GROWING OR STEADY CITIES? ACCOUNTING THE URBAN METABOLISM OF ITALIAN CITIES

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Abstract

This contribution aims to identify a theoretical model to develop tools for reducing cities GHG emissions. Cities' urban metabolism is responsible for at least 70% of total GHG emissions. To reach future reductions of GHG emissions we need a tool to account urban metabolism. We suggest to use a consumption-based model instead of conventional production-based models of accounting. In this survey we used data coming from National Italian Institute for Statistics covering tha length of time from 2002 to 2010. Data collected and elaborated show that the urban metabolism of the Italian cities is, at the aggregate level, stable in time. It means that, as it has been revealed by many studies, western urban systems have reached saturated consumption patterns. Expecting or forecasting future strong increasing levels of consumption will be difficult.

1_Growing and consuming cities

Global urban growth implies increasing consumption. The specular aspect of city as a growing machine is that of a "spatial unit of collective consumption" (Castells, 1977: orig. ed. 1972). Urban system functions are arranged in huge areas of activities aimed at reproducing the system itself. Sociologists have mainly investigated the 'urban symbolic' (the meanings emitted by socially produced spatial forms) of the cultural arena provided by "urbanism" (Wirth, 1938). However, to perform these cultural or political functions cities must exchange matter and energy with the environment. It means that urban reproduction might be unpacked into three great areas of activities: production, consumption and exchange, each of which corresponds to different elements in the urban system (such as factories and offices, housing and recreational facilities, and means of transportation respectively). Yet urban systems – principally Western cities – are less and less places of production of goods since capitalist production is increasingly organized on a global scale. Different stages in the production process are located at different countries or continents, factories in one town are administered from offices in another, the old urban production has been dislocated either in near places and around the world. It follows from this that the global system of exchange has growth over the time building up huge networks of transports and huge hubs of exchange usually situated outside urban boundaries. For many cities it has meant that their main function begun to be focused in the process of consumption and reproduction of their inhabitants.

Consumption performs a number of societal functions, as, for example, the necessary end point of commodity production or the human agents reproduction. In other words, it is only by consuming socially necessary use values (housing, food, energy, water, leisure facilities, etc.) that agents are able to reproduce their capability to engage in activities and practices. This specific function of reproduction of the urban system is performed on a daily basis and on a generational basis (through the production of new generations of agents to replace the existing one), and it entails both simple reproduction (recreation of daily capacities) and extended reproduction (development of new capacities to perform social practices). The means whereby such

reproduction is realized are the means of consumption – housing, shops, hospitals, schools, leisure facilities. Unlike the means of production, these means of consumption are specific to urban spatial units. The result is that the means of consumption have not only become concentrated within specific spatial units, but have also become more and more collectivized, and it is this growing significance of the collective provision of the means of consumption what makes the urban system the fittest locus for consumption giving rise to increased concentration and centralization.
Urban systems as described by Castells and Molotch (1976) at least forty years ago seem to be still very valuable. At global level, cities and large urban areas are already where most of the world's population lives. By 2030, an estimated 59% of the world's population will live in urban areas, with developed countries as the most urbanized at 81%. Meanwhile, in developing countries the average is projected to be around 55% by 2030. The rise of urban population is among the core causes of great environmental impact of cities. Environmental crisis involving climate change, loss of bio-diversity, nitrogen cycle damage, and many more, is opening new and more sustainable strategies for governing urban metabolism. Urban areas are hot spots that drive environmental change at multiple scales. According to the UN-HABITAT's Cities and Climate Change global report on Human settlements 2011, the world's cities are responsible for 75% of global energy consumption and up to 70% of harmful GHG greenhouse gases, while occupying just 2% of its land and being home to just half of the global population, clearly indicating the carbon-dependence of the urban economy. At the same time, material demand of consumption and production alters land use, biodiversity, ecosystem services, local and global hydrosystems, and urban waste disposal so affecting local to global biogeochemical cycles and climate (Grimm et al., 2008). Yet another crucial aspect must be underlined. It refers to the fact that different paths of evolution are featuring Western and non-Western cities. If these latter are becoming the place of global production the former are becoming the site of global consumption, as Max Weber pinpointed years ago.

2_Addressing Urban Metabolism

If we admit that cities are consumption growth machines, we are thrust to define them as complex systems of urban metabolism, whereby metabolism is more than an input/output mechanism. Urban metabolism refers to the metabolic processes by which cities transform incoming raw materials, biomass, energy, and water into physical structures, built environment, technical devices, food, waste (Decker et al., 2000) which support a huge amount of reproductive activities performed by their inhabitants. Urban Metabolism (UM) is a multi-disciplinary and integrated platform that examines material and energy flows in cities as complex systems as they are shaped by various social, economic and environmental forces. The adoption of this concept has fostered new images of what the city is and how material and non-material flows make possible the production and reproduction of the city, both as a biophysical and as a socio-economic entity (Swyngedouw, 2006). The Urban Unit at the World Bank released in 2010 a high profile report called Eco2Cities

(Suzuki et al., 2010), which advocated urban metabolism understandings of the city in sustainable urban development. Urban metabolism can be seen under three perspectives: functional, where city is considered as an organism based on input/output mechanism (*physiology*) that exchange energy and matter with its environment (focus is paid on maintaining a balance); analogical, where city is looked from a *morphological* point of view and where attention is paid on its internal organisation; *political*, where city is looked from is regulatory political economy based on social and economic tensions and conflicts (Rapoport, 2011).

The bio-physical or physiological approach to studying and quantifying urban material and energy flows and stocks is the predominant interpretation of urban metabolism today (see e.g. Gandy, 2004; The BRIDGE project, 2008; Suzuki et al., 2010;). Such studies generally focus on quantifying the flows of particular materials or energy in an urban system (Baccini, 1997; Brunner, 2008; Barles, 2010;). Many scholars also claim that urban metabolism studies can be a tool both for identifying environmental problems and for designing more efficient urban planning policies (Barles, 2010; Niza et al., 2009). In general, the metabolism model looks at links between urban and environmental quality, as well as among urban drivers, patterns of consumption and metabolic flows. In few words, urban metabolism is a set of processes taking place in the urban system involving transformation and transportation of matter and energy in such a way that the systems work as an organized entity.

This paper attempts in the same wake to depict the metabolic profile of cities through the analysis of quantitative data from national statistics, being a first attempt to evaluate and compare urban metabolism among Italian cities. Here, we have chosen the consumption based approach to evaluate resources consumed by urban dwellers. We did not translate resources' consumption in CO2 equivalent emissions, but it is clear our attempt to foster a contribution to evaluate the evolution of urban impact on resources consumption and indirectly on climate change. Secondly, we chose to investigate aggregate individual consumption leaving out from data the urban drivers of consumption such as public buildings or public services provision and indirect energy consumption such as food and drink among others. It means that we covered around the 50% of the total urban system consumption.

3_Accounting the metabolism of the Italian provincial capitals

This section contains the description of the steps we moved in the direction of trying to approach the urban metabolism description by starting from a distance that is bigger than the usual. We decided to use low-resolution data on the per-capita consumption of some resources/services in order to compare some metabolic aspects of a larger number of cities: of more than 100 Italian towns, all of them being provincial capitals. We wondered whether it was possible to isolate some features of Italian towns that could explain, at least partially, the reasons of the levels of consumption that they show, and that could explain if they are facing some common or peculiar metabolic paths or trajectories. We were moved by the idea that only by first using such a distant perspective it will become clearer how to approach it more deeply and which kind of indicators would be useful in addressing the urban metabolism calculation more properly. That is why we did not calculate the aggregated total levels of consumption for provincial capitals, and that is why the statistics that will be shown in the following paragraphs are not weighted for towns' population.

3.1_The data we used

Since year 2000 ISTAT, the National Italian Institute for Statistics, has been annually producing the Urban Environmental Indicators for the provincial capitals. Italy is currently divided into 20 regions and 110 provinces. It is only during the last few years that some new provinces were created having, some of them, more than one capital. However, due to lack of data for the most recently created provincial capitals, we took into consideration the provinces (and their capitals) as they were before the latest changes occurred in 2009, meaning that 107 provinces and 111 provincial capitals compose the sample. Our paper considered only per capita/consumption accounted in terms of physical quantity. It is in line with Eurostat's Urban Audit data sources, which provides relevant statistical data for over 300 cities in Europe. Such data include share of car journeys among all work journeys, number of registered cars per 1000 inhabitants, number of public transport stops per square kilometre, and solid waste production per inhabitant. We divided the variables we used into three main categories, according to the role we gave to them in our analysis, as follows:

[1] In the following of this paper, electricity and natural gas consumption will sometimes be fused in the indicator "kWh". The transformation of natural gas in kWh is based on a coefficient of 10.5 kWh = 1 cubic meter of natural gas. Towns without a natural gas distribution network are not taken into consideration.

Consumption / Dependent variables	
Water:	per-capita consumption for domestic uses (liters per day)
Natural gas:	per-capita consumption for heating and other domestic uses (cubic meters per year)
Electricity:	per-capita consumption for domestic uses (kWh per year)[1]
Wastes:	per-capita production (kg per year)
Motorization rate:	number of cars (per 1,000 inhabitants)
Demand for LPT:	per-capita demand for Local Public Transport (passenger trips per year)
Offer of LPT:	per-capita offer of Local Public Transport (km-seats per year)
Socio-demographic / Primary explanatory variables	
Population density:	inhabitants (per square km)
Ageing Index:	ratio - people aged ≥65 / people aged <15
Income:	per-capita at current prices
Family size:	average number of family components
Degree-days:	they represent the sum, extended to all days of a conventional heating period, of only the positive differences between the daily indoor temperature, fixed by convention at 20°C, and the daily average outdoor temperature (Law n°412, 26th August 1993)
Secondary explanatory variables	
Present population:	not resident people that was present in town during the 2001 national census, as percent of the total resident population
Commuters:	balance between outbound and inbound commuters, as percent of the total resident population
Tourist Attraction Index:	number of nights spent in the receptive structures of the town, per inhabitant
Additional population:	commuters, city users, present but not resident people, tourists, as percent of the total resident population

For all variables related to consumption, we took into consideration data coming from the two years 2002 and 2011, in order to cover the two extremes of an entire decade.

3.2_Characteristics of the sample: socio-demographic structure and levels of consumption

By taking into consideration provincial capitals, we are concentrating our attention on peculiar towns, clearly not representing the whole national conditions even if their population – being 83 the provincial capitals among the 100 most populated Italian towns – represent the 28.8% of the total population of Italy.

Table 1. Cities' size.

Inhabitants (in 1.000) (2011)	Freq.	%
<50	28	25.2
50-100	40	36.0
100-200	28	25.2
200-400	9	8.1
>400; max: 2,614	6	5.4

The data at our disposal confirms the well-known, perceived, or maybe sometimes taken-for-granted, difference between Northern and Southern-Insular Italy. This difference operates on many levels, being climatic feature, age composition, family size and per-capita income – i.e. some of the variables we used to explain the variability of the levels of consumption – only some of the possible examples. Higher densities in northern (mainly North-Western) towns are partially due to the fact that in many cases they have, for both historical and geographical reasons, smaller territorial extensions than towns of the other zones, so that agricultural lands, wooded lands and naturalistic sites are beyond town's administrative borders. At the same time we can say they are still deriving from the massive phenomenon of internal immigration that accompanied the industrial development of Northern (again, mostly North-Western) towns in the 1960s and 1970s.

Table 2. Primary explanatory variables.

Variable	Zone	Mean	Median	St.Dev.	Min	Max
Degree-days	NW-NE	2394	2418	385,8	1201	3043
	C	1803	1715	300,5	1220	2324
	S-I	1336	1226	490,7	707	2514
	All	**1863**	**1885**	**633,5**	**707**	**3043**
Pop. Density (2011)	NW-NE	1411,6	1003,7	1328,5	234,5	6786,1
	C	799,3	464,1	810,5	154,9	3484,7
	S-I	950,8	362,4	1456,8	65,3	8202,3
	All	**1113,1**	**732,0**	**1318,2**	**65,3**	**8202,3**
Family size (2010)	NW-NE	2,11	2,13	0,11	1,80	2,31
	C	2,26	2,25	0,12	2,00	2,49
	S-I	2,48	2,51	0,18	2,15	3,04
	All	**2,28**	**2,24**	**0,22**	**1,80**	**3,04**
Income (2010)	NW-NE	16298	16133	1705,9	13218	22604
	C	14404	13836	1979,6	11650	19699
	S-I	11061	10634	1704,6	7033	15506
	All	**13864**	**13898**	**2952,0**	**7033**	**22604**
Ageing Index (2009)	NW-NE	197,5	193,4	29,3	126,6	257,0
	C	183,9	179,7	31,3	106,8	250,6
	S-I	144,4	143,1	29,5	87,3	234,1
	All	**173,9**	**177,2**	**38,3**	**87,3**	**257,0**

Both of the two geographically most distant zones are characterized by areas with climatic conditions that are quite different from the average climatic conditions of their respective zones. The coastal region of Liguria, in Northern Italy and the mountainous areas of the Apennines in Southern Italy have, respectively, significantly higher and lower temperatures than their co-zonal provinces. Degree-days is an important explaining factor of energy use for heating. Data on energy consumption could have been eventually influenced by climatic anomalies. Annual average temperatures were high in both years 2002 and 2011 if compared with the historical temperatures of the period 1961-1990. More precisely, years 2002 and 2011 annual average temperatures were respectively almost 1°C and 1.3°C higher than the annual average temperatures of the period 1961-1990. However, the annual average temperatures of these two years are situated very close to the tendency line of the period 1961-2012. That is another reason explaining our choice to continue keeping these two years as points of reference.

3.3_Changes over the period 2002-2011

The percentage variation of the dependent variables has been higher where the initial levels were lower. While that could be found being not so much surprising, at the same time we should not forget it was not an inevitable outcome. Moreover, what is relevant is the fact that - as it results from simple correlations among 2002 levels of consumption and their percentage variations in the period 2002-2011 (Table 3) – their force may significantly vary from one case to another, while in other cases there is no statistically significant correlation.

Table 3. Variations between 2002-2002 (R Pearson).

Variable	R	Variable	R
Electricity	**-.511**	Income	**-.838**
Water	**-.458**	Ageing Index	**-.829**
kWh	**-.440**	Family size	**-.558**
Natural gas	**-.424**	Pop. Density	*-.206*
Motorization rate	**-.420**	Legend:	
Wastes	-.172	Bold: p<.01	
LPT Demand	-.042	Italic: p<.05	

Simple correlations among structural variables show the highest coefficients (with the only partial exception of population density (p<.05)). For many of the consumption variables, the coefficients are quite similar among them, with the notable exceptions of those related to wastes and LPT (Local Public Transport), whose coefficients are not statistically significant. Another important finding emerges by looking at the variations of the Coefficients of Variation (CV). The differences among provincial capitals are decreasing on the great majority of the aspects we controlled for. That is definitively clear for what refers to the socio-demographic variables we used (Table 4), were the CV decreased even within each of the three geographic zones.

A more differentiated situation characterizes the variations of consumption variables. For all of the environmental indicators used here the mean values of per-capita consumption show an increase, with the exception of the consumption of water, as it can be seen in Table 5. At least that is valid through a national level perspective, because by dividing the sample into geographic zones different paths emerge, and where the most significant lie in the fact that Northern provincial capitals show steady levels of consumption.

Table 4. Variation of primary explanatory variables.

Variable	Zone	Mean t0	Mean t1	Mean var.	Coeff. Var. t0	Coeff. Var. t1
Pop. Density	NW-NE	1390,0	1411,6	1,55%	0,958	0,941
	C	781,5	799,3	2,28%	1,025	1,014
	S-I	968,0	950,8	-1,78%	1,550	1,532
	All	**1107,6**	**1113,1**	**0,49%**	**1,206**	**1,184**
Family size	NW-NE	2,18	2,11	-3,38%	0,060	0,054
	C	2,39	2,26	-5,47%	0,063	0,055
	S-I	2,69	2,48	-7,73%	0,068	0,071
	All	**2,40**	**2,28**	**-5,00%**	**0,113**	**0,096**
Income	NW-NE	14614	16298	11,52%	0,108	0,105
	C	12595	14404	14,36%	0,151	0,137
	S-I	9170	11061	20,62%	0,177	0,154
	All	**12074**	**13864**	**14,83%**	**0,246**	**0,213**
Ageing Index	NW-NE	202,9	197,5	-2,65%	0,179	0,148
	C	182,9	183,9	0,51%	0,232	0,170
	S-I	118,1	144,4	22,34%	0,226	0,204
	All	**169,2**	**173,9**	**2,79%**	**0,305**	**0,220**

Table 5. Variation of consumption variables.

Variable	Zone	Mean t0	Mean t1	Mean var.	Coeff. Var. t0	Coeff. Var. t1
kWh	NW-NE	7588,6	7600,0	0,15%	0,264	0,231
	C	5339,2	5819,3	8,99%	0,226	0,233
	S-I	3348,2	3476,6	3,84%	0,348	0,317
	All	**5771,4**	**5914,1**	**2,47%**	**0,426**	**0,394**
Water	NW-NE	207,9	180,0	-13,41%	0,155	0,160
	C	181,0	155,2	-14,26%	0,182	0,184
	S-I	165,3	162,2	-1,85%	0,205	0,195
	All	**185,9**	**168,3**	**-9,49%**	**0,205**	**0,187**
Wastes	NW-NE	607,2	603,8	-0,56%	0,164	0,169
	C	636,3	648,1	1,85%	0,173	0,155
	S-I	517,8	539,3	4,15%	0,179	0,263
	All	**577,3**	**586,6**	**1,61%**	**0,190**	**0,213**
LPT Demand	NW-NE	113,6	126,7	11,56%	1,157	1,192
	C	93,6	95,7	2,25%	1,185	1,344
	S-I	49,4	46,3	-6,30%	1,009	1,074
	All	**85,3**	**90,1**	**5,65%**	**1,248**	**1,356**
Motorization rate	NW-NE	626,8	621,2	-0,90%	0,077	0,081
	C	661,9	668,8	1,04%	0,076	0,084
	S-I	600,0	650,3	8,38%	0,101	0,088
	All	**622,8**	**642,1**	**3,11%**	**0,093**	**0,089**
Electricity	NW-NE	1181,2	1187,8	0,56%	0,086	0,085
	C	1128,9	1177,6	4,31%	0,103	0,105
	S-I	1084,0	1178,9	8,75%	0,175	0,152
	All	**1132,8**	**1182,4**	**4,38%**	**0,133**	**0,117**
Natural gas	NW-NE	610,2	610,7	0,08%	0,308	0,272
	C	401,0	442,1	10,25%	0,281	0,290
	S-I	221,9	224,3	1,11%	0,531	0,499
	All	**443,1**	**452,3**	**2,09%**	**0,517**	**0,487**

Two limitations of our data set should be accounted for before going on. First, the quantity of wastes is expressed in kg per-capita, so that it does not tell too much about its composition – and consequently about its environmental impact – so that it might have varied not only because of changes in household consumption practices, but also of differences among local recycling systems. Second, the motorization rate tells us about cars ownership and not about cars utilization, even if it could be considered as a proxy of it. Has LPT demand behaved as a substitute for private transport? We have not a clear answer to this question. Indeed, LPT demand variation has no correlation with the variations of other variables, but with the variation of the motorization rate ($R = -0.199$; $p < .05$). However, it is not a very strong correlation. Moreover, the correlations calculated within the three geographic zones cannot support its robustness. Indeed, they are even weaker. The different increases in electricity and natural gas consumption in Central and Southern-Insular Italy can be explained by the fact that the use of natural gas for heating does not take place in the warmest provinces where, if necessary, other heating methods are mostly used, by means of electric energy being one of them.

3.4_Data preprocessing and regression model

After having showed the features of the most important variables in our model and some of their correlations, we used some regression models in order to capture the factors explaining the variability of the levels of consumption (for both years 2002 and 2011) as well as the variability of their percentage variations between years 2002 and 2011. Different sets of explanatory variables were chosen according to the variable whose variability was to be explained. Socio-demographic factors show strong correlation with each other, making multicollinearity an issue for the power of the regression models. Our preferred method for model selection is then forward stepwise selection because it allows to rank the explanatory variables based on their importance, and in sequentially adding variables to the model, it minimizes multicollinearity (Kavousian et al., 2013). Outliers were excluded based on the following method[2]: for all variables having curtosis and/or asymmetry statistics $\geq|1|$ their Z-scores were calculated and values with Z-scores $\geq|3|$ (if any) were excluded. This procedure (that was only applied for the entire data-set and not at the level of the geographically based sub-samples) was repeated till having all Z-scores between -3 and +3, and till obtaining values of curtosis and/or asymmetry being all between -1 and +1, for a maximum of three times. We then used a pairwise method for the selection of cases, as listwise method prevented almost 25% of the cases from being computed into the regression models. While Degree-days was used only for electricity, natural gas and kWh, all the other variables (as well as their variations) we before referred to as Primary explanatory variables were inserted into all regression models. The variables we before referred to as Secondary explanatory variables were only used for specific regression models. Dependent variables at 2002 were inserted only into the regression models for their respective variations. We then ran the regression models not only with the entire sample, but also with the three sub-samples, each one of them composed by the provincial capitals of the three main geographic zones. The results of the regressions for the

[2] The before mentioned correlation coefficients (Pearson's) too are based on the sample without outliers.

Central provincial capitals are not discussed here mainly because the results we obtained (or that we could not obtain) are weakened by the limited number of provincial capitals by which Central Italy is composed.

4_Summary of findings

At the national level the explanatory power of our models (adjusted R-square value) ranges from 0.143 (Wastes 2011) to 0.737 (LPT Demand 2002 - with LPT Offer in the model). For all cases but one, where it was almost constant (LPT Offer), our models lost their ability to explain variability in the passages from year 2002 to year 2011.

Income. Where income was an important explanatory variable it however lost, partially or completely, its power to predict variability, only gaining momentum for what refers to LPT.

Population Density. It increased its power to predict variability for what refers to water and motorization rate, while losing it for what refers to LPT.

Degree-days. It only explains a little share of the variability of the consumption of electricity, natural gas and kWh. Nonetheless, it slightly increased from 2002 to 2011.

Ageing Index. It completely lost its power to predict the variability of motorization rate and electricity consumption. It weakly became an explanatory factor of natural gas and kWh consumption.

Family size. It is the only factor that help us explaining the variability of waste generation. It completely lost its power to predict the variability of electricity consumption and LPT Demand; however, it was the most important factor explaining the variability of the former in 2002.

Tourist Attraction Index. Contrary to our early expectations - that were based on the fact that as consumption levels are expressed as per-capita consumption (of resident people) higher rates of presence of commuters, city users and so on, could sensibly modify the values - almost all the secondary explanatory variables played no role in explaining variability. The only exception is the Tourist Attraction Index. It explains only a little share (and only in 2002) of the variability of the consumption of water, electricity and kWh. However, in this latter case the Beta coefficient is negative. The higher coefficient and the higher share of explanatory power that is registered in Northern capitals suggested us how to interpret this somehow counter-intuitive outcome. Higher levels of Tourist Attraction Index characterize both warmer (seaside) and cooler (mountain) provincial capitals. While for the former there is a minor use of energy for heating, for the latter the heating services are likely to be obtained with energy sources (like wood, for example) that are not taken into consideration within the Urban Environmental Indicators.

Given the relevant structural and socio-demographic differences between Northern and Southern-Insular provincial capitals, a bigger insight could derive from the applications of the regression models to these distinct sub-samples. We can see that variability is better explained in Southern-Insular Italy for what refers to the consumption of energy, while in Northern Italy it is better explained for what refers to the variables related to mobility.

Mobility (motorization rate and Local Public Transport). Not only population density is the most important explaining factor for Northern capitals motorization rates, but it also became even more important. Population density also gained a role in it in Southern-Insular capitals, with income continuing being there (with a decreased importance in 2011) the main explanatory factor. Moreover, population density is by far the most important explanatory factor for LPT (both demand and offer) in both Northern and Southern-Insular provincial capitals, with a secondary role of socio-demographic aspects like family size and Ageing Index.

Energy consumption (electricity and natural gas). Even if our model explains only a little part of the variability of energy consumption in Northern capitals, it is possible to say that it is explained by income levels. For what refers to Southern-Insular capitals, variability is (and is ever more) explained for the most part by Degree-days. It is relevant to notice that Beta coefficients are inverted between electricity and natural gas use, confirming the before mentioned hypothesis that in the warmest towns electricity is preferred to natural gas for heating.

Water and wastes. Our model is weak in explaining their variability, even within sub-samples. However, the application of our regression model to the production of wastes for the Southern-Insular sample seems to confirm the importance of family size as explanatory variable.

Variations. The last step we did was the application of our regression model to the variations (2002-2011) of the levels of consumption. At the national level the explanatory power of our models ranges from the very low levels of 0.030 and 0.031 (Variation of LPT Offer and Variation of LPT Demand) to 0.695 (Variation of motorization rate), while we did not obtain any explanation for the variation of the per-capita production of wastes. The levels of consumption at 2002 explain part of the variability of the variations, with the exclusion of LPT (both demand and offer) and wastes. That is evident for the energy consumption in Southern-Insular capitals where, according to our model and differing from what emerges from Northern capitals, the 2002 levels of consumption are the only explanatory factors.

A special attention should be paid to both private and public mobility. While in Southern-Insular capitals the main explanatory factor of the variation of the motorization rate is the variation of the per-capita income, for what refers to Northern capitals the demand for (and the offer of) LPT and the motorization rate are interrelatedly explainable. The above-mentioned findings are confirmed. Moreover, it emerges the situation in which LPT is operating as a substitute for cars ownership whose increase is hampered by the population density. Socio-demographic features are also playing a role in all that, with Ageing Index explaining the variability of both private and public mobility. This also happens with family size coefficients, suggesting that the differences in mobility schemes could be also determined by the prevalence of different family structures. Finally, it is relevant to notice that the variation of the per-capita electricity consumption in Northern capitals is explained by Ageing Index and family size. However, coefficients are inverted with respect to the regression model for the 2002 levels of consumption.

5_Conclusions

In this paper we attempted to approach the investigation on Urban Metabolism from an unusual distance, that is by comparing the metabolic profiles, and their evolutions over a decade, of a significantly high number of towns. Notwithstanding the limitations of the statistic model we used, also deriving from the fact that the variables we used were not designed to our aims, we dare propose here some hypothesis and some reflections, as some quite clear phenomena have been anyway emerging. While cities are given more and more relevance as sites were policies and innovations aimed at tackling climate change and curbing CO_2 emissions could be implemented, at the same time they are not isolated entities, being their metabolic features partly mutually interrelated, at least at a national level, so that a national-level guiding intervention could be somehow needed or appropriate. Indeed, cities have been changing their metabolic profiles in an homologous way, as it results from the generalized convergence towards common (and slightly increasing at the same time) levels of consumption, towards some standards of consumption that are more and more enrolling the Italian households in provincial capitals. At the same time, the socio-demographic variables have been converging at an even faster pace. This fact could explain, at least partially, the loss of predictive power that hit our regression model in the great majority of cases. This also happened within the main geographic zones, in the passages from the first to the last year of the decade taken into consideration. Further insights could derive from the expected data updates about the different categories of not residents using the cities, from updated and more disaggregated data about the productive and economic structure, from improved indicators about population density also taking into account the different uses of the towns' surfaces, from data about more and other items of consumption. The urban metabolism of the Italian cities is, at the aggregate level, stable in time. It means that, as it has been revealed by many studies, western urban systems have reached saturated consumption patterns. Expecting or forecasting future strong increasing levels of consumption will be difficult.

6_References

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