Spatial Configuration of Residential Area and Vulnerability of Burglary

Case Studies from UK and Taiwan

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Abstract
This paper focuses on the correlation between spatial configuration and burglary distribution patterns and presents two successive case studies in Taiwan and compares research results with findings from three towns in the British context. In this detailed study, three major elements are considered: the road types, the degree of road accessibility (i.e. the integration measure), and the immediate surroundings of each dwelling. Pedestrian and vehicular flow, which might have an influence on crime distribution, can be represented by degrees of accessibility of each road axial line through the space syntax analysis, thus the space syntax method will be adapted for this research. It is believed that through comparing the situation in different countries, the space-crime issues, particularly for the distribution patterns of residential burglary, can be teased out in a more rigorous way, therefore better crime prevention strategies can be laid down to deal with this issue.

Our findings show that road types, the dwellings' front door to front door inter-visibility and the degrees of road accessibility all have a highly measurable influence on burglary distribution. Among the three influencing factors, the degrees of inter-visibility exhibit the strongest influence on burglary distribution patterns. In the mean time, the types of street use and the degrees of road accessibility also play an important role in influencing the crime distributions. By and large, segregated areas, allowing fewer passers-by entering the areas, turn out to be more vulnerable than integrated ones where one finds more pedestrians and vehicle flow. Particularly segregated streets turn out to be extremely vulnerable when combined with low inter-visibility in the areas whereas integrated streets with higher accessibility can be very safe from crime when associated with good inter-visibility. Thus this research confirms that more strangers or passers-by in highly accessible streets with strong inter-visibility can be beneficial as crime prevention strategies due to the mechanisms of informal (natural) surveillance generated naturally in these areas. Though there are differences in the street layout configuration between the UK and Taiwan's city context, such as the fact that a cul-de-sac complex combined with footpath network has been largely employed in the British context, which is not the case for Taiwan, the degrees of road accessibility and the front door to front door inter-visibility are two important attributes to protect residential areas from burglary.

1. Issues and Questions

Most research on crime prevention of burglaries focuses on target hardening, such as good locks, or secured alarms, etc., and fewer research projects have studied the spatial configuration and its relation to crime incidences. Moreover, residential burglary has always been pointed out as one of the highest volume groups among all types of crime. Therefore, this research proposes to study the correlation between the spatial configuration of street network patterns in urban areas and residential burglary. It intends to identify those vulnerable spatial attributes that contribute to higher risk of burglary offences.

This study is specifically about the location of residential burglary in the urban layout. It seeks to answer several questions: Does space exert an independent influence on distribution patterns of residential burglary? What features in the urban layout increase vulnerability to residential burglary? Are there any differences or similarities on distribution patterns of residential burglary between the British context (Hillier & Shu 2000) and the one in Taiwan? It is believed that through comparing the situation in different countries, when some common features of spatial configuration turn out to be associated with higher volume of a particular type of crime incidences regardless of different social context, then one can be sure of the fundamental influence of the spatial attributes on crime distribution patterns across borders. Thus, the space-crime issues, particularly for the distribution patterns of residential burglary, can be teased out in a more rigorous way, therefore better crime prevention strategies can be proposed to deal with this issue.

Factors studied in this research include the road types, i.e., street land use patterns, the degree of integration of each street axial line, i.e., accessibility of street network patterns and the inter-visibility between dwellings, etc. Multi-variant analysis will be carried out to detect which combinations of spatial features and environmental characteristics make areas safer and which combinations of environmental situations make areas more vulnerable to offences of residential burglary.

2. Literature Review

Jane Jacobs noted that streets with higher accessibility to the public allowing more passers-by could attract more eyes from the buildings to the street and this mechanism of natural surveillance can work effectively against crime (Jacobs 1962). To some extent contradictory to Jane Jacobs' views was the study of Oscar Newman (Newman 1972). He used the concept of 'territoriality' as basis of his defensible space model. Anonymous streets where more strangers appear are considered more vulnerable than dead end cul-de-sacs where strong local inter-visibility in an enclosed area can increase a well defined neighborhood to deter any intrusion of strangers, thus spatial control by local inhabitants is the key to prevent area from crime (Newman 1972:60-62; Newman 1980:124-144).

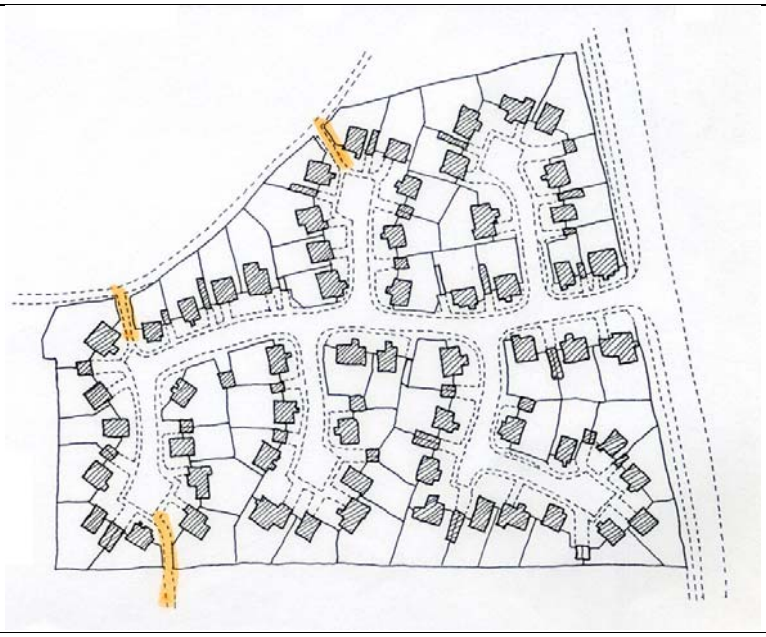

Figure 1
The spatial layout of a tree cul-de-sac pattern (Poyner 1991, p.111)

Considering crime prevention, Poyner and Webb, in their major work of Crime Free Housing, proclaim that the layout of an area plays an important role in protection from residential burglary. Following the same ideology of defensible space postulated by Newman, Poyner and Webb identify the spatial layout of tree cul-de-sac patterns as the safest system (Figure 1) that can deter occurrence of residential burglary (Poyner & Webb 1991).

Similar to the conceptual framework of Jacobs, Hiller argues that "intelligible deformed grid" and "constituted outward facing block" are the main features of spatial configurations that protect areas from crime (Hillier 1988). Contrary to the position of a territoriality based defensible space system advised by Newman and Poyner who deem passers-by as potential offenders who should be expelled from residential areas, Hillier considers passing strangers often generated by the intelligible through street system as beneficial elements who can in effect protect streets from crime incidences whereas strong inter-visibility of the immediate surroundings of each dwelling within those constituted outward facing blocks allows residents to guard the strangers. It is exactly this mechanism of "strangers protect the streets and residents watch the strangers" which echoes the function of natural surveillance observed by Jacobs in traditional through street patterns and which makes dwelling environments work against crimes.

In spite of the different viewpoints of spatial layout on protection from crime, Ronald Clarke in his book of Situational Crime Prevention (Clarke 1997) suggests the defensible space patterns provided by Newman as the fundamental system to make areas less vulnerable to crime, especially for residential burglary. Moreover, the scheme of "Secured by Design" advocated by the British Home Office though has long been influenced by Newman's ideology of defensible space patterns, has also noted the controversial findings from Hillier and others (Hillier and Shu 1999).

Clearly there is the issue of which type of spatial layout can better work against crime. It seems that a through street system which facilitates higher flows of vehicles as well as pedestrians movements and thus allows more passers-by entering dwelling areas has been considered by Jacobs and Hillier as a positive feature to deter offenders whereas for Newman and Poyner the defensible function of cul-de-sac carriageway which can work efficiently to exclude all possible strangers hence should be better than the through system. Due to the above dispute on the role of strangers in relation to the space-crime issue, the study of road types and degrees of accessibility of axial lines within the street network system have become the two main factors that need to be carefully examined across different social contexts to detect which combination of these spatial elements can really work against crimes, especially for the residential burglary in this research.

3. Research Methodology

There are three major spatial attributes related to the analytical methodology. Those are the attributes of street use patterns, road accessibility and inter-visibility between dwellings. Definitions of these spatial elements are to be illustrated as the followings:

Attribute of street use patterns (i.e. road types) can be described in function of seven major spatial elements:

- Thrc indicates through carriageway that is wider than 8 meters and allows all possible passers-by entering this area freely without any restriction.
- Culc presents a cul-de-sac carriageway that mostly serves as a dead-end access route for local inhabitants and people entering the area have to return to the point of entry in order to leave the area.
- Culdri stands for cul-de-sac driveway that is for private use of the home-owner and not for public use.
- Tfp is an abbreviation for through footpath that is a route for pedestrians to walk from one area to another.
- Cffp stands for cul-de-sac front footpath that is a dead-end route for pedestrians to walk to a specific area.
- Cba is cul-de-sac back alley that allows pedestrians access to the back of buildings.
- Thra means through alley that allows pedestrians to walk from one area to another, but does not allow easy access to cars as homeowners generally park their cars there, prohibiting other cars from easily passing through. This type of alley is very common in Taiwan.

The second spatial attribute under discussion is the measure of integration (i.e. degrees of accessibility) of each street axial line. Vehicular and pedestrian accessibility can be represented

through two Space Syntax variables, i.e. global integration (Rn) and local integration (R3). Global integration is accessibility measured in relation to the whole spatial system, whereas local integration measures accessibility in relation to a system of streets moving only three steps away. The more integrated streets (i.e. the higher accessible streets) are represented by reddish colour. The more segregated streets (i.e. the less accessible streets) are represented by bluish colour. Because the study areas are so many only Rn will be discussed in this research.

The third type of variable is related to inter-visibility, i.e. the attribute of constitutedness, which means front door-to-front door relationship to represent the degree of inter-visibility between houses on both sides of each street. "Con" is defined as more than 75% of adjacent dwellings on one road having front door-to-front door inter-visibility. "Uncon" is defined as fewer than 75% of adjacent dwellings having front door to front door. This is decided through on-site observation of the area under research. There are two major issues related to the degree of vulnerability of each type of spatial properties defined from different combination of those three types of attributes, the concept of Point of Access (POA) and the use of crime rate statistics based on crime per type of line.

The first concept, POA (Point of Access off public spaces), is one of the major ideas employed in this research, as the important question of this research is to clarify the degree of the vulnerability of the public spaces. Each case of burglary is presented by a dot with a little tail based on the information provided by the crime records obtained from the respective police. The dots on the map represent the point of entry (POE) into the dwelling, whereas the little tail links the break-in points into the dwellings to the access point from the public space. This research is based on POA that shows the vulnerability of the public spatial layout.

A word needs to be said about the quality of the crime records obtained from the various police departments. The crime records for the UK case studies were generally very detailed and allowed for a precise mapping of the crime incidence on the map, however, the crime records for the Taiwan case studies were often not as detailed as the UK ones. This created more problems to map crimes. This problem has been overcome through negotiation with the respective police departments to start taking more detailed crime records based on the UK model. As a result data from later periods were more complete than those from the early period. For the Taiwan case, this research project is based on the later period with more complete data. However, a further problem with the Taiwan case studies is that many people in Taiwan simply do not bother to inform the police of burglaries, as many people do not have property insurance. As a result the number of black data is much higher in Taiwan than in the UK. This problem was partly solved through on-site observation and investigation through questionnaires and interviews of local residents.

The second point is related to the calculation of crime rate statistics. It is not advisable to use crime rates per line as study method, because the longer a line is the more dwellings and points of access (POA) will be located on it. Shorter lines with fewer dwellings will seem to have high crime rates. Therefore, crime rate is based on the number of POAs offended against total number of POAs per type of line and not per line. For example, a crime rate of 1/240 means that on every 240 POAs of a particular type of line one POA was offended, which is used for representation of burglary rate in this research. In this way, a rate for crime can be calculated for each type of line across all study areas expressed in a fraction of one out of how many points of access are offended against. This type of crime rate calculation provides a better view of real crime vulnerability.

4. Study Areas

Study areas in this research include three study areas in three different towns each with different social income levels in the British context and furthermore two study areas in two different towns in the Taiwan context. Detailed analysis of correlation between different combinations of various spatial attributes and crime rates of burglary has been carried out for each study area. Moreover, comparison of findings between areas with different income levels as well as different social context across different countries has been examined to detect the common features of spatial configuration that contribute to higher vulnerability of burglary.

Due to the restriction of the data protection act, all study areas in this research have to be kept anonymous and will be labelled as town A, town B, and town C respectively for the British context whereas study areas in the Taiwan context will be called town 1 and town 2. For each study area the visual inspection on the space-crime distribution pattern will be described first. Then, analysis of crime rate statistics will be discussed in some detail for the areas separately and for the three British case studies together.

All study areas in this research are mainly made of low-rise buildings. There are very few flats in the areas. However, burglaries in flats will be counted as ground floor access points because that it is the point the burglars use to enter the building as a whole. No differences between burglaries on different floors of the building are considered in this research. This is the case for Taiwan as for the UK.

For the Taiwan context we need to also mention that many windows have additional iron or steel grilles that protect the windows and prohibit burglars from entering these buildings through the windows. In Town 2 a distinction has been made between windows with iron grilles and those without when discussing results.

4.1. Case Studies in UK - Town A

Town A is a mid of the road area and was newly developed in the 1970s. The research area is around 60 hectares and there are 1180 house units. The street layout is dominated by cul-de-sac complexes, including cul-de-sac carriageways and through footpaths. Most of the roads have a meandering quality to help keep vehicle speed down in the area. The crime records used for this study are based on the years 1994-1995. There are a total of 71 residential burglaries. From a visual viewpoint, the right area, which is globally segregated and locally broken up, has a high concentration of burglary. An especially strong concentration of burglary (7 cases) can be detected in a globally and locally segregated cul-de-sac near the right edge. Also on the right, a line of houses with front doors facing onto a through footpath, and with rear cul-de-sac carriageway functioning as parking space is also extremely vulnerable to burglary and car crime.

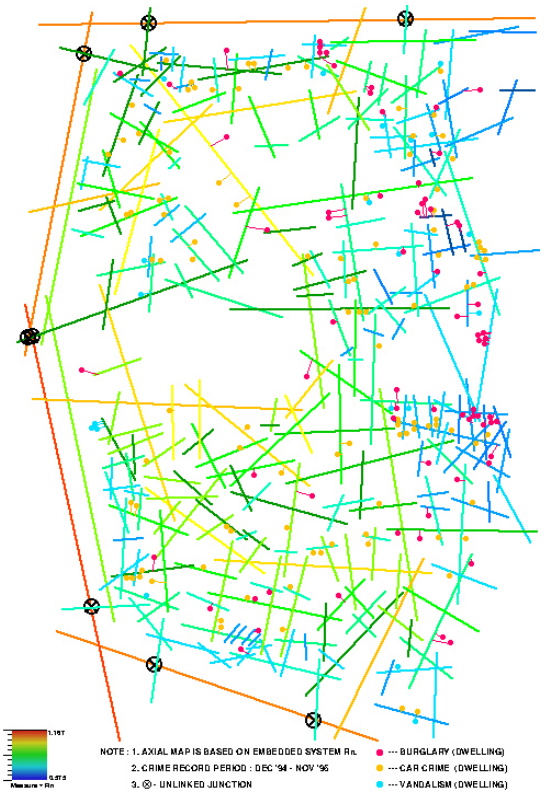

Figure 2

The crime distribution patterns against axial integration (Rn) of Town A in UK

It is noticed that the two linear through carriageways, one at the top and one in the bottom of the estate, which are also for the most part 'constituted', are burglary free. The study area in Town A shows burglary hotspots in relation to the spatial layout, syntactic variables (global & local integrations) and the attributes of constitutedness in different maps of crime distribution patterns. It seems that through footpaths or cul-de-sac back alleys, segregated areas both globally and locally, and unconstitutedness (i.e., lack of front door to front door inter-visibility) are all major elements which contribute to the vulnerability to burglary.

Table 1 shows that all carriageways, including through and cul-de-sac carriageways, have a crime rate of 1/36. This is twice as safe as all non-carriageways, which have a burglary rate of 1/18 when considered together. The cul-de-sac driveways have a crime rate of 1/13, through footpaths 1/17, and cul-de-sac back alleys, which have a rate of 1/27. These three road types are the most vulnerable to burglary in this area. Through carriageways have a crime rate of 1/63, which makes this road type the safest of this study area. Through carriageways are twice as safe as cul-de-sac roads that have a crime rate of 1/29.

When other features are taken into consideration through combining different spatial attributes together through carriageways with strong inter-visibility have a crime rate of 1/165. This is one of the safest types in this area. When through carriageways with strong inter-visibility are further combined with high accessibility, i.e. high Rn or more integrated, then the crime rate is 0/218. This is the safest combination of all. Cul-de-sac carriageways that are combined with high visibility have a crime rate of 1/44 whereas cul-de-sac carriageways with high integration have a crime rate of 1/53. This means that strong inter-visibility and high accessibility have beneficial effects on crime rates in cul-de-sac carriageways, although they are not as pronounced as the effects of these variables on through carriageways. However, when cul-de-sac carriageways are highly accessible and have strong inter-visibility together, then the crime rate is 0/184, which is as safe as the situation for through carriageways with these features.

road types / Combination	Thrc	Culc	Carriage-way	Culdri	Tfp	Cffp	Cba	Non-carriageway	sum
basic crime rate	1/63	1/29	1/36	1/13	1/17	1/40	1/27	1/18	1/29
High Rn (top50%)	1/316	1/53		0/1	1/52	1/37	1/33		1/63
More than average POA	1/74	1/35		1/10	1/18	1/37	1/23		1/35
Con	1/165	1/44		---	---	0/14	---		1/67
High Rn + Con	0/218	0/184		---	---	0/14	---		1/261
More POA + Con	1/256	1/48		---	---	0/14	---		1/76
Low Rn (bottom50%)	1/31	1/22		1/12	1/10	0/3	1/21		1/17
Fewer than average POA	1/49	1/20		0/3	1/12	0/3	0/9		1/21
Uncon	1/34	1/24		1/13	1/17	1/26	1/27		1/22
Low Rn + Uncon	1/23	1/21		1/12	1/10	0/3	1/21		1/16
Fewer POA + Uncon	1/40	1/19		0/3	1/12	0/3	0/9		1/20

Table 1
Combination of spatial attributes in relation to burglary vulnerability (UK-Town A)

On the other hand, crime rates increase when there is a lack of inter-visibility or when areas are more segregated. This is true for cul-de-sac carriageways and for through carriageways as well. Areas with little visibility and with less accessibility are less safe. Segregated through carriageways which lack inter-visibility have a crime rate of 1/23 which is almost as vulnerable as cul-de-sac carriageways with the same features that have a crime rate of 1/21.

4.2. Case Studies in UK - Town B

Town B is known as a posh town. The total study area is 81 hectares with 1324 house units. The spatial types are through street system and cul-de-sac system which each take half of the area.

There are a total of 45 residential burglaries in the area during the period of study. In the bottom left corner of the area there are many cul-de-sac driveways leading to detached houses. From a visual viewpoint, burglaries cluster in the top right sub-area, which is also the most globally segregated and locally far more broken up than other sub-areas, and it is characterized by through footpaths connecting to a tree-pattern cul-de-sac layout. This is similar to the vulnerable spatial pattern in Town A. The area with the many cul-de-sac driveways also has a higher proportion of burglaries.

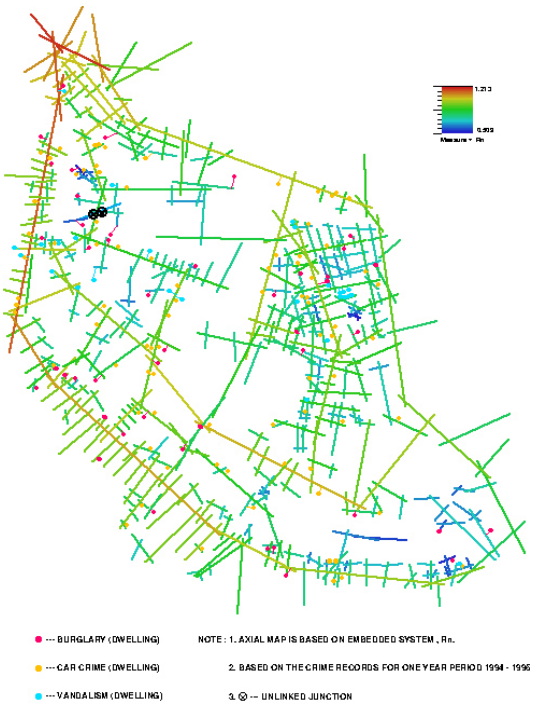

Figure 3
The crime distribution patterns against axial integration (Rn) of Town B in UK

road types / Combination	Thrc	Culc	carriageway	Culdr i	Tfp	Cffp	Cba	Non-carriageway	sum
basic crime rate	1/118	1/63	1/78	1/12	1/62	1/22	1/12	1/22	1/45
High Rn (top50%)	1/118	1/60		1/12	1/63	1/14	1/12		1/49
More than average POA	1/219	1/101		1/14	1/50	1/29	1/17		1/74
Con	0/227	1/92		---	---	---	---		1/168
High Rn + Con	0/73	1/35		---	---	---	---		1/108
More POA + Con	0/205	1/136		---	---	---	---		1/167
Low Rn (bottom50%)	1/118	1/66		1/12	1/61	1/38	1/12		1/40
Fewer than average POA	1/50	1/31		1/9	0/59	1/8	1/7		1/19
Uncon	1/72	1/55		1/12	1/62	1/22	1/12		1/36
Low Rn + Uncon	1/66	1/41		1/12	1/61	1/38	1/12		1/33
Fewer POA + Uncon	1/43	1/36		1/9	0/59	1/8	1/7		1/19

Table 2
Combination of spatial attributes in relation to burglary vulnerability (UK-Town B)

There is a tendency for burglaries not to occur on longer linear through carriageways, such as the spatially integrated through route from bottom right to top left which also has continuous double

facing entrances (i.e. constituted) and exceptionally good linear inter-visibility, i.e. without concealing bushes. Those long linear constituted cul-de-sac carriageways just off integrated through streets (at the bottom right of the map) are also burglary free.

As Table 2 shows all carriageways have a crime rate of 1/78 that is three times safer than all non-carriageways 1/22. The most vulnerable types are the cul-de-sac driveways with a crime rate of 1/12 and cul-de-sac back alleys 1/12. These two are the most vulnerable types. These findings are similar to the ones for Town A. Clearly burglars tend to choose footpath access instead of carriageway access. Through carriageways have a crime rate of 1/118, which is twice as safe as cul-de-sac carriageways with a rate of 1/63. When further combined with inter-visibility and integration measures the results show that through carriageways which are highly integrated with strong inter-visibility have a rate of 0/73 and become the safest type in this area. On the other hand, segregated through carriageways with low inter-visibility have a crime rate of 1/66, which is as vulnerable as cul-de-sac carriageways in general (1/63).

Similar to the case study area in Town A, the burglary distribution patterns in the study area of Town B show that through footpaths or cul-de-sac back alleys, globally segregated areas, and unconstitutedness are major elements contributing to the vulnerability of burglary.

4.3. Case Studies in UK - Town C

Town C is less affluent compared to the previous two study areas in the UK. The area is 45 hectares large and has 1044 house units. The study area of Town C has many more burglaries (97) than either Town A or Town B area, a fact related to the lower social and economic level of Town C as a whole. The spatial pattern of Town C is similar to that of Town A and is dominated by cul-de-sac complexes.

Figure 4

The crime distribution patterns against axial integration (Rn) of Town C in UK

Visually speaking, the top left and bottom right sub-areas, which are highly broken up, spatially segregated and made up of vehicular cul-de-sacs linked by footpaths are vulnerable to burglary. Constituted through carriageways on the bottom border record only two burglaries. The tendency for linear through carriageways to be low on burglary can again be observed. It is obvious from looking at the crime distribution map that rear footpaths, both through and dead end ones, offer the greatest vulnerability for burglary.

Table 3 shows that all carriageways have a burglary rate of 1/26, which is three times safer than all non-carriageways (1/9). The cul-de-sac back alleys have a burglary rate of 1/5, making it the most vulnerable type. Through carriageways (1/37) are safer than cul-de-sac carriageways (1/24). When further combined with global integration and inter-visibility highly integrated through carriageways

with high visibility have a rate of 0/52 and become the safest spaces. On the other hand, segregated through carriageways with low inter-visibility have a high burglary rate of 1/12.

road types / Combination	Thrc	Culc	carriage-way	Culdri	Tfp	Cffp	Cba	Non-carriageway	sum
basic crime rate	1/37	1/24	1/26	1/7	1/14	1/11	1/5	1/9	1/17
High Rn (top50%)	1/62	1/25		1/3	1/16	0/16	1/7		1/20
More than average POA	1/64	1/28		1/6	1/12	0/38	1/5		1/27
Con	0/52	1/25		---	---	0/14	---		1/28
High Rn + Con	0/52	1/24		---	---	0/14	---		1/29
More POA + Con	0/52	1/24		---	---	0/14	---		1/28
Low Rn (bottom50%)	1/12	1/23		0/12	1/11	1/8	1/4		1/14
Fewer than average POA	1/10	1/18		0/4	1/20	1/4	1/13		1/10
Uncon	1/29	1/23		1/7	1/14	1/9	1/5		1/14
Low Rn + Uncon	1/12	1/22		0/12	1/11	1/8	1/4		1/12
Fewer POA + Uncon	1/10	1/17		0/4	1/20	1/4	1/13		1/9

Table 3

Combination of spatial attributes in relation to burglary vulnerability (UK-Town C)

The study area of Town C confirms that footpaths, segregated areas, and unconstitutedness are again the three major elements contributing to the vulnerability of burglary as is the case detected from the previous two studies.

4.4. Case Studies in UK – Three Towns Combined

When combining the three areas, there are a total of 3548 dwellings, which are situated on 854 axial lines with 5704 points of access (POAs). The total number of crimes for the three areas combined is 213 burglaries. There are no burglaries on constituted cul-de-sac front footpaths where there are only 28 points of entry in total.

road types / Combination	Thrc	Culc	carriage-way	Culdri	Tfp	Cffp	Cba	Non-carriageway	sum
basic crime rate	1/69	1/32	1/39	1/11	1/21	1/18	1/8	1/15	1/27
High Rn (top50%)	1/94	1/40		1/12	1/27	1/24	1/14		1/40
More than average POA	1/82	1/38		1/12	1/20	1/25	1/7		1/36
Con	1/148	1/36		---	---	0/28	---		1/52
High Rn + Con	1/201	1/42		---	---	0/28	---		1/104
More POA + Con	1/263	1/37		---	---	0/28	---		1/56
Low Rn (bottom50%)	1/52	1/27		1/10	1/17	1/15	1/5		1/19
Fewer than average POA	1/45	1/22		1/9	1/22	1/9	1/12		1/15
Uncon	1/43	1/29		1/11	1/21	1/15	1/8		1/22
Low Rn + Uncon	1/35	1/24		1/10	1/17	1/15	1/5		1/17
Fewer POA + Uncon	1/33	1/22		1/9	1/22	1/9	1/12		1/15

Table 4

Combination of spatial attributes in relation to burglary vulnerability (UK-Three Towns Combined)

Table 4 shows observations about the vulnerability to burglary for those three study areas in the UK combined. First, the influence of the road types can be noticed from the most vulnerable ones to the safest ones. The most vulnerable road type is cul-de-sac back alley (1/8), followed by cul-de-sac driveway (1/11), then cul-de-sac front footpath (1/18), through footpath (1/21), cul-de-sac carriageway (1/32) and finally through carriageway 1/69. When combining road types with other features burglary rates change. Globally integrated through carriageways with strong inter-visibility

have a burglary rate of 1/201 and this is one of the safest types. Accessibility and inter-visibility also help a little with cul-de-sac carriageways (1/42).

By and large, the following points in relation to burglary can be concluded from the UK studies and need to be further examined: (1) Layouts with cul-de-sac complexes allowing fewer passers-by turn out to be more vulnerable than traditional through street patterns that facilitate movement. (2) Rear alleys or footpaths connecting cul-de-sacs are negative attributes, which increase the vulnerability to burglary. They seem to provide not only more access but also escape routes for the burglary offenders. (3) Positive attributes are constitutedness with strong front door-to-front door inter-visibility. (4) Highly integrated (accessible) streets allowing more passers-by are generally safer provided there is a high degree of constitutedness. (5) High integration and inter-visibility exert a greater influence on through carriageways than on cul-de-sac carriageways. (6) Both through carriageways and cul-de-sac carriageways become safer when they are globally highly accessible within the whole spatial system and at the same time are locally less accessible without connecting to too many roads, especially footpaths. Thus locally broken up areas, such as cul-de-sac complexes exhibiting patterns of dead end roads linked with many footpaths, turn out to be more vulnerable to burglary.

4.5. Case Study 1 in Taiwan

This affluent town is located in the North of Taiwan, but the study focuses on the residential area, which is in District C. This district has a total of 150 residential burglaries within an eight-month period. There are only four types of road types in this study area, including through carriageways, through alleys, through footpaths, and cul-de-sac carriageways. The bottom right area of District C is mainly a grid pattern, in which the residences are concentrated. The other parts of District C are mainly farms and rice fields. Visually, the burglary hotspots are concentrated on the top right sub-areas of the bottom right area of District C that are more globally segregated and locally broken up.

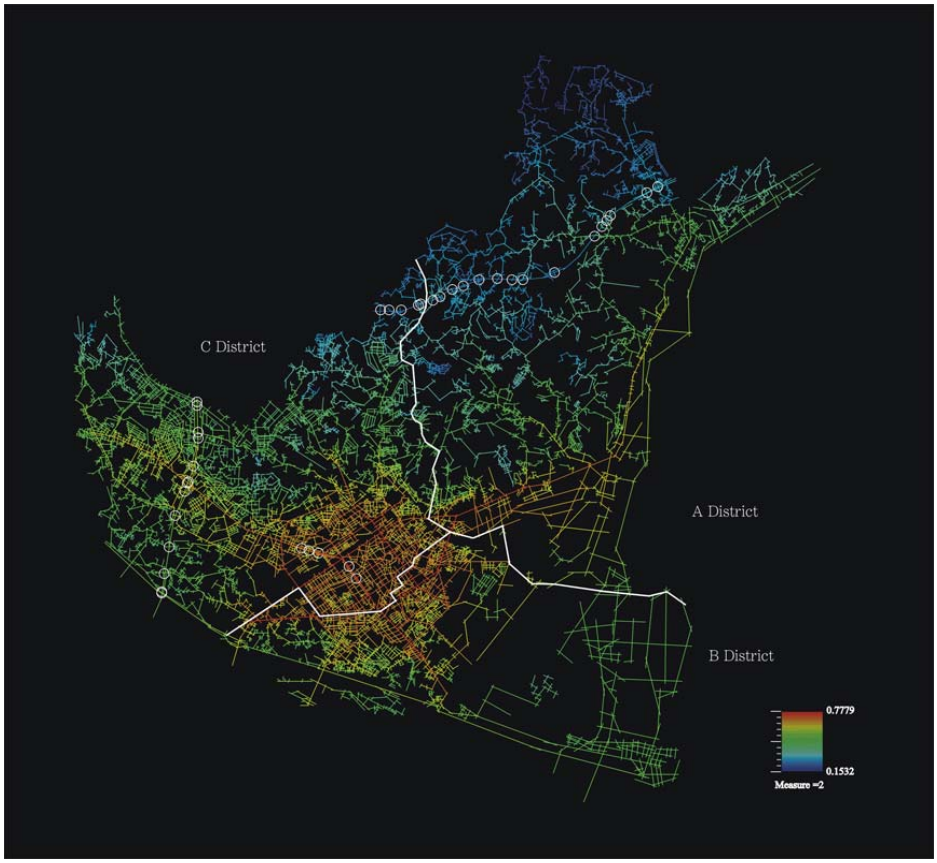

Figure 5
Axial integration (Rn) map of Town 1 in Taiwan

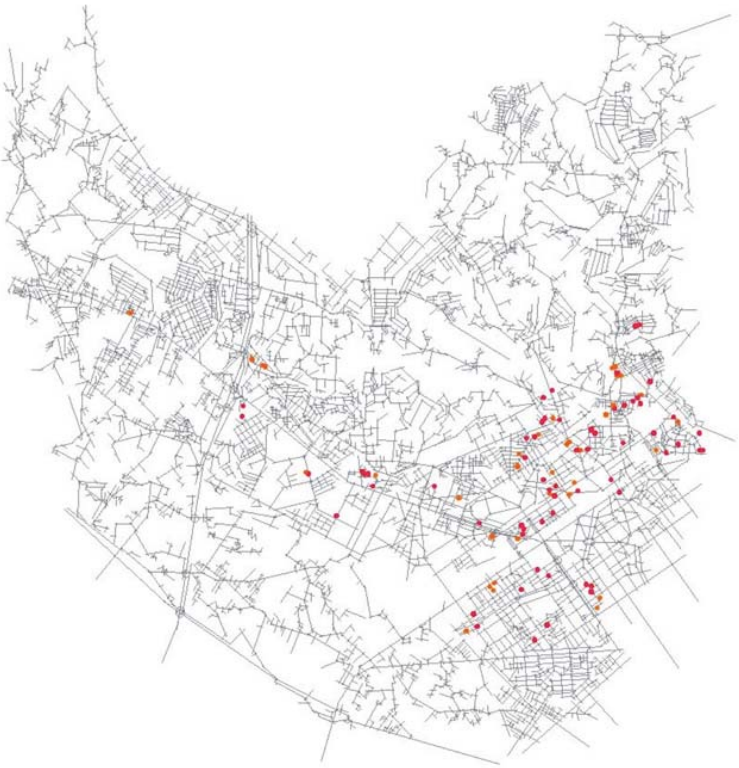

Figure 6
The crime distribution patterns of District C in Town 1 in Taiwan

Combination / road types	intervisibility		Rn		intervisibility + Rn		sum
	Con	Uncon	High Rn	Low Rn	Con + High Rn	Con + Low Rn	
Thrc	1/183	1/126	1/175	1/70	1/177	0/55	1/153
Thra	1/100	1/53	1/71	1/67	1/145	1/69	1/70
Tfp	0/177	1/30	0/161	1/38	0/122	0/55	1/119
Culc	1/73	1/26	1/57	1/38	1/53	1/87	1/42
sum	1/121	1/59	1/101	1/58	1/156	1/79	1/83

Table 5
Combination of spatial attributes in relation to burglary vulnerability (Taiwan-Town 1-District C)

Table 5 shows the different road types and the most vulnerable to the safest road types are as follows: cul-de-sac carriageways 1/42, through alleys 1/70, through footpaths 1/119, and finally through carriageways 1/153. The results are similar to those for the three case studies in the UK; that is through carriageways are much safer than cul-de-sac carriageways. When further combined with the attributes of inter-visibility and accessibility, then the crime rates go down which means that the influence of these attributes is beneficial to burglary rates. Through carriageways with strong inter-visibility (1/183) are improved.

On the other hand, lack of inter-visibility makes spaces more vulnerable to burglary, especially for through footpaths (1/30) and cul-de-sac carriageways (1/26) which is worse than the base rate for these types. Similar to the influence of constitutedness, high accessibility also helps protect against burglary, but its effect is less pronounced. Integrated through carriageways (1/175) are safer and integration helps improve burglary rates. At the same time, segregated through carriageways become more vulnerable to burglary (1/70), which worsens the burglary rate. The influence of accessibility can also be observed for through alley, through footpath, and cul-de-sac carriageway.

4.6. Case Study 2 in Taiwan (FIGURE7&8, TABLE6&7)

This middle class town is located in the centre part of Taiwan and its urban layout structure is characterised by low density of residential areas constituted by many cul-de-sac complex patterns and t-junction nodes street network system. The town covers 707 hectares. There are 8 administrative areas in the town of which three are residential areas (KW, KZ, KM). In total 1932 dwelling units are located in the 3 residential areas. The house types in the study areas consist mostly of detached, semi detached, and terraced houses. About 82% of the dwellings have iron grilles in front of the windows. There are 36 burglaries that occurred during the period of 2003-2004.

Figure 7

The spatial layout plan of Town 2 in Taiwan

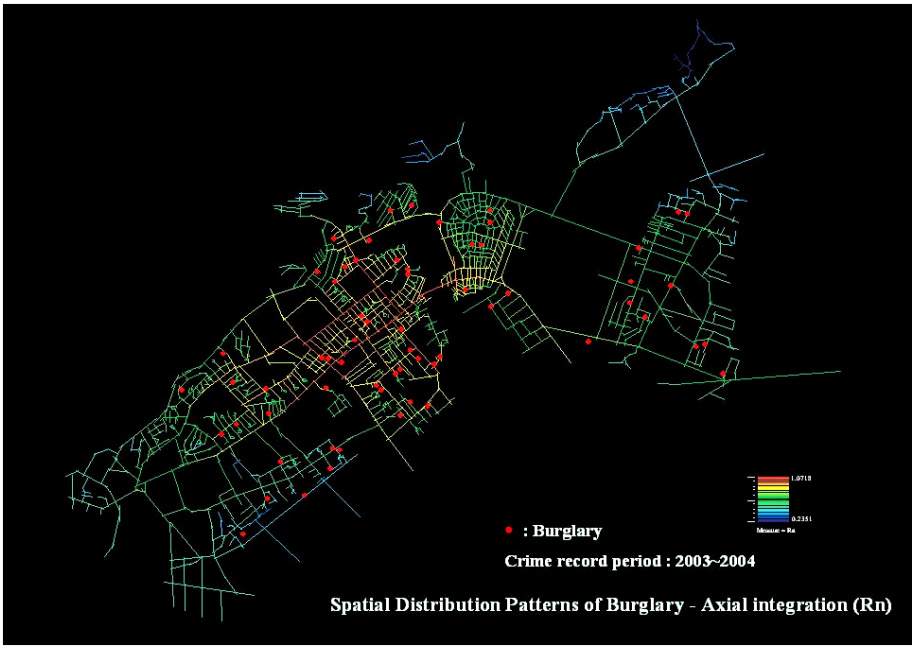

Figure 8

The crime distribution patterns against axial integration (Rn) of Town 2 in Taiwan

From the visual inspection of the crime distribution maps, several points can be observed. First of all, houses located at corners of t-junction node of streets seem to be vulnerable to burglary. The tendency for linear through carriageways to be low on burglary can again be observed. The distribution pattern of burglary in this area seems to be more dispersed than others. However, it is noticed that burglary tends to cluster around those locally broken up sub-areas.

Combination / grilled windows	intervisibility		road types				position		sum
	Con	Uncon	Thrc	Thra	Tfp	Culc	Non-corner	corner	
with	1/104	1/81	1/84	1/59	1/110	1/87	1/115	1/65	1/88
without	1/78	1/57	1/67	1/108	1/58	1/66	1/65	1/71	1/68
sum	1/96	1/77	1/81	1/65	1/97	1/80	1/101	1/66	1/78

Table 6

Combination of spatial attributes in relation to burglary vulnerability (Taiwan-Town 2)

Table 6 shows that spatial features of grilled window, constitutedness with strong front door to front inter-visibility, non-corner position (mid terrace), exert positive influence on most types of spaces. By and large, dwellings with iron grilles have a burglary rate of 1/88 and are relatively safer than those dwellings without iron grilles (1/68). Houses on corners (1/66) are more vulnerable than those not located on corners (1/101). Spaces with strong inter-visibility (1/96) are safer than unconstituted ones with low inter-visibility between dwellings (1/77).

The influence of the road types seems to be different from Town 1 and previous case studies in Britain. Through footpaths (1/97) turn out to be the safest type followed by through carriageways (1/81), cul-de-sac carriageways (1/80), with through alleys (1/65) being the most vulnerable type. Dwellings, which are located on the through footpaths in Town 2, are generally protected by additional fences and window grilles. This is a main reason for the increased safety of through footpaths. Interviews with residents established that the through footpaths used to be very vulnerable to burglary, but residents united to add fences with the effect of making the through footpaths safer. The focus of this research is the vulnerability of the public space rather than the influence of target-hardening measures, therefore a new table was created to look at dwellings which all have grilled windows and fences to see whether spatial attributes still exerted an influence on burglary.

combination / road types	grilled + intervisibility		grilled + Rn		grilled + intervisibility + Rn				sum
	grilled +con	grilled +uncon	grilled +high Rn	grilled +low Rn	grilled +con+high Rn	grilled +con+low Rn	grilled +uncon+ high Rn	grilled +uncon+low Rn	
Thrc	1/99	1/79	1/235	1/34	0/66	1/33	1/169	1/35	1/84
Thra	1/73	1/46	1/34	1/84	1/49	1/96	1/20	1/72	1/59
Tfp	0/233	1/90	1/112	1/107	0/89	0/144	1/98	1/83	1/110
Culc	1/78	0/37	1/45	1/213	1/37	1/198	0/22	0/15	1/87
sum	1/104	1/81	1/84	1/92	1/73	1/142	1/91	1/73	1/88

Table 7

Combination of spatial attributes with grilled windows in relation to burglary vulnerability (Taiwan-Town 2)

Table 7shows that the influence of constitutedness seems to be more pronounced than that of accessibility. Dwellings with grilled windows which have strong inter-visibility between them (1/104) are relatively safer than those unconstituted grilled dwellings (1/81), which is true for most road types. However, the influence of global accessibility is not as pronounced as in those previous

studies carried out in the UK and Taiwan. It seems that spatial features of higher global accessibility only exert beneficial effects on through carriageways and not on other road types in the second study area in Taiwan. Dwellings on through carriageways with grilled windows (1/84) improve to (1/99) when combined with the feature of constitutedness and become even safer when they are located on highly accessible areas (1/235). On the other hand, highly accessible cul-de-sac carriageways (1/45) and through alleys (1/34) seem to perform in a different way and become more vulnerable than those segregated ones (segregated cul-de-sac carriageways 1/213, segregated through alleys 1/84).

By and large, through carriageways tend to be safer than most other road types, such as through alleys and cul-de-sac carriageways, which is mostly true for all different combination of spatial features under discussion. Highly accessible through carriageways (1/235) are much safer than more integrated cul-de-sac carriageways (1/45) and highly integrated through alleys (1/34). Constituted through carriageways (1/99) are also better than constituted cul-de-sac carriageways (1/78) and constituted through alleys (1/73). Moreover, through carriageways when they are constituted and also highly accessible in the whole system then they turn out to be the safest one of all with a crime rate of 0/66.

5. Discussion - Burglary vulnerability - UK case studies vs. Taiwan case studies

There are differences in socio-environmental context between the UK and Taiwan; besides cul-de-sac complexes are more popular in the UK than in Taiwan. In Taiwan through alleys are the more popular road type, and grilles added to windows are also more typical to protect houses. These two elements are less prevalent in the UK. Taiwan houses have very few gardens, either front or back gardens, whereas many houses in the UK have some kind of garden in residential areas. Despite these differences between the two countries, it can be noted that through carriageways tend to be safer than most other spatial types, such as local alleys and cul-de-sac carriageways, which is true in most case studies in the UK and Taiwan. Moreover, constituted areas, which exhibit strong front door-to-front door inter-visibility, are generally the safest ones. Houses located in those globally integrated areas, which are highly accessible, tend to be less vulnerable than those situated in globally segregated areas, which is also true in most case studies. However, the beneficial influence of constitutedness is still more pronounced that the beneficial effect of accessibility. Moreover, the beneficial effect of constitutedness and accessibility is more easily observed for through carriageways than for other road types. However, when through carriageways are unconstituted they can also be as vulnerable to crime as cul-de-sac carriageways.

The more cul-de-sac carriageways are linked with through footpaths to form patterns of cul-de-sac complexes, the more broken up the sub-areas will be and thus become more vulnerable to burglary. Moreover, these linking through footpaths not only provide more access for offenders to carry out burglary offences without being disturbed by local inhabitants but also become escape routes for offenders. However, it should be noted that the negative effect of through footpaths can be countered through target hardening, such as adding grilles to windows and fences, as can be seen in case study Town 2. Overall, it can be argued that cul-de-sac complexes are generally more prone to burglary than through grid systems. It is also clear that footpaths should be avoided, either in the through grid system or in the cul-de-sac system. Cul-de-sac carriageways can also be very safe when they benefit from strong inter-visibility and some degree of accessibility.

In the UK case studies it was noted that linearity (meaning that the roads are long and dwellings have more neighbours) has been proven to be beneficial (Hillier and Shu 2000), however, the data for the Taiwan case studies are too limited to allow to discuss this attribute of linearity clearly. The data for Town 2 in Taiwan also indicate problems with the influence of accessibility on burglary, especially for cul-de-sac carriageways and through alleys. Therefore, further and longer studies are necessary to study the influence of more variables on burglary in more detail.

Note

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