Time, urban routines and New Information and Communication Technologies. Some insights by means of a MAS model

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Abstract

Time has a major role in cities. It is argued that the kind of changes taking place in today societies involve a greater attention to time from both a substantial and methodological perspective. To support this argument some results of a MAS model are illustrated which deal with the impact of the introduction of New Information and Communication Technologies on urban routines. In the model different notions of time are included which reflect the intrinsic complexity of the role of time in cities.

1. Introduction

Time plays a manifold role in cities, i.e. it allows for urban morphology to be shaped, it imprints hallmarks on the architectonical, physical and cultural components of urban landscapes, it is twin to the space dimension in the deployment of the trajectories in urban evolution.

Also because of the institutional, socio-economic, and cultural changes now occurring in most developed countries (see Castells, 1989, 1996), the ways cities understand and manage time are modifying. Space-adjusting technologies (the so-called New Information and Communication Technologies), in particular, are deeply influencing both the range and temporal organisation of activities offered in an urban setting and the ways individuals participate in them (Janelle and Hodge, eds. 2000, Graham and Martin, 1996, 2002), i.e. at an individual level, the spatial behaviour of households and businesses is becoming more heterogeneous and diversified, while, at the meso-level, more complex patterns of interaction and timing of activities are emerging. One major consequence, which is also particularly crucial from a planning perspective, is that several time-dependent urban phenomena, such as traffic congestion and the temporal ordering of activities are increasingly difficult to control (Occelli, 2000).

On a more general ground, the above features can be related to the more general topics accounting for the complexities of urban systems (Bertuglia and Staricco, 2000, Portugali, 2000, Pumain, Sanders and Saint-Julien, 1989). Although these are not the subject of this note, the recognition of the role of time in generating these complexities is worth being given further attention.

In this respect, the following discussion is articulated into two main sections.
The first recalls some main perspectives of the treatment of time in the analysis of urban phenomena. A few city profiles are also mentioned which show how the differences between cities which can be identified according to socioeconomic features also imply different notions of time (and accessibility).
The second deals with urban routines and analyses how these may be modified by the introduction of NICT, i.e. by substituting physical interactions (i.e. time-consuming commuting) with virtual contacts (tele-working). Some results of the application of a MAS model which has been recently developed at IRES to deal with work related urban routines in an artificial environment are presented (Bellomo and Occelli, 2000, Occelli and Bellomo, 2003). In the model, several notions of time are included, which refer to its substantial and analytic components. Attention is focussed in particular, on how the consideration of the co-existence of different time horizons in the agents' behaviours affect the resulting spatio-temporal outcomes at the city level.
A general argument pointed out by discussion is that individuals' cognitive abilities may introduce an additional perspective in the treatment of time likely to yield new *complexes* of temporal entities, according to which urban routines are construed and modified. In addition, by influencing cognitive abilities, NICT may also have a role in the formation of these temporal complexes.

2. Notions of time and city profiles

In urban analysis, the treatment of time usually involves two often intertwined components:

- The first, which can be called substantial, refers to the intrinsic value of time as an entity which matters for the current living of individuals, also because it is associated with biological constraints (i.e. those defined by one's biological clock and life span). Time, therefore, can be considered as a resource which is important for individuals as much as other natural, economic, social, natural and cultural resources. The notion of value of time conventionally referred to in urban economics and that of time use in human geography and economics of household production are well known examples in this regard (see Merz J., Ehling M. eds., 1999).
- The second, which can be defined as analytic, concerns the reference dimension intrinsically associated with time as a 'locational and co-locational continuum' (see Carlstein, Parkes and Thrift, 1978). This involves the recognition of specific features of time, depending on the scales of observation (i.e. short, medium or lung run), approach of analysis, (i.e. comparative static or dynamics), type of measurement, i.e. discrete or continuous, direction of the time ladder, i.e. irreversibility of time. According to this component, therefore, it is possible to specify the kind of processes underlying urban changes, i.e. slow and fast

processes, and their related features, i.e. recursion, discontinuities, path-dependence.

Building on these components, a number of perspectives for dealing with time have been developed in the analysis of urban phenomena. They refer to[1]:

- Periods, i.e. the time perspective marking the developmental process of city evolution in history. For each period, therefore, specific conditions can be identified, i.e. level of technological progress, type of social organization, war, which constrain the overall kind of urban changes. Period effects, therefore, impact the whole city at the same time, determining the specific conditions experienced by its population and economic system.
- Life-cycle, i.e. the time involved in the ageing of living entities, i.e. population, firms, institutions, as well as well as non-living ones, i.e. buildings, landscapes. Biological changes occur with age. Many demographic changes, i.e. household formation, retirement, and certain urban processes, i.e. migration and residential mobility, also depend on life-cycle. Ageing also affects the built stock in cities. With passing time, dwellings suffer deterioration, become obsolete and may undergo an occupancy transition.
- Longitudinal marks, i.e. the differences between cohorts that persist over time. The weaker competition in the housing market and school which has been observed as a result of the small size cohort of population born during the war and the differences in the filtering rates of different vintage dwellings are instances of cohort effects.
- Routines, i.e. the periodic repetition of actions in time (and space). As a result of both the internal biological constraints on human behaviour and social practices prescribing the timing and locations of events (i.e. work, school), human movements are organized according to rhythms which are also spatially constrained by the maximum distance limits between urban activities. These limits, however, depend on the level of technological progress. This latter, in fact, modifies the time required by each activity and can reduce the time required to move among places, thus altering the time individuals spend in the various activities or in travelling greater distances.

A point which has been emphasized is that the complexity features which are recognized for several urban phenomena are not simply time dependent, but derive from the interplay of several time perspectives, i.e. certain urban phenomena have own differential time perspectives, whose interaction can generate those complexities. As a result, criticalities and bifurcation may be produced in the developmental trajectories of a city (besides those which may be caused by exogenous impacts of random events).

One fundamental concept in urban analysis which is most sensitive to time is that of accessibility as this depends on: a) the functional and spatial organisation of activities existing in a city *over time*, b) range of interaction choices, which, at *certain times,* are available to an individual because of his/her own capacity and

[1] A discussion of these notions is detailed in Myers ed.(1990).

resources and c) types of urban routines which are established, followed and consolidated in space and time.
If we adopt a developmental view of cities, for example, one might argue that the more complex notions of accessibility and of its time components in today city is associated with the many changes accompanying the evolution of urban systems, and with the increasing complexity of phenomena one is able to observe (Bertuglia and Staricco, 2000, Portugali, 2000).
This is particularly evident, for example, when we contrast the descriptions of the Fordist and Post-Fordist types of urban development, see Tab.1[2].
Unlike the latter, the Post-Fordist city can be understood as an information-based spatial system characterized by an increasingly wide range of social, cultural, economic and functional relationships, animating the city life.
As a result, also the urban routines in which individuals currently engage in order to partake to the urban activities become more varied and diversified, both at an individual level and across a population. In this respect, one major endeavour in the Post-Fordist City, relates to the structuring, updating and consolidating of these routines over time.
In addition, the kind of 'time-space shrinking' made possible by the diffusion of the New Information and Communication Technologies (NICT) (Couclelis, 1996, Occelli, 2000), is likely to deeply affect both the features of urban routines and how they will be effectively carried out in the various urban environments.

3. Urban routines and NICT in a MAS model

Urban routines are based on a notion of action-spaces within which individuals currently live[3] (see Golledge and Stinson, 1997). Fig. 2 depicts a daily profile of an individual's action space. This, of course, can be modified according to both changes in the individual's time-budget and activity patterns (i.e. changes in the operating hours of existing services, provision of new population services, etc.) and technological progress (i.e. the possibility to communicate at a distance as a result of the introduction of NICT).
Of course, other kinds of action-space profiles can be identified whenever we consider different time horizons. Indeed, the fact that low and fast processes of change underlie the evolution of urban phenomena is a well established notion in dynamic approaches to cities (see for example Bertuglia, Leonardi and Wilson, eds., 1990 Clark, Perz-Treio and Allen 1995).

[2] The city profiles show how the differences which can be identified according to their socioeconomic and functional features also imply different notions of time, spatial patterns and accessibility. This association relies on the assumption that spatial patterns cannot be fully understood without taking into account the socio-economic and interaction structure underlying it. The spatial features relate to both components of spatial systems, i.e. the spatio-temporal pattern of activities as well as the spatio-functional pattern of interdependencies.
[3] The notion of action spaces was originally introduced by the Swedish geographer Hagestrand in the fifties. Now it is gaining increasing popularity, also because of the increased availability of survey micro data for their description and computing potentials for their analysis.

Table 1 A meta-typology of urban systems in an evolutionary perspective

FEATURES	*Pre-industrial city (merchant and agricultural based society)*	*Fordist city*	*Post-Fordist city*
Socio-economic and institutional aspects			
Production sectors	Agriculture, electrical machinery, steel ships	Cars, armaments, consumer durables, petrol-chemicals. Mass production	Computers, capital goods, telecommunications, optical fibres
Tertiary sectors	Domestic services, state and local bureaucracies, growth of transportation and distribution	Growth of social and financial services. Decline of domestic services	Expansion of information services. New forms of craft production
Infrastructures	Canals, railways, roads	Electrical cables, highways, airlines, airports	Digital communications network, satellites
Social organisation and population trends	Rigid class divisions. Urbanisation, high population turnover	Unified class formation and parties. Concentration of population in urban areas	Pluralistic class formations, multi-party system, regional diversification. Counter urbanisation and ageing of population
Aspects of regimes of regulation	Craft unions and early social legislation	Welfare state and its crisis	New-style of participatory decentralised welfare state
Spatial aspects			
Settlement pattern and urbanisation processes	Isolated, small settlements with stable population	Formation of polarised, high-density agglomerations. Marginalisation of peripheral areas	Metropolisation, edge cities, dispersed, polycentric settlements of various size, network of cities
Type of interaction	One-to-one. Open non connected network	One-to-many. Radial network	Many-to-many. Interconnected network
Determinants of accessibility	Physical distance and transport. Place-based determinant	Cost of movement, centrality, transport means. Person-based determinants	Time-space opportunities, physical vs. virtual interactions
Major urban issues	Housing and health conditions	Employment, cost of opportunities, resource allocation urban growth	Environmental sustainability, quality of life, urban performances, city competition

In the following, we will hint at an application of a Multi-Agent System (MAS) model, in which changes in the urban routines engaged by individuals for partaking to work are investigated as a result of the introduction of NICT.

SimAC (Simulating Accessibility) is a MAS model which is being developed at Ires to investigate new model capabilities for dealing with commuting, accessibility and telecommuting adoption (Bellomo and Occelli, 2000, Occelli and Bellomo 2003).
The city dealt with by SimAC is the city of everyday life, where ordinary people live and operate.
In this world, furthermore, agents are not blind avatars, but they are supposed to possess a few cognitive abilities, i.e. they have certain perceptions of their urban environment and these guide their spatial behaviour. As a result, they are aware of their action spaces and have a certain capacity to evaluate their performance.
This featuring of agents, which ultimately depends on their ontological properties, underlies the idea of self-organization in the urban environment simulated by the SimAC model.

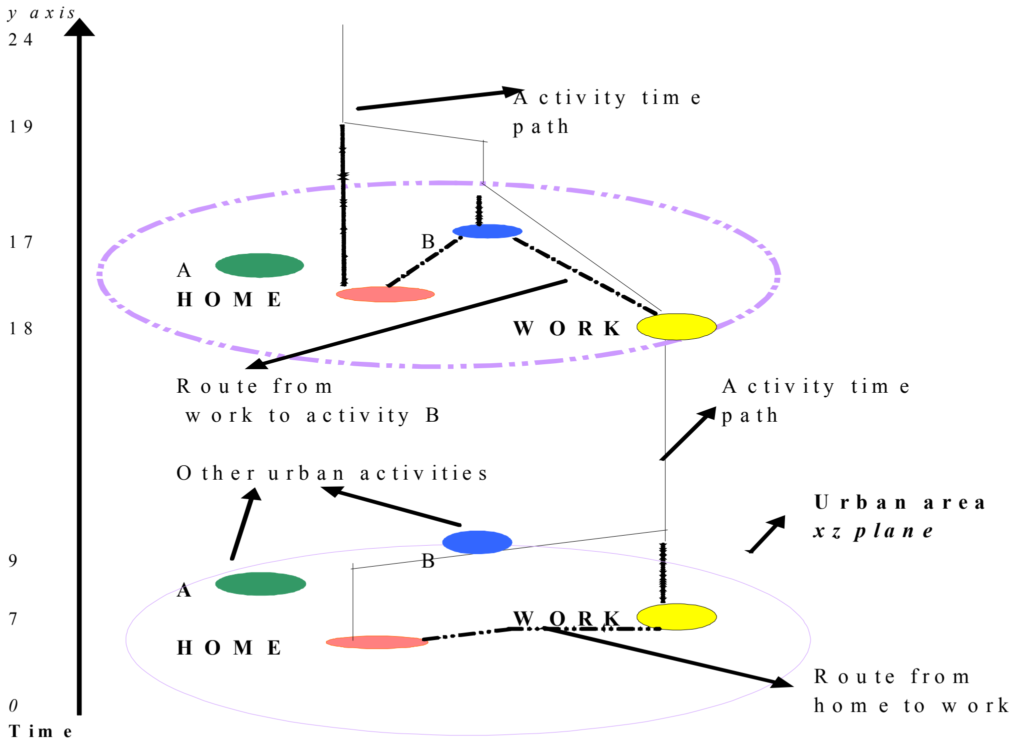

Figure 2 A scheme of an individual’s action space

Three types of agents populate the artificial world, i.e. Inhabitants, Localities and Whisper, see Tab. 2 (a detailed description of the model is in Occelli and Bellomo, 2003).
INHABITANTS: These agents mimic certain features of mandatory mobility behaviour of individuals in an urban setting. Inhabitants daily commute in order to get to their workplace. This shapes their action space and determines their accessibility. Inhabitants are able to make an evaluation of their accessibility and to modify their travel path accordingly. They also have the possibility to telecommute. This decision depends on both drives and constraints, acting at individual and system

levels (Mokhtarian and Salomon, 1994). The drives depend on the individuals' action spaces. The constraints are both external, i.e. the availability of telecommunication networks and labour regulations, and internal, i.e. the psychological factors related to the need of face-to-face contacts. Inhabitants' overall dynamics unfolds on two different time scales. Accessibility changes occur on a relatively short time span, while the decision to telecommute is made on a relatively longer one.

Table 2 General features of the profiles of agent types

	Inhabitant agents	**Locality agents**	**Whisper**
Main goal within the artificial world	They have to work. To reach their workplace they have to travel, but can substitute physical movement with virtual contacts	They have to provide employment to INHABITANTS and job accommodations for their employees	He gives prescriptions and recommendations for action to INHABITANTS and LOCALITIES
Role in the artificial world	As they value time, have a time budget and are sensitive to time constraints, they are motivated to reach their workplace as soon and easily as possible.	They have to maintain (improve) a certain performance level in their production activity	He monitors the behaviours of both INHABITANTS and LOCALITIES at a system level
Drives to action	Changes in the commuting time and in the factors underlying their drive to telecommute	Changes in the environmental and socio-economic factors	Variations in the system diagnostic indicators
Communication	They send complaints to the Swarm Manager and receive information from LOCALITIES and WHISPER	They send complaints to the Swarm Manager and receive information from IHABITANTS and WHISPER	He collects complaints (signals) from the Swarm Manager and give information to INHABITANTS and LOCALITIES

LOCALITIES: These agents embody features related to work activity and urban places. In the current version of SimAC, localities refer to workplaces which are spatially 'fixed'. Besides providing jobs to inhabitants, localities have to supply a bundle of job accommodations, i.e. car parking availability, office floor space, telecommunication infrastructure, etc. Localities are able to monitor the behaviours of their own employees as they access their workplace, i.e. they can measure the traffic congestion produced in the surrounding areas.
Consequently, they can introduce more flexibility into working times to contrast the negative externality effects. In order to evaluate their performance, localities take into account their overall revenues and costs. We suppose that these latter depend on a relatively slow changing set of structural determinants, i.e. costs of labour, rents

and facilities and a relatively faster changing set of factors, i.e. congestion, road price, adoption of new information technologies, which are more sensitive to the dynamics of the SimAC world.

WHISPER: This agent does not represent any given physical entity. Broadly speaking, he can be understood as a kind of repository of the tangible and intangible *information pool* existing in a city. On a more practical ground, he may represent an external observer, who is able to observe certain outcome of the behaviours of both Inhabitants and Localities. As he collects and processes, information for policy purposes, he also computes a set of diagnostic indicators of the overall performance of the system. Some of these are used by the Whisper to undertake certain actions, i.e. providing information about the diffusion of the NICT in the population and making available the NICT infrastructures and equipments in the residential zones.

Others may be used to give prescriptions or recommendations.

In SimAC an effort is made to account for the co-existence of different time horizons in the agents' behaviours. Agents are able to put into perspective the changes occurring in their surrounding environment. This means that they have certain 'windows of observation' of these changes, i.e. their decision-making and decision to act may refer to different time periods. Each type of agent, therefore, can undertake his/her evaluation activities considering different time intervals. As a result, agent decisions do not necessarily occur simultaneously, but may be shifted in time. Although the implemented approach is still a group centred view, it nonetheless allows us to investigate how different time scales in agents' decision-making can affect their outcome in the urban evolution.

Figure 3 shows the initial conditions of the artificial environment simulated by the experiments. This represents a metropolitan area, where the spatial pattern is characterized by:

- a central urban core, consisting of six very close residential zones (i.e. the travel times of their transportation network are the lowest). This is surrounded by a transport ring connecting the core area it to the outer ones;
- a set of suburban residential areas on the fringe of the urban core;
- a set of sparsely distributed residential areas located in the outer parts of the area.

Inhabitant agents are almost uniformly distributed over 35 residential zones. There are 2 Locality agents located in the core of the area, which employ the same number of Inhabitants.

Each experiment simulation has a fixed time period consisting of 100 time units (days).

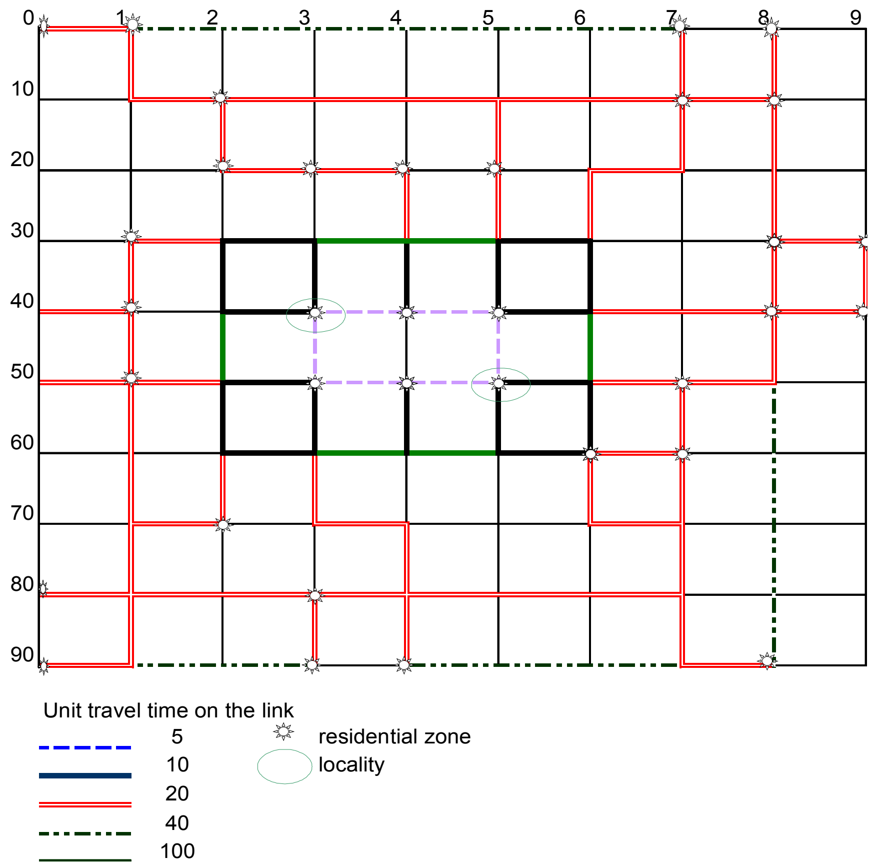

Figure 3 Configuration of the urban environment with an irregular spatial network

Attention is focussed on the results of the adoption of tele-work by Inhabitant agents, considering different widths of agents' observation windows, in an urban environment characterized by an irregular spatial network (that shown in Fig. 3) and a regular network (all the links in the spatial network have the same travel times).
As already observed in previous experiments, the number of adopting agent's increases more significantly in those experiments in which the width of the observation window for the Whisper agent is relatively smaller, see Fig.4.
In these cases, in fact, the constraining factors to adoption tend to be weaker as a result of a greater availability of telecommunication services in residential zones, i.e. the Whisper agent is able to make telecommunication investments in a greater number of zones
This happens in both urban environments with a regular and irregular spatial network. Fig. 4 also shows that the less performing results are observed in the experiment, W101010, in which the width of the observation window, for all types of agents is the largest, i.e. in this case, in fact, the agents' awareness to the changes in the urban area is the lowest.

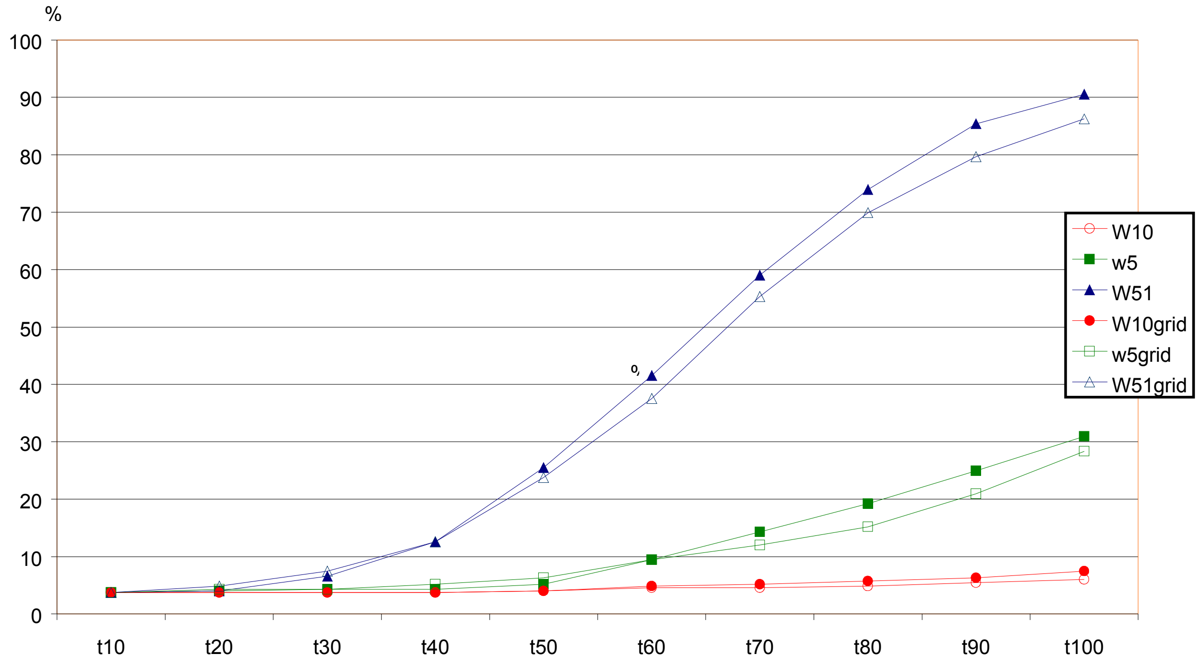

Figure 4 tele-work adoptions in an urban environment with regular (grid) and irregular spatial network for different widths of the observation window (*)

(*) W indicates the width of the observation window taken into account by the Inhabitant, Locality and Whisper, i.e. W51 means that the width for the Inhabitant and Locality agents is 5, whereas for Whisper is 1.

A major aspect worth being emphasized is that the increases in tele-work adoption are higher for the urban environment with an irregular spatial network. Although this result may depend on the particular configuration of these simulation experiments, a plausible explanation is that, in a more highly constrained spatial environment, agents' drive to improve their accessibility is likely to be higher.
The variations in the average travel times as observed at the end (T100) and beginning (T10) of the simulation period seems to support this explanation, see Fig. 5.
This result also provides further evidence to what has already been pointed out in earlier experiments (see Bellomo and Occelli, 2000, 2003) about the fact that the higher is agents' sensitivity to travel time, the greater their propensity to explore alternative travel paths, in order to improve their accessibility. To some extent, one may argue that agents have learned about their urban environment.

4. Concluding remarks

In this note an effort was made to point out a few aspects of the role of time in generating the complexities of today cities. Besides underlining, once more, the relevance of this role, our arguments suggest that there are two aspects which will deserve further attention in future research.

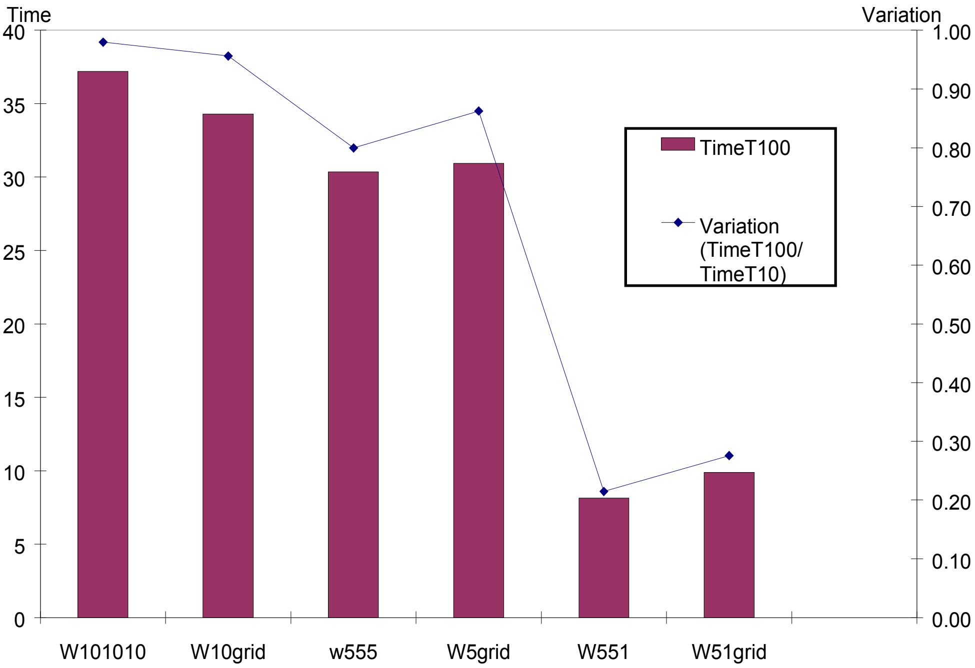

Figure 5 Average travel time at the end of the simulation period and time variation in an urban environment with regular (grid) and irregular spatial network for different widths of the observation window

First, the importance of the profiles of urban routines in contributing to the overall dynamics of cities should be underlined. The fact that most of them can be considered as ordinary does mean that they do not have a responsibility in city complexities. Although this responsibility has already been recognized on a methodological ground, there is a need to go beyond a simple quest for improving their analytic treatment.

On a substantial ground, actually, this is particularly challenging in planning as it calls for a greater attention to the management of everyday urban life (i.e. monitoring the city performances and impacts of policy actions), which in the long run should support stakeholders in the formulation of urban policies and in decision-making .

On a conceptual ground, furthermore, urban routines should be seen not only as the periodic repetition of actions in an urban environment but as the outcome of actions undertaken by *cognitive* agents in their action spaces. In this respect, coping with their temporal deployment also implies accounting of the time necessary to agents for learning about, moving in, adapting to and extending their action spaces. The claim that accessibility is a resource which can be actively construed by agents (see Occelli, 2000) was based on this presumption.

This probably calls for a new kind of attribution of the temporal dimension, in which for real agents (as well as for urban analysts) the different time perspectives, i.e. periods, life-cycle, longitudinal marks, routines, cannot be distinguished but need to be considered in combination, thus producing a range of more complex *temporal bundles.* To deal with these latter, furthermore, might also require paying attention to what time really represents for city, just because looking at urban processes does not make sense without considering what is at stake and for whom. These raise more fundamental questions of cognition, sense and knowledge which have social, cultural and ethical implications.
Second, it is doubtless that the introduction of NITC will be a key factor in instantiating the kind of Post-Fordist type of development that will take place in city. In this respect, the application of the SimAC model was a stimulating exercise which made it possible to articulate in a novel way some well known hypotheses about the diffusion and impact of NTIC on work related urban routines. Apart from any assessments about the model capabilities, the simulations showed how the coexistence of different temporal windows in the agents' decision making may affect the final outcome of NTIC adoption. One major aspect not included in the present model but worth being addressed in the future, is the recognition that these temporal windows may not depend simply on agent's attitudes (i.e. being myopic or anticipatory) but on their cognitive abilities to learn about their environment. This learning, itself, is likely to be very sensitive to NTIC.

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