NEIGHBOURHOOD MOBILITY: A LONG-GONE PARADIGM? APPROACHING “PROXIMITY” AND “LAND USE MIX” USING DATA FROM HOME-BASED SURVEYS

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ABSTRACT

Policies trying to increase walking within urban mobility modal split usually highlight the importance of the functional patterns and the environmental quality of the urban space as major drivers of citizens' modal choices. Functional characteristics would be mainly associated to an appropriate mix of land uses within neighbourhoods, whereas environmental quality would be associated to the characteristics of urban spaces.

The purpose of this research is threefold: first, to identify relevant proxy indicators, which could characterize pedestrian-friendly land use mix and environmental quality. Second, to assess, for both traits, existing disparities among neighbourhoods in a major metropolitan area. And finally, to explore the association between both indicators and children mobility patterns: according to their built environment, which neighbourhoods have a greater proportion of children and, how is their mobility?

Using data from the 2004 household mobility survey in the 128 neighbourhoods of the municipality of Madrid, this paper concludes that potentially favourable conditions at the neighbourhood level seem to have only a modest influence in,mobility patterns , in terms of both, selection of closer destinations and a higher share of walking within modal split. The city's policy choices, with intensive investment in road and public transport infrastructure may explain why short-distance mobility is not as important as it could have been expected in those neighbourhoods with more pedestrian-friendly conditions. The metropolitan transport system is providing mobility conditions, which make far-away destinations attractive to most citizens.

Keywords: urban mobility; household surveys; pedestrians; space syntax.

SCOPE AND CONTEXT OF THE STUDY

The scope of the study

Land use patterns and the characteristics of the urban space have traditionally been considered as having a significant influence on travel behaviour. Neighbourhoods with a rich mix of land uses should be able to better accommodate citizens' needs, keeping more trips within the neighbourhood's boundaries and thus favouring short-distance trips, better suited for non-motorized transport modes. Pedestrian-friendly urban spaces would have a similar effect on users. Those neighbourhoods with both characteristics should be able to attract residents with less car-dependent lifestyles, possibly including households with children.

A review of travel patterns in the neighbourhoods of the municipality of Madrid was made to check how this vision operates in practice, using data from the last mobility household survey (2004). Pedestrian-friendly neighbourhoods should present a significant association of the following traits:

a. A high percentage of intra-neighbourhood trips (internal trips), associated with a high mix of activities and pedestrian-friendly environments.

b. A higher percentage of children (and teenagers below 18) within their residents. Children's mobility patterns in these neighbourhoods were expected to show a higher degree of autonomy, with a higher percentage of internal, pedestrian trips compared to children in other neighbourhoods.

The identification of the variables defining the built environment (land use patterns and urban space) in its relationship with urban mobility has been the topic of substantial research, which substantially follow a "subjective" or an "objective" perspective. Under the "subjective" perspective, the attention is focused on the "needs" of the person, i.e. the factors influencing her travel choice decisions. Under the "objective" perspective, the focus moves towards the characteristics or "requirements" of the built environment to satisfy the needs of particular users. In the case of pedestrians, those needs within the subjective perspective would include walking-friendly conditions (proximity, safety, security, climate protection) and walking-appealing potential (liveability, urban environment enjoyment, multipurpose trips, etc.). The objective perspective would focus on "requisites" such as residential density, land use mix, and public space network characteristics.

The relationships among subjective "needs" and the objective "requisites" still remain far from being empirically worked out (TRB, 2005, 2009; KRIZEK, 2009). An expert- panel (qualitative) approach, within the "La Ciudad Paseable" research project (LAMIQUIZ & POZUETA, 2008), identified some strong, moderate and weak influences among them (see POZUETA et al., 2009, 66).

The debate on the relationship between mobility and the built environment

It should be borne in mind that objective environment requisites are not the only variables affecting citizens' modal choices for walking. Physical variables (climate, topography, etc.), socio-economic factors (life styles, economy, regulations, etc.) and even personal conditions (age, gender, race, income level, car ownership, etc.) have been largely reported to be influential.

A literature review on the relationships between the built environment and mobility shows that the number of relevant underlying factors is limited. However, those are described by a wide diversity of different variables, which have been brought into the scientific discussion at different moments. Chronologically, the variables related to land uses (density and mix of activities) appear at the very initial stages. The first studies are found them to be relevant in determining mobility patterns. This is the case of land use density (generally referring to residents or dwellings), which is found as highly relevant by NEWMAN & KENWORTHY, (1989), but also by BANISTER et al. (1997), and even more influential for soft modes (walking and cycling) (NIEMEIER & RUTHERFORD, 1994). These results are consistent with the primary intuition that denser environments should yield an increased probability of getting potential destinations nearby, and therefore more pedestrian trips. However, more detailed studies such as GIULIANO (2002) are not so conclusive: other factors, such as trip´s destination, would also be influential. This relative loss of relevance of the "density" variable would be linked to the use of more disaggregated data with smaller spatial units, providing for a more detailed analysis, and to the consideration of a wider range of potential influential variables.

The land-use mix variable underwent a similar evolution. At the beginning, an interesting debate took place, on job-housing balance as a means to reduce automobile dependence (CERVERO, 1989; GIULIANO, 1990; LEVINE, 1998). The most popular proxy to this variable was the employment to population ratio. None of the studies made in Spain using this ratio got a clear association with modal split (ECHEVARRIA, 1995; LAMIQUIZ&POZUETA, 2008). However, when the job-housing balance is considered in a more integrated way, (i.e. MA&BANISTER (2006), a more clear association is found: In this case, the balance should incorporate some kind of a qualitative dimension (i.e. linked to personal choices). In this way, MA & BANISTER proof that job/housing can be an interesting approach to analyse the consequences of decentralization processes on mobility. Using a different approach, more complex measures have been introduced to improve the description of the built environment, such as the entropy index (KOCKELMAN, 1997) or the dissimilarity index (YANG & FERREIRA, 2005; HORNET & MARION, 2009). As in the case of job/housing balance, they have the intention to form synthetic description standing for built environments types. On the other hand, the definition of measures based in the access to activities for individuals (i.e., KITAMURA, 1997), could be considered a complementary approach for the mix of land uses. However, when compared independently, variable to variable FRANK (2007) found that this way of accounting for land use mix is still less related to mobility than density (considered alone).

A step ahead in order to account for land use influence is the definition of "walkable environments", that is to say, places that better suit pedestrian needs. McNALLY &

KULKARNI (1997) may be considered as one of the firsts to related mobility patterns to specific urban tissues (traditional, planned and mix neighbourhoods), More developed approaches to this are the new concepts of "pedestrian friendly environments", "LADUF" (Less auto-dependent urban form) or "neighbourhood accessibility", a synthesis of the characteristics a neighbourhood needs to have to be "walkable" (KRIZEK, 2003). A similar concept, more oriented to policy-making, is the "walkability index", which aims to comprehensively assess the walking conditions in urban areas (e.g. FRANK, et al., 2006)

The idea of the built environment as a combined force on mobility habits is precisely one of the conclusions of a major meta-analysis of the built environment-travel literature. EWING & CERVERO (2010, 11) show that "*relationships between travel variables and built environmental variables are inelastic. The weighted average elasticity with the greatest absolute magnitude is 0.39, and most elasticities are much smaller. Still, the combined effect of several built environmental variables on travel could be quite large*".

Another category of built environment variables is related to the spatial structure or public street network (PSN) characteristics, and it is especially relevant for this study. Public space network factors were proposed early in the 70´s by some researchers such as Martin, March & Echenique, but their development took off later on, based on the availability of Geographical Information Systems (GIS) and geo-data. McNALLY & KULKARNI (op.cit), used some of them in order to define a neighbourhood typology (% cul de sac, % "x" shape intersections, nº of intersections per acre, nº of accesses for each area, etc.). More recently, new studies such as those by KRIZEK (2000), GREENWALD Y BOARNET (2001), SCHLOSBERG et al. (2006) suggest that these indexes have a significant influence on mobility. On the contrary, CERVERO & DUNCAN (2003) or FRANK (op. cit), find that what they call "micro-design variables", such as block size or intersection's configuration, do not have a significant influence on walking.

Within public street network, there is yet another subset or group of factors to be considered, the micro design local ones. Broadly speaking they refer to those elements directly perceived by the pedestrian such as facades, pavements, greening, traffic conditions, etc. It is hard to find empirical, comprehensive studies about their influence on mobility. Some exceptions are GEHL (1981) on the influence of creating pedestrian schemes in Copenhagen and other cities or GIL (2003), on the relationship of the ground floor configuration and pedestrian use in Madrid. The obvious limitations of these factors are their close relation to the direct experience of people while walking. Hence they are more difficult to quantify, especially for mobility studies analysing an entire metropolitan area, in spite of offering a closer relationship to the attractiveness of the urban space. It can be argued that they are more relevant to the no-mobility-related use of public space (in the sense of W. White or J. Jacobs) than to transport modal choice.

Finally, a common problem found in studies on the built environment and mobility, is the issue of residential self-selection. This has been revisited since HANDY et al. (2006) and recent studies such as EWING & CERVERO (2010) or ADITJANDRA et al. (2012), proved that the influence of built environment is pervasive and independent of this factor.

Therefore and following this review, two groups of variables are selected for the description of the built environment: land use, its density and mix, and public space network. They offer a global description of the built environment sufficient to carry on this study and they are helpful to analyse the effect of a new measure of PSN, the configurational accessibility of the network.

Configurational Accessibility to PSN and "Space Syntax" theory

In this paper, the description of the Public Space Network (PSN) concept provided by the "Space Syntax" theory is followed, under the name of "configurational accessibility". Generally speaking, configurational accessibility indexes describe intrinsic network properties, which have an influence on the network's use.

This sort of function has been related to land uses at least since the theory of Von Thunen about the differential rent of rural land. Already in the XIX century, this author claimed that lands' rents are related to their distance to the markets where agricultural products could be sold. This concept was applied to transport models many decades afterwards by Willian Alonso's "Location and Land Use: Towards a general theory of land rents" (1964). Nowadays, there are quite a lot of accessibility indexes in mobility studies. BATTY (2009) makes a systematic and useful classification of them into three types, depending to which of the elements take the major role or which ones are involved. All these approaches consider spatial activities (i.e. Land Uses) as the key explanatory factor, and the spatial networks as an impedance making accessibility more or less difficult, Space Syntax, on the contrary, focuses on the network, considering it as a potential generator of mobility and not merely as a channel (HILLIER et al., 1993, HILLIER, 1996), therefore as a provider of new opportunities to its users. Space Syntax measures accessibility just within the network, i.e., from one street to the others, regardless of which users or opportunities are connected by this network. This change of perspective offers a sharp distinction between the network and the other elements of the built environment (i.e land uses).

As a theory and research field, Space Syntax is in fact rooted in the previous work by Phil Steadman and others, during the late 1970's focusing on the relationship between society and urban morphology. Its main contribution probably is the systematic description of human spatial habitats, providing for a rigorous and quantitative methodological approach. The key element for this sort of description is what was called their 'syntax' or after and probably in a more purposeful way, their "configuration" (HILLIER, 1996, 1).

Within configuration's theory, topological and angular-geometrical distances replace metric distances (or travel time) as impedance factors (HILLIER, 2009). In fact, this theory's more distinctive way of measuring distance is called "depth", the amount of changes of direction necessary to go from one street (or, more appropriately, visual line) to another. Systematically measuring depth in this way, it is possible to get one of the most important families of measures in this theory: integration. This is basically defined as the inverse of the mean depth from one axial (i.e. visual) line to other lines in the system. If the mean depth is small, the element will be central, close to all the others; if it is big, it will be far, segregated from them.

It is argued that introducing Space Syntax measurements in mobility studies could help to overcome the shortages of current design or street network variables, which are significantly less developed than the ones associated to land use patterns. One example is the use of "street connectivity" by North American governments in their development review process. A formulation of this factor is included in "LEED for Neighbourhood Development Rating System", and it is being increasingly used to test the ability of the network of roads and pedestrian paths to support urban sustainability. STANGL & GUIN (2011), have questioned its reliability by proving that using key "obstructions" in the network could easily skew its results. They argue that more complex parameters are needed.

METHODOLOGICAL APPROACH

This study's aim is to describe the influence of built environment on neighbourhood mobility. Its sources are a Geographical Information System (GIS) and a Configurational Model of municipality of Madrid. The first one was carried out for the revision of the Local Master Plan of Madrid, and the second was built for the PhD research of one of the authors. The GIS was fed with mobility data from the Madrid 2004 Mobility Household Survey, with a sample of more than 96.000 individuals for a Metropolitan Region of 6 million inhabitants. The basic disaggregation units were neighbourhoods (average population = 24.706, average area=472 ha).

The two variables related to the built environment included in the study (Land Use and Public Street Network, PSN) were described using as proxies the job/housing data from the mobility survey and the configurational accessibility of the PSN. For mobility, two variables were selected: the proportion of intra-neighbourhood trips (internal trips: a proxy to short-distance trips) within each neighbourhood, and the modal share of walking within all the trips originated in each neighbourhood. Those figures were analysed for the entire population and for children (focusing on travel to school).

The use of a configurational accessibility index ("Integration Radius 5") as a synthetic proxy for the built environment is based on the association of Space syntax with a number of urban processes, including pedestrian flows in cities. PENN & TURNER (2004) claim that up to 80% of the variation of pedestrian flows (i.e. the number of pedestrians passing through a particular point) can be explained thanks to simple measures related to the built environment, such as integration (Hillier et al., 1993; Peponis et al., 1994 and Read, 1996 in PENN & TURNER, 2004). Going one step further, and through its influence in pedestrian flow distribution, it is argued that configuration could even influence land use distribution (HILLIER, 1996, ch. 4), crime location (ibid., ch. 5), or show an important role in how people cross urban grids ("navigation studies"), psychology and the city's symbolic dimension (ibid,. ch. 6). In this sense, a derived and relevant concept (although not used in this study) is that of "Movement economy": the commercial activity supported by the concentration of urban travellers (particularly pedestrians) in certain elements (i.e., streets) of the network as a

consequence of the greater accesibility of the network in these elements. (ibid., GENRE-GRANDPIERRE, 2003).

The study will analyse the differences in internal trips among neighbourhoods, and identify whether the main variables linked to the built environment (land use mix and PSN) have an influence in these differences. The methodological approach includes three steps:

1. A qualitative, GIS-based analysis of the distribution of the percentage of internal trips within the municipality of Madrid, identifying those neighbourhoods with higher values and their common traits.

2. An econometrics analysis to test whether there is a significant association between Configurational Accessibility and Land Use mix and Neighbourhood as explanatory variables and the percentage of internal mobility.

3. To test whether there is an association between neighbourhood characteristics and children's (as a particularly vulnerable and dependent group) mobility.

ACCESSIBILITY AND SHORT-DISTANCE TRAVEL PATTERNS

Although the aim of the paper is not to perform a detailed analysis of the characteristics of neighbourhoods, some land use and PSN indicators will be used herein to present them.

Functional differences among neighbourhoods: density and mix of land use

The first is the population density, a synthetic descriptor of aspects such as the time of development of the district, and also a determining factor for the viability of public transport or for their suitability to pedestrian traffic.

The central area of Madrid has a high building density that, in general, is distributed fairly evenly. However the population density has a much less homogeneous distribution, reflecting low values in significant parts of the urban core, as a result of the migration of residents to the suburbs and its substitution by tertiary activities. Anyhow, the population density in the centre is still generally greater than that of the periphery (between 460 and 110 compared to between 0 and 150 hab. / Ha). The only exceptions to this rule are some particularly dense peripheral neighbourhoods at the northeast and the south of the municipality.

In fact, the central area has been gaining increasing specialization for some years now, yielding significant concentration of employment in some neighbourhoods. In many of the cases, this specialisation has not lead to homogeneous retail or office districts but to more complex areas, preserving in both cases a significant proportion of residential buildings. In order to describe this idea, i.e. land use mix, this factor is approached in the study with two complementary proxies: the employment to resident ratio; and the ratio between attracted

and generated trips, for each neighbourhood. High or low values of these two ratios would indicate high specialisation and limited mix of activities in the neighbourhood, while more balanced situations would referred to land use mix.

Differences in configurational accessibility in the neighbourhoods of Madrid

Figure 1 shows the distribution of the configurational accessibility index (Integration Radius 5), in the axial map of Madrid. It represents the configurational accessibility of the system of visual lines, covering all the publis space network of Madrid. It can be underlined that the map simply depicts the accessibility of the public space network, and it does not include any information of the land use distribution. However, it can be said that the lines in red are tightly related to the system of centres and sub centres of the metropolitan area.

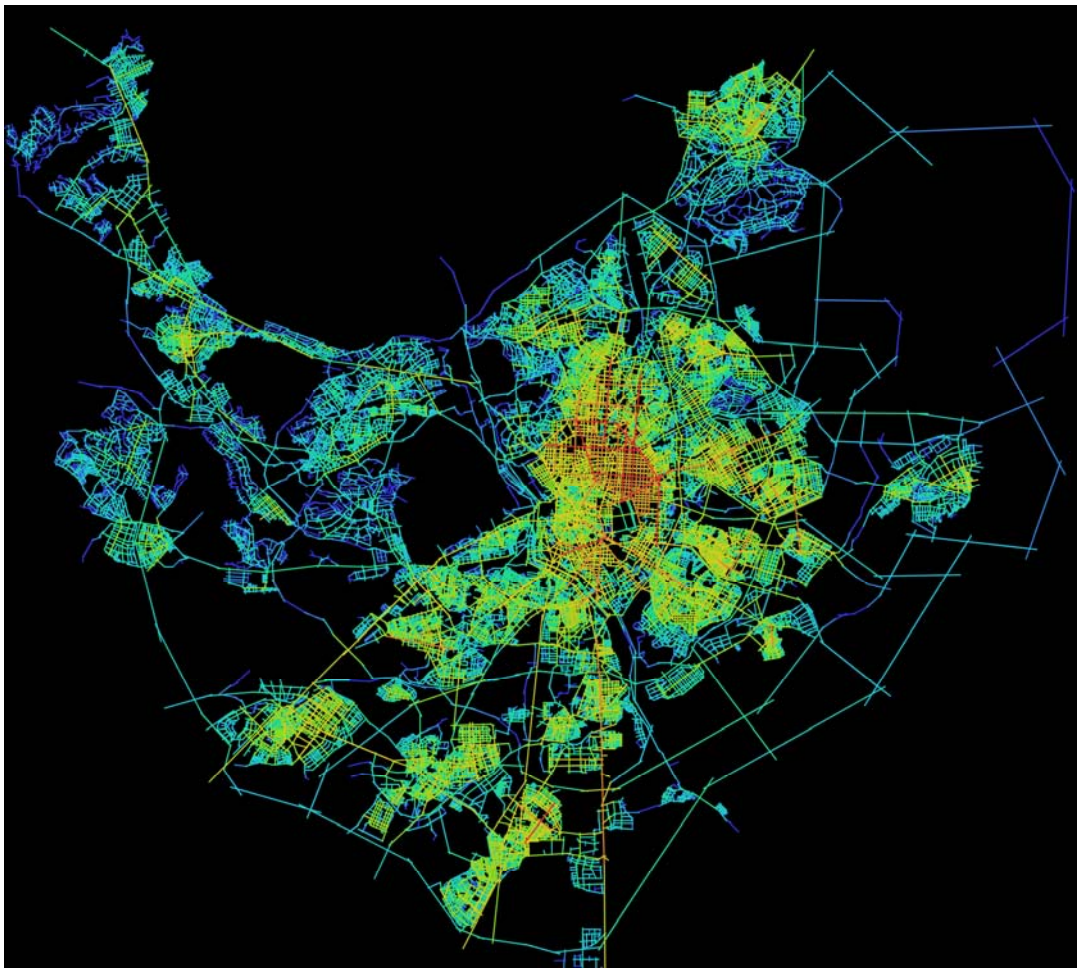

Figure 1 – Distribution of configurational accessibility index (Integration Radius 5), in the axial map of Madrid. It shows the configurational accessibility of the system of visual lines, covering all the public space network of Madrid. Red are most integrated lines, dark blue, most segregated (no information about land uses).

Space Syntax literature shows that configurational properties (and the index used herein, Integration Radius 5) are not just a measure of accessibility but can efficiently be used as a proxy to the attractiveness of the urban environment to pedestrians. From a subjective perspective, this index has been associated to proximity, security and attractiveness, three of the five basic pedestrian needs: proximity, safety, security, climatic comfort and

attractiveness (POZUETA et al., 2009). Configuration is associated to proximity, because the configurational centrality is usually accompanied by a grid intensification (HILLIER, 1999), reducing block's size and shorting actual distance by potential shortcuts. And configuration does reduce perceived distance. The other way round, HILLIER&IIDA (2005) have shown that by increasing the amount of direction changes perceived distance is increased. Even more, in a more subtle way it could be hypothesized that slights change in direction in big axis could misguide people´s perception of distance, making it less aware of big distances in cities, through offering still axial but more amusing routes that make perceived itineraries as shorter.

Therefore it is proposed that the concept of proximity should change, to include not only the usual one, based on distance, but the configurational one. Furthermore, it could be said that this could be important even for modal choice.

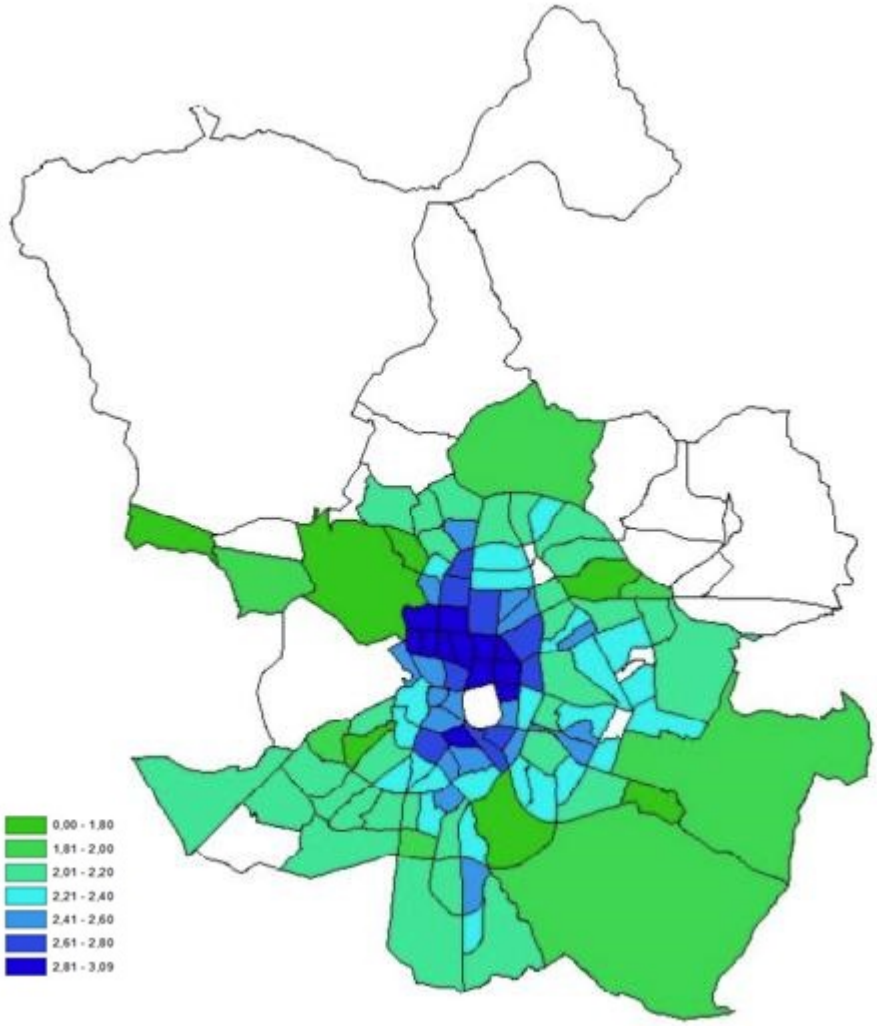

Figure 2 – Distribution of configurational accessibility index (Integration Radius 5), for Madrid neighbourhoods. It shows how IR-5 is associated to the percentage of internal trips, particularly in the upper-right zone of the diagram: neighbourhoods with a high percentage of internal trips tend to have higher values of IR-5.

Therefore, the IR-5 indicator will serve to identify those neighbourhoods better suited to accommodate pedestrian flows, as well as the services and facilities usually associated with

them. The distribution is quite central, and expanding from there to the north and east but the index is able to identify also peripherical neighbourhoods with good conditions for pedestrian flows.

Short-distance mobility, internal trips and walking

Internal trips within neighbourhoods can be taken as a reasonable proxy to the mobility of proximity. While there may be some short trips between different neighbourhoods, the size of the districts of Madrid (average size = 472 ha, hypothetical mean radius = 1.2 km), for a significant part of travel is given within the same (37% of total trips and 76% of pedestrian travel, according to Lamíquiz, 2011) and therefore can be considered as an approximation timely and statistically significant when speaking of pedestrian mobility.

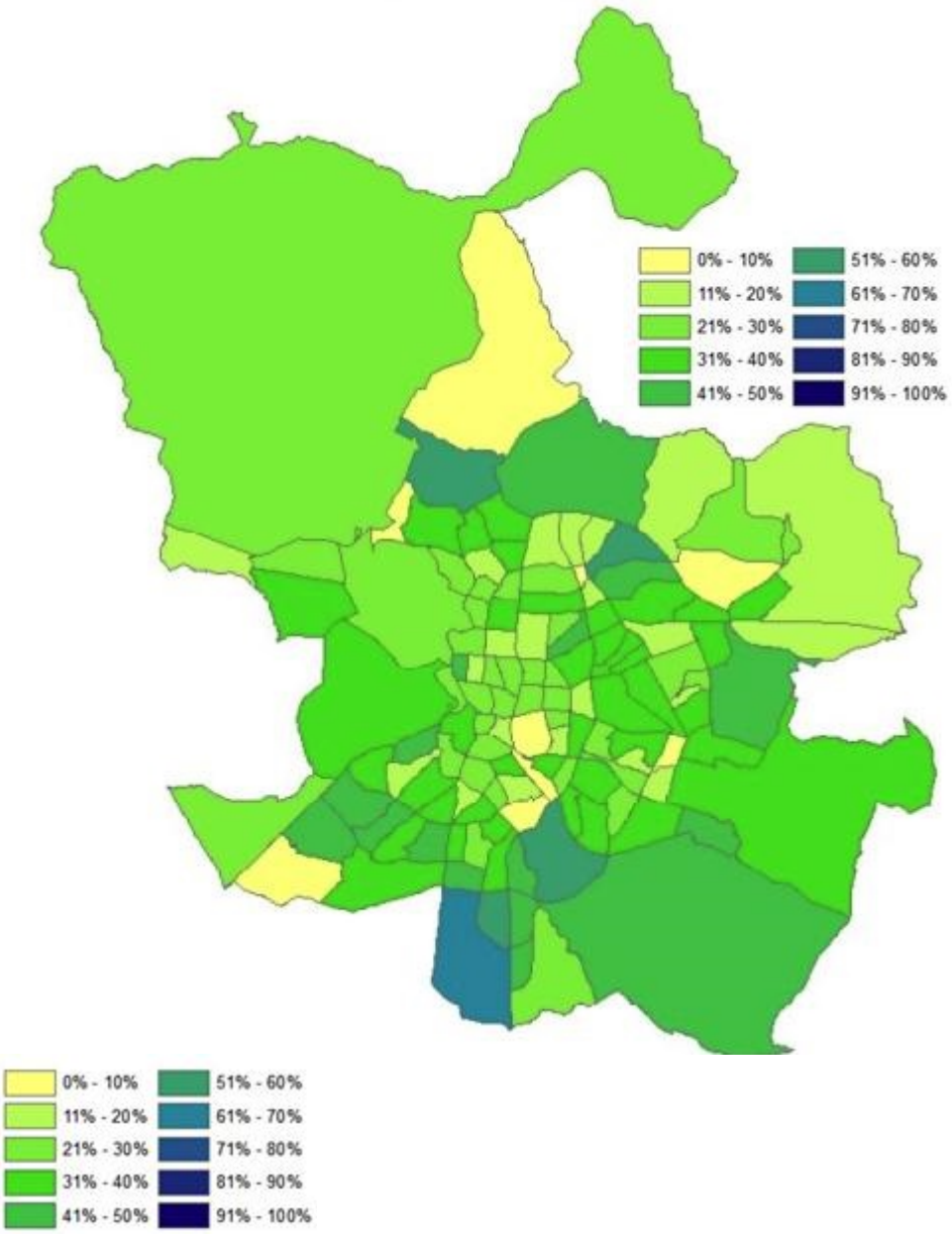

Figure 3 – Proportion of internal / total trips, for Madrid neighbourhoods

While considering the percentage of internal trips (figure 3), it is necessary to bear in mind that large-surface neighbourhoods (located in the outer periphery of the municipality), could be more likely to show higher values. Otherwise, higher values usually correspond to consolidated neighbourhoods with significant residential activity, whereas low values are associated to low residential activity, particularly in neighbourhoods including extensive green zones or large metropolitan infrastructures. Not surprisingly, high internal trips are closely associated to a high pedestrian split in modal split, since 82% of internal trips are done on foot.

ECONOMETRIC ANALYSIS.

Table I summarizes the 6 variables considered in the econometric analysis for the 128 neighbourhoods of Madrid. Average values correspond to the average of the 128 neighbourhoods, different from the city average.

Table I – Summary of the variables

	INT/TOT	**IR-5**	**DENSITY**	**EMPL/POP**	**ATTR/GEN**	**CHILDREN**
Unit	Ratio	Dimensionless	Inh/ha	Ratio	Ratio	Percentage
Average	0.45	1.95	157.60	1.377	1.25	13,6%
Maximum	1.80	3.09	455.82	25.477	10.46	40,4%
Minimum	0.001	0.000	0.16	0.029	0.078	0,0%
St.Deviat.	0.268	0.898	112.80	3.27	1.13	0.06

Note on variables (neighbourhoods):

INT/TOT = Ratio of internal / total trips,
IR-5 = configurational accessibility index, "Integration Radius 5"
DENSITY = Inhabitants / Hectare
EMPL/POP = job/housing balance
ATTR/GEN = ratio attracted / generated trips
CHILDREN = percentage of children and teenagers / total population

Overall, the variance explained by the model remains modest (R^2 = 0,204), reflecting that other unexplained factors may have a significant influence on the ratio of internal to total trips. Those factors found to be significant are the following ones:

a. IR-5, the configurational index, as a proxy to the characteristics of the built environment.

b. DENSITY (number of inhabitants per ha), EMPL/POP (the ratio between the number of employments and the residents in the neighbourhood) and ATTR/GEN (ratio between the number of trips attracted and generated in the neighbourhood).

The last variable was replaced by a dummy variable, controlling for those neighbourhoods with extreme ratios (under the 10 percentile or over the 90 percentile), for which the dummy variable takes value 0. These three variables, together, represented the influence of land-use mix.

The main results are presented in table II.

Table II – Summary of the regression results

	Constant	**IR-5**	**DENSITY**	**EMPL/POP**	**ATTR/GEN**
Coefficient	0.262	0.075	-0.001	-0.16	-0.198
Error	0,072	0.030	0.000	0.007	0.059
p-value	0.000	0.014	0.013	0.030	0.001

All the coefficients have the expected signs, except density, with a negative although low value: an increase in density of 10 inh/ha would result in a modest decrease of 0.01 (1%) in the ratio of internal to total trips generated in the neighbourhood. This role of density could be related to the pre-eminence of other combined measures of the effects of built environment, such as Empl/Pop or even IR-5. This was pointed out in the literature review (EWING & CERVERO, 2010) and it is probably balancing the effect of the other variables. The effect of IR-5 is quite relevant: an increase by one unit results in a 7.5% increase in the percentage of internal trips. Unbalanced neighbourhoods (ATTR/GEN = 0) would a decrease of 19.8 point in their percentage of internal trips. High levels all employment compared to population have a similar effect, resulting in a decrease of 16 points in the percentage of internal trips.

Overall, the regression results confirm the expected association among the variables associated to the built environment and mobility patterns: pedestrian-friendly environments result in a higher percentage of internal trips, which are better suited for walking.

A FOCUS ON CHILDREN MOBILITY

The mobility of the different social groups presents particular profiles. As children and teenagers (those under 18) are particularly vulnerable to mobility constraints, the analysis of their mobility patterns and of their residential patterns within the city was considered as a complementary approach to the identification of pedestrian-friendly neighbourhoods.

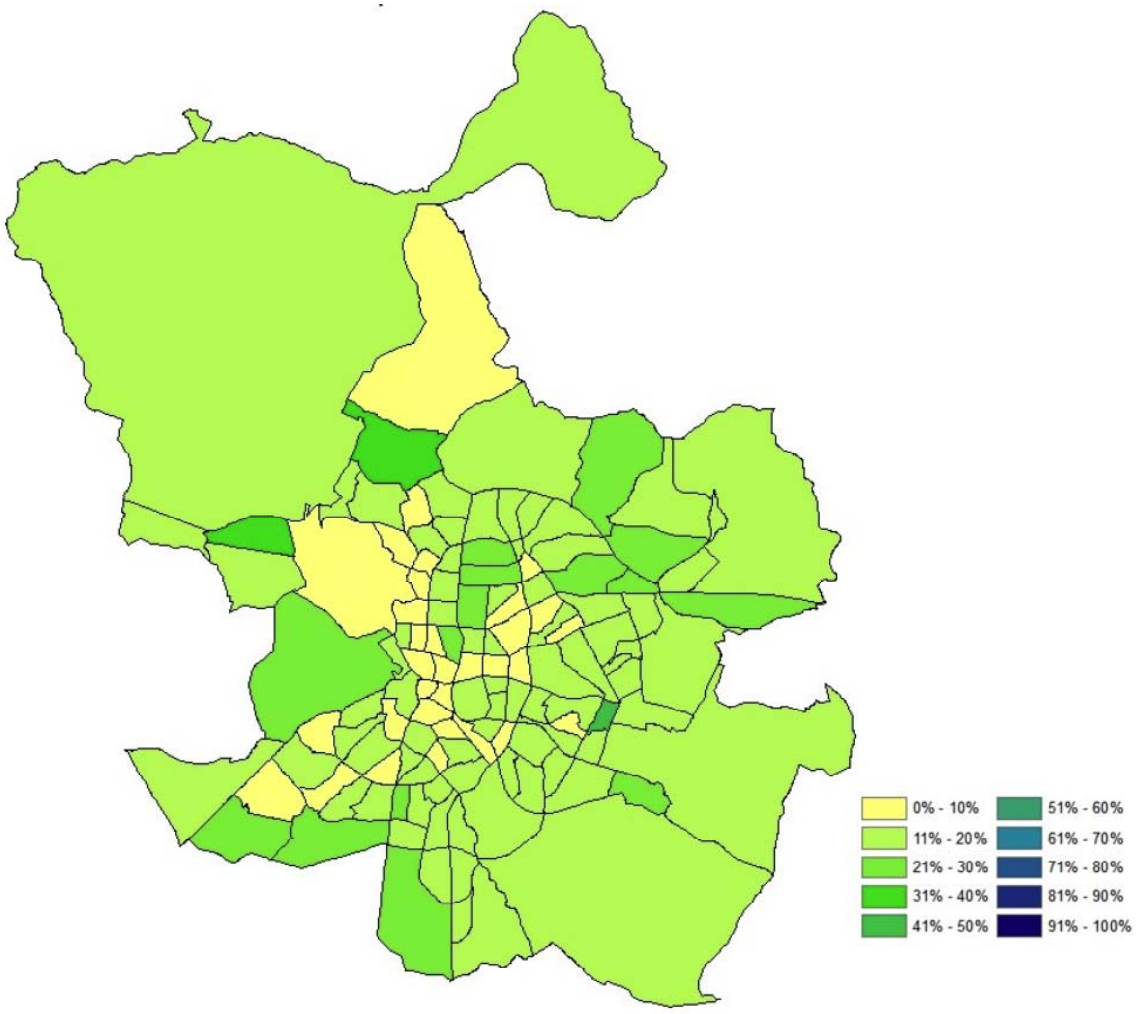

Figure 4 – Proportion children and teenagers (4-17), for Madrid neighbourhoods

The percentage of children and teenagers is presented in Figure 3. Surprisingly, they largely overlap with some neighbourhoods with the highest proportion of travel by car: furthermore, the Pearson coefficient among this variable and the ratio of internal to total trips is extremely low (R=0.02).

At the same time, families with children choose peripheral neighbourhoods: mean children population ratio in the central almond of Madrid (within the M-30 ring road) is 11,2% while it's 15% for the external neighbourhoods.

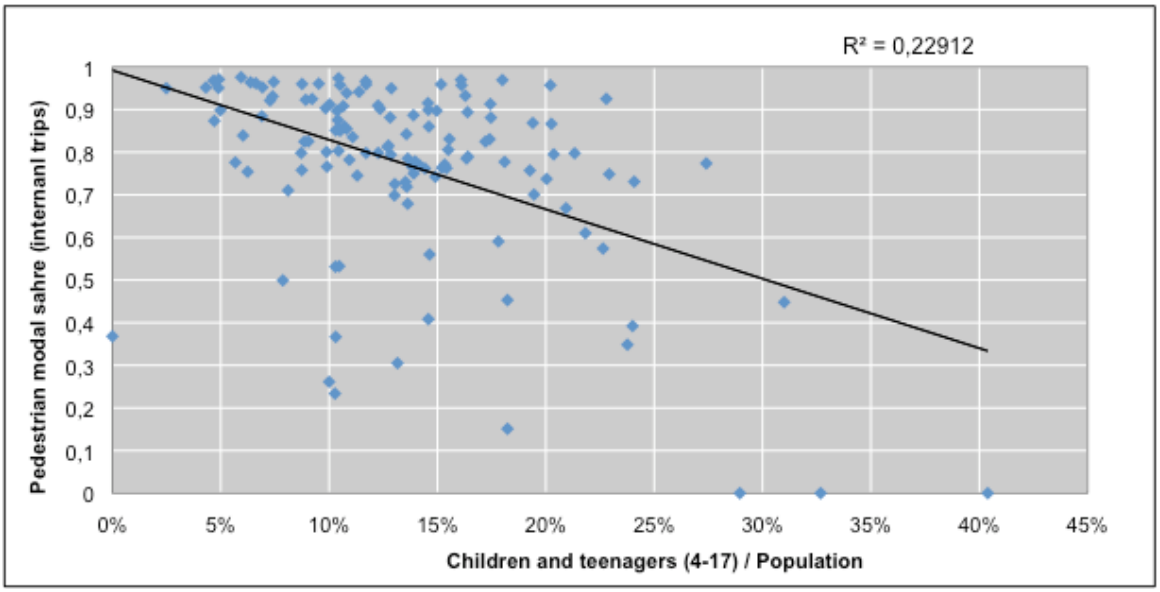

Figure 5 – Proportion children and teenagers (4-17), for Madrid neighbourhoods

As shown in Figure 5, neighbourhoods with a younger populations also seem to be associated with lower proportions of pedestrians trips in the modal share, yielding a significant correlation coeficient of R^2 = (-) 0,2291, the relationship between both variables.

Negative signs in bivariant correlation analysis also show that younger neighbourhoods are less dense ($R^{2=}$= 0,204273544) and have a less accessible configuration (R^2 = 0,084676642) than older ones. The latter means that this kind of neighbourhood is more isolated from its surrounding area and also that they do not to provide the central services and activities at the district level, that tend to be brought in by IR-5.

CONCLUSIONS

The results confirm that, as expected built-environment factors have an influence on mobility, which is reflected in a higher percentage of internal trips (highly associated to a higher modal share for walking) in those neighbourhoods presenting a higher mix of land uses and pedestrian-friendly built environments. However, these factors only partially explain mobility patterns (as reflected by a low R^2 value, 0,20 in the regression analysis).

Land use factor can successfully be described using the ratio of trips attracted and generated by each neighbourhood. However, this variable proved to be better suited to identified extreme situations (as reflected by a dummy variable identifying those neighbourhoods with ratios below or above the 10 and 80 percentiles).

"Proximity" or pedestrian friendly areas can be described using internal rather than pedestrian trips. Both variables are closely associated, and internal trips further reflect short-trips that could potentially be made by foot.

However neither areas with a good level of mixed used development nor pedestrian friendly areas house families with children, whose mobility patterns tend to be more car oriented. Also, their location is increasingly peripheral, choosing neighbourhoods less dense and more isolated from its surrounding area. On the contrary, the activities that benefit from mixed use seem to be central tertiary ones (those with a big proportion of attracted trips) and, at the same time, pedestrian friendly environments populations seem to be undergoing an aging process. Therefore, what seems to be coming out is a process of decentralisation and change in mobility patterns towards more car oriented patterns, whose protagonists are, precisely families with children, so children themselves.

It was also noted that the differences among neighbourhoods were not so substantial, as the large differences in terms of built environment (Space Syntax accessibility in particular) and demographic characteristics of Madrid's neighbourhoods suggested. This is probably due to the big expansion of the primary road network and public transport in the last two decades, which hinders, even in the most dependent -children and the elderly-, the neighbourhood function as a relevant element in the daily mobility.

Finally, it can be said that the findings could have implications both at the policy level, the discussion on the relevance of land use policies on mobility, and also at the methodological one, regarding home based survey data. Some problems such as the underrepresentation of walking trips in data collection have to be pointed out.

BIBLIOGRAPHY

Aditjandra, Paulus Teguh; Cao, Xinju; Mulley, Corinne (2012). Understanding neighbourhood design impact on travel behaviour: An application of structural equations model to a British metropolitan area. Transportation Research Part A, 46 (2012), p. 22-32.

Banister, D., Watson, S., Wood, C. (1997) "Sustainable cities: transport, energy and urban form" in *Environment and Planning B: Planning and Design* 1997, volume 24.

Batty, M. (2009) "Editorial. Accesibility: in search of a unified theory" *Environment and Planning B: Planning and Design* 2009, volume 36, pages 191 - 194

Cervero, R., Duncan, M. (2003) "Walking, Bicycling, and Urban Landscapes: Evidence from the San Francisco Bay Area". *American Journal of Public Health*, Vol. 93, No. 9, pp. 1478–1483.

Cervero, R. (1989) "Jobs-Housing Balancing and Regional Mobility", Journal of the American Planning Association, vol. 55 (2), pp.136-150

Echevarria, D. (1995) Análisis de la influencia de la estructura urbana en la distribución modal de los desplazamientos al trabajo: aplicación a las ciudades españolas de tamaño medio Tesis doctoral en la ETSICCyP, Universidad Politécnica de Madrid

Ewing, R., Cervero, R. (2010) "Travel and the Built Environment. A Meta-Analysis." *Journal of the American Planning Association*, Summer 2010, Vol. 76, No. 3

Frank, L., Kerr, J., Chapman, J., Sallis, J. (2007) "Urban Form Relationships With Walk Trip Frequency and Distance Among Youth", en *Health Promotion*, March/April 2007, Vol. 21, No. 4 Supplement.

Frank, L. D., J. F. Sallis, T. L. Conway, J. Chapman, B. E. Saelens, and W. Backman. (2006) "Many pathways from land use to health: Associations between neighborhood walkability and active transportation, body mass index, and air quality". *Journal of the American Planning Association* 72 (1):75.

Gehl, J (1971) Life between buildings, VNR, NY.

Genre-Grandpierre, C., Foltête, J.C. (2003) « Morphologie urbaine et mobilité en marche à pied », en *Cybergeo: European Journal of Geography*, nº 248, 7 October 2003.

Gil, T. (2003) Influencia de la configuración del borde público privado sobre el comportamiento del peatón. El caso de la ciudad de Madrid. Tesis doctoral leída en el Departamento de Urbanística, de la Escuela Técnica Superior de Arquitectura. UPM.

Giuliano, G. et al (2002) "Another look at travel patterns and urban form: The US and Great Britain."

Giuliano, G. (1990) "Is jobs housing balance a transportation issue?", *Working Paper*, School of Urban and Regional Planning. University of Southern California, Los Angeles, CA

Greenwald, M. J., and M. G. Boarnet (2001) "Built Environment as Determinant of Walking Behavior: Analyzing Nonwork Pedestrian Travel in Portland, Oregon". In

Transportation Research Record: Journal of the Transportation Research Board, No. 1780, TRB, National Research Council, Washington, D.C., pp. 33–42.

Guo, Z., Ferreira, J. (2008) "Pedestrian environments, transit path choice and transfer penalties: understanding land-use impacts on transit travel", en *Environment and Planning B: Planning and Design* 2008, volume 35, pages 461-479

Handy, S. L., Cao, X., Mokhtarian, P.L. (2006) "Self selection in the relationship between the built environment and walking". *Journal of American Planning Association*, Vol. 72, No. 1

Hillier, B. (2009) "Spatial Sustainability in Cities", Key Note, *Proceedings of the 7th International Space Syntax Symposium*, Stockholm

Hillier, B., Lida, S. (2005) "Network and Psychological Effects in Urban Movement" in A.G. Cohn and D.M. Mark (Eds.): COSIT 2005, LNCS 3693, pp. 475–490. Springer-Verlag Berlin Heidelberg

Hillier, B. (1996): Space is the Machine Cambridge University Press

Hillier, B., Penn, A., Hanson, J., Grajewski, T. and Xu, J. (1993) Natural movement: or configuration and attraction in urban space use, *Environment and Planning B: Planning and Design*, 20: 29–66

Horner, M.W., Marion, B.M. (2009) "A spatial Dissimilarity-based Index of the Job-Housing Balance: Conceptual Framework and Empirical Tests". *Urban Studies* 46(3) 499-517, March 2009

Kitamura, R., P. L. Mokhtarian, and L. Laidet (1997) "A Micro-Analysis of Land Use and Travel in Five Neighborhoods in the San Francisco Bay Area". *Transportation*, Vol. 24, No. 2, pp. 125–158.

Kockelman, K. M. (1997) "Travel Behaviour as Function of Accessibility, Land Use Mixing and Land Use Balance: Evidence from San Francisco Bay Area". In *Transportation Research Record* 1607, TRB, National Research Council, Washington, D.C., pp. 116–125.

Krizek, K. J.; Forsyth, A.; Baum L. (2009): Walking and Cycling International Literature Review. Final Report. Department of Infrastructure. Victoria Department of Transport. Australia http://www.doi.vic.gov.au/DOI/DOIElect.nsf/$UNIDS+for+Web+Display/70D43560D1141DDFCA2575E8000BA1EE/$FILE/WalkingCyclingLiteratureReview.pdf

Krizek, K. J. (2003) "Residential Relocation and Changes in Urban Travel: Does Neighborhood-Scale Urban Form Matter?" *Journal of the American Planning Association*, Vol. 69, No. 3, Summer, pp. 265–279.

Krizek, K. J. (2000) "Pretest-Posttest Strategy for Researching Neighborhood-Scale Urban Form and Travel Behavior". In *Transportation Research Record*: Journal of the Transportation Research Board, No. 1722, TRB, National Research Council, Washington, D.C., pp. 48–55.

Lamíquiz, F.J, Pozueta, J.-Dir. (2008) Informe Científico del proyecto de investigación "Influencia de las variables urbanísticas sobre la movilidad peatonal y

recomendaciones consecuentes para el diseño de MODELOS URBANOS ORIENTADOS A LOS MODOS NO MOTORIZADOS: LA CIUDAD PASEABLE" Documento no publicado, DUyOT-UPM y CEDEX, Ministerio de Fomento

Lamíquiz, F.J. (2011): Implicaciones de la accesibilidad configuracional en la movilidad peatonal: el caso de Madrid. Documento sin publicar. Tesis Doctoral Departamento de Urbanismo y Ordenación del Territorio, UPM

Levine, J. (1998) "Rethinking Accessibility and Jobs-Housing Balance", *Journal of American Planning Association*, vol 64, nº 2., APA, Chicago, IL

Ma, K. y Banister, D. (2006) "Extended excess commuting: a measure of Jobs-Housing imbalance in Seoul" *Urban Studies,* Vol. 43, No. 11 2099-2113

McNally, M. G., and A. Kulkarni (1997) "Assessment of Influence of Land Use–Transportation System on Travel Behavior". In *Transportation Research Record* 1607,TRB, National Research Council, Washington, D.C., pp. 105–115.

Newman, P. and Kenworthy, J. (1989) Cities and automobile dependence. An international sourcebook. Gower, Aldershot, UK

Niemeier, D.A. and Rutherford, G.S. (1994). Non-Motorized Transportation, NPTS: Travel Mode Special Reports, nº 3, U.S. Department of Transportation, Federal Highway Administration, Office of Highway Information Management, Washington, D.C.

Penn, A.; Turner, A. (2004) "Movement-generated land-use agglomeration: simulation experiments on the drivers of fine-scale land-use patterning". *Urban Design International* 9:81–96

Pozueta, J., Lamíquiz, F., Porto, M. (2009) La Ciudad Paseable. Recomendaciones para un planeamiento, un diseño urbano y una arquitectura considerada con los peatones CEDEX, Ministerio de Fomento, Madrid

Schlossberg, M, J. Greene, P. Paulsen Phillips, B. Johnson, and B. Parker (2006) "School trips. Effects of Urban Form and Distance on Travel Mode", en *Journal of the American Planning Associalion*, Vol. 72, No, 3, Summer 2006.

Southworth, M. (2005) "Designing the Walkable City" in *Journal of Urban Planning and* Schlossberg, M, J. Greene, P. Paulsen Phillips, B. Johnson, and B. Parker (2006) "School trips. Effects of Urban Form and Distance on Travel Mode", en *Journal of the American Planning Associalion*, Vol. 72, No, 3, Summer 2006.

Stangl, P.; Guinn, J.M. (2011): "Neighborhood design, connectivity assessment and obstruction", in *Urban Design International* 16, 285-296 (Winter 2011)

T.R.B. (2009) "Travel and the built envirnoment. The E!ects of Compact Development on Motorized Travel, Energy Use, and CO'' Emissions". *T.R.B. Special Report* 298. Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption. Transportation Research Board. Washington, D.C.

T.R.B. (2005): "Does the built environment Influence Physical Activity? Examining the evidence". *T.R.B. Special Report* 282. Committee on Physical Activity, Health, Transportation and Land Use. Transportation Research Board. Washington, D.C.

Yang, j., Ferreira, J. (2005) "Evaluating meausero of job-housing proximity: Boston and Atlanta 1980-2000, en D.M. Levison and K. Krizek (Eds) *Access to Destinations*, pp. 171-192 Amsterdam: Elseiver Science & Technology Books.