von Thünen, J. H. (1966). Isolated State. London, Pergamon (orig. 'Der isoliertie Staat in Beziehung auf Landwirtschaft und Nationalökonomie' Hamburg,1926).

Walter, R. (1993). Axis as a political strategy: a study of two proposals for the capital Berlin, University College London.

Webb, R. B. and J. D. Fisher (1996). "Development of Effective Rent (Lease) Index for the Chicago CBD." Journal of Urban Economics **39**(1): 1-19.

Wegener, M. (1994). "Operational Urban Models- the State of the Art." Journal of the American Planning Association **56**: 17-29.

Westrup (1996). "New supply proves difficult to absorb." Europroperty **August**.

Westrup (1998). "Ups and downs as Berlin catches up." Europroperty **April**.

Wheaton, W. C. and R. G. Torto (1994). "Office Rent Indices And Their Behavior Over Time." Journal Of Urban Economics **35**(2): 121-139.

Wingo, L. (1961). Transportation and Urban Land. Washington D.C., Resources for The Future Inc.

Wyatt, P. (1996). "Using a geographical information system for property valuation." Journal of Property Valuation and Investment **14**(1): 67-79.

Wyatt, P. (1997). "The development of a GIS-based property information system for real estate valuation." International Journal of Geographical Information Science **11**(5): 435-450.

Wyatt, P. J. (1994). Property Valuation Using a Geographical Information System. Brighton, University of Brighton.

11 APPENDIX B: DEFINITION OF LEASE VARIABLES

Variable	Description	Type	Sample size (n)
Building Quality	'old' for buildings built before the fall of the wall and 'new' for office space built since 1990.	Dummy variable	437
Lease start date	The occupation start date in months since January 1991	continuous	437
Pre-letting time	The period in months between the date of the lease signature and the start date of occupancy.	continuous	206
Obligatory lease term	The length of time in years until the first point at which the tenant can leave the contract.	continuous	317
Length category	The minimum length term split to lower than 5 years, 5years and 10 years	Category	317
optional renewal time	Optional renewal time has been calculated as the total period that a tenant may choose to remain under the same lease conditions after the obligatory lease term. First and subsequent renewal periods have been summed.	continuous	206
Unit floor-space size	Unit floorspace size is the leased area of office space and the share of communal space (always charged at the same price) in square metres taken by the tenant Garages or other use spaces were excluded.	continuous	437
Floor-space category	This category was based on the variable Unit Floorspace Size. The break point for categories was arbitrary, after discussions with agents suggested that this would be useful. It was used to explore the differences between small and large leases, more detial of which can be found in [Desyllas, 1998 #402] Small: <500m2 leased area medium: 500 to 999m2 leased area Large:>1000m2 leased area	Category	437
Rent-free periods	The number of months of occupation during which no rent must be paid	continuous	206
Cash incentives	Any amount in DM paid to the tenant from the landlord	continuous	206
Headline rent	The price in DM per square metre per month stated in the contract in constant 1991 prices. All rents are exclusive of tax and service surcharge costs.	continuous	437
Total lease value	The headline rent multiplied by the floorspace	continuous	437
Considerati on rent	mean rent p.a. paid by the tenant after adjustment for all incentives in the lease	continuous	206
Effective rent	mean net present value of the consideration rent discounted at 6% p.a.	continuous	206

Table 11.1: Definition of lease variables

12 APPENDIX C: ECONOMETRIC STUDIES OF OFFICE RENT AND LOCATION

Study Info				Aggregation			Dependent Variable		Non-Spatial Variables Tested											Spatial Variables Tested			
Study Years	Author	City (source)	Sample Size	Leases Units	Whole Bldg Avg.	Whole Area Avg.	asking rent	headline rent	Bldg Size	Bldg Age	No. Floors	Intern. Parking	Lease Lengths	unit size	space per floor	Bldg Vacancy Rate	Aesthetics	Year dummies	Other non-spatial variables	Area Dummies	Sky distances	Road distances	Other spatial variables
1954-1959	Knos	Topeka, Kansas	75 blocks			block avg.	(assessed land values)															●	Population potentials, growth area zones
1974	Clapp	Los Angeles Metro. Area	111		●		●		●	●	●	●							annual property tax, air quality (smog), amenity (subjective eval)		●	●	amt office space in two block radius, avg. commuting time employees
1978	Hough and Kratz	Chicago	139		●		●		●	●	●	●					●		rentable space per floor. availability of conference facility		●		
1979-1980	Canaday & Kang	Champaign Urbana	24		●		●			●			●	●	●						●		
1980-1983	Brennan et al	Chicago ('several real estate brokers')	29	●				●	●	●	●		●	●	●			●	loss factor (proportion of area rented but not used)	●		●	
1985-1988	Glascock et al	Baton Rouge, Louisiana	675		●		●		●										building type, vacancy rates	●			
1990	Mills	Chicago (Cushman Wakefield)	543		●		●		●	●		●			●	●	●		internal restaurant/bank/healthcentre, historic landmark	●			

Table 12.1: Econometric Studies of Office Rent and Location (continued overleaf)

Study Info				Aggregation			Dependent Variable		Non-Spatial Variables Tested											Spatial Variables Tested			
Study Years	Author	City (source)	Sample Size	Leases Units	Whole Bldg Avg	Whole Area	Avg. asking rent	headline rent	Bldg Size	Bldg Age	No. Floors	Intern.	Parking Lease	Lengths unit size	space per	floor Bldg	Vacancy Rate Aesthetics	Year	dummies Other non-spatial variables	Area Dummies	Sky distances	Road	distances Other spatial variables
1994-1995	Dunse	Glasgow	477	●			●			●		●		●				●	floor of contract, aircon, carpeting, raised floors, tea prep area, double glazing, cellular layout, acoustic tiling	●	●		
1990	Sivitanidou	Los Angeles (Coldwell Banker)	36 (*146 2*)			●	●								●							●	
1988	Vandell	Boston and Cambridge MA (Spaulding and Slye)	55		●		●		●	●	●	●					●		date of last rehab, aesthetic evaluation of design by Architects panel		●		
1991	McDonald	Chicago (bldg owners association)	259		●			●	●	●	●					●			Percentage of bldg in office use	●			

(Table 12.1 continued from previous page)

13 APPENDIX D: KEY TO THE PLANZEICHENVERORDNUNG

Residential Land (Wohngebiete)- where the building is principally residential. In Berlin, this leaves the mixture of other uses, particularly in the large blocks of the 'Gründerzeit' (late nineteenth century) unrecorded except for the shop frontage on a residential block.
Mixed Use Land (Mischgebiete). This category can be a mixture of any or all of the others but is most likely to be a mixture of residential and core (commercial) uses.
Continuous Shop Frontage (Durchgehende Ladenfront) This category shows the main shopping streets and does not require the rest of the building use to be consigned to commercial uses, consequently within residential areas a more detail land use breakdown is possible.
Core (commercial) Land (Kerngebiete) This designates a building that is principally of commercial use (office and retail).
Industrial Land (Gewerbe- und Industriegebiete)
Special Area (Besondere Gebiete)
Local Authority Land (Gemeindebedarfsflächen)
Military Land (Militärisch genutzte Flächen)
Servicing and Utilities Land (Ver- und Entsorgungsflächen)
Green Area (Grünflächen)
Farming Area (Landwirstchaftsflächen)
Gardening Area (Gärtenbauflächen)
Marshland (Feuchtgebiete)
Forest (Waldflächen)
Water (Waserflächen)
Building Site (Bauflächen)
Use Unknown or Land Unused (Nutzung nicht ermittelbar oder Flächen nicht genutzt)
Principal Traffic Routes (Hauptverkehrsstraßen)
Rail Routes

Table 13.1: Key to the Planzeichenverordnung (PlanzVO)

14 APPENDIX E: SUMMARY OF MULTIPLE REGRESSION MODELS

LnHeadlineRent=	4.070	-.016 Ln Floorspace	-.063 BuildQuality Dum	-.010 Leasebeginmonthcode	+.001 Contractlength	
	(4.070)	(-.054)	(-.101)	(-.561)	(.007)	Adj R^2=.321
	35.790**	-1.026	-2.052**	-11.207**	.141	N=317

Table A: MRA for Ln Headline Rent of All JLW leases 1991-1997

LnHeadlinerent=	3.773	-.011 Lease begin month code	-.013 Ln Floor space	+.002 Contract length	-.056 Build Quality Dum	+.286 Divided Global Integration	
	(3.773)	(-.587)	(-.043)	(.019)	(-.0880	(.126)	Adj R^2=.361
	21.824**	-11.626**	-.804	.357	-1.720*	2.490**	N=284

Table B: MRA for Ln Headline Rent of All JLW leases 1991-1997

LnHeadlinerent =	3.101	-.013 Lease begin month code	-.011 Ln Floor space	+.006 Contract length	+.012 Build Quality Dum	+.921 Reunif Global Integration	
	(3.101)	(-.699)	(-.037)	(.050)	(.019)	(.439)	Adj R^2=.473
	21.551**	-14.949**	-.809	1.085	.410	9.354**	N=300

Table C: MRA for Ln Headline Rent of All JLW leases 1991-1997

LnHeadlinerent=	3.806	-.011 Lease begin month code	-.001 Ln Floor space+	+2.743E-4 Contract length	+.001 Build Quality Dum	+.002 K 3	
	(3.806)	(-.615)	(-.002)	(.002)	(.001)	(.385)	Adj R^2=.448
	35.422**	-13.422**	-.042	.045	.026	8.378**	N=300

Table D:MRA for Ln Headline Rent of All JLW leases 1991-1997

LnHeadlinerent=	3.311	-.012 Lease begin month code	+.574 Reunif Global Integration	+.001 K 3	
	(3.311)	(-.669)	(.278)	(.202)	Adj R^2=.488
	36.889**	-18.160**	6.035**	4.581**	N=420

Table E: MRA for Ln Headline Rent of All JLW leases 1991-1997

LnHeadlinerent=	3.308+	-.015 Lease begin month code	+.824 Divided Global Integration	
	(3.308)	(-.710)	(.189)	Adj R^2=.592
	8.882**	-9.785**	2.599**	N=83

Table F: MRA for Ln Headline Rent of "Old Build" units in West Berlin 1991-1997

LnHeadlinerent=	4.367	-.015 Lease begin month code	+.003 K 3	-.074 Ln Floor space	
	(4.367)	(-.732)	(.270)	(-.169)	Adj R^2=.659
	22.086**	-11.276**	4.162**	-2.615**	N=83

Table G: MRA for Ln Headline Rent of "Old Build" units in West Berlin 1991-1997

LnHeadlinerent=	3.373	-.013 Lease begin month code	+.651 Divided Global Integration	
	3.373	-.751	.323	Adj R^2=.587
	33.845**	-16.000**	6.872**	N=193

Table H: MRA for Ln Headline Rent of "New Build" units in West Berlin 1991-1997

Headline Rent =	31.322	-.370 Lease begin month code +	+17.959 Divided Global Integration +	
	(31.322)	(-.763)	(.309)	Adj R^2=.599
	11.081**	-16.498**	6.683**	N=193

Table I: MRA for Ln Headline Rent of "New Build" units in West Berlin 1991-1997

Ln Headline Rent=	2.658	-.009 Lease begin month code	+.984 Reunified Global Integration	
	(2.658)	(-.532)	(.429)	Adj R^2=.349
	8.257**	-4.700**	3.794**	N=54

Table J: MRA for Ln Headline Rent of "Old Build" units in East Berlin 1991-1997

Headline Rent	15.112	-.280 Lease begin month code	+24.587 Reunified Global Integration	Adj R^2=.356
	(15.112)	(-.570)	(.379)	
	1.669	-5.065**	3.370**	N=54

Table K: MRA for Ln Headline Rent ("Old Build" units in East Berlin 1991-1997)

LnHeadlinerent=	2.110	-.017 Lease begin month code	+1.827 Reunified Global Integration	+.044 Contract length	
	(2.110)	(-.859)	(1.101)	(.262)	Adj R^2=.556
	7.574**	-6.119**	8.069**	2.301**	N=55

Table L: MRA for Ln Headline Rent of "New Build" units in East Berlin 1991-1997

Headline Rent	-10.061	-.471 Lease begin month code	+55.224 Reunified Global Integration	+1.434 Contract length	
	(-10.061)	(-.803)	(1.103)	(.283)	Adj R^2=.543
	-1.180	-5.640**	7.972**	2.447**	N=55

Table M: MRA for Ln Headline Rent of "New Build" units in East Berlin 1991-1997

15 APPENDIX F: GLOSSARY

Asking Rent	The rent price advertised in the marketplace as a starting point for negotiations. No asking price data has been used as primary data in the empirical analysis of this thesis, but some secondary asking price information from Berlin property agents is evaluated in Chapter 5.
Axial Map	A simplification of the network of public space as the set of fewest and longest axes that link all the convex spaces of a continuous street system together.
Choropleth	Colour shading representing the attribute values of a phenomenon. This technique has a major advantage for the representation of spatial patterns because the use of colour does not distort the spatial pattern of the phenomenon in the way that isopleth representations can. This allows as detailed a spatial map as possible while simultaneously displaying the attribute values in their original location.
Consideration Rent	Consideration rent is the headline rent adjusted for the lease provisions that influence the value of the lease but without any discounted cash flow calculation. It is the average rent price per square metre per month for the jagged income flow of a lease with its incentives considered. In this thesis, this means the average rent price per square metre per month in 1991 prices of each year of the lease, after the particular incentives or provisions effective in each year have been deducted or added to the price. (see also: effective rent)
Effective Rent	As a general concept, effective rent is that rent which has the same net present cost to the tenant and the same net present value to the landlord as the package of rent plus incentives comprising the actual open market letting. However, the valuation of incentives and other lease provisions is complex and the subject of some debate, as discussed in Chapter 2. In this thesis, effective rent is the average Net Present Value of the consideration rent expressed in Deutsche Marks per square metre per month. A discount rate of 6% was used for the calculation of NPV, which was the average German interest rate for the period under consideration.

Floorspace Size	(see Unit Floorspace Size)
Headline Rent	The rent price recorded in a lease at the start of the lease term. In the German market, discussion of achieved rents refers to this figure, rather than the rent that is reached at the end of a lease. In this thesis the leases are German and so all headline rents are in Deutsche Marks per square metre per month. In the leases themselves, the nominal price at the date of lease signing is recorded (without adjustment for inflation, although adjustment of various kinds over the length of the lease term may be provided for in the lease- see effective rent). For all statistical purposes in this thesis unless explicitly declared otherwise, the nominal price has been adjusted to the real price expressed in constant 1991 prices.
Isopleth	A continuous surface interpolated from individual values, used to represent changes in value. The technique is used in cartography and natural geography to map the form on the outside surface that encloses a geographic volume. It is normally used when the focus is on the attribute values at points on a truly continuous distribution, such as land elevation. Isarithms showing distributions of values that can be referenced to points (such as a point on a rented office floor) are called isometric lines. The surface can either be represented as contours on a plan view or explicitly as a three dimensional object in an axonometric view. Some of the theoretical problems of this approach when applied to rent data are discussed in chapter 7.
Lease Length	(see Obligatory Lease Length)
Lebenshaltungskostenindex	The cost of living index used in German office leases. It is a consumer inflation index, not a property market index. There are variations as to when the rent is first adjusted to this index and how often, the most common being in year 2 and every year afterwards.
Location Rent	As a general concept, location rent is the part of rent value that give rise to

spatial differences in rents that cannot be explained by intervening variables and are assumed to be a premium for location. This normally means that alternative variables that could explain rent differentials have been controlled in some way as far as is possible. The remaining differential in rent that cannot be explained by the systematic influence of any other factor is thought to be location rent. The extent to which it is possible to determine location rent is highly dependent on the availability and quality of data for alternative factors. In this study, the residual from a 'location blind MRA' is used to create a proxy for location rent.

Location Blind Multiple Regression Analysis	A Multiple Regression Analysis that deliberately has no independent variables representing location. The purpose of this analysis is to produce a residual value in the rental data that is not attributable to any non-location variables, in order to arrive at a residual differential in rent that can be used as a proxy for location rent.
Nominal Rent Price	Any rent price that has not been adjusted for inflation with reference to a specific base year index. For all statistical purposes in this thesis unless explicitly declared otherwise, primary nominal rent data has been adjusted to real rents expressed in constant 1991 prices.
Obligatory Lease Length	The length of time in years specified in a lease that a tenant has occupancy of a unit, until the first point at which the tenant can choose to leave. This is effectively the period until the first break clause, rather than the maximum period that a tenant could choose to stay. This variable has been given the name leaselength in the regression models.
Optional Renewal Time	The total period after the obligatory lease length that a tenant may choose to remain under the same lease terms. First and subsequent renewal periods have been summed in this study. For example, a lease with two renewal periods of 5 years would have an optional renewal time of 10 years. This variable has been given the name *optiontotal* in the regression models of this thesis.

Pre-Letting Time	The period in of time between the date of the lease signature and the start date of occupancy.
Real Rent Price	A rental value expressed in constant prices that have been adjusted for inflation. For all statistical purposes in this thesis unless explicitly declared otherwise, primary nominal rent data has been adjusted to real rents expressed in constant 1991 prices.
Renewal Period	(see Optional Renewal Time)
Rent Multipliers	Lease clauses that allow for the adjustment of rent over the length of the lease with reference to either an independent variable index or a fixed multiplier, to offset the depreciation that comes from inflation. This variable has been given the name *appreciation*% in the database. Index multipliers (or any variable index) must be used both upwards and downwards in adjusting rents according to German law.
Rent Pattern	Spatial differences in rents that cannot be explained by intervening variables and are assumed to be a premium for location
Space Syntax	A research programme investigating the role of spatial configuration as an independent variable in social systems. A number of analysis techniques have been developed in this programme, including the axial map representation and integration measures used in this thesis.
Step Additions	Yearly additions to the rent over the course of the lease length. The simplest example would be an increase of x DM per square metre per year. More complex might be a varying amount added to the price per square metre each year or an amount added once only or at arbitrary times during the lease. In some cases a fixed *decrease* takes place in the first year and in very few cases a fixed decrease is specified for later years.
Unit Floorspace Size	The leased area of office space and the share of communal space (always charged at the same price) in square metres taken by the tenant. Garages or

other use spaces were excluded from the primary lease data used in this thesis.

Urban Street Configuration — The layout of the street network in which people move around. It is the morphology of streets and public spaces considered as a whole spatial system.