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SELF-GENERATED NEIGHBOURHOODS

the role of urban form in the consolidation of informal settlements

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01.1

0 Abstract

Rapid urbanisation in Santiago de Chile has led to a large number of informal settlements on the periphery of the city which from an initial common origin, now exhibit very different degrees of social and physical consolidation. Of particular interest to planners and architects is whether locational or spatial factors play a role in determining the long term development of a settlement. This paper presents the findings of a joint research project between University College London and Pontificia Universidad Católica de Chile on peripheral settlements formalised through a Neighbourhood Upgrading Programme in Santiago. A sample of 17 settlements was examined through a set of objective instruments for measuring housing, neighbourhood and community consolidation; detailed surveys of pedestrian and vehicular patterns of movement and land use patterns; and computer configurational models of the urban form. Key findings are that spatial and locational factors, especially the layout of the settlement and its relation to its urban context, have played a major role in the pathway of development of the settlements and the different degrees to which they have become consolidated. The critical spatial factor is the degree to which the settlement is able to develop 'edge oriented commercial activity' through its outward facing edges, and through this to participate in wider local economy. The prime determinant of the development of this type of economic activity is the extent to which the streets on the settlement, especially the edges, are strategically integrated within the surrounding area and therefore carry significant levels of vehicular movement. Where this edge-oriented economic activity is strong there are further benefits to housing consolidation, community development and crime levels.

KEY TERMS: space syntax, informal settlements, movement economy, housing, community, neighbourhood, consolidation.

1 Introduction

Rapid urbanisation in Santiago de Chile has led to a large number of informal settlements on the periphery of the city which from an initial common origin, now exhibit very different degrees of social and physical consolidation. These are the settlements of the poorest section of society, often first generation urban migrants, which started with similarly scarce resources in the early nineteen seventies. However, some have become vibrant communities with strong social networks and considerable success in the consolidation of stable basic housing by the investment of their inhabitants, while others remain in 'slum-like' conditions. Understanding the divergent processes

of consolidation was the subject of a three year joint research project undertaken by University College London (UCL) and the Pontificia Universidad Católica de Chile (PUC) from April 1995 to April 1998. The main findings of this study, funded by the European Union programme for collaborative projects between universities and developing countries, are presented in this paper .

The main hypothesis of the project was that the spatial configuration and location of the settlements, in particular the way in which the site is embedded in the surrounding network of streets and the spatial character of that network, are important variables in consolidation. The theoretical background to this conjecture is the idea that spatial configuration can ultimately affect complex social process (such as, perhaps, consolidation) through the influence it has on the pattern of movement in streets and the potential this has for generating economic activity. Much research has already demonstrated that the spatial configuration of streets plays an enormously influential role in determining differences in the concentration of movement (Hillier 1996; Penn et al, 1998). Because levels of movement and space use seem to be critical at the generative level of many social processes, like shopping and crime, it was thought that this could play some role in accounting for the divergent experiences of consolidation in these settlements.

The project focuses on informal settlements that were legalised through the Chilean 'Neighbourhood Upgrading Programme' (NUP), where the state regularises informal settlements and provides each site with basic services (water, electricity and drainage) and a small sanitary unit consisting of a bathroom and kitchen. The consolidation of housing is left to the inhabitants. This line of action is a widespread solution to the legalisation of informal housing in developing countries and has shown to be cost effective. That is, it produces a considerable improvement of sanitary and housing conditions while requiring a relatively low governmental investment. The fact that so much of the process of consolidation is left to the inhabitants themselves makes it critical to understand what initial on site conditions assist or hinder their efforts.

The research involved the analysis of the city of Santiago and a detailed analytical and contextual study of a sample of settlements legalised through the NUP using a range of data gathering, representation and modelling techniques. In this paper we start by describing the first tasks carried out during the development of the research project: the building of the configurational models of Santiago and the design of the instruments to measure consolidation on the settlements. In Section 2 we present the analysis of the macro-structure of the city, and in Section 3 the settlements of the sample. In Section 4 we present the statistical analysis of the data, and finally, a synthesis and discussion of the major findings is presented in Section 5.

2 Configurational Models and Consolidation Tools

Prior to the in depth study and analysis of the NUP settlements two main research tasks were carried out: the computer modelling of Santiago's street network and the design of instruments to measure consolidation.

1.1. The Configurational Models

In order to isolate the spatial variable in the process of consolidation and to quantify the spatial differences between the sites, 'space syntax' models of the spatial structure of the city and settlements were built. The quantitative measures of spatial characteristics of individual streets within the street network provided by the computer models made it possible to compare the spatial characteristics with the consolidation indices both at the macro and micro scales.

The Santiago axial model followed the usual principles of creating an axial map (Hillier and Hanson, 1984). The method represents the continuous open space network by a matrix of the fewest and longest possible lines of sight and movement that can be drawn along the streets and public spaces of a system, without leaving any street segment or space left out of the network. Each street's network position relative to all other streets is analysed using a computer programme which considers each line as a node in a graph and calculates the depth (the fewest number of intervening lines) to every other line in the system . This measure, called 'global integration', determines how each line is ultimately linked to all others in the system. Figure 2-1(d) presents the global integration of each line in the entire Santiago system in a greyscale where black indicates the most integrated, and light grey the most segregated lines .

As well as calculating the integration of streets relative to the entire city, it is possible to calculate more localised measures of integration by limiting the calculation to a specific number of steps of depth. Integration measures for the whole model of Santiago were calculated at all depth radii up to 17. Figure 1-1 shows the 'local' measure of integration of each line calculated only within three steps of depth. This is also known as 'radius-3 integration', whereas the global integration measure is also known as 'radius-n integration' (all lines). Figure 1-2 shows the 'connectivity' measure, which refers to the number of direct connections of each street.

The importance of these configurational measures is that they have been shown to correlate strongly with pedestrian and vehicular movement in many cities, including Santiago, without reference to any other factors such as land use or population density. The configuration of the street grid itself has an impact on the street level distribution of movement rates because the streets passed through in any journey will tend to be those that provide the simpler routes through the grid. The importance of configuration lies in this effect on movement because of the vital influence of movement patterns in generating co-presence between people and therefore supporting social exchange. For the process of settlement consolidation, this may manifest itself in many ways: in terms of the level of informal networks between residents, the success of local retail, levels of crime on streets and the willingness of residents to invest in their housing and their community.

In order to explore the characteristics of the sites without reference to the global position within Santiago, as well as the model of the Santiago metropolitan area, a number of smaller models were created of the sample settlements within their local areas. The most useful of these was the seven kilometre area model, where a radius of 1.5 km was taken from the centre of the settlement, drawing a circle with an area of 7 sq. km. of the settlement in its surrounding area .

From these 7-km models a new measured was derived which has been termed 'local spatial advantage' or LSA. It is calculated by taking the mean radius-n integration value of each settlement in the context of the 7-km local system, and dividing it into the mean integration value of the whole 7-km system. The higher the value, the more the settlement has a higher integration relative to a uniform metric context. We may think of this as expressing the degree to which a settlement occupies a strategic position in its contextual area - hence 'local spatial advantage'.

1.2. The Instruments to Evaluate Consolidation

For the objective set out in this research project, it was decided that the tools to measure consolidation should focus on measuring the investment and efforts put in by the inhabitants in their habitat rather than in aspects where they have less control (e.g. the instruments privilege self build enlargements of the houses or the planting of trees in the open space, rather than the provision of hospitals or air contamination in the area). The two basic questions that needed to be answered were:
- which are the most relevant housing attributes to consider in the consolidation process of NUP settements?
- which is the relative value or weight of each one of them in the overall process?

The task was faced in five consecutive phases. The first two involved the identification, making operative and defining the 'levels of want' of the attributes composing the 'housing package'. This was done through the application of a Delphi survey to 52 experts in the field, followed by a set of semi-structured interviews applied to five focus groups of the most significant housing situations among the poor sectors of Santiago.

In the third and fourth phases the subjective valuation and prioritisation that the inhabitants make of the housing components or attributes was estimated. This was done collecting data through a customised stated preferences exercise implemented in portable computers, which was applied to the five different housing situations identified before, and through the estimation of discrete choice models with this data (Greene et al, 1995).

The final phase was the construction of a set of indices customised for NUP inhabitants which would allow relevant consolidation aspects to be recorded in continuous numerical variables. From the previous phases it was decided to decompose consolidation into three basic aspects -housing, neighbourhood and community - which could be measured separately. The three aspects when put together (weighing housing in 40% and the other two in 30% each), form a Global Consolidation Index (GCI) through which each settlement can be valued in a continuous variable.

The three basic indexes -Housing Consolidation Index (HCI), Neighbourhood Consolidation Index (NCI), Community Consolidation Index (CCI)- were build through the disaggregation of each aspect into components and sub-components, assigning successive weights to each accordingly to the results of the previous phases. By a simple calculation of the successive weights a maximum value was assigned to each indicator, summing up to a total of 100. These values were corrected more than once during the data collection and analysis , searching for a maximum differentiation

between surveyed houses and the inclusion of a maximum -yet reasonable- number of variables that could be measured objectively on site work. In Figures 1-3 to 1-5 the construction of the three basic tools is presented indicating the successive weights and maximum values for each indicator.

Finally, the indicators were categorised according to the degree of satisfaction they provided. Normally, at least three levels were assigned: 0% when the sub-component is unsatisfied and where no consolidation process has taken place, 50% where a minimum level of satisfaction of the sub-component has been accomplished, and 100% when it is fully satisfied. The medium range in each category -calculated at 50%- was defined according to the minimum adequate level considered by the experts in the Delphi study.

The application of the tools allows each settlement to be characterised by four continuous variables (HCI, NCH, CCI and GCI) with values ranging from 0 to 100, where 100 would reflect a fully consolidated house, 50 a minimum acceptable level, and 0 one where no consolidation action has been carried out and the original sanitary unit has deteriorated.

The following special characteristics of the indices should be pointed out:
The HCI is the most objective of the three indices as it deals mainly with physical aspects (materiality and area) of the building. The CCI, because of its social nature, is a more subjective index. It relies in subjective questions such as feeling of insecurity in the settlement, migration wish and perception of social problems (drug addiction, alcoholism). The NCI is characterised for being practically homogenous inside each settlement, as it deals basically with level of services which are the same to all households (paving, commerce, etc.). Also this index, contrary to the two previous ones, is expressing the actions of external agents (government officials, NGOs) and not of those carried out directly by the inhabitants. It must be said though that inhabitants have an indirect bearing in that well organised communities are known to achieve higher rates of governmental or NGOs action.

2. Macro-Structure of Santiago

Before assessing the level of consolidation at the fine scale street and settlement level, an analysis of the macro-structure of Santiago was undertaken. This was done, in order to understand the context of the global spatial structure and the broader economic and social structure of the city within which the consolidation process of the sample settlements has occurred .

2.1. Historical Development of the City's Morphology

The first part of the macro-analysis of the city was to investigate the evolution of the city's morphology and the position of the settlements within it. The peripheral settlements are themselves part of the process of rapid urbanisation that has taken place in Chile in the second half of the twentieth century as rural migrants came to the cities to find work, especially in the capital. Santiago's population has grown from just under one million in 1940 to 4.7 millions in 1995. The expansion of the city to accommodate this growth is noticed when observing the historical ax-maps presented

in Figure 2-1.

This urban expansion has precipitated changes in the configuration of the street network. These were investigated using axial maps of the city at equal 35 year periods of its expansion. Figure 2-1 shows the axial map models of Santiago from 1890 to the present, with the integration values displayed graphically in a greyscale. The measure here is global integration, the relation of each line to every other in the network. The changing distribution of tones through time shows how the enormous growth of the city (with rapid urbanisation this century) has dramatically affected the structure of accessibility in the street grid, shifting the core southwards, out of the historic centre.

The Alameda axis that runs through the traditional downtown was the most integrated axis at the beginning of the century. Then the expansion up until the 1960s can be seen to have pulled integration eastwards along the Providencia route that leads into the richer suburbs of Oriente. The most marked change occurred with the accelerated sprawl between 1960 and 1995; the core of integration (the black lines) has been pulled southwards by the long radial lines leading to the new poorer districts of southern Santiago. The most segregated part of the map in the east (Oriente) is notable as the location of the highest income residential areas.

2.2. Economic and Social Structure of Santiago

The first stage of statistical analysis relating the configurational model to consolidation indices was undertaken at the scale of the 36 districts of Santiago. The spatial boundaries of these districts are more or less arbitrary but the availability of economic and social data at this level makes an analysis of their spatial characteristics worthwhile, to determine the extent to which the economic and social performance of each district can be related to the way in which it is embedded in the spatial structure of the city.

Economic and social variables were compared with the mean spatial variables of all lines within or partially within a district. The economic and social data at district level were gathered from government sources (INE,1992; CASEN, 1992) and linked directly with the model. However, for the key variables income, housing and education, weighted indices were made by combining a number of relevant related variables. All major economic and social indicators for Santiago, as shown in Figure 2-2, show an enormous and very clear spatial divide between the richer area of Oriente and the rest of the city. The darker five districts clustered together in the east of the income and education indicators, illustrate the enormous divide between rich and poor in Santiago. The obvious similarity between income and education is also demonstrated in the correlation between these two indexes (r-squared of .964).

2.3. The Two Cities

The strong economic and social divisions between Oriente and the rest of Santiago have proven essential in understanding the role of spatial configuration in the economic and social structure of the city. Space plays a different role for Oriente and for the rest of the city in all the economic and social indices shown. This is particularly clear in the case of income and poverty . There is a positive relationship between

income and spatial integration outside the Oriente area, as shown in Figure 2-3(a), which demonstrates a messy but significant relation between spatial accessibility and economic well being at the district level (there are some important outliers in the poorer districts). The negative relation of poverty to integration is stronger and much more significant, as can be seen both by the r-squared and by the slope of the regression line in Figure 2-3(b).

The linking of the social data to configurational measures showed that the economic and social structure of the Oriente area does not relate to the spatial structure of the city in the way that the rest of the city does. In the rest of the city, there is a positive relationship between integration and income levels. There is also some relationship between the concentration of commercial land use and the pattern of integration in the model shown for example on streets like Gran Avenida, which is the most integrated one and a key shopping street.

However, in Oriente these relations do not appear to hold: income and education are both high regardless of the segregation of the area. The shift of Central Business District functions eastwards into Oriente, that has taken place in Santiago since 1960, does not relate to the spatial model which is pushing the pattern of integration southwards. Oriente leads from the historical centre, which is still well integrated, right up to the most segregated area of the whole city (the residential developments in the valleys of Lo Barnechea). Unlike most European cities, this more segregated residential development has pulled commercial land use out towards it, almost in the opposite direction to the shift in spatial accessibility of the city as a whole (southwards). This is a key aspect of the well known 'divided city' characteristic of Santiago so evident in terms of economic and social data (CED, 1990).

However, when the street network of the Oriente area is analysed as an independent spatial system (Figure 2-4) a very clear match emerges between commercial land use and spatial integration. The integration core within Oriente, considered alone, directly mirrors the commercial development axes of Providencia, Vitacura, Kennedy and Apoquindo. Thus the spatial model directly reflects the conjecture of 'two cities': the rich and poor areas of Santiago are virtually independent of each other.

2.4. Time Factor in Consolidation

As might be expected in a case of rapid growth, the time factor seems to be very important in the economic and social consolidation of each district. Thus the older settlements of Maipú, San Bernardo and Puente Alto, that were adjoined to Santiago in the 1960s, perform much better on income indicators than one might expect from their peripheral position. When the formerly independent settlements are removed from the correlations shown in Figure 2-3, the relation improves to r-squared .196 for income and r-squared .402 for poverty.

It seems fair to assume that the consolidation process in these older settlements is different from that of the new peripheral districts that grew from nothing. Therefore the measurement of economic and social consolidation should aim at controlling for how much time has been allowed and what the initial conditions were. However, obtaining detailed and accurate data on this (such as the mean age of building stock) is not straightforward at district level. For the sample settlements, this time factor

was controlled by selecting settlements of a similar age, that had received the same NUP input and by checking the amount of time that each surveyed inhabitant had lived on the settlement.

3. The Settlements

The NUP has been implemented at a national level in Chile since 1983, with financial support from the Interamerican Development Bank (IDB), through four separate consecutive operations. The first three are already completed and amount to 716 projects involving 134,356 sanitary units, while the fourth operation is currently under way and has been estimated to consider another 13,000 individual units.

The criteria to select the sample settlements considered the following three aspects: to concentrate in the first and oldest operation (implemented from 1983 to 1988) in order to allow for a maximum time for the residential consolidation process to take place; only projects located in Santiago urban area were chosen; and the sample was restricted to those with over 100 and under 400 units, in order to allow for settlement comparison. The size of the sample regarding households to be interviewed was calculated according to a methodology proposed by Ortúzar and Willumsen (1994) and the actual plot selection was done through a random process.

The gathering of data included site survey data for all 3,485 plots on the 17 settlements, a structured questionnaire applied to 553 surveyed households and an observation study on patterns of pedestrian and vehicular movement in every street segment in the sample.

Figure 3-1 shows the axial map of Santiago, highlighting the lines of the 17 settlements of the sample. As can be seen, the length of axial lines in the settlements varies considerably, as does the number of lines that each is directly connected to.

3.1. Consolidation in the Settlements

It is interesting to first review some basic statistics and how the settlements perform on what have been traditional variables and physical indicators related to housing consolidation. As shown in Table 3-1 settlements are homogeneous in plot size (plot area) but vary greatly in size (number of units, area) and density (measured both as inhabitants and plots per area).

Two of the most traditional variables related to housing consolidation are income and time (both as time of residence of the inhabitants in the settlement and as age of the owners); while the size of the house and the presence of second floors have been considered important indicators of consolidation (Greene et al, 1992; Greene and Ducci 1997). On this project we found an additional, and most important variable, related to the process of consolidation: the presence of commercial activity.

As explained before, the sample selection criteria aimed at controlling the time of residence. Table 3-2 shows that time does not vary significantly among the sample: the mean time that the families have been in the places is just over 20 years, and the mean owners age is around 50 years. On the other hand, income varies more significantly, and one settlement acts as an outlier with a higher mean income than the rest.

This case, Arturo Prat in Peñalolén, will be referred to later as it seems to be the case where its location in the city -in the richer Oriente area- has provided a special advantage to its inhabitants.

On the other hand Arturo Prat- Peñalolén, together with Villa El Rodeo and El Almendro, stand out for their high standards in terms of house area and density, while Yungay-Los Colonos and Panamericana Norte are noteworthy for the poor standards in this aspect. The second floor aspect was found more difficult to interpret as in the last years there has been governmental support for this type of home improvement through the action of non-governmental organisations (NGOs). In fact, second floors are being built at a rapid rate.

As will be seen later, the aspect which was found to correlate most significantly with consolidation is the presence of commercial activity in the plots, especially in the construction of small informal shops, kiosks or workshops. Villa El Pino has a very high proportion in this respect: 13% of the plots have commercial activity. This settlement is located in an important cross-roads of the city and opposite a hospital which attracts a considerable amount of pedestrian and vehicular movement, which as shall be seen, is directly related to the development of commercial activity.

In Table 3-3 the mean of the consolidation indices per settlement is presented: HCI, CCI, NCI and GCI. The last one summarises up the findings of the partial indexes, giving a complete picture of the process. As can be seen Villa Ovalle, Santa Elvira, Caupolicán-Las Torres, followed by Robinson Rojas and Progreso Aurora are the better performing settlements; while Primero de Septiembre, Panamericana Norte, Arturo Prat-Renca, Manuel Acevedo and La Viñita are the worst performing. Figure 3-2 presents this graphically rank ordering the settlements from higher to lower level of global consolidation.

3.2. Movement Patterns in the Settlements

Using the experience gained in a pilot survey done in Progreso Aurora during the second year of the research project, a full programme of movement studies in and around all the settlements was carried out in April 1998 . The study used the 'movement gates' technique, where notional gates are defined covering all axial line segments. Observers count the number of passing people and vehicles through each of these gates, distinguishing between men, women, children and various vehicle types. Six hourly periods were defined (starting at 12:00, 13:00, 14:00, 16:00, 17:00 and 18:00 hours) and two observations per hour during five minutes each were made at a total of 489 gates, covering 198 axial lines.

The results of the movement studies were mapped using the Geographical Information System (GIS) package 'Mapinfo' in equal greyscales to allow for comparison across settlements. In each case mean adult and vehicular movement rates were plotted segment by segment (see Figures 3-5 and 3-8). Because vehicle rates are nearly twice as high as pedestrian rates, it is not possible to compare them with pedestrian rates even within individual settlements. Overall, mean adult pedestrian movement rates on the gates are low (at 36 people per hour, or little more than one every two minutes), but twice the child rates (at 18 per hour), and a little over half the vehicular movement rates (at 84 per hour). The overall mean gate movement rate is then over

two movements per minute (148 per hour). This is a relatively low rate. These settlement are not in general alive with movement, although as shall be seen, a few are. The graphics demonstrate a number of key points:

movement rates are very different among settlements; there is a strong tendency for vehicular movement to be highest at the edges (though sometimes it is also strong within the settlement, as in Progreso Aurora), and for (the lower rates of) pedestrian movement to be more evenly diffused and to peak internally (though again in some cases -for example, Villa El Pino- the peak is at the edges); variations in vehicular movement are much greater than those for either adult of child pedestrian movement.

Figure 3-3(a) shows this graphically: the settlements are plotted from left to right in order of highest overall movement rates (that is, the sum of pedestrian and vehicular movement). The plot shows that while in the low-movement settlements, pedestrians tend to outnumber vehicles, in the high-movement settlements vehicles outnumber pedestrians, sometimes by a large margin.

Child movement rates follow a very similar pattern to adult movement rates (they correlate at r-squared .874 when considering settlement means and .571 when considering individual lines). Figure 3-3(b) plots mean adult and child movement rates on the same basis as the previous figure, showing that adult rates are constantly about twice the child level. This ensures that for the most part there is a fairly constant natural surveillance of children by moving adults. This is undoubtedly a benefit of the simple, street based design of the settlements, and contrasts strongly from results in studies of housing estates in the UK which shows that complex internal layouts lead to adults and children using space in quite different ways, so that natural surveillance of children through everyday movement is lost, with negative social consequences for the estate (Hillier, 1996).

3.3. Database of Individual Settlements

Each settlement was described through graphical representations, text and summary datatables for the spatial and social data collected for the study. As an example, in this paper, we present a high and a poor performing settlement regarding consolidation also characterised by a high and low development of commercial activity.

Settlement 9. Caupolicán-Las Torres, Macul

Caupolicán-Las Torres is located on the east side of the city, very close to Santiago's ring road Américo Vespucio. It is the largest settlement in the sample, with 326 plots. The settlement has two identifiable parts -a southern and northern area- each bordering an important road. Both areas are linked by an internal road that crosses the whole settlement in a north-south direction. There is also an internal ring towards the east, where small pockets of undeveloped land have been left.

The bordering roads -Avenida Las Torres and Chacarillas- to the south and west of the settlement, offer high movement rates which have been reflected in the development of commercial activity. Across these roads, there are established housing estates. The north border of the settlement also limits with housing estates, but this time internally through the back of the plots, giving a more quiet and interior feeling

to this area. Towards the east the empty plots allow the back of a neighbouring food industry to be perceived from the interior of the settlement. This seems to have a negative impact on the settlement, especially noted are the empty plots which are used as garbage dumps by the inhabitants.

There is a contrast between private and public trees and vegetation: front gardens show well kept plants, shrubbery and trees, giving a green effect much superior to the one found in the public open space of the streets and passages. Nevertheless, the settlement has abundant community equipment: a community building, an illuminated sports ground, two sports club buildings and a church, located deep inside the settlement. On the west border there is a green area, a children's playground and a Lions Club building.

Overall Caupolicán-Las Torres rates highly on consolidation, especially in HCI and CCI. It also has one of the highest ratio of houses with second floors (15%). In this respect, it must be noted that the Canadian government supported an NGO programme for building mud second storeys in the houses. In the distribution of consolidation, there seems to be a positive influence of the two active borders of the settlement: the best consolidated houses seem to locate near the west and south active edges, and the worst in the internal east ring road of the settlement.

Figure 3-4 shows some basic syntactic measures of the settlement axial maps calculated in different level models; Figure 3-5 shows land use and movement patterns; and Figure 3-6 shows the distribution of the consolidation indices in the settlements. All maps were drawn in equal ranges considering the 17 settlements, in order to make the maps comparable among one another.

Settlement 12. Manuel Acevedo, Pudahuel
Manuel Acevedo is located on the west side of the city quite near, but not adjacent to San Pablo, a main road in Santiago. It is characterised by a visual segregation from the surrounding area due mainly to two factors: (i) it has almost no edge streets bordering the settlement, but in general limits through the back of the plots with the neighbouring area, and (ii) the presence of a cemetery in the east side, blocking its relation with Errázuriz, a relatively important local road.

The settlement is crossed by two perpendicular roads creating four recognisable segments, the southern ones in a more disadvantageous position. The northern segments limit towards the east and north with well established detached one storey housing, and towards the east with Errázuriz, the main connection with the city, with high rates of movement (although across the street there are warehouses). These sectors seem to have better consolidated houses and most of the shops.

The southern sectors limit towards the south with a derelict space poorly controlled and badly illuminated, used as a garbage dump and with informal sporadic dwellers, towards the east with the blank back walls of the cemetery and towards the west with informal dwellings developed in a small strip of land against another blank wall.

At the moment of the first surveys for this study, all internal roads of the settlement were unpaved, but were later paved due to governmental action. The unpaved roads,

had a clear negative impact in the consolidation of the settlement. The settlement has a community building (also used by the sports club), a child assistance centre, a green area with public seating and a kindergarten located in its geometrical centre. There is also a playground and a fenced and illuminated sports ground located at the side of the cemetery, in the perimeter of the settlement.

In terms of global consolidation Manuel Acevedo is one of the worse settlements, but specially in its NCI which is the lowest of the sample. The expressions of this low consolidation can be seen in the public and semi-public (front gardens) space: most of the fencing is timber of poor building standards and maintenance; the houses facade are opaque, no colour, nor additional semi open spaces (verandas, covered patios).

As in the previous case, Figure 3-7 shows some basic syntactic measures; Figure 3-8 shows land use and movement patterns; and Figure 3-9 the distribution of the consolidation indexes in the settlement.

4. Statistical analysis of Settlement Consolidation

Prior to the testing of factors affecting the consolidation process it was necessary to examine the relation between its different expressions: do the physical and social expressions of consolidation follow similar patterns of development?

The second stage involves an analysis of the relation between movement patterns and the configurational models. The idea is to first test the conjecture that the spatial layout of the settlements has an effect on their patterns of movement.

The third stage will be a first order statistical analysis to establish which variables are prima facie involved in each aspect of settlement consolidation: housing, community and neighbourhood. The impact of social factors, of spatial configuration and of space and land use variables on the various aspects of settlement consolidation will be examined.

Finally, regression techniques will be used to answer a series of specific questions about the patterns of influence between the variables. In this way, a picture will be built of the process by which spatial configuration, movement patterns and land use factors have played a key role in determining the pathways of consolidation of the settlements.

The statistical analysis was carried out at threel levels of resolution: movement patterns and configurational variables were analysed at axial line level (n=198); consolidation and social variables were analysed at individual families level (n=434); and the mean values of all variables were analysed at settlements level (n=17).

4.1. The Indices Among Themselves

The first enquiry was to ascertain whether housing, community and neighbourhood consolidation follow similar paths of development. If this was the case, it could be suggested that there is a single -if perhaps complex- process affecting the basic three aspects of consolidation. On the other hand, if they show different paths of develop-

ment, it could be suggested that they are the result of independent processes probably involving different variables.

The relation between the indices was approached by correlating the variables that differ at family level: HCI and CCI. When this two partial indices -which could be described as the physical and social expressions of the consolidation phenomenon- were compared at the individual family level no correlation whatsoever was found (r-squared of 4.041E-6, p=.9675); nevertheless, significant correlations were found when the means of the indices per settlement were compared (see Figure 4-1). This first exercise gave us certain important clues to understand the elusive consolidation process of peripheral settlements. They could be summarised as follows:

there is evidence to suggest that the physical consolidation of individual houses bears little or no relation with the social relations developed by its inhabitants in their settlement; nevertheless, there is also enough evidence to suggest that physical and social consolidation of settlements goes 'hand in hand': that is, that settlements that achieve good quality houses also tend to achieve good and healthy communities, and vice versa.

The correlation shown in Figure 4-1(a) also shows two important outlying settlements -Panamericana Norte and Manuel Acevedo- with high community development in relation with their poor quality houses. In fact, when excluding these two cases, as shown in Figure 4-1(b) the relation between HCI and CCI rises considerably (from r-squared of .204, p .0686 to r-squared of .597, p .0007). These cases are considered important clues to reveal the process we aim at understanding, and are being currently studied independently.

4.2. Movement Patterns

As has been found in many other studies (Hillier, 1996; Penn et al, 1998; Read, 1997) the pattern of movement on settlements relates strongly to the configuration of the street grid. As shown in Figure 4-2 the best correlations of adult and vehicular movement rates with spatial variables were obtained when considering maximum levels of movement at the most local syntactic measures (radius-3 integration and connectivity) of the most local model level (7-km model level). Considering that we are dealing with a group of small settlements scattered around the edges of a very large city, the r-squared obtained are quite remarkable, especially those with vehicular movement . The relations for vehicular movement are by far the strongest, although adult movement is still highly significant (p=.0001).

Broken down into individual settlements, the mean r-squared for mean vehicular movement with log connectivity in the 7-km model is .556 and .577 if La Viñita is excluded (where the settlement comprises only two long lines with three cross connections, too small and weakly differentiated a system to detect significant differentiation in the movement pattern). It is a matter of some interest that the best vehicular movement correlation is with the connectivity of lines, not their radius-3 integration which has proved the most powerful in previous studies (Penn et al, 1998). The conjecture is that this is the result of the importance of relatively few important lines that connect together the 'patchwork' pieces of orthogonal grid which characterises Santiago. Taking the settlements individually, the mean r-squared for mean adult

movement with connectivity in the 7-km model is .351 and without La Viñita it rises to .401.

Figure 4-3 plots the r-squared values for vehicle and adult movement from left to right in the order of the best correlations . In most cases the value for pedestrian movement is less good than for vehicular movement. There is a broad relationship between the two sets of correlations (r-squared .356). It is significant that the worst five settlements regarding these correlations (at the right edge of the figure) have conspicuous features of segregation: La Viñita and Villa El Rodeo are both at extreme edges of Santiago bordering the mountains, Arturo Prat-Renca is immediately above the river and completely cut off to the south, Panamericana Norte is strongly cut off on three sides by industrial development and Manual Acevedo, is cut off south and east in the direction of Santiago, and linked only a short way into surrounding areas to the north and west. All of these poor levels of correlation seem in some way or other to be associated with poor embedding of the settlement into its contextual area, and this, in fact, is known from previous studies to be one of the factors commonly associated with poorly structured pedestrian movement in urban areas (Hillier, 1996).

Overall, the configuration of space in and around the settlements, and of Santiago in general, clearly has a powerful role in structuring movement. This of course is a key element in the theory of the movement economy, where the process of development is sparked by the effect of the differentiation of the urban grid on movement pattern, and the subsequent impact that this has on land use patterns and further multiplier effects. It is notable in the case of the Santiago settlements that well structured movement, as indicated in high level of correlation between space structure and movement, seems to be associated with settlements with spatially strong edges and good levels of associated vehicular movement. The good relation seems to be one of adjacency: settlements with well structured movement are directly adjacent, in some cases on two sides, with strong spatial lines with high movement levels.

4.3. Variables Involved in Consolidation

The analysis was carried out simultaneously at two levels: settlement's level, that is working with the settlement's means, and family's level by working with all the remaining 413 cases . For the development of the EU funded project and the work presented in this paper, special importance is given to the analysis at settlements level. This is consistent with one of the first intuitions that started out the project: that is, that although significant differences of consolidation can be perceived from one house to another, the general feeling of good consolidation and vice versa is much stronger from one settlement to another. Nevertheless, further work is under process, where the data is being analysed at individual family's level and where settlements are studied independently.

Social Factors

The first task was to interrogate the data regarding to how far settlement consolidation, as shown in the three partial indices -HCI, NCI and CCI- is prima facie a social process independent of spatial and planning factors. If this is the case, correlations between social factors such as age, time in the settlement, income, education, spending and saving patterns, and the consolidation variables would be expected to be

found.

A correlation matrix at settlements level was produced for the three indices and a set of social variables measuring aspects traditionally associated with consolidation (see Table 4-1 where significant correlations are highlighted). Only a few significant relations were found at the level of the settlements. However at the level of the family, specially regarding HCI, significant and positive correlations were found with type of family as well as income related variables. These are reflecting the importance of economic resources (income, rate of income from work, spending, income stability) and social resources (educational level, type of family) in housing investment at the family level.

Nevertheless most of these variables do not show significant correlation with CCI nor with NCI, and -even more important- when they correlate they show negative relations. In the case of CCI, this could reflect a survival strategy of weaker families: those with lower levels of education and income need to develop stronger community ties to assist one another. However it may also reflect a difference in expectations about community between higher and lower income families: the better off may be more critical. In the case of NCI it can be explained as governmental prioritisation towards poorer sectors: intervention in the provision of urban services (which NCI reflects) tends to be higher in areas of more extreme poverty pointing. This analysis showed that social variables seem to be playing a significant role in the physical development of the houses (HCI) at the level of individual families. However, there seems to be very little positive effect to consolidation variables at the level of settlements. This suggests the presence of additional important variables intervening at the settlement level.

Spatial Factors

A similar exercise was carried out regarding the prima facie correlations between selected spatial variables and the consolidation indices (see Table 4-2). It showed that the pattern of correlation is in general positive with many more instances of significant relations.

In particular, at the level of the settlement, it was found that radius-9 integration (both at whole city level and at the 7-km models) and LSA are significant with NCI; and that synergy (the correlation between local and global spatial integration for lines on each settlement) is significant with HCI. For individual families, the instances of significant correlations are even more frequent: HCI correlates positively and significantly with all levels of integration and connectivity in both the city and 7-km models; NCI correlates positively and strongly but only with the more global integration measures; while CCI correlates positively with global measures of integration but negatively with local ones. This was indicating that while housing and neighbourhood development were being affected positively by integration, regarding community development, the local and global integration were playing different roles

The analysis left us with the impression that spatial configuration was playing an important role in the consolidation process (at least for neighbourhood and housing) both at the settlement and the family level. What mechanism could explain a relation

between the spatial structure and the consolidation process? Since we had previously found significant correlations from configurational variables to patterns of movement, the evidence was pointing towards a role for space use and land use factors.

Space and Land Use Factors

Space and land use variables turned out to show much stronger correlations with consolidation indices than any other variables (see Table 4-3). Three aspects in particular seem to be important: vehicular movement, delinquency and commercial activity.

Firstly, a strong positive correlation between vehicular movement and all consolidation indices was found. Having previously found a strong relation between configuration and vehicular movement, the further correlation with consolidation forms an important threefold relation that runs through the data: spatial structure influences movement patterns which in turn influence consolidation.

Secondly, strong negative correlations were found between CCI and the experience of mugging and burglary both at the settlement and family levels, as well as with security perception and perception of drug and alcohol addiction at the level of the family (it must be noted that to avoid auto-correlation these regressions were calculated excluding in each case the relevant sub-component from the compound CCI index). These are the strongest relations found for CCI: reported levels of community networks appear to be highly related to those of delinquency.

The third important space use factor in consolidation is the rate and distribution of commercial activity (shops, kiosks and workshops built in the inhabitants plots) in the settlements. In an attempt to capture this, an index of 'edge oriented commercial activity' or EOCA, was created. This takes three ratios: the ratio of houses with commercial activity to the total number of houses (shops/plots); the ratio of such houses located on outward facing edges to the total number of houses (edge shops/plots); and the ratio of houses with commercial activity located in the border to the total number of shops in the settlement (edge shops/shops). The two first ratios are weighed by a factor of ten and added with the third for the single EOCA index .

Strong positive correlations of the indices were found with the rate and degree to which commercial activity is oriented to the outside edges of the settlement (particularly edgeshops/plots, edgeshops/allshops) and with the compound variable EOCA. Most strikingly, this single (although complex) variable of EOCA has the strongest correlations of all for two of the three partial consolidation indices: HCI and CCI. The exception is NCI whose strongest correlation is with the spatial variable of radius-9 integration at the city level. Figure 4-4 shows the three scattergrams for these relations.

The graphics of the two cases presented in Section 3 are helpful to visually compare this phenomenon. While Caupolicán-Las Torres does not present the highest rate of commercial activity (it ranks fifth in the ratio shops per plots) a high percentage of its commerce is located on the edges of the settlement; Manuel Acevedo on the other hand shows a low rate of commercial activity and little orientation of it towards the

edge.

4.4. The Consolidation Process

Although strong relations have been found between the indices and a number of configurational, social and space use factors, the mechanism where by the process of consolidation takes place still requires further explanation. Since other variables also correlate with the indices, it was necessary to explore how far these play an independent or dependent role. This was done by multiple and stepwise regression, for each of the consolidation indices, using all variables which correlate with each or all of the consolidation indices at the $p<.1$ level.

For HCI, a stepwise regression at the settlement level against 13 selected variables, (see Table 4-4(a)) confirms that EOCA is the sole surviving variable. It must be taken therefore as the strongest determinant of HCI (r-squared of .368).

However, a caveat must be added. Figure 4-5(a) shows the regression of mugging against HCI for all 16 settlements. It shows what appears to be a negative correlation, but with a single disconforming case of Panamericana Norte. Burglary follows a similar pattern. If this settlement is removed, as in Figure 4-5(b), the r-squared value becomes .66, making it the strongest correlate of HCI. If the stepwise regression is re-run with this settlement eliminated, then mugging becomes the stronger factor, and EOCA is replaced by the simpler EdgeShops/Plots variable, and the r-squared value, considering both this variables, leaps to .804 (see Table 4-4(b)). We must then allow the possibility that the experience of crime has a significant impact on the degree to which residents are prepared to invest in the consolidation of the house.

If CCI is examined with the same variables, a more complex story is found. In Table 4-5, three of the 13 variables tested survive in the stepwise equation: burglary and edgeshops/plots and LSA. These three variables between then give a multiple r-squared of .806.

Regressing the same variables stepwise against NCI shows that two spatial variables survive: radius-n and radius 9 integration at the level of the whole city. However, these showed different signs. This must be considered a statistical artefact of using two variables with a high covariance together in a multiple regression. When the regression is run omitting integration radius-9 (the weakest of the two), integration radius-9 at the Santiago level is the only surviving variable for NCI, giving an r-squared of .277 (see Table 4-6).

Finally, a stepwise regression for the compound index of global consolidation (GCI) was run. This showed mugging and EOCA to be the two critical variables, with a multiple r-squared from the two of .613 (see Table 4-7).

Thus a relatively small group of variables are directly implicated in the four consolidation indices: edge oriented commercial activity , crime, vehicular movement, and various aspects of spatial configuration. Of these, however, only the spatial configuration variables are truly independent. Movement, crime and EOCA activity are all likely to be dependent variables in some underlying process. What are the independ-

ent variables of the process in which movement, crime and EOCA are the outcomes? The pattern of movement has already been shown to be strongly determined by aspects of spatial configuration at a street by street level. To further explore the determinants of movement at settlement level, a stepwise regression of mean vehicular movement per settlement was set out with ten selected variables : Two variables are found to be critical: synergy (the correlation between local and global aspects of spatial layout) and LSA, which between them give an r-squared of .453. It is notable here that mean vehicular movement is negatively correlated to vehicle ownership and to other income related variables, corroborating that it cannot then be an endogenous variable in the settlement. Vehicular movement rates are determined by factors describing its spatial positioning within the larger surrounding structure of the city. This confirms the importance of the measure of LSA.

Next, the determinants of the key variable, EOCA, were analysed through a stepwise regression with 11 variables . It was found that EOCA is overwhelmingly determined by vehicular movement, but with one other variable playing a significant role: monthly spending (not income) within the settlement, showing that EOCA also correlates endogenously to the settlement. These two variables give a multiple r-squared of .907, indicating that they give a more or less complete account of the process.

On its own, however, the r-squared between vehicular movement and EOCA is .894. by far the strongest relationship anywhere in the data (see Figure 4-6). Even this is likely to be an underestimate, since the slight outlier, the fourth highest settlement in EOCA (Caupolicán-Las Torres) does not take account of movement on the ring road, Américo Vespucio, immediately adjacent to the settlement, which was not observed because it is not quite tangent to the settlement. If the movement rate in that part of Américo Vespucio approximate other observed sections, the r-squared would rise to well above .9.

What about levels of crime? A stepwise regression with six selected variables showed that mugging is most strongly affected by edgeshops/allshops (as opposed to the level of economic activity in the settlement as a whole) but also by income per head and stability of income. These three give a multiple r-squared of .674. Finally, burglary, in a stepwise regression considering the same variables, gives a very similar answer: income per capita and the edgeshops/shops are affecting the process, giving among them a total r-squared of .534.

The Spatial Process

A clear picture of a process by which spatial and location factors affect the pathways of development of the settlements is emerging. The order of events would seem to be:

local (and to a lesser extent global) spatial layout factors create a pattern of movement, particularly vehicular movement; settlements that are well embedded in their local context (high LSA and synergy), have higher vehicular movement rates; where a settlement has adjacent thoroughfares with high vehicular movement, commercial activity is generated (EOCA); this commercial activity generates a higher degree of housing consolidation, and increases internal security in the settlement; which in turn increases community consolidation.

This, of course, is the movement economy process. The movement economy process is at least one of the critical factors in the pathways of settlement development from similar origins to different present states. Are there any other factors involved? In the next section three factors will be further explored: income, pedestrian movement and the subjective evaluation by the inhabitants themselves.

Other Intervening Processes

At an early stage of the analysis it was shown that social factors such as income were not critical to the settlement consolidation process, while at the same time were critical to the pathways of individuals. What is the role of per capita and family income in the process we have described?

As was seen in the analysis of the local authority data, education level was a very strong predictor of income. If income is stepwise regressed against the main variables two (education level and LSA) are found to play an almost equal role and between them show strong correlations (r-squared of .656 for family income, and r-squared .711 for income per person). This suggests that income in the settlement is affected both by the spatial factors which give rise to the edge led commercial activity and by factors which are entirely independent of it. Education appears to be a genuinely independent social variable in this context: a thorough search have revealed no spatial or land use variable correlating with education levels.

A simple way of demonstrating the effect of the local economy on income is to test the statistical difference in income levels for households with commercial activities attached and those without. The annual average income for houses with shops, kiosks or workshops is 191,095 pesos, and for those without is 162,981 a difference which is significant at the .059 level.

There also remains the puzzle of pedestrian movement. What role was it playing? This enquiry brought to light some of the more hazardous aspects of pedestrian movement in these settlements. At an early stage of our movement studies, observers reported informally that some of the highest levels of internal pedestrian movement were found in settlements with the highest levels of reported drug and alcohol culture, as well as in those with strong edge-led economies. This turns out to be substantiated by the numerical evidence. There are significant positive correlations between reported drug and alcohol culture (which are themselves very strongly correlated: r-squared of .965) and both adult and child pedestrian movement (also highly correlated), which is strongest when both are considered together. There is no correlation, however, either with vehicular movement or with the edge-economy variables. If we examine the relation between pedestrian movement and LSA (which was the prime determinant of the level of vehicular movement in the settlement), we find a U shaped relation, shown in Figure 4-7.

In the left part of the U-shape are to be found three of the four worst settlements on drug and alcohol problems, while the best are to be found towards the bottom of the scatter where pedestrian movement rates are lowest. Those on the right tend to be mid-range and coincide with settlements with a high development of commercial activity. This suggests that higher pedestrian movement can reflect LSA in two dissimilar ways: one where LSA promotes the development of the edge led economy

leading to higher movement rates in general; and the other where the lack of LSA leads to the development of a kind of pedestrian activity more strongly associated with a drug and alcohol culture.

Finally, regarding the subjective factors, it was clear that the perception of crime and drug problems strongly affects the subjective view taken of the settlement by residents, as reported through the questionnaires. The responses to the relevant questions at the end of the questionnaire covering all aspects of the individual's evaluation of the settlement were factor analysed. This gave eight factors and showed that responses to questions about, for example, transportation, health facilities or schools and nurseries were quite specific to those aspects and not inter-correlated. The strongest factor, however, combined responses about the settlement: the perceived quality of its location, its community, and its neighbourhood. Stepwise regression against other key variables showed that this factor was very strongly determined by drugs problems, crime, shops/plots and by edgeshops/shops (in that order) with a multiple r-squared of .882.

In spite of this strong result, however, this subjective variable does not correlate with the 'objective' assessments of CCI and NCI, but it does, and quite strongly, with HCI. There are two ways of understanding this: it could be that families that have been unable to achieve a good consolidation of their houses will be more critical of their settlement, including their perception of drugs and crime; or -a more interesting proposition- that the main consequence of a negative perception of a settlement, itself mainly as a result of perceived drugs and crime problems, will be an unwillingness to invest in the consolidation of the house.

The second most important factor in the evaluation of the settlements concerned the quality of the house, and was quite specific to questions about the dwelling. First, it is notable that this subjective evaluation correlates well with the more 'objective' HCI measure (r-squared of .632). It also correlates with the 'crime and drugs' variables, strongly if Panamericana Norte is removed, and with edge commercial activity. This again confirms the picture that edge commercial activity tends to affect perception of the settlement positively , just as the 'negative economy' of drugs and crime affects it negatively.

5. Synthesis and Conclusions

5.1. Principal Findings

The main findings of the study are that:
spatial and locational factors, especially the layout of the settlement and its relation to its urban context, have played a major role in the pathway of development of the settlements and the different degrees to which they have become consolidated; the critical spatial factor is the degree to which the settlement is able to develop 'edge oriented commercial activity' (EOCA) on its vehicular thoroughfares, and through this to participate in a wider local economy; the prime determinant of the development of this type of economic activity is the direct adjacency of outward facing settlement edges to streets and roads with significant local vehicular movement, and the accessibility of the internal layout of the settlement to the lines on which this occurs; where this 'edge oriented economic process' is strong, the overall level of self gener-

ated economic activity in the settlement increases.

This then has a series of beneficial effects:
the experience of mugging and burglary (but not necessarily of drugs and alcohol) in the settlement is reported to be lower; there is greater consolidation of houses; and there is a higher level of community development; these two giving a higher level of overall consolidation in the settlement; the critical spatial property that sparks off the process is 'local spatial advantage' (LSA), meaning the degree to which the settlement is spatially integrated with respect to its local contextual area of 1.5 km radius and 7 sq. km in area, regardless of the degree to which this is developed; this economic process influences and is affected by income levels within the settlement, but income cannot be considered the critical factor in settlement consolidation.

These are strong findings, and have clear policy implications. The most important theoretical result is the association proposed between social development and local informal economic activity, the relation this has to local vehicular movement, and the relation this has in turn to local spatial design. At a theoretical level, these results are in line with other studies of the evolution of European cities. In particular, the theory of the 'movement economy' argues that in the growth of cities, spatial factors first influence movement patterns, and these then affect land use distributions (in that movement sensitive land uses move towards certain lines and locations). This then produces multiplier effects on movement, which then attract a greater concentration and diversity of movement-dependent land uses. Over time, the whole process gives rise to the characteristic pattern of European cities with their intensive pockets of mixed use activity distributed within larger areas of less intense, mostly residential development. A comparable process seems to be under way in Santiago, and this must hold out much promise for the future both of these settlements and for this type of government initiative.

5.2. Policy Implications

The evidence of this study has a number of policy implications. At a general level, the most important are that:
there is a critical link between small scale informal economic activity and the social and physical development of settlements; this is facilitated by spatial and urban design; and there is also likely to be a link between positive development of this kind and crime rates (though this at present is not based on officially reported crime).

At the more detailed level of the spatial location and planning of future settlements, and the adaptation of existing ones, settlements should be planned on the understanding that:
Vehicular movement plays a critical role in the informal economy of such settlements through supporting informal commerce and thus allowing some income from surrounding areas to be drawn into the settlement. At least for lower income groups, no attempt should be made to isolate homes from movement thoroughfares. For these groups movement is a resource. Mixed use, in particular informal shops, should be allowed and perhaps incentivised. Since the peripheral settlements today will be the established districts of the future, the informal shops may presage the location of a consolidated neighbourhood shopping streets. The location and layout of the settlements should aim at achieving a degree of spatial integration into its urban context to

permit the positive developmental process we have identified. Overall, planning should be seen as the nurturing of an organic process, requiring ever improving understanding of these processes and feedback from interventions. Therefore regular procedures to monitor development of new settlements and to identify problems and possibilities as they grow, should be considered.

5.3. Concluding Remarks

In the past, the common assumption about consolidation on informal settlements has been that it is really just one aspect of poverty: poorly consolidated housing and social pathologies such as crime and drugs arise through lack of money. This study has shown that the considerable differences in consolidation between a sample of 17 settlements cannot be explained by income alone but are far more dependent on the space use and land use characteristics of the settlement, and that these in turn are heavily influenced by urban design.

Previous research on the investment of inhabitants in their housing has already shown that a crude economic determinism (i.e. assuming income as the overwhelming causal variable) cannot explain the process of consolidation . What this study has added to knowledge has been a better understanding of the process by which some settlements have achieved better functioning social ties and better standard of houses, communities and neighbourhoods. In this process spatial configuration itself is the primary spark, setting in motion influences that affect the physical and social well-being of developing neighbourhoods.

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For further information on the research project and detailed analysis see Hillier et al (1998). The graph depth measure can be generalised as mean depth and calculated for every line in the system. This is used to calculate a comparable measure of 'integration' for each line as in the equation 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. A further adjustment is made to allow for scale differences between axial maps, as shown in the equation below: Where RRA is the real relative asymmetry, D is the RA value for the root of a diamond shaped system. It should also be noted that the values produced by the computer programme 'axman' or 'orange box' (as used in this study) are reciprocal values so that higher numbers are more integrated. The main model of Santiago involves more than 30,000 axial lines. The base maps used for the creation of the axial analysis of Santiago correspond to the Instituto Nacional de Estadísticas (INE) archives, scale 1:5000 updated to 1993. Further checking of the model was undertaken using Local Authorities maps, Plano Guía del Gran Santiago, and on site surveys. It is worth noting that the geographical centrality of the settlement did not inevitably lead to it being the core of integration. As part of this correction process, a pilot study was carried out in 'Ampliación La Higuera' a NUP settlement located in La Florida, Santiago, where both the tools and the instruments to collect data on site were tested. For further information on this stage of the research, see Desyllas et al (1998) Poverty here has been measured as percentage of the population below the Unsatisfied Basic Needs line (UBN). Nevertheless, a further checking of the data found out that some surveyed families had arrived to the settlement after the implementation of the NUP. The final analysis excluded these families, and was done on the 434 surveyed families that were original NUP beneficiaries. A segment is considered to be the section of a street between two intersections For practical reasons, only movement on the site and its immediate surrounding streets was observed. Maximum movement rates were calculated considering the highest rate of total observations during the day in a gate of the axial line. Therefore it is not reflecting the peak movement at a given time period, but the highest movement observed in the line. The r-squared for vehicular movement against connectivity was .544 and against radius-3 integration was .485; for adult movement it was .289 against connectivity and .296 against radius-3 integration. Movement rates considered logged maximum values, and integration values were calculated at the 7-km model level and also logged. In the case of adult movement, four lines with less than five movements per hour were excluded. Calculated as the sum of r-squared of vehicle movement and connectivity, plus the r-squared of adult movement and local integration). One settlement, Arturo Prat-Peñalolén, was removed from the sample because of a number of factors which made it exceptional (it has the highest income and oldest population in the sample, lowest proportion of dependants and highest proportion who bought the house after the implementation of the NUP). For detailed explanation refer to Hillier et al (1998). The level of significance was set at $p<.1$ all through this analysis. The formula for this index is the following: EOCA = 10 (shops/plots) + 10 (edge shops/plots) + (edge shops/shops) These correspond to: integration measures (radius-n, radius-9 and radius-3 at the city model level), ln(x) of connectivity also at the city level, synergy, LSA, vehicle ownership and income related variables (monthly, per capita and stability of income). The variables considered were: integration measures (radius-n, radius-9 and radius-3 at city level model, and integration radius-3 at 7-km level model), synergy, LSA, vehicle mean movement and

income related variables (monthly income and spending, income per capita, stability of income). The following variables were considered: income per capita, stability of income, edgeshops/shops, LSA, EOCA and mean vehicle movement. The following variables were considered: LSA, education level of the couple, mean vehicle movement and commercial activity variables (edgeshops/shops, edgeshops/plots, shops/plots and EOCA). For example, Galster's detailed analysis of housing reinvestment in two US cities showed that the quality of neighbourhood social ties is critical: 'Homeowners sense of solidarity with their neighbour is as significant at determining their efforts at home upkeep as are their income or age'. (Galster, 1987)