A quantitative method to measure and characterize the daily functionality of cities

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3. Motivation

The spatial and temporal dimension of urbanization process is not a simple theme. They need first a conceptualization exercises to formulate different theories or paradigm, and then the construction and implementation of a type of methodology to evaluate the defined concepts.

In this sequence, is usual that best conceptualization or methodologies must be modified, because the information (from different sources) has specifics scales, formats, or objectives, different of the required by the formulated theories/paradigm. So, the method must be changed to incorporate these source restrictions.

The principal research problem in my work is to conceptualizing and to evaluate the effects of the daily activity pattern of people (and it change), in the dynamics of the activity location process, and in the formation of spatial territorial activity systems. The daily activity pattern of cities is not a concept widely discussed in scientific literature, although there are some similar names in the classical works in regional science. So there is a first problem of conceptualization and construction of a methodology, restricted to the characteristics of the available information.

The motivation to participate in the ERSA summer school 2011 is due to the level of progress of my PhD research, since I have built a quantitative methodology for a space-time data analysis, to support the next stages of understanding part of the urban phenomena. Therefore, it is very important to have the opportunity to present and discuss the developed methodology (and its results), in a critical context (strengths, weaknesses, validity, etc.) by a qualified public. This opportunity is not achieved in scientific dissemination conferences.
4. Previous and current research work

Previous research works has generated convergent questions to the subject of the population mobility pattern and their relation with the activity location in the city.

A first study (1993) developed an econometrical model for influence area of the metro stations in the city of Santiago (Chile). The model predicts the distance (and direction) that people walk when they leave the stations, based on the activity location in a micro-territorial scale. The calibrated models showed different thresholds of walk distance for different purposes. This raises the question on the validity of this behaviour at an urban scale (macro-territorial).

In the explanation of the activity location in the city of Santiago of Chile, a first master thesis (2001) searches the relation between the competitive behaviour in the supermarket industry and the location pattern. The results show that the supermarket locations, responds to the traditional “cycle of life” of a market product. This cycle started with a phase of introduction (associate to a dispersed location pattern), following with a development phase (associate to a random space pattern), to finalize with the maturity phase (associate to a concentrated space patterns). The different detected phases depend mainly on the space-time behaviour of the demand (residences for supermarket).

The residence location, understand by a system approach (with other activities), generate a second master thesis (2007). This thesis intends to explain the discontinuous urban expansion (sprawl), by a territorial accessibility approach. The result shows that, conceptually there is a clear divergence in the understanding of “sprawl”. The urban sprawl studies have been mainly focused in the physic aspect. The discussion about the discontinuities in the occupation pattern has a second priority, in compared to the analysis and detection of the conditions that allow the urban development far away from the urban centre. The traditional models explain the location of activities considering, among others, a variable of a general accessibility, which definition and understanding are divergent and ambiguous. The investigation raises a new dimension of accessibility (called functional probability), that it is constructed with the population pattern of mobility. This dimension was compared with traditional measures of accessibility (distance, time), in its capacity to explain the spatial pattern of residential densities, in Santiago (Chile) and Barcelona.

The functional probability, in both cities, shows a statistical similarity in travels to shop and to study, but dissimilarity in travel to work. This purpose (work) is highly elastic, in comparison to the inelastic behaviour of travels to shop or to study. The functional probability appears to be the accessibility measurement that better explains the spatial densities in both cities. But in Barcelona, all of the measures (distance, time, and functional probability) are significant. The results are interesting in the sense that Barcelona and Santiago are structurally different cities, since Santiago has more population, is more extensive, and has more number of trips. Also, the structure of Santiago is relatively monocentric versus the polycentrism of Barcelona. In spite of these differences, the percentage of trips purpose and their curves of “willingness to travel” are similar. In both cities the phenomenon of physical expansion coexists with a time contraction (the distance increase, and time decrees).

The above results, based in the functionality of the territory, generated the doubt of the validity of this situation in other cities, and for others land uses. In this context, the current investigation treat to explain the urban structure (spatial concentrations of
different activities) with the daily functionality behaviour of people in the city, in addition to traditional accessibility variables.

The current work is based on the new paradigm of understanding the integration of the mobility (transport) in a social territorial system. This new approach has not developed a method, in comparison with the development of the causal paradigm, represented by in the classic transport model.

The main hypothesis of the current research is that the behaviour of the daily functionality (of people) in the “use” of the city (willingness to travel and to spend time in the different activities), change the spatial structure of non-residential activities in the urban territory. So, technological changes in transport, together with the functional behaviour of people, make possible the physical expansion of the cities (behaviour in travel distance), with a breakdown of the spatial structures of land use (monocentric toward a polycentric structure), but with the contraction of travel time.

The first problem who posed de hypothesis verification is the conceptualisation and quantification of the daily functionality of people in the city. This space-time behaviour of people must be differentiated by purposes (activity), social class, and type of day. The transport mode choice must be a consequence of the spatial structure of activity and the time threshold of access and develop each activity.

Actually, a specific conceptual basis and methodology to understand and measure the daily functionality was developed. The newness of the method is the way (quantitative) to measure and to characterize the space-time operation of social systems in the city, understanding them not only by the trips (mobility), but also by the space-time behaviour of the duration of the activities in different zones of the city. Different synthetic index have been construct to characterize this space-time multivariate behaviour.

The cities (and years) for which information is available for this research are the metropolitan areas of Barcelona (2001, 2006), Santiago (1991, 2001), and Bogotá (2005). Also there are antecedents from other European cities solicited.

5. Short description of career plans

The first step in my career plan is to get my Phd.

My second intention is to stay as researcher at the Centre of Land Policy and Valuations (Polytechnic University of Catalonia). For this reason, I am now preparing (with the research team of the centre) a main research project, to participate in different programs.

The main project to be proposed includes the dynamic (daily) approach of the social territorial system in a metropolitan scale, for different cities in the EU and USA. Any city with a household travel survey (with the travel diary method) is susceptible of being analyzed with the developed space-time method.

There are several potential types of analysis based on the developed method (i.e.):

- Daily social segregation analysis
- Social-activity approach for prioritising transport corridors
Daily activity impacts in the real state values
Organic conceptualization and characterization of the cities

6. Extended abstract of the presented work

A quantitative method to measure and characterize the daily functionality of cities

Abstract
The daily functionality is the form of how people satisfy their needs in the different activities inside the city, throughout the day. Various scientific disciplines cover the matter, but they have problems with the social, spatial, and temporal scale required. The research purpose and apply a method to measure and characterize the spatio-temporal behaviour of the daily functionality. The methodology is based in a trip chain and a time geography approach to processing and to analyze household travel surveys of metropolitan areas. The analysis is for different types of day, activities (work, study, shop, social, etc), and social class. The cities with available information are; Barcelona, Santiago-Chile, and Bogotá. Some results for Barcelona (2001) show a high constriction of time to travel in relation to the duration of activities, and also a high spatial coexistence by certain activities throughout the day (dynamics centralities).

Keywords: space-time, daily functionality

Introduction
The "daily functionality" concept don’t exist in scientific literature. More usual are concepts like centrality or function. The simplest meaning of centrality refers to the point that, given its geometrical position in geographical space, or the provision of communications infrastructure, is able to minimize the effort to reach it from the remaining territory, and in that sense, is susceptible to centralize functions (eg is a good distribution of services).

The function can be defined as all activities that influence each other regularly through relationships that enable the social system to continue operating. Function is thus the equivalent of activity. Activities can be of administrative, commercial, industrial, tourism, etc., so that each centrality (good connection point) can concentrate one or more activities.

The functionality is the interaction that is generated between parts of the city, to meet the needs of located residents and activities. The functionality (or interaction) usually proceeds through flows of matter, energy, information, and people between the nodes (functions). In other words, is affecting by how people are willing to use their time for travel, to choose their destinations and routes, in the daily routine.

In this sense, the daily functionality is the form of how people satisfy their needs in the different activities inside the city throughout the day.

Various scientific disciplines cover this matter with different approach, like as the use of time, the use of space, and the integrations of both. But there are some problems
in their approaches, in terms to respond to the social, spatial, and temporal scale required by the daily functionality of cities. Some of these problems are:

- The research on time use has mainly an individual approach, without representation for the entire population [6].
- The current activity-based paradigm of transportation research examines how aggregated human phenomena emerge from individual activity participation in space and time [1]. Despite this intention, the studies are based mainly on time (travel and activity), and the sequence of activities carried out by people in the day.
- The social and anthropological approach of the use of space also has mainly an individual approach. A new theme has emerged in this line of research, who studies the use of spaces to access to activities [4], but with the same social scale (individual).
- In the well know land use transportation model (LUTM), the daily dynamics view is unusual [3]. Also the accessibility concept, used in this and in another type of models, is divergent and ambiguous [2].
- The use of space and time represented in the “time geography” approach (Hägerstrand, 1969), is a powerful conceptual and analytical basis for the understanding of urban social phenomenon [5][1], but mainly with an individual approach.

**Purpose and methodology**

A simple approach to understand and to characterize the behaviour of the people in the city throughout the day, is to recognize that it has two analytical dimensions (space and time), and two physic actions (to access and to develop the activities). So, the combination of both (dimensions and actions) characterized de daily functionality in terms of “time to access”, “time to develop (duration)”, “space to access”, and “space to develop” the specifics activities [2].

The purpose of the present research is to measure and to characterize the spatio-temporal behaviour of the daily functionality of people, by different activities and social class.

The methodology applies a trip chain and a time geography approach to processing and to analyze household travel surveys of metropolitan areas.

The following process has been applied to the travel surveys to obtain quantitative measure of the daily functionality:

- The applied trip chain approach to the travel survey has two objectives; the first is to allow the validation of the travel database, in order to identify time and spatial codification mistakes. The second is to construct (or to validate) the information about the time that each passenger spends in each activity (associated with the trip purpose), information which was not incorporated in some surveys. So, the first step was constructing the trip chain for each person. With the final trip chain was building the sequence of activities every 30 minutes (the activity being developing at each half hour).

- With the activity sequence database was building the daily rhythm of the city. This term was generated by the time use research to characterize the sample of people to be analyzed. Represents the distribution of people (number and/or
percentage), in different activities, at every half hour of the day. Travel is considered as an activity.

- With the activity sequence database also was building the **daily spatial rhythm** of people in the city, which is the spatialization of the daily rhythm. The query is where are people, developing what activity, in every half hour of the day. The result is a temporal space density of people by activity. This information is valid only when the travel survey has a good spatial representation of travellers.

- While travel is one of the activity that people develop throughout the day, with the activity sequence database also was building the **daily flow rhythm** of people in the city, which is the spatialization of travels from the daily rhythm. The approach here is like the dynamic traffic assignment methods, but in this case the different matrices are instant matrices (how many people are travel between each O/D, in each half hour of the day, by each activity). The results are temporal distribution matrices, by activities. These matrices were assigned to the transport network, with an “all or nothing” method without capacity restrictions. The intention here is to characterize main corridors, and not to apply a traditional transport assignment model. Finally, the process generates temporal flows (by activity) in the structural network of the metropolitan area.

The above processes was applied for different types of day (week and weekend), activities (work, study, shop, social, personal, leisure, etc), social class (educational level as a proxy), and specifically for people over 16 years old.

To characterize the daily functionality, different synthetics indexes (or analysis) have been applied.

**Final remarks**

The developed space-time method achieves a good measurement and characterization of the daily functionality of cities. The synthetics indices constructed based on the different space-time results show a dynamics dimension of the behaviour of the different activities in the city, through the behaviour of people who develop it.

The validity and reliability of the results depends directly on the basis of the travel survey to be used.

The functional approach generates several arguments to be highlight.

- Several studies of travel time traditionally use the average travel time [7], but as shown, the travel time is a random variable of mobility, whose statistical distribution is usually not symmetrical. So, it would be wrong to use the average time as a representative value.

- The social view of travellers, with different purpose, in the form of how they use the city in space and time, is a more real criterion to take account in different politics decisions, like as prioritising different transport corridors, doing the analysis of who uses them, for what, and in what time, or to evaluate the main projects inside a master plan of the city.
The dynamics view of the city gives more information to be included in the planning and management process, to pre-evaluate desirable or not desirable situation in the city.

It is necessary to rise that the work, as an activity with a singular behaviour, must be understood not as a normal activity in the city, sons as a factor that is the human interface necessary for the functionality of cities. If this human interface does not exist, the city could not perform its functions (processing, trade, knowledge, etc). Hägerstrand named this restriction as “coupling restriction”

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