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A Qualitative Segmentation of Drinking Water Market in Tunisia: Regional Diversification

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Strictly as per the compliance and regulations of :

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Originality / value : In most developing countries, we notice absence of real drinking water markets which did not lead to a true and fair valuation of drinking water. The integration of the variable quality to estimate regional demand functions allows Tunisian policymakers to rethink current drinking water management. Market segmentation based on qualities will create a fairer market where the consumer pays a fair price consistent with the quality received.

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I. Introduction

There is no doubt that water is vital for both humans and for other species. Thus, according to Frederico Mayor [1999] "Water is first a natural and ecological good that plays an important role in the biosphere and whose functions are useful to mankind. It can not be reduced to that of a raw material exploitable and expendable at will. It is a social and economic good whose uses by humans are regulated by law. "

However, despite the importance of this resource, we notice that it exists in limited quantities and is unevenly distributed in the world. Moreover, very large spatial and regional disparities in the quality of fresh water are recorded. To this shortage is added a quantitative mismanagement which is explained by many factors (patterns of unsustainable development, population growth, drought, ecological imbalances etc.). The figures show that more than a billion people do not always have access to clean and safe water. The problem of quality is one of the leading causes of death and disease in the world. Climate change and pollution threaten drinking water which represents only 3% of the world's water.

Faced with this multidimensional challenge (political, socio-economic and ecological), the World Bank, in recent statistics, estimated that water supply would require $ 180 billion a year for developing countries in the next 25 years, while the current investment is around 70 to 80 billion. Henceforth, it is necessary to review current use patterns of this resource in terms of production and consumption so that any water use is done while preserving the interests of future generations.

Tunisia, like many countries in the world, can be classified as a disadvantaged geographical area where available water resources continue to decline and where reserves have reached their threshold. The relative scarcity of this resource is one of the major challenges facing the Tunisian decision-makers for a more effective and efficient management of the said resource.

The current principle of water management depends, in a large measure, on recorded rainfall. In other words, the surplus in years of high rainfall must be used and operated in low rainfall years. But as long as these resources are often limited, random and unevenly distributed across the country, this solution remains inadequate and highly risky. Indeed, a policy of sustainable development should be based on stable water resources in order to promote the productive sectors (agriculture, tourism, agribusiness, etc.).

Urbanization, migration to the capital (Tunis) and coastal governorates and climate change have created an imbalance between water supply and demand. The adjustment to be done is primarily quantitative and the central constraint to take into account. It is that of satisfying global demand. However, this quantitative water resources management did not often integrate water quality as a decision variable in pricing policy. That quality is considered homogeneous by SONEDE despite the huge variation in the physico-chemical nature of water distributed within and across regions.

Thus, the underlying objective of this paper is to study the influence of the variable quality on the structure of the global and spatial drinking water

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demand in Tunisia. The variable "quality" that was excluded in the policy of SONEDE may present a critical factor in changing consumer preferences.

The remainder of this paper is organized as follows: the second section presents an analysis of drinking water quality. The third section will describe the empirical methodology checking for the quality problem in water resources management. The fourth section gives the estimation results of the econometric models and their interpretation. The last section concludes the paper.

II. Definition and Analysis of the Quality of Drinking Water in Tunisia

In a crude way, quality of drinking water needs to satisfy two basic criteria. The first takes into account the enforced national and international standards determining the physico-chemical characteristics that water should meet in order to be a drinking water (taste, clarity, smell ... etc..). The second criterion relates to the quality of different services and facilities necessary to ensure efficient production and a continuous distribution.

In Tunisia, the issue of water quality is always raised as we easily notice that this good is not homogeneous either within or across regions. By way of illustration and not exclusive, treatment of surface waters in the North of Tunisia offers water quality that complies with that required by international standards. However, this quality can cause problems especially in Centre and in the South of the country. Although the Tunisian strategy recommends nationally serving water salinity less than 1.5 g / l. This objective is not fully achieved between different regions of the country and even within the same region.

While aware of this problem, in the context of an approach aimed at improving quality of services to its customers, "the SONEDE conducted a satisfaction survey in April 2003 and had two fundamental objectives. First, assess current quality of service provided by SONEDE and secondly to measure level of quality expected by customers. The selected sample covered 2100 subscribers (in domestic drinking water) spread over 33 districts and centres and including all social levels. The results indicate that 19% of customers believe that quality of supplied water is excellent, 30% judge it as good, 32% consider it average, while the rest (19%) consider it bad."[3]

Low levels of satisfaction are recorded especially in the South where salinity is relatively high. These results confirm bacteriological studies and analyzes by samples that showed evolution (in percentage) of filthy water (i.e. quality of drinking water is a consumption problem for users) for the whole of Tunisia, reaching 1.5% in 2009 and ranged from a minimum of 0.4% recorded in the northern regions to a maximum of 1.7% recorded in the South.

It follows from what has been mentioned above that quality of drinking water is a serious problem in the Tunisian context which makes its current management inefficient and unfair especially that the constraints faced by decision-makers are numerous (scarcity, unequal distribution, quality heterogeneity etc..). In other words, variability of water quality within and across regions needs a price discrimination policy that takes into account scarcity of the resource and financial resources of users.

III. Empirical Methodology

To analyze the problem of drinking water quality in Tunisia, we used a study of a statistical survey conducted on a sample of 1,200 households. The underlying thinking behind this study is to cover and represent all professional categories of consumers who are served water from the SONEDE. Variation in consumer preferences is detected by the personal assessment of households questioned about their drinking water consumption (taste, smell, clarity, etc.).

a) Presentation of the Survey

As already mentioned, the survey we conducted during 2004, allowed us to better understand households behaviour with respect to their consumption of drinking water and their reactions towards a set of independent variables of strategies of consumption. To meet the ratio of 10% of the population base as minimum size of the sample, the total size of the sample is 1200 households. To involve all socio-professional categories we had recourse to a stratified sampling design which allowed us to ensure their representativeness. Each stratum includes a definite socio-professional category and classified according to a given number of individuals. Finally, each stratum is distributed in their appropriate cities.

The questions of the questionnaire are designed to clarify two distinct problems. First, how consumers feel they current water management and secondly, how they know to evaluate the water quality they consume. The basic unit of our sample is the "household" while the independent variables of demand function are household income, quality of drinking water, the quantity of bottled water consumed, existence of alternative sources, type of occupied residency, household size and education level (Point (1993) and Howe (1982)).

b) Functions of Global and Regional Demand

Research focusing on estimating water demand function are scarce and mostly exploratory in nature, since consumed water quantity is often independent of current costs incurred by distribution companies. According to Point [1993] analysis of drinking water demand is primarily focused on the needs. Quantity of water consumed and prices depend on the particular evolution of population as well as their lifestyle.

Among the few studies that have focused on estimating drinking water demand function include those of Howe [1982] and Point [1993]. The first has linked consumption and price through a cross-sectional analysis. Point [1993] focused on the problem of sharing water resources between different users. To do this, the author took into account three categories of use; commercial, industrial and domestic. The results indicate that price elasticity is around -0.167 compared to average price for the department of Gironde in France (such a study is conducted to estimate drinking water demand, throughout Tunisia and for "domestic use" category in 2004, which reached an elasticity approaching - 0.42 compared to the average).

Like in several countries of the world and Tunisia, the demand function model does not include water quality as a variable. This variable can be fixed in advance by the supervisory authority as in France where it offers a multitude of water agencies available to consumers. In other countries such as Tunisia quality is considered, or rather assumed, as a homogeneous entity, although it is not.

Therefore, the introduction of the variable quality in the demand function model aims at anticipating changes in consumer preferences due to a change in the nature of quality offered. Indeed, these variations can be explained by the negative or positive effect that the variable quality may have on the quantities consumed by households expressed by the amount of the bill. To achieve this goal, drinking water demand function model should take the following form:

$$y_i = \alpha_0 + \alpha_1 x_i + \alpha_2 z_i + e_i$$

Where y_i represents the amount spent by a household to purchase drinking water, x_i represents a vector of variables related to water management and z_i represents a vector of variables related to households' socio-economic characteristics.

Therefore, according to the followed empirical procedure, this model will be estimated in various ways. At first, demand function estimation will include all observations in the sample, and this to see and understand the inter-regional impact and how quality varies from one region to another. In a second step, estimation of demand function is done separately in three major geographical areas of Tunisia, namely Greater Tunis, Sousse and Gabes, to infer intra-regional information on drinking water management.

IV. Results and Discussion

a) Descriptive Analysis

Through a rough view of the information gathered from the questionnaire, we can draw the following conclusions:

i. The most frequent quarterly amount of the bill is 30 dinars. This amount is spent by 138 households which represent 11.5% of our sample.
ii. Availability of drinking water is not generally a problem for the Tunisian consumer given that this resource is distributed continuously throughout the year (359.11 / d 365) and given a rate of availability approaching 98.6%. The few disturbances and interruptions are recorded during summer season.
iii. Households with higher incomes are more likely to put at risk current water quality and this because they have the means to substitute it. The figures confirm the hypothesis that the proportion of households (86.4%), who had a poor evaluation (to an average limit) of water quality provided by SONEDE mostly belongs to the class of rich households.
iv. Most respondents have no idea about SONEDE pricing policy. Those who know pricing (16.9%) generally have a secondary second cycle or higher education level.
v. Analysis also indicates that 24% of households have alternative sources (Magin, Well, others ...) in favour of domestic consumption. This category of consumers is assumed to be in search of new water sources substitutable to SONEDE water especially if that category believes that drinking water quality is bad.
vi. According to the results of the survey, 57.1% of households use bottled water. This type of good is indeed an effective solution for a broad class of consumers, especially in the case where drinking water quality poses problems in terms of consumption. Most respondents believe that bottled water is a necessity especially for those who have some diseases (renal failure, etc.) or who have fear of having them. Faucet water and irrespective of its quality is assumed to have a lower quality than that of bottled water. We note that in average each household consumes 5.19 liters per week.
vii. Most respondents felt that drinking water quality is bad or average at most (86.4%) while only 13.6% consider it satisfactory.

b) Econometric Analysis

Data processing of the statistical survey indicates that water demand depends on a complex structure of variables which are alternative sources, household size, how consumers evaluate faucet water quality, occupation of housing and income level. These variables have a significant effect on determining consumer behaviour towards demanded water quantity.

The econometric analysis aims at estimating the coefficients of these variables based on econometric methods appropriate for estimating evaluation functions in order to have highly significant results, which may be consistent with economic intuition, and useful to the design and implementation of all appropriate policies for sustainable management of a resource that is becoming dramatically scarce.

In this context, the main objective of the various econometric estimation is to determine the variables that are capable of influencing consumer behaviour. Then, the variables retained the in various econometric regressions are given by:

i. MFEPT : Amount of Quarterly Water Bill
ii. SAE : an alternative water source of household.
iii. Achat : amount spent on the purchase of bottled water.
iv. LIT : number of liters of bottled water consumed per week.
v. Qualité : quality of tap water.
vi. Prop: a variable for the legal nature of housing occupation (1 if owner is 0 otherwise).
vii. Taille: household size.
viii. Nivist: educational level of the interviewee.
ix. Nbdac: number of people in the household.
x. Prof: occupation of the interviewee.
xi. Revenu: household income.

Construction of econometric models resulted in a mixed set of independent variables; in this case we speak of covariance models. The goodness of fit of these models also depends on the choice of predictors. It is desirable to select a limited number of variables, non-redundant and with predictive power. The most common technique used to select the most explanatory variables is the Forward Stepwise Regression method[4].

i. *Global Demand Function*

Applying a "Forward Stepwise Regression" allows us to overcome problems encountered in a multicolinearity model. Therefore, the model chosen (after testing normality of errors) and corrected of all the problems of heteroskedasticity and autocorrelation of errors allowed us to obtain the following results:

$$\mathrm{MFEPT}_i = \underset{(5,553)}{7,870} + \underset{(20,406)}{4,009}\ \mathrm{Taille}_{1i} + \underset{(14,918)}{0,0123}\ \mathrm{Revenu}_{2i} \underset{(-21,408)}{-21,400}\ \mathrm{SAE}_{3i} - \underset{(-4,130)}{0,305}\ \mathrm{LIT}_{4i} + \underset{(1,692)}{1,125}\ \mathrm{Qualité}_{5i} \quad (1)$$

$$R^2 = 0,523 \quad \bar{R}^2 = 0,521$$

Indeed, it is observed that the size variable has a positive and significant coefficient with an error risk of 1%, which means that water consumption increases with number of people who constitute the household. The coefficient on household income is also positive and significant at an error risk of 1%. This result is consistent with economic predictions as long as the richer the household is the more water it consumes. Thus, a household with a high income had to pay a higher MFEPT.

The variable SAE coefficient is negative and significant at the 1% level. This means that when the household has alternative water sources, drinking water consumption decreases. This confirms the economic theory that states that a demand for a good decreases when the consumer makes use of perfect or near perfect substitutes.

The coefficient on LIT is negative and significant at the 1% level. Indeed, as consumers use mineral water they spend less on purchasing drinking water delivered by SONEDE.

The coefficient of the variable "faucet water quality" is positive and statistically significant at the 10% level. This implies that amount of bill varies with the level of quality estimated by households (good - average - poor). Therefore, amount of bill is low in case of poor quality especially if the household has an alternative source.

ii. *Spatial Demand Function*

In this section we try to estimate demand function in the regions of Greater Tunis, Sousse and Gabes to know the specifics of consumption structure and consumer behaviour in each of them. To this end, we will introduce permanent and fundamental variables in the construction of a valid econometric model for each region.

a. *The Greater Tunis Area*

For this region the estimated model has the following results:

$$\mathrm{MFEPT}_i = \underset{(3,381)}{6,737} + \underset{(13,348)}{4,691}\ \mathrm{Taille}_{1i} + \underset{(-10,627)}{19,588}\ \mathrm{Revenu}_{2i} - \underset{(5,176)}{0,00677}\ \mathrm{SAE}_{3i} \quad (2)$$

$$R^2 = 0,560 \quad \bar{R}^2 = 0,556$$

The estimated model indicates that the coefficients of size and household income are positive and significant with an error risk of 1%. These results are perfectly logical because large families or who have high incomes consume more water. In addition, the variable SAE coefficient is negative and significant at an error risk of 1%, which means that consumption decreases with the existence of alternative sources, in which case consuming SONEDE water becomes smaller.

b. *The Sousse Area*

In this region the linear regression estimated is given by:

$$\text{MFEPT}_i = \underset{(12,183)}{41,761} - \underset{(-2,881)}{1,553}\ \text{Taille}_{1i} + \underset{(2,464)}{0,00451}\ \text{Revenu}_{2i} + \underset{(2,194)}{4,827}\ \text{Qualité}_{3i\ i}\ (3)$$

$$R^2 = 0,228 \quad \bar{R}^2 = 0,220$$

In this region, the coefficient on Taille (Size) is negative and significant at an error risk of 1%. This result is not consistent with reality, since in principle water consumption increases with household size. Can we say that there is some correlation between family size and household wealth? A priori, the answer is positive, which means that a small family is probably richer and therefore it consumes more water.

The coefficients on income and water quality are positive and significant at the 5% level. As household income increases, more water is consumed. Moreover, when drinking water quality improves then consuming water increases, thereby increasing the amount spent by consumers.

c. *The Gabes Region*

The linear regression estimated in this region gave the following results:

$$\text{MFEPT}_i = \underset{(3,352)}{11,454} + \underset{(3,291)}{2,436}\ \text{Taille}_{1i} + \underset{(3,886)}{0,00949}\ \text{Revenu}_{2i} - \underset{(-4,868)}{15,975}\ \text{SAE}_{3i} - \underset{(-2,387)}{0,663}\ \text{LIT}_{4i} + \underset{(1,779}{2,074}\ \text{Nbdac}_{5i} \quad (4)$$

$$R^2 = 0,355 \quad \bar{R}^2 = 0,338$$

The coefficients on Size, SAE and income are significant at the 1% risk level. Size and income have positive coefficients but SAE has a negative coefficient. The coefficient of the variable Nbdac is positive and significant at the 10% risk level, which means that when the number of people in a household increases there will probably be a wealth effect that is created and encourage the said household to consume more drinking water, resulting on a positive effect on MFEPT. The coefficient on LIT is negative and significant at an error risk of 5%. This means that in this region, there's a general movement towards consuming bottled water to replace SONEDE water especially for drinking.

V. Conclusion

The estimation of water demand function indicated that the dependent variable (MFEPT) in the different models is influenced by many variables that need to be integrated in water management. The most important variable is the quality variable which essential in household consumption structure. The estimation of regional demand functions in the areas of Greater Tunis, Sousse and Gabes showed that variation of the variable MFEPT is mainly due to household size, income, SAE and especially the variable quality which differs significantly between these three regions. In Greater Tunis, this variable is not problematic while in the other two regions of Sousse and Gabes, the situation becomes more complicated. In these two regions faucet water quality is a dominant factor in explaining consumer behaviour. Indeed, in the region of Sousse bill amount varies directly with the level of quality offered, while in the region of Gabes this variation is explained by the fact that consumers are looking for substitutable goods (SAE, LIT).

However, despite its importance in water management, the variable quality is still neglected by decision-makers. Should we rethink SONEDE pricing policy and restructure it so that it is fairer and more effective? The answer is, a priori, positive because the current strategy of drinking water management in Tunisia has reached almost its limits. Thus, it would be wiser to recognize heterogeneity in the quality of water distributed and price according to the quality offered taking into account households' socio-economic status and this to ensure their right to healthy and pure water consumption.

Footnotes

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2. Assistant Professor in Economics; researcher in contemporary philosophy. Graduate School of Business la Manouba Tunis, Manouba University, Tunisia. E-mail: fakhriissaoui@yahoo.fr
3. Bouchrika, A ; Issaoui, F and Charfeddine L. (2012) "La qualité de l'eau potable et les préférences de consommateurs : cas de la Tunisie"

in Global business and Management research vol 4 n°2.

4. When the number of variables is important and to avoid multicolinearity problem between the independent variables, it is necessary to have methods for the automatic selection of variables: forward stepwise regression, back ward stepwise regression or a combination of both methods.

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Appendix 1

❖ **Phase 1 : questions relatives à la gestion de l'eau.**

Q1 : Pouvez vous m'indiquer le montant de votre facture d'eau trimestrielle ?
Combien ?................

Q2 : Avez-vous une idée sur la tarification de l'eau potable ?

Non ☐ Oui ☐

Q3 : Quel est le nombre de jours pendant lesquels l'eau est régulièrement disponible dans l'année ?................/365.

Q4 : Avez-vous des sources alternatives d'eau (magin, puits, autres…)

Non ☐ Oui ☐

Q5 : Achetez-vous de l'eau en bouteilles ?

Non ☐ Oui ☐

Q5 a: Combien de litre par semaine ?…………………………

❖ **Phase 2 : questions relatives à la qualité de l'eau potable.**

Q6 : Que pensez-vous de la qualité de l'eau de robinet ?

Bonne ☐ Moyenne ☐ Mauvaise ☐

Q7 : Quelles sont les raisons de cette appréciation ?

Son goût Oui ☐ Non ☐

Sa limpidité Oui ☐ Non ☐

Son odeur Oui ☐ Non ☐

❖ **Phase 3 : questions relatives aux caractéristiques socioéconomiques.**

Q8 : Genre : Homme ☐ Femme ☐

Q 9 : Etes vous locataire ☐ Propriétaire ☐

Q 10 : Quelle est la taille de votre ménage ?
…………………………..personnes.

Q 11 : Quel est votre niveau d'instruction ?

Analphabète ☐ Secondaire 2eme cycle ☐

Primaire ☐ Supérieur ☐

Secondaire 1er cycle ☐

Q 12 : Quel est le nombre d'actifs dans votre ménage ?..................

Q 13 : Quelle est votre profession

Journalier ☐ Ouvrier ☐ Indépendant agricole ☐

Indépendant industriel ☐ Indépendant commercial ☐ Cadre ☐

Q 14 :Quel est le montant total des revenus mensuels nets de votre ménage?
Combien ?..................

Appendix 2

Analyse statistique du questionnaire

Tableau 1 : Connaissance de la tarification

		Fréquence	Pourcentage	Pourcentage valide
Valide	Non	997	83,1	83,1
	Oui	203	16,9	16,9
	Total	1200	100,0	100,0

Tableau 2 : Sources alternatives d'eau potable

		Fréquence	Pourcentage	Pourcentage valide
Valide	Non	911	75,9	76,0
	Oui	289	24,0	24,0
	Total	1200	99,9	100,0

Tableau 3 : Qualité de l'eau de robinet

		Fréquence	Pourcentage	Pourcentage valide	Pourcentage cumulé
Valide	Mauvaise	561	46,8	46,8	46,8
	Moyenne	476	39,7	39,7	86,4
	Bonne	163	13,6	13,6	100,0
	Total	1200	100,0	100,0	

Tableau 4 : Consommation d'eau embouteillée

		Fréquence	Pourcentage	Pourcentage valide
Valide	Non	515	42.9	42,9
	Oui	685	57.1	57,1
	Total	1200	100,0	100,0

Tableau 5 : Genre

		Fréquence	Pourcentage	Pourcentage valide
Valide	Féminin	473	39,4	39,4
	Masculin	727	60,6	60,6
	Total	1200	100,0	100,0

Tableau 6 : Occupation du logement

		Fréquence	Pourcentage	Pourcentage valide
Valide	Locataire	326	27,2	27,2
	Propriétaire	874	72,8	72,8
	Total	1200	100,0	100,0

Tableau 7 : Niveau d'instruction du chef de ménage						
		Fréquence	Pourcentage	Pourcentage valide	Pourcentage cumulé
Valide	Néant	128	10,7	10,7	10,7
	Primaire	179	14,9	14,9	25,6
	Secondaire 1er cycle	165	13,8	13,8	39,3
	Secondaire 2ème cycle	245	20,4	20,4	59,8
	Supérieur	483	40.3	40.3	100.0
	Total	1200	100,0	100,0	

Tableau 8 : Profession du chef du ménage				
		Fréquence	Pourcentage	Pourcentage valide
Valide	Journalier	139	11,6	11,6
	Ouvrier	216	18,0	18,0
	Ind. agricole	134	11,2	11,2
	Ind. Industriel.	274	22,8	22,8
	Ind. commercial	178	14,8	14,8
	Cadres	259	21,6	21,6
	Total	1200	100,0	100,0