4 Urban Form and Internal Transport Efficiency

Introduction

The comparison of internal traffic demand between cities is, if the other conditions are exactly the same, determined by the urban form. For example, English towns with population 100,000 but varied density (and thus area) will show a reasonable correlation with traffic demand, with higher correlation coefficient.

One of the reasons is that the definition of city boundary varies in different countries and in different datasets, yet this consideration is not always taken (see chapter 3). For example, cities in China usually contain a vast area of agricultural land while administrative Tokyo region relies heavily on the commuters from outside. Even within a country, different boundary for different purposes, such as administration, education, and census, may be open to question.

Taking account of them, I shall start to discuss what urban factor affects the traffic to what extent. The discussions reviewed in the previous chapter focus much on self sufficiency and density. However, few of them have discussed in the way that these factors can be compared. That is, the discussion on density does not do the same on city size in the same way even other research demonstrate it. I shall, therefore, analyse as many urban physical factors as possible in the consistent way to compare the effects of these factors.

Data and samples

There are two available data sets about travel length. Travel survey by DoT, now DETR, has constantly collected travel data of all modes and purposes. However, it has lacked the data of the trips below 1.6 kilometres which do not just account for 35% of all trips (Banister *et al.* 1994), but also are significantly important in the recent discussions of transport policy.

Therefore, the Census journey length to work dataset is used to compare the efficiency in different cities. It may not seem useful as trip to work accounts only for about 30 per cent and the ratio has been declining (Banister *et al.* 1994). However, although it is weak, it surely has a correlation with overall journey demands and fuel consumption (Newman and Kenworthy 1989).

All the Census data are obtained through Manchester Information Data Archive and Statistics Computing Centre (MIDAS, midas.ac.uk) in digitised formats. The tabular data of area, persons present, density and workplace in districts and metropolitan area are in Small Area Statistics (SAS) for England while journey length to work are in Special Workplace Statistics (SWS) data. They are exported as DBF format in SASPAC on MC6000 via telnet and then imported in Microsoft Excel on a workstation.

The average journey length to work (AJL) is calculated based on two datasets: census SAS and SWS. SAS supply with the number of residents in the area and the number of residents whose workplace is home (P_0) while SWS supply the number of residents whose work journey length is less than 2km (P_1), 2~4km ($P_{3.5}$), 5~9km ($P_{7.5}$), 10~19km (P_{15}), 20~29km (P_{25}), 30~39km (P_{35}), more than 40km (P_{60}). Thus, AJL is:

$$AJL = \frac{P_1 + 3.5 \times P_{3.5} + 7.5 \times P_{7.5} + 15 \times P_{15} + 25 \times P_{25} + 35 \times P_{35} + 60 \times P_{60}}{P_1 + P_{3.5} + P_{7.5} + P_{15} + P_{25} + P_{35} + P_{60}}$$

Definition of City

It is one of the most controversial part of this thesis how to define a 'city'. It will directly affect the measurements we will use in this chapter and subsequent chapters. However, as Atkinson and Moon (1994) have attempted to isolate the geographical and social meaning of the term 'urban' and have drawn a conclusion, it is impossible to draw a line round an area on a map and call it urban. It is inevitable to define, in some way, to define the boundary for the purpose of the thesis, not for general use.

Self-sufficiency is the starting point because it defines the boundary of the city. This has often been ignored by urban developers as the post-war new towns in Britain now show little advantage in this term compared to other towns (Breheny 1992b). However, it was one of the necessities in many urban theories such as Howard's original Garden City plan. It, in the thesis, refers exclusively to employment, although it usually includes the foods and service sufficiency, because the thesis seeks the relationship of journey length to work and urban structure. Of importance is, therefore, the ratio of residents working in the same area to all working residents in the area (***S/R***). Here, a city is a census district or a metropolitan area with enough self-sufficiency as ***S/R*** greater than 0.800.

On the other hand, the districts with high ***S/R*** are also excluded. The boundary of census and administrative districts and metropolitan areas is not necessarily the boundary of the district's urban area and may contain a significant area of countryside. Districts tend to be larger when they are seen more self-sufficient. At an extreme, England as a whole is fully self-sufficient, but it is hardly a city. Another example is isolated islands which have high self-sufficiency tend to have different travel patterns. In this thesis, therefore, only the districts with ***S/R*** less than 0.900 are chosen as samples.

Self-sufficiency

Many theoretical discussions of ideal and/or sustainable cities start with, or assume as essential, self-sufficiency. Howard (1898) devoted most pages to achieve economic and food sufficiency, yet the Garden Suburbs, including those influenced by Garden City but modified significantly, have also been generated all over the world with little consideration of self-sufficiency (Hall 1996). Despite its importance, however, self-sufficiency has not been taken into account in many researches and practices, or sometimes ignored intentionally. Among the urban studies reviewed in Chapter 3, Banister et al. (1994) analysed survey data of six parishes in South Oxfordshire. Only 41% of full-time workers live and work in the same parish and the ratio varies among the parishes. It is easily expected that the distance and public transport availability to the nearby cities, London, Oxford and Reading significantly affect the journey-to-work pattern and length.

Figure 4.1 shows four different self-sufficiency indicators related to employment. Some empirical research uses Independence Ratio (***I***, also known as Independence Index) defined as the number of residents working in a town divided by the sum of residents working outside the town and the workers in the town residing outside as:

$$I = \frac{S}{(R-S) + (W-S)}$$

where ***R*** is the number of the residents in the town, ***W*** the workers and ***S*** those residing and working in the town (see ECOTEC 1993, Breheny, Gent and Lock 1993). Through this chapter, residents means those who are self-employed or employees, residing in the same area or another area. The second diagram shows the ratio of working residents to jobs in the district or metropolitan area (***R/W***). R/W therefore implies the potential of how far the district can be self-sufficient (***R/W*** =1). The next diagram is for the residents working in the same area to all jobs in the area (***S/W***). And the last, as already defined to identify the city boundary, the ratio of residents working in the same area to all working residents (***S/R***).

Three sets of ten samples are selected at a given density and area (Table 4.1). The results are also graphed in Figure 4.2. The towns in the first set are compact, i.e., dense (3,400 to 4,000 persons per sq km) and small (23 to 50 sq km). The second set is medium towns (density between 1,000 and 1,500 and area between 70 and 200). The last set is countryside towns (density between 200 and 250, area between 400 and 700)

As ***R/W*** implies the potential of self sufficiency in the district, the cities with ***R/W*** less than 1 supply jobs while those with ***R/W*** more than 1 offer workers. It can be assumed in job supplier cities such as major cities, that people are able to find a job near where they live and thus tend to have less journey length to work. The diagram supports the assumption. However, we have to be aware that job supplier cities can live only together with their satellite cities and towns. ***S/W*** seems to have less relation than the rest. This is explained by that the journey length is counted for those who reside, not work, in the area.

Of significance are ***I*** and ***S/R***. At a given density and area size, ten samples show a linear correlation between the average journey length (***AJL***) and ***S/R***, with reasonable correlation in countryside towns. This tendency is available in the figure for all districts and metropolitan

Table 4.1: Samples for theAanalysis of Self Sufficiency and Average Journey Length to Work

Zone ID	County	Zone name	*A* / sq km	*HR* / km	*P*	ρ	*I*	*R/W*	*S/W*	*S/R*	*AJL*
COMPACT TOWNS											
25JP	Hampshire	Southampton	49.7	3.98	195,906	3,941	0.94	0.82	0.59	0.72	6.68
20GG	Dorset	Bournemouth	46.1	3.83	154,677	3,358	1.06	0.92	0.65	0.71	6.85
10DJ	Bedfordshire	Luton	43.2	3.71	167,009	3,864	1.04	0.97	0.67	0.68	11.38
23HS	Essex	Southend-on-Sea	41.6	3.64	154,102	3,704	0.98	1.09	0.69	0.64	15.99
11DQ	Berkshire	Reading	40.3	3.58	128,266	3,184	0.68	0.72	0.49	0.69	10.29
34NF	Norfolk	Norwich	38.9	3.52	122,661	3,156	0.68	0.56	0.45	0.81	4.70
37PE	North Yorkshire	York	29.4	3.06	101,436	3,455	0.92	0.75	0.57	0.76	5.90
28KT	Humberside	Great Grimsby	28.0	2.98	89,345	3,195	1.05	0.75	0.59	0.79	5.23
11DR	Berkshire	Slough	27.3	2.95	98,790	3,613	0.56	0.80	0.48	0.60	8.04
22HC	East Sussex	Hove	23.8	2.75	82,891	3,480	0.52	1.14	0.55	0.48	9.86
MIDEUM TOWNS											
14ER	Cheshire	Warrington	175.4	7.47	179,986	1,026	1.08	0.98	0.68	0.69	8.73
03BQ	Greater Manchester	Rochdale	159.1	7.12	196,899	1,238	1.23	1.12	0.75	0.67	7.41
06CH	Tyne & Wear Met	Gateshead	142.8	6.74	197,051	1,380	0.70	0.99	0.58	0.59	7.13
04BZ	Merseyside	St. Helens	132.9	6.50	175,826	1,323	1.08	1.18	0.75	0.63	7.56
23HG	Essex	Basildon	109.6	5.91	157,781	1,439	0.68	1.11	0.61	0.55	15.34
30LP	Kent	Thanet	102.9	5.72	123,079	1,196	3.05	1.16	0.93	0.80	9.83
44QZ	Surrey	Elmbridge	96.4	5.54	110,580	1,148	0.50	1.21	0.55	0.46	11.46
38PH	Nottinghamshire	Broxtowe	80.8	5.07	105,418	1,305	0.42	1.48	0.57	0.38	8.12
25JF	Hampshire	Eastleigh	79.6	5.03	103,742	1,304	0.50	1.15	0.54	0.47	9.83
45RM	Warwickshire	Nuneaton and Bedworth	78.7	5.01	115,653	1,469	0.79	1.33	0.71	0.54	8.50
COUNTRYSIDE TOWNS											
25JD	Hampshire	Basingstoke and Deane	632.0	14.18	141,823	224	1.29	1.06	0.74	0.70	11.98
31LZ	Lancashire	Lancaster	574.3	13.52	126,682	221	4.21	1.04	0.91	0.88	8.07
46RW	West Sussex	Horsham	529.3	12.98	107,354	203	1.04	1.11	0.71	0.64	14.71
47SD	Wiltshire	West Wiltshire	515.5	12.81	106,255	206	2.20	1.08	0.85	0.78	8.35
10DK	Bedfordshire	Mid Bedfordshire	501.3	12.63	108,113	216	0.75	1.36	0.71	0.52	14.96
27KE	Hertfordshire	East Hertfordshire	474.9	12.30	114,831	242	0.73	1.14	0.64	0.56	14.02
41QE	Somerset	Taunton Deane	461.2	12.12	93,958	204	2.95	0.93	0.82	0.89	8.20
24JB	Gloucestershire	Stroud	459.4	12.09	102,024	222	1.58	1.19	0.83	0.70	10.13
14EL	Cheshire	Crewe and Nantwich	429.1	11.69	102,231	238	2.10	1.01	0.81	0.81	7.98
38PN	Nottinghamshire	Rushcliffe	407.9	11.40	95,941	235	0.49	1.39	0.59	0.42	10.15

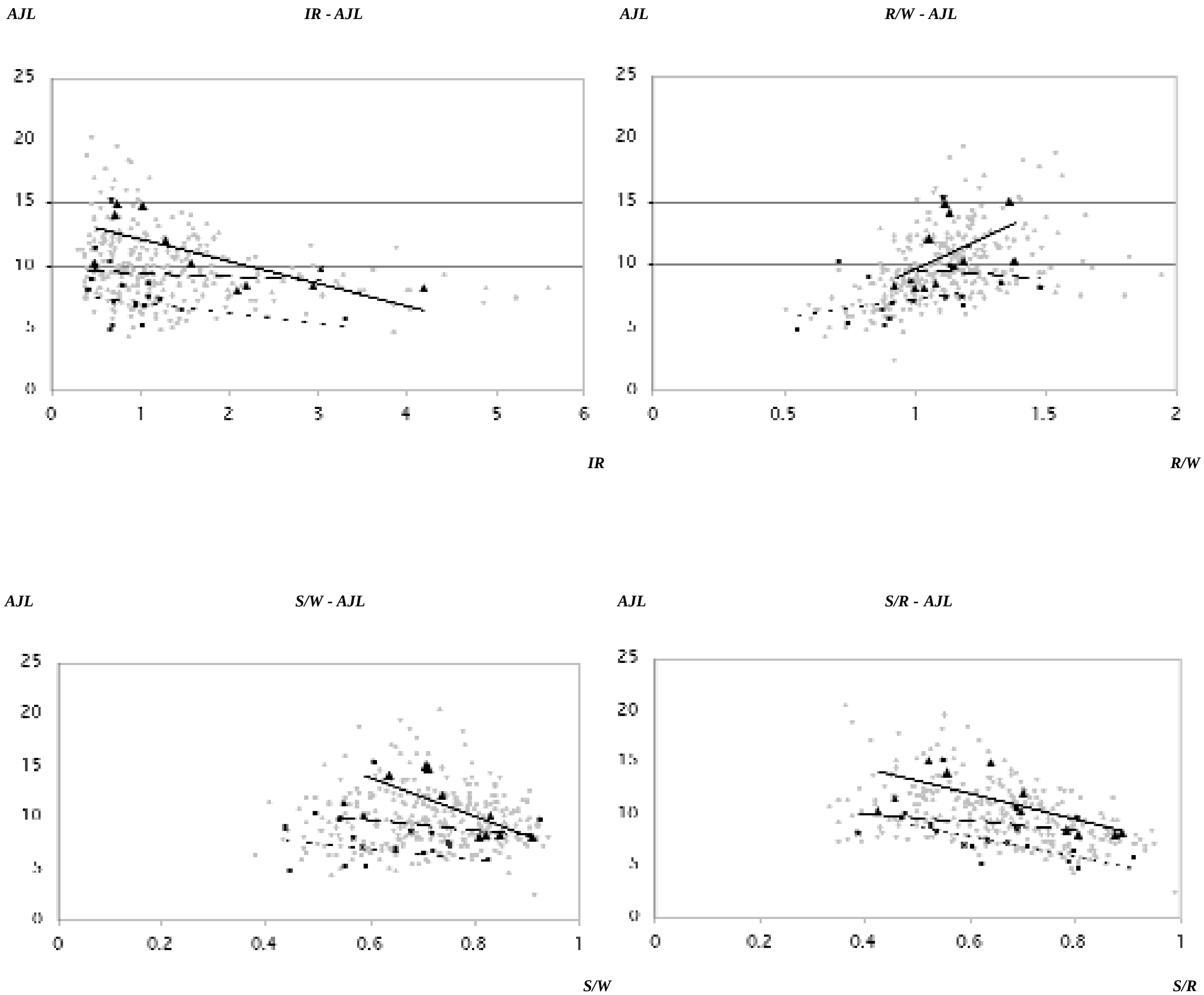

Figure 4.2: Analysis of Self-Sufficiency and Average Journey Length to Work in England

Table 4.3: Results of Self-Sufficiecy - Average Journey Length Analysis

	I	R/W	S/W	S/R
COMPACT TOWN	-0.856x + 7.92	3.00x + 4.37	-5.61x + 10.0	-9.27x + 13.4
	0.128	0.097	0.103	0.397
MID TOWN	-0.256x + 9.65	-1.27x + 10.9	-4.46x + 12.4	-3.42x + 11.4
	0.006	0.006	0.048	0.030
COUNTRYSIDE	-1.78x + 13.9	9.61x - 0.011	-18.2x + 24.7	-12.6x + 19.6
	0.529	0.245	0.422	0.470

areas in England. A triangle in the figure implies, at any size and density, that higher ***S/R*** is likely to require less journey length.

This result shows that the average journey length is dependent on self-sufficiency, density and area size. Intuitively, this can be explained easily. At low self-sufficiency, many people work outside the area. Therefore, ***AJL*** for those working outside the area is longer than the radius of the area, which subsequently result in the larger value of total ***AJL***. And high-density seems to supply services and jobs in walkable distances.

Size of Area and Population

Rapid urbanisation is the most visible effect of the industrialisation on cities and is seen as potentially undermining the overall efficiency of a country because it supposedly creates an unbalanced settlement pattern, especially in the case of urban primacy, where cities are exceptionally dominant in relation to the rest of country. Regarding the growth of very large cities, there is particular concern about whether they are economically efficient in their own right and about whether they efficiently drain their hinterland areas of natural, financial and human resources, weakening these economies in the process (Haughton and Hunter 1994). However, we are also concerned with the effects of population and settlement size on traffic demand because it is assumed as an area becomes larger in population terms its capacity to support a wider range of job opportunities and services will tend to increase, generating greater potential for self-containment (ECOTEC 1993). Large areas may also be better able to support a wider range of public transport services, both to accommodate internal movements and travel to other cities. Conversely, with a given urban structure, the average distance between places will tend to increase as population and city area increase. These conflicting considerations suggest, as turns out to have been the case, that the relationship

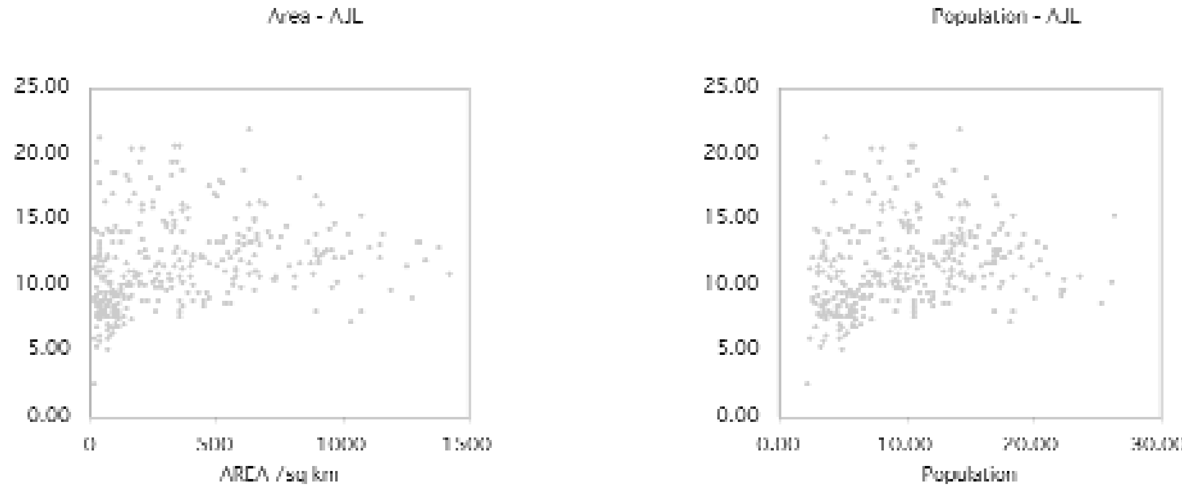

Figure 4.4 : City size (area and population) and Average Journey Length to Work in England

between population size and travel is unlikely to be a straightforward one.

PPG13 is also concerned with this issue: settlement size is an important influence on the range of activities within settlements and hence the scope for reducing the need to travel. A medium or large settlements can be relatively more self-sufficient in that it offers a full range of employment, goods, services and activities. This myth is, however, easily tested and denied. Although there is such tendency, the Figure 4.4 shows that this does not always happen. Even smaller districts can be more self-sufficient than larger districts. Although it is obvious that settlements, in PPG13, are smaller category than districts, it is still possible to say that settlement size does not determine the self-sufficiency nor the journey length on its own, but rather it is one of the determinant elements.

Density

Because of Newman and Kenworthy's (1989) impressive evidence, as discussed in chapter 3, the most planners have been misled to the compact city as a sustainable urban form. The likely effect of density is “low density appears to have a multiplicative effect, not only ensuring longer distances for all kinds of travel but making all nonautomobile modes virtually impossible, since many people live too far from a transit line and walking and biking become

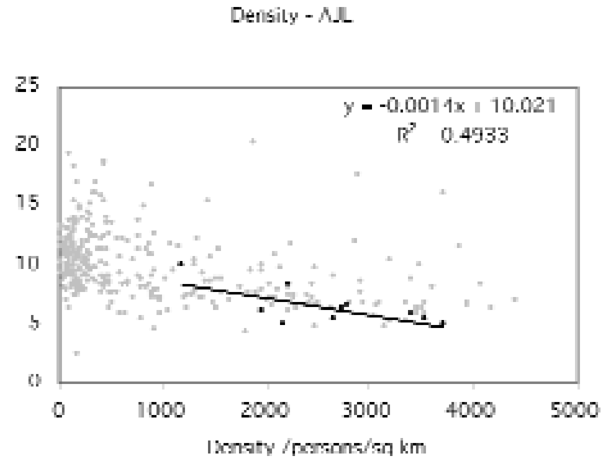

Figure 4.5: Analysis of Density and Average Journey Length to Work in England

impossible" (Newman and Kenworthy 1989 p. 29). The discussion seems appropriate if, and only if, the city supplies enough jobs and services. Therefore, it would finally make to the end the long lasting myth of density-prejudiced view.

According to PPG13, both the length of car journeys and the share of journey made by car are lower in high density areas and therefore residential densities should be planned to take advantage of proximity to activities. However, as discussed above, Newman and Kenworthy's result rather shows less impact of density on journey length in European context (Figure 3.4). The evidence in England shows the tendency that, in even low density towns, ***AJL*** can be as small as, or even smaller than, high density towns. This tendency is found even in England as a whole; there is less contribution of area size and self-sufficiency. The result is not contradictory with Newman and Kenworthy discussed, but it does not have effect in Europe as much as in North America.

Figure 4.5 is for the districts and metropolitan areas in England. Ten samples are selected at a given condition ($1000 < \rho$ /persons /sq km < 4000, 0.8 < ***S/R*** < 0.9, 45 < ***A*** /sq km < 110). Although there can be seen a linear relation with r^2 =0.493, ***AJL*** is limited within a narrow range by the condition and shows less relation with density than with self-sufficiency and

Table 4.6: Density and average journey length to wrok in England

Zone ID	County	Zone name	*A* /sq km	*HR* /km	*P*	ρ	*IR*	*R/W*	*S/W*	*S/R*	*AJL*
39PQ	Oxfordshire	Oxford	45.46	3.80	124058	2729	0.90	0.62	0.52	0.84	6.35
19FX	Devon	Exeter	46.89	3.86	101395	2162	1.37	0.74	0.64	0.86	4.98
19GD	Devon	Torbay	62.91	4.47	122885	1953	2.88	1.03	0.87	0.84	6.03
28KW	Humberside	Kingston Upon Hull	71.47	4.77	253111	3541	1.54	0.83	0.69	0.83	5.43
32MM	Leicestershire	Leicester	73.08	4.82	272133	3724	0.93	0.67	0.54	0.81	4.93
18FP	Derbyshire	Derby	77.78	4.98	215866	2775	1.60	0.86	0.71	0.83	6.45
35NM	N'shire	Northampton	80.51	5.06	178570	2218	1.76	0.89	0.73	0.83	8.29
42QP	Staffordshire	Stoke-on-Trent	92.44	5.42	244317	2643	1.42	0.84	0.68	0.81	5.38
30LP	Kent	Thanet	102.88	5.72	123079	1196	3.05	1.16	0.93	0.80	9.83
09DD	Avon	Bristol	109.23	5.90	372088	3406	1.19	0.76	0.62	0.81	5.78

size. This result is consistent with the assumption made earlier.

Despite these evidences, we can hardly ignore the density effect as a diversity generator (Jacobs 1961). It is not net density that causes this effect, nor "numbers loosely added up indefinitely from thinly spread populations" but concentration and distribution of people "for whatever purpose they may be there" (Jacobs 1961: 213). The cities are spatial objects, and have undulations in population density. No matter how much is the net density, if the jobs and services are well distributed around the residential distribution, the journey lengths are likely to reduce. We, therefore, devote a section and subsequent chapters for a new kind of discussions on density, or more properly distribution of settlement, jobs, roads and land uses.

Urban Form and Travel Length: An Unsolved Issue

Spatial factors such as land uses and transport have been identified as important factors because most traffic arises between different land uses. Indeed, commuting traffic and shopping traffic are two major traffic generators as commuting accounts for about half of all kilometres travelled by private motorists and one-third of all trips. As a result of travel demand and transport management, the road network may well reflect the traffic demand of the area (ECOTEC 1993). However, it has not been sufficiently discussed because it has been impossible to compare those of the actual cities.

Most planners are ambiguously aware that settlement distribution does not consist of size and net density but also of spatial structure. Wang (1998) describes "over the past decades, design and development of higher residential density in suburbs have always been a challenge for planners. The benefits are obvious: cost savings on infrastructure, preservation of farmland, less commuting and promotion for public transport." (p. 246) In his research, a simulation revealed that increasing suburban road density has more noticeable impacts on suburban population density than adding more radial roads towards the central business district. Therefore, it can be easily estimated that higher road density in suburb tend to reduce travel and thus energy use.

It is easily understood that the road network in the city is developed by the transport and traffic demands to deliver people, goods and information. In the simplest form, the traffic arises as the gravity model. This modelling is useful when, and only when, the number of places are few and clearly defined. However, the actual cities and towns contain large numbers of neighbourhoods and urban villages which let the road network fairly complex. By complex, I shall review in chapter 5 that it is not just complicated, but it generates unpredictable internal effects. Suppose you start your journey at A, through B and C and go back to At. However, you may see your old friends by chance on the way home and may go back to pub with them.

This kind of complexities cannot be well incorporated in simpler Euclidean geometry of lines and circle, within which the ideal forms of road network proposed are limited. Moreover, the ideal road network is never achieved. The hierarchical V7 plan in his city plans, Le Corbusier proposed a combination of hierarchical gridiron road network. Any existing road network is fractal, unlike city models, no matter how simple or complex it is.