Water Consumption and Long-Run Urban Development: The Case of Milan

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NOTA DI LAVORO 109.2005

SEPTEMBER 2005

NRM – Natural Resources Management

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Summary

Analyses of long run consumption series are rare in literature. We study the evolution of water consumption in Milan in the twentieth century. The objective is twofold: on one side, the univariate analysis tries both to assess the impact of relevant socio-economic and environmental changes on water consumption in Milan and verify if consumers have deeply rooted consumption habits. On the other side, the multivariate analysis is used to identify the socio-economic factors that are relevant in explaining consumption evolution. Results indicate both that water users have well entrenched consumption habits and that population, climate and economic structure behave more similarly, in Euclidean terms, to water consumption than to other economic and social variables.

Keywords: Urban consumption, Long-run, Development, Environmental changes

JEL Classification: Q25, R1, C22, C19

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1. Introduction

Historically Milan could count on a great abundance of water thanks both to a large number of private wells and to a dense network of canals – that dates back to Leonardo da Vinci contribution – drawing water from the Adda and Ticino rivers (Lapini, 2004). This huge availability of water delayed the waterworks building relatively to other European cities, which created water distribution lines as early as the eighteenth century.

Starting with its foundation in 1889, the progressive development of waterworks should be considered as one of the most important urbanisation works, since it illustrates the economic and social growth of Milan following the European development of the twentieth century (Lapini, 2004).

We analyse the evolution of water consumption in the city of Milan from 1889 to 2001. The objective is twofold: on one side, the univariate analysis tries both to assess the impact of relevant socio-economic and environmental changes on water consumption in Milan and verify if consumers have deeply rooted consumption habits. On the other side, the multivariate analysis is used to identify the socio-economic factors that are relevant in explaining consumption evolution.

Although the literature investigated massively water demand (Dalhuisen *et al.*, 1999; Arbuès Garcia *et al.*; 2000; Nauges and Thomas, 2000), the analyses of long consumption series are rare. Martínez Espiñeira (2001), for instance, estimates a water consumption function in the usual cointegrating framework. In our context, however, giving that the series spreads over different social and economic phases of urban development, the estimation of a cointegrating relationship may produce misleading results because it imposes the stability over time of the estimated coefficients.

Nevertheless, water consumption may be considered, at least in a long run perspective, as an indicator of urban transformation which is, more than other environmental variables, strictly connected to socio-economic and cultural factors that are at the root of long run urban changes (Nyong and Kanaroglu, 1999).

Consequently, instead of estimating a water demand function with the aim of measuring consumption elasticities, we use multivariate statistics tools in order to capture simple similarities - in Euclidean terms - between water consumption and the above mentioned factors of urban modifications.

Another original aspect of this paper concerns some of the peculiarities of the city of Milan: on one hand, it is the second largest city in Italy – with almost two million inhabitants - and it is generally considered the most important and dynamic Italian city from an economic point of view; on the other hand, some socio-economic and environmental profiles of the city -– productive structure evolution, demographic trends, climatic changes, water management– are shared with many European cities. Hence, despite Milan’s peculiarities, some results and policy implications presented in this analysis could be extended to other European cities.

The structure of the paper is as follows. Section 2 analyses the development of water consumption in Milan over the course of a 113-year period using the intervention model methodology. Section 3 focuses on the similarities existing between water consumption and some socio-economic variables connected with long-run urban evolution. Section 4 sheds light on the policy implications suggested by the analysis that we carried out. Section 5 presents some final remarks on the main results achieved and on future research objectives.

2 A century of water consumption in Milan

The main goal of this section is to analyse water consumption over the period 1889-2001 within an ARIMA framework. In detail, we apply the Box and Tiao (1975) intervention models methodology which tests the null hypothesis that a postulated event causes a change in a social process measured by a time series.

In this framework we can take into account both the different phases of urban evolution and the role of habits in water consumption which can be captured by the auto-regressive component of the ARIMA model.

2.1 Evolution of water consumption: identification of significant changes in urban development

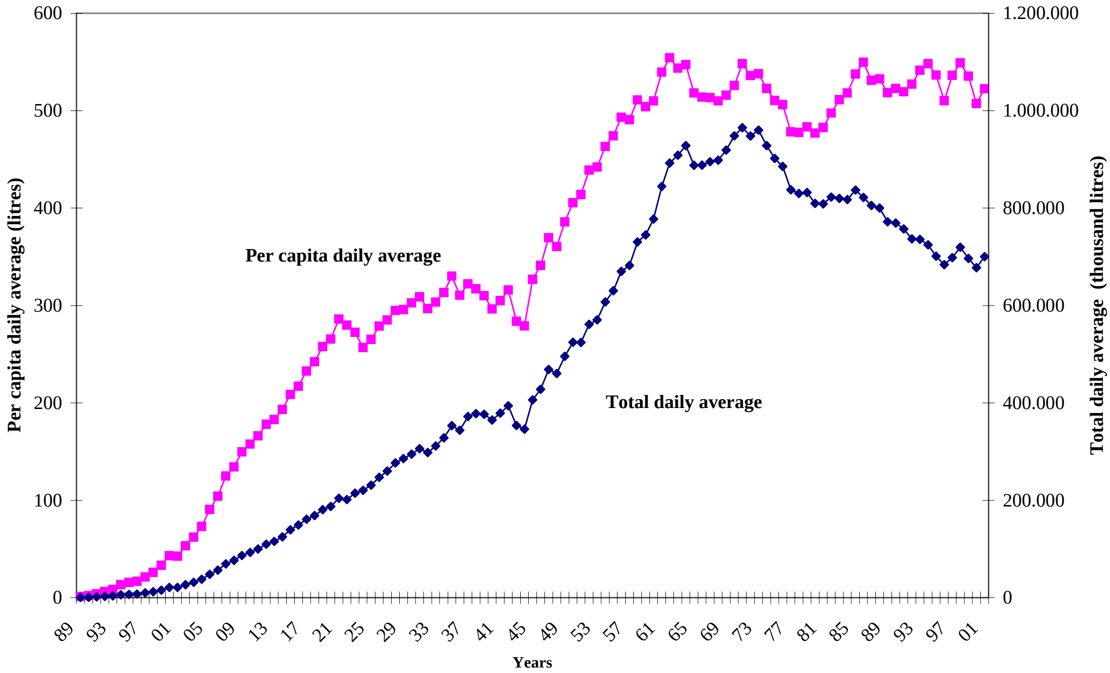
Data on water consumption has been collected by the *Acquedotto del Comune di Milano*[1] – municipal waterworks - since 1889, the year of the foundation of the first waterworks in the city. The waterworks building marked the beginning of a new era for Milan, fostered by a cultural movement which pushed for the architectonic renewal and the introduction of up to date facilities (Isenburg, 2000).

The plot of total and per capita daily average water consumption (in litres) is depicted in Figure 1. Total consumption rises uniformly until the sixties, although the effect of the second world war appears clearly. Starting from the seventies, however, it begins a constant decline that lasts until the present.

In this paper, however, we primarily focus our attention on per capita consumption. Daily per capita water consumption increased until the sixties, when it stabilised around 500 litres. In the 112 years considered, it thus increased over 400-fold, showing the exceptional development of waterworks capacity that occurred in the twentieth century

[1] In 2003 the Milanese waterworks was privatised when it was purchased by Metropolitana Milanese.

Figure 1 - Average daily water demand: total and per capita (Litres).



Source: Acquedotto di Milano

The evolution of per capita consumption, obviously, is not stable over the entire period; rather, it shows different phases. The objective of this section is the identification of the events that could have modified the consumption series, whose impact will be measured in the following section through the intervention models analysis.

Some relevant events can be attributed to demand side factors. In particular, in the two years period 1923-24, a dramatic population change occurred. This was due to a territorial expansion of the Milan municipality, which incorporated 10 neighbouring small towns. Moreover, world wars produced dramatic changes in the normal evolution of consumption. Finally, an important demand side factor is represented by the change in the productive structure: the strong industrialisation process that occurred after the second world war and the tertiarisation process that started from the sixties can be considered as potential factors for change.

On the supply side, crucial events can be mostly attributed to modifications of the water systems' structure and management.

The early sixties represent the beginning of pollution problems in the Milan water system. This led to the closure of 37 out of 55 wells in 1963. In the mid seventies (1974) a further discovery of serious water pollution was coupled with the lowering of the water table due to its over-exploitation (Motta, 1989, Colombo *et al.*, 1996). Milan waterworks solved the problems related to pollution at the beginning of the eighties.

2.2 The univariate analysis of water consumption trough an intervention model

In this section we try to understand, through the intervention model methodology, both if the events postulated in the previous section have really modified water consumption evolution and if consumption habits exist.

A viable intervention model can be built in three phases. The first phase of model building includes the following steps: determination of the order of integration of the series, identification of orders of auto-regressive and moving average parameters of the noise component, and addiction of the exogenous impact component. In the second phase, identified parameters of the full model are estimated. The third phase consists of the diagnostic checking of the estimated residuals forms. If diagnostic checks show that residuals are white noise, then the identified model can be used to produce forecasts. The procedures used in model building are discussed below.

Before identifying the model, a preliminary statistical analysis is conducted, in order to detect possible data nonstationarity. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests - with linear trend for the series in level (CMOYL) and without trend for the differentiated series (DCMOYL) - provide evidence of a unit root for water consumption, i.e. the coefficient associated to the first auto-regressive component equals to one. This clearly indicates that water consumption is a highly persistent series, or in other words, that habits play a central role in consumption evolution.

Table 1: Integration tests

Variable	ADF	PP	K
CMOYL	-0.82 (0,961)	-0.66(0.973)	1
DCMOYL	-9.26(<0.0001)	-10.23 (<0.0001)	0

In brackets the p-value relatively to the non stationarity null hypothesis.

It is well known that structural breaks in the deterministic components of the stochastic process tend to bias both ADF and PP tests towards the unit root null hypothesis. For this reason, for example, Perron (1997) proposes both innovative and additive type outlier tests of a I(1) null hypothesis against a I(0) alternative with a single break that occurred at an unknown point in time.

The presence of multiples breaks suggests another strategy. We apply here the ADF and PP tests to the sub-samples corresponding to the modifications of the slope: 1889-21, 1925-44, 1945-62 and 1963-2001. The non reported results confirm the presence of a unit roots for the water consumption. Hence, we will identify and estimate a first-order integrated ARIMA model.

The basic idea underlining the identification process is that changes that occurred in the series may produce biased estimates of the ACF and PACF. In order to avoid this problem, if sufficient data are available, the noise component can be identified using data referring to the period preceding the first intervention. After this step, the impact components, which are assumed to be caused by events that are known a priori, can be added to the model on the basis of two characteristics: onset and duration.

In our application, however, data concerning the period preceding the first intervention – namely the first world war - are not sufficient to identify the noise component. Indeed, the underling hypothesis of this identification methodology, i.e. that the noise component of the series is the same before and after the intervention, seems difficult to confirm over a century-long time series.

We thus follow an alternative way to duild the model: namely, we apply a general-to-specific procedure to the entire sample. The initial model contains both a fairly general noise component and an intervention component. The final model is obtained thorough the exclusion from the initial model of non significant impacts using the "backward" algorithm.

The slow decrease of the auto correlation function (ACF) and the partial auto correlation function (PAFC), estimated from the differentiated series, seem to point out that the series has a quite long memory (Figures 2 and 3).

Figure 2: Auto correlation function

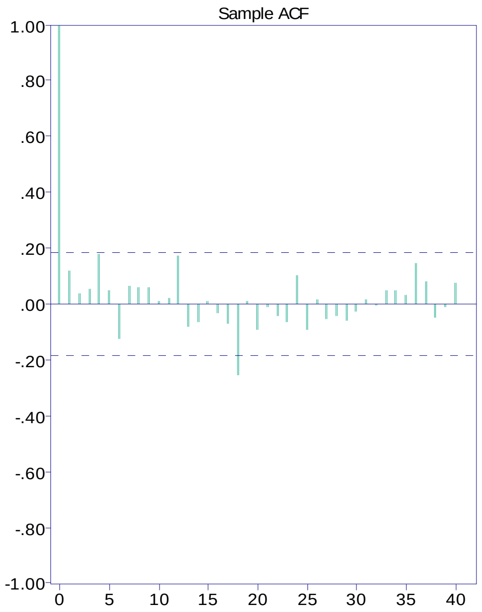
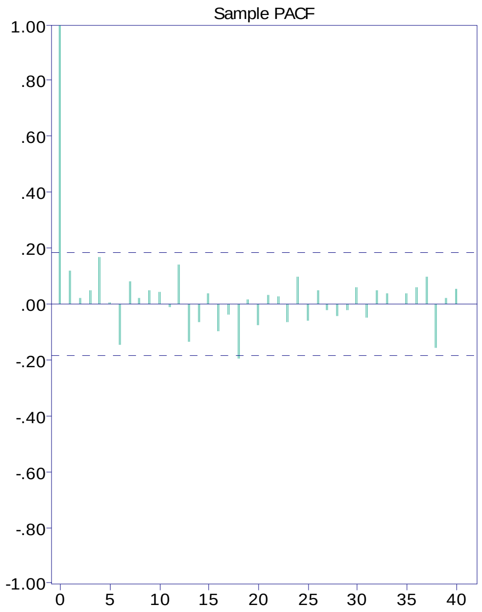


Figure 3: Partial auto correlation function



However, as stated above, the changes occurred duiring the twentieth century could have overwhelmed the ACF and PACF.

In order to build the model, we start from an ARIMA(4,1,4) - which can be a reasonable point of departure - and we add the intervention components corresponding to the postulated events which may have modified consumption evolution. The initial model is as follows:

$$Y_t = \sum_{j=1}^{6} I_{jt} + N_t$$

where Y_t denotes per capita water consumption, the I_j are the intervention components which are deterministic functions of time and N_t is the ARIMA(4,1,4):

$$(1-\mathrm{B})N_t = c + \frac{1-\theta_1\mathrm{B}-\theta_2\mathrm{B}^2-\theta_3\mathrm{B}^3-\theta_4\mathrm{B}^4}{1-\varphi_1\mathrm{B}-\varphi_2\mathrm{B}^2-\varphi_3\mathrm{B}^3-\varphi_4\mathrm{B}^4} Z_t$$

where B is the backward shift operator such that $\mathrm{B}^i X_t = X_{t-i}$, the φs and the θs are respectively the auto-regressive and the moving-average coefficients while $Z_t \sim iid(0,\sigma_Z^2)$ is a white noise process. The exogenous inputs which enter in the intervention component are presented below.

The world wars and 1923-24 population shock – The world wars and the population change occurred in 1923-24 are assumed to provide abrupt impacts on per capita water consumption. Therefore the corresponding inputs are:

$$I_{1t} = a_1 P_t^{15-18}$$
$$with\ P_t^{15-18} = \begin{Bmatrix} 1, \text{ if } 1915 \le t \le 1918 \\ 0, \text{ otherwise} \end{Bmatrix}$$

$$I_{2t} = a_2 P_t^{23-24}$$
$$with\ P_t^{23-24} = \begin{Bmatrix} 1, \text{ if } 1923 \le t \le 1924 \\ 0, \text{ otherwise} \end{Bmatrix}$$

$$I_{3t} = a_3 P_t^{40-45}$$
$$with\ P_t^{40-45} = \begin{Bmatrix} 1, \text{ if } 1940 \le t \le 1945 \\ 0, \text{ otherwise} \end{Bmatrix}$$

The parameters a_1, a_2 and a_3 measure the magnitude of the average impacts in the three period considered.

The industrialisation/economic growth after 1945 - The strong industrialisation process which took place after the second world war was coupled with an high economic growth. These phenomena should gradually modify per capita consumption. This is given by:

$$I_{4t} = \frac{a_4}{1-\delta_4 \mathrm{B}} S_t^{46}$$

$$with\ S_t^{46} = \begin{Bmatrix} 1, \text{ if } t \geq 1946 \\ 0, \text{ otherwise} \end{Bmatrix}$$

The magnitude of the impact that occurred in 1946 is given by a_4 and δ_4 is the rate of increase in the impact after 1946. Here we impose δ=1, i.e. that the corresponding input variable is a simple ramp function.

The beginning of pollution/tertiarisation of the early sixties - The early sixties represent the beginning of both pollution problems in the Milan water system (wells closure in 1963) and strong de-industrialisation. As it is impossible to distinguish the single effects of these different phenomena, our impact assessment model assumes all these as one intervention. Indeed, like the industrialisation process, the impact is assumed to be gradual:

$$I_{5t} = \frac{a_5}{1-\delta_5 \mathrm{B}} S_t^{63}$$

$$with\ S_t^{46} = \begin{Bmatrix} 1, \text{ if } t \geq 1963 \\ 0, \text{ otherwise} \end{Bmatrix}$$

The 1974 pollution shock – As underlined by Motta (1989), the effect of pollution in 1974 was abrupt and non-persistent. We thus utilise the following input:

$$I_{6t} = \frac{a_5}{1-\delta_6 \mathrm{B}} P_t^{74}$$

$$with\ P_t^{74} = \begin{Bmatrix} 1, \text{ if } t = 1974 \\ 0, \text{ otherwise} \end{Bmatrix}$$

The parameter α_6 represents the magnitude of the 1974 impact, while δ_6 is the rate of decay of the effect of pulse input. If δ_6 is close to 1, the impact is slowly decaying in successive time periods, while if δ_6 is close to 0, the impact is rapidly decaying to 0 after few time periods.

In the final model, in Table 2, the noise component is an ARIMA(0,1,0) and the intervention component of the model consists of four parts: 1923-24 population impact, post second world war impact , post 1963 wells closure impact and 1974 high pollution impact. The estimated parameters using the Maximum Likelihood Method are reported in Table 2.

Results suggest that the impacts related to the world wars (I_1 and I_3) are not significant, while those that occurred after the second world war are only significant at a 10% level.

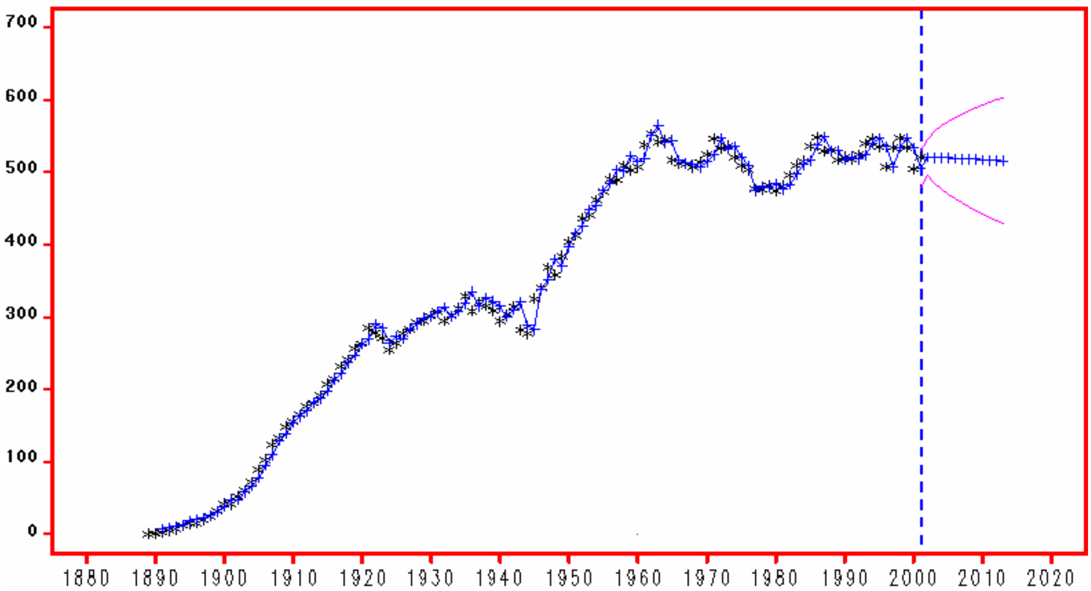
All other impacts considered are highly significant. The rate of decay of the effect of 1974 high pollution (δ_6) is estimated at 0.86 which indicates that the impact is quite slowly decaying in the following years. Diagnostics indicates that residuals are not different from white noise.

Table 2: Maximum Likelihood estimation of the intervention model

Coefficient	Estimate	Standard error	t-statistics
φ_1			
φ_2			
φ_3			
φ_4			
θ_1			
θ_2			
θ_3			
θ_4			
α_1			
α_2	-12.73	5.57	-2.28
α_3			
α_4	6.14	3.48	1.76
α_5	-12.57	3.68	-3.41
α_6	-27.85	12.62	-2.20
δ_4	1		
δ_5	1		
δ_6	0.86	0.31	2.74

The high R^2 (0.96) proves that the estimated intervention model fit the data very well. In the final step of the analysis, we use the intervention model to produce forecasts (Figure 4). The forecasted values are almost constant and present a very slowly decreasing trend, going from 522 litres in 2001 to 516 litres in 2015. This result is coherent with the idea that per-capita consumption has reached a sort of equilibrium level and therefore water users have well established consumption habits.

Figure 4: Forecast for per-capita water consumption



Legend:

Plus = real values

Stars = fitted values

Sketched line = forecasted values

Continuous lines = 95% confidence interval

3. Water consumption and urban evolution: in search of similarities

In this section we firstly investigate Milan's long term trends through the analysis of those socio economic factors that the literature identifies as relevant for water consumption understanding. Secondly, we try to find out, through the application of cluster analysis, if these socio-economic variables show statistical similarities with water consumption.

3.1 Long term evolution trends: population, productive structure, rainfall and price of water

Demographic trends - In 1889, Milan's population was 386.211 (Comune di Milano, 2003); in the following 112 years considered here, the peak was achieved in 1973 when Milan's population reached 1.743.427. In the following decades a continuous decline brought Milan's population down to 1.256.211 people in 2001, confirming the general de-urbanisation trend that has been under way in Italy since the 1970's.

Some demographic changes can be ascribed to specific shocks in natural balances: the world wars, the baby boom of the early sixties and the following strong reduction of the birth rate registered since the early seventies until the end of the nineties.

Migration balance, as it happened in many European cities, strongly influenced demographic trends. In particular, with a certain degree of simplification, four different migration waves can be distinguished. The first wave of immigration corresponds to flows from southern Italian regions, which increased population in the thirties. The second wave is the relevant increase of immigrants registered during the post-war industrialisation that occurred during the fifties and the sixties. The third wave is the negative migration balance registered between the mid seventies and the mid nineties, due both to de-industrialisation and to the diffusion of tertiary activities in the downtown area. The final wave corresponds to the beginning of a new immigration flow, mostly due to foreign immigration, and started in the late nineties.

A final a relevant demographic phenomenon is the growing age of resident population, because increasing living cost – especially with regards to housing – accompanied the increasing difficulty for younger generations to move to Milan. In 1999, Milan's ageing index – the number of people older than 65 over the number of people younger than 14 - was about 1.6 times higher than the Italian average.

To conclude, these long term demographic trends are very relevant given their potential impact on overall water consumption, as the literature shows (Renzetti, 2002, Arbués Garcia *et al.*, 2001).

The evolution of productive structure - This brief section outlines the most crucial evidences on the dynamics of manufacturing and services in Milan (ISTAT, 2001).

Manufacturing shows a quite constant increase until the sixties, the decade in which Milan reaches a top position as an industrial pole. However, the 1960's also marked the beginning of an upsurge in the tertiary sector, a trend which is still ongoing. These years also saw the emergence of a new leadership for Milan, which became the landmark city in Italy for lots of tertiary sector activities, namely: fashion, finance and banking, university and research.

The evolution of economic structure deeply influenced water consumption since industrial water accounts for about a quarter of total water use in industrialised countries (Dupont and Renzetti, 2001). Moreover, the impact of technological innovations in reducing water demanded by "thirsty" industrial processes should also be taken into account.

In terms of firm size, the service sector is far more fragmented than the manufacturing sector, since the average service sector firm has less than five employees while the average manufacturing sector firm has less than seven (ISTAT, 2004). Small family-owned firms are still prevalent, especially in retail trade activities, and often waterworks data on their water consumption is lumped with data on household water consumption.

Rainfall since 1889 - As most literature suggests, annual rainfall should be carefully considered since it represents an important key factor in explaining water consumption variations (Arbuès Garcia *et. al*, 2001). Our data measures the annual millimetres of Milan rainfall collected by *Osservatorio Metereologico di Milano Duomo* (2002).

These figures show the typical evolution of long rainfall data series: a very high yearly variability in a substantially stable trend during the 113 years considered. In fact, the majority of yearly precipitation falls inside the layer defined by a lower boundary of 800 millimetres and an upper boundary of 1200 millimetres. Climatic anomalies emerge particularly in three years with very low (420 millimetres in 1920) or very high (1587 millimetres in 1950, 1583 in 1958) precipitation levels. These rainfall outliers account for very few cases in our long-run data set.

Water tariff and income – Since its waterworks foundation, Milan's water price plan has always featured an increasing block tariffs model. We concentrate our analysis on the lower level tariffs, which are applied to water consumption level up to 350 litres per day. This tariff accounts for a significant share of total consumption – more than 40%. Municipal waterworks statistics on tariffs goes back to 1914, allowing the examination of a sufficiently long time series.

In Milan, like in all Italian municipalities, water tariffs have always been controlled by a government committee and primarily set according to social goals. Hence, for a long time water tariffs have been low and stable.

In the last twenty years increases in water tariffs became much more frequent than in the past. Nowadays, the tariff block we are considering is 0.09 euro for each cubic meter of water consumed.

The development of tariffs - in real terms – during the twentieth century highlights two further points. The first point is connected to the fact that tariffs reached their maximum level during the mid 1930's. The second point refers to the fact that the three years around the end of II world war exhibit the sharpest tariff rises: in 1945 +32%, in 1947 +90% and in 1948 +90%. The interpretation of this evidence seems to suggests that the second world war marks a real divide for the water system. From a pre-war condition of stable tariffs and poor water network coverage, we move to a sensible growth in both tariffs and network coverage after the worldwide conflict. This last phenomenon could be ascribed to the economic recovery and to the rapid redevelopment of urban infrastructures that took place in Milan in the post-war era.

Starting from 1994 – with the so called Galli Law - municipal waterworks operates as a private firm in the water distribution market. The real effects of privatisation on price dynamics and working efficiency could be discussed only in the future.

In terms of income, data availability only allows us to analyse income evolution through the proxy of per capita value added in real terms since 1951. After a tremendous growth lasting almost two decades, Milan shows a decreasing income starting in the ‘70s. However, Milan has always been one of the top ranked Italian cities in terms of income, and per capita income is consistently much higher than the national average[2].

3.2 Similarities among water consumption and socio-economic factors

In order to find similarities among water consumption and socio-economic variables, we apply cluster analysis. By using this technique, borrowed from multivariate statistics, we partition the entire set of variables, using the euclidean distance, so that relatively homogeneous groups of variables can be formed. The groups, or “clusters”, obtained with this method should be highly homogeneous internally - members are similar to one another - and highly heterogeneous externally - members are not similar to members of other clusters.

Obviously, we will focus our attention particularly on the specific cluster which includes water.

A preliminary step of the analysis is the standardisation of values since variables in the data set are measured by different scales. Therefore, our raw

[2] To give an example, in 1999 the average per capita value added in nominal euro was 28.116 in Milan and 17.841 in Italy (Istituto Tagliacarne, 2003).

data is converted to standardised values with zero mean and unitary standard deviation .

We apply the single linkage algorithm, but we use also other algorithms generally adopted by this technique – complete linkage and average linkage – in order to control results stability. Distance coefficients suggest that the three cluster result should be chosen, since other solutions can produce less efficient clusters with a resulting loss of significance.

Table 3: Cluster membership results. Single linkage algorithm

Variables	Clusters
Per capita average daily water consumption	1
Population	1
Rainfall (millimeters)	1
Service firm	1
Service employee	1
Natural balance	2
Migratory balance	2
Per capita value added (real term)	2
Manufacturing firm	2
Manufacturing employee	2
Water tariff in real terms	3

The cluster analysis results, illustrated in Table 3, show that clear similarities emerge among water consumption and some socio-economic variables - population, rainfall and service data - in the years considered[3]. In other words, water consumption can give some insights on long term evolution of some crucial factors for urban development, such as: population, weather, some aspects of the economic structural change trough the evolution of tertiary sector. This last issue can be explained by the fact that tertiary firms' water demand exhibits some characteristics which are comparable with those of households demand. Both the scarce water utilisation in its production processes and the small size of firms, place service sector water consumption patterns closer to those of households rather than to those of the manufacturing sector. This first cluster, in synthesis, shows how these factors evolved homogeneously.

A second cluster put together the evolution of economic variables related to manufacturing and value added with demographic variables associated to population flows. This group of variables seems to indicate that, in recent Milan's history, structural change due to manufacturing exhibits a co-evolution with changes in birth rates and/or in migration flows. In other words, this reveals that relevant population variations happened alongside periods of manufacturing transformations as in the sixties, for example. This cluster basically tells a story of urban development where economic variables are prevalent and their evolution is also reflected by demographic flows.

[3] Here we consider the interval 1951-2001 because data on value added start from 1951.

A third cluster isolates the variable relative to water tariff. Its progress through the decades has been subject to political control and, for this reason, it cannot be associated with other economic or social variables considered in this article. This cluster confirms that water price "tells its own story", without any strong interaction with other structural characters of urban evolution.

4. Policy implications

Policy implications, deriving from our analysis, raise some relevant issues with regards to urban water policy implementation.

These deeply-rooted habits, highlighted by the intervention model suggest that policy makers should look to the long-run as their policy horizon. The consolidated level of per capita consumption - at least for the last thirty years - seems to indicate that any policy intervention should be calibrated on an sufficiently extended time span.

Cluster analysis results seem to imply that changes in tariffs could have a weak impact on water consumption. This is consistent with the fact that water has been always distributed within a public monopoly regime in which price has been determined regardless of economic considerations.

Since water is perceived as an unbounded and low-price resource, suitable policy instruments should be adopted both on demand and on supply side.

On demand side, policy makers could launch information campaigns on water use to increase consumers awareness of problems linked to water provision. Such policies could be able to modify water consumption because they should impact consumption habits directly- at least in the long-term.

On the supply side, future interventions should mainly rely on two issues: diversification of water quality and technical innovations in water supply. The former involves subsidies for the replacement of all water using capital, both for households – washing machines, dishwaters, toilets, showers – and for communities – swimming pools and lawn sprinklers (Arbuès Garcia *et al.*, 2001; Nauges and Thomas, 2003) The latter entails the chance to invest in diversification of the quality of water, supplying fresh water for drinking consumption and low-quality water for other uses (Dalhuisen *et al.*, 1999). This seems to be very relevant, particularly for municipal water consumption, where a sizeable quantity of water is used for outdoor needs, like irrigation for public gardens or streets washing.

Finally, our results highlight the need for constant monitoring of some specific issues underlying water consumption: demographic, environmental and tertiary sector changes. Gathering and connecting long term statistics on these topics should be at the heart of an ordinary control of water consumption evolution exerted by municipalities.

5. Concluding remarks

In this paper we both provide an assessment on relevant changes in Milan's water consumption over the course of a 113-year period and try to find out similarities between water consumption and other socio-economic factors.

A fundamental result of the univariate analysis refers to the presence of well entrenched water consumption habits, which are stable over long periods and presumably derive from the common idea that water is a low price and abundant good.

Multivariate analysis indicates that water consumption presents strong similarities with demographic, environmental, and tertiary sector evolution. Some of these variables were decisive in determining crucial modifications in the water consumption. Indeed, the application of intervention models confirms that some demographic and pollution shocks were decisive to determine shifts in water consumption evolution.

From all these outcomes, we derived different policy proposals suited both to intervene on the persistency of consumption habits and to control future development of water utilisation.

In our view, given the existence of shared trends in many European cities, the policy recommendations obtained could be probably extended to other large urban areas.

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(lxv) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications” organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003

(lxvi) This paper has been presented at the 4th BioEcon Workshop on “Economic Analysis of Policies for Biodiversity Conservation” organised on behalf of the BIOECON Network by Fondazione Eni Enrico Mattei, Venice International University (VIU) and University College London (UCL) , Venice, August 28-29, 2003

(lxvii) This paper has been presented at the international conference on “Tourism and Sustainable Economic Development – Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003

(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003

(lxix) This paper was presented at the Fourth EEP Plenary Workshop and EEP Conference “The Future of Climate Policy”, Cagliari, Italy, 27-28 March 2003

(lxx) This paper was presented at the 9th Coalition Theory Workshop on "Collective Decisions and Institutional Design" organised by the Universitat Autònoma de Barcelona and held in Barcelona, Spain, January 30-31, 2004

(lxxi) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by Fondazione Eni Enrico Mattei and Consip and sponsored by the EU, Rome, September 23-25, 2004

(lxxii) This paper was presented at the 10th Coalition Theory Network Workshop held in Paris, France on 28-29 January 2005 and organised by EUREQua.

(lxxiii) This paper was presented at the 2nd Workshop on "Inclusive Wealth and Accounting Prices" held in Trieste, Italy on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics

(lxxiv) This paper was presented at the ENGIME Workshop on “Trust and social capital in multicultural cities” Athens, January 19-20, 2004

(lxxv) This paper was presented at the ENGIME Workshop on “Diversity as a source of growth” Rome November 18-19, 2004

(lxxvi) This paper was presented at the 3rd Workshop on Spatial-Dynamic Models of Economics and Ecosystems held in Trieste on 11-13 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics

(lxxvii) This paper was presented at the Workshop on Infectious Diseases: Ecological and Economic Approaches held in Trieste on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics.

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