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Agricultural Economics 28 (2003) 1–12

AGRICULTURAL ECONOMICS

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Welfare consequences of water supply alternatives in rural Tunisia

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Received 14 November 2000; received in revised form 26 August 2001; accepted 14 November 2001

Abstract

Many economic studies have addressed the issue of inefficiency of public water supply in rural areas and the potential for improved service by private companies. Many of these analyses focused on identifying either willingness to pay or comparing average service costs and prices paid by customers. This paper performs a welfare analysis of two water supply systems—public and self owned—in rural Tunisia. The paper calculates consumer and producer surplus and compares the performance of the two systems from a social point of view. Results suggest that both systems are inefficient, mainly because of a production level that is low compared with production capacity.

JEL classification: O18; Q25; R13

Keywords: Rural water supply; Social welfare; Consumer and producer surplus; Water demand and supply

1. Introduction

Water is an expensive commodity in rural areas of developing countries. Only 30, 50 and 70% of the rural population world wide had access to safe water supply in 1980, 1990, and 1994, respectively (Table 1). In spite of the significant improvements made to facilitate access to safe water in rural areas, services provided in many countries are still not up to standard.

Water supply policy in developing countries has focused to a greater extent on population coverage and low tariffs (Atlaf, 1994). This policy, coupled with limited government funds, lead to a situation in which highly subsidised water supply systems produce low levels of service (Briscoe and de Ferrenti, 1988). Recent research on willingness to pay for improved water supply services[2] in the rural areas of developing countries indicates very clearly that households demand a higher level of service (World Bank Water Demand Research Team, 1993). Other findings suggest that they are willing to spend more to upgrade their level of service, and that they are actually spending significant amounts of money to augment the low level of service provided by the public water supply (Atlaf, 1994; Brookshire and Whittington, 1993; Mangin, 1991; Whittington et al., 1990).

Evidence on willingness to pay for improved service suggests that existing public supply systems are associated with social inefficiency. Moreover, the limits on the state's ability to provide water supply at a

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[2] Service levels can be measured by different variables such as: amount of water per person per day; number of hours per day for water supply; water quality; cost structure.

0169-5150/02/$ – see front matter
PII: S0169-5150(02)00032-4

Table 1
Percentage of persons with access to safe drinking water

	1970	1975	1980	1985	1990	1994
Tunisia						
Urban	92	93	100	100		100
Rural	17		17	31		89 (68[a])
Total	49		60	70		99 (87[b])
World						
Urban			77		82	82
Rural			30		50	70
Total			44		61	74

Source: all entries are from Tables 5 and 6 in Gleick (1998), Tables 5 and 6, unless otherwise indicated. Note: empty cells mean no data.

[a] INS estimates for 1996 suggest 68%.

[b] Based on estimates in MEAT (1997).

higher service level call for alternative solutions such as private companies, community participation and other decentralised arrangements. The World Bank Water Demand Research Team (1993) concluded that the level of service and the level of cost recovery for rural water supply at the village level can be adjusted to community characterisation and ability to pay, so that the long-term sustainability of the system can be achieved.

Parker and Skytta (2000) reviewed 15 World Bank rural water supply and sanitation projects, with a total investment of US$ 1 billion and 20 million beneficiaries. Their findings are very relevant to the work in this paper. Parker and Skytta (2000) suggest even more detailed policy measures than The World Bank Water Demand Research Team (1993) in that they allow various service levels per village, and request that projects should be adapted to the socio-economic characteristics of each village served. While we agree that village level design may be a necessary factor in improving the likelihood of efficient performance of the system, it may not be a sufficient condition for sustainability and equity. For example, data in Saleth (1996) indicate that water supply and sanitation programs in India between 1974 and 1989 could not produce sufficient revenue for financial sustainability. Comparing rural with urban performance, it is evident that rural schemes have operational costs that are two to three times higher, and run deficits that are four times larger than similar sized urban schemes. The explanation given by Saleth (1996) for this phenomenon is the fact that rural water supply schemes are undertaken as welfare activities under various basic needs programs and, therefore, financial viability cannot be applied to these schemes. Saleth suggests that financial viability can be improved by considering appropriate water rates structures, which will allow capturing both the needs of the greater proportion of poor in rural communities and the need for financial viability. In this regard, reforms of water supply rate design in the urban sector (Boland and Whittington, 2000) demonstrate the important role of various tariff structures, and the political economy consequences in developing countries that may explain why various stake holders may resist certain reforms.

Economic analysis of public rural water supply services is in most cases restricted to the village level (e.g. Mullick, 1987; Perkins, 1994; Wahadan et al., 1990; Roark et al., 1987; Mangin, 1991; Atlaf, 1994; and Whittington et al., 1990), or it attempts to estimate the potential value to consumers of an upgraded service level. Parker and Skytta (2000) also refer to this issue by distinguishing among three approaches—the top-down, the community-based, and the demand-responsive approaches. However, their review does not provide a clear cut among the various approaches. From the literature we have reviewed in this section, we conclude that it is not trivial to demonstrate whether alternative water supply arrangements, such as private sector or community management of the supply, are socially more efficient. Lack of appropriate data and locally restricted analysis may provide biased and partial answers.

To cast light on these issues, we analyse a dataset from Tunisia (Zekri, 1999). This dataset allows us to compare public provision with alternative provision of water supply services at sub-regional levels. The paper focuses on various comparisons between public and local water supply agencies, including cost effectiveness, price of service and welfare calculations. The next section introduces a simple economic framework by which welfare calculations of public and 'alternative' water supply arrangements can be compared. In the third section, a short summary of the rural water supply situation in Tunisia is provided. This is followed by an empirical section, which provides calculations of demand and supply of public and 'alternative' elasticities; of welfare calculations with public and 'alternative' water supply arrangements;

and of comparisons between cost effectiveness and price of service of the two supply arrangements. The paper concludes with a discussion of the social consequences of the two rural water supply systems in Tunisia.

2. Analytical framework

Why and when should public rural water supply be re-considered? We attempt to answer this question using the following simple analytical framework. Assume that water supply service level (Q) is expressed by one variable, that the public supply function (S_P) is inelastic, that demand (D) is monotonically declining and that the alternative supply function (S_A) is monotonically increasing (Fig. 1). Public supply at service level Q_P (the actual service level is lower than Q_P because users will turn away to other alternatives, leading to lower cost recovery rates and so on...) is provided at price P_P. At P_P the quantity demanded is $Q_{P'}$ ($>Q_P$), but this quantity cannot be provided by public supply. Consumer surplus at P_P is P_Pbcd', which does not reach its potential level P_Pbe, and producer surplus at this point is $aP_Pd'Q_P$. Social surplus at P_P is $abcQ_P$. Consumers are willing to pay up to P_1 to improve the service level. Therefore, alternative supply services will be introduced.

An alternative supply, characterised by a supply function S_A will produce equilibrium values of P_2

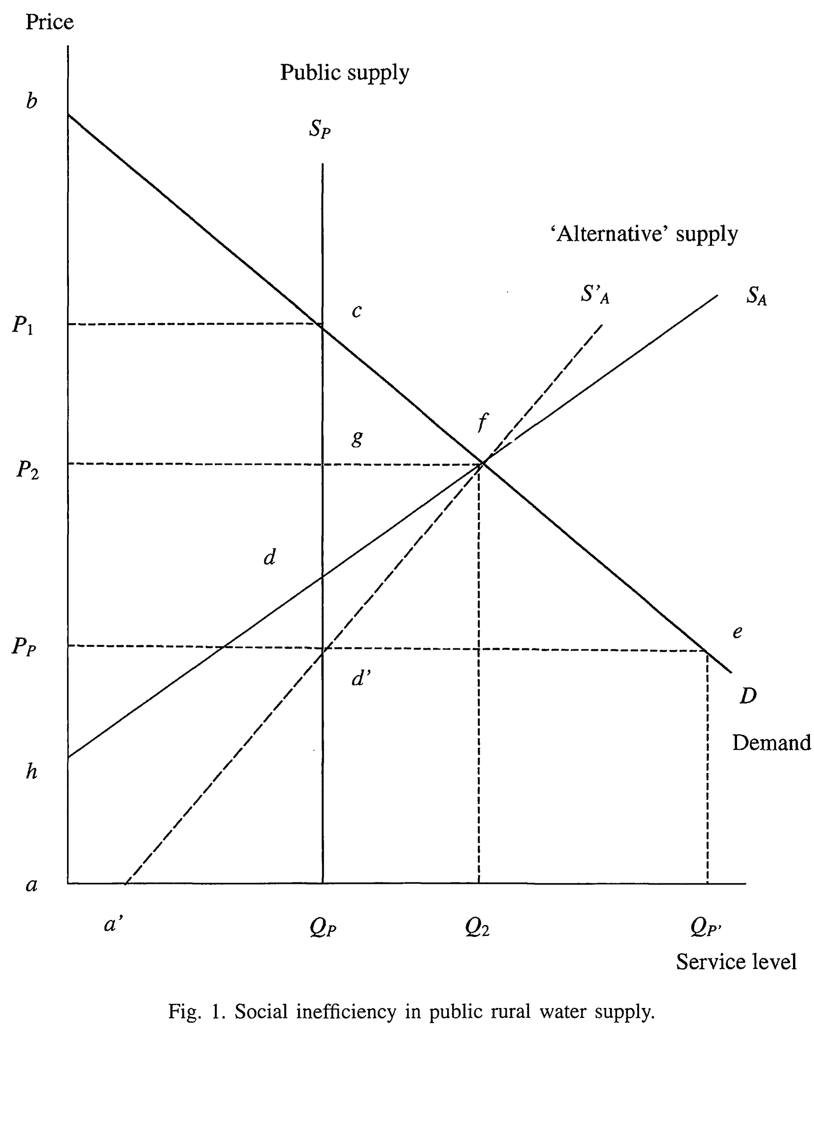

Fig. 1. Social inefficiency in public rural water supply.

and Q_2. Consumer surplus at P_2 is P_2bf and producer surplus is P_2fh. Social surplus at P_2 is hbf. An alternative supply will therefore be socially justified if $hbf - abcQ_P > 0$ or if $cfd > ahdQ_p$. Furthermore, with two alternative supplies, S_A and S'_A, both going through point 'f' and characterised by price elasticities ε_{S_A} and $\varepsilon_{S'_A}$, we can see that $\varepsilon_{S'_A} < \varepsilon_{S_A} \Rightarrow |cfd - ahdQ_p| < |cfd' - a'd'Q_p|$.

Estimation of demand and supply elasticities make it possible to empirically calculate the areas under the demand and supply curves, and perform welfare comparisons. Let ε_D be the price elasticity of demand, and ε_{S_P} and ε_{S_A} the price elasticities of public and 'alternative' supply, respectively.[3] Note that $\varepsilon_{S_P} \gg \varepsilon_{S_A}$. Since all quantities are known, and if we assume that while changing supply arrangement quantities demanded will not change dramatically (or in other words, that the demand function remains intact), one can derive the equilibrium price and calculate areas under the supply and demand curves. Suppose that Q_P and Q_2 are observed at levels of q_P and q_2, respectively, with $q_2 > q_P$. Then $\Delta q = q_2 - q_P$. By using the price information in the same way, define $\Delta P = P_2 - P_P$. Let the 'alternative' supply curve be $q_A = \alpha + \beta P$, where α is an intercept and $\beta = \Delta q/\Delta P$. Note that $\varepsilon_{S_A} = (\Delta q/q)/(\Delta P/P) = (\Delta q/\Delta P)(P/q)$. Since ε_{S_A}, P and q are known, $(\Delta q/\Delta P) = \varepsilon_{S_A}/(P/q)$. This can be inserted into the 'alternative' supply equation which becomes $q_A = \alpha + [\varepsilon_{S_A}/(P/q)]P$. A similar procedure can be used to specify the public supply equation and the demand equation.

3. Water supply in rural Tunisia

Investments in water provision to the rural communities in Tunisia are borne mainly by the public authorities, loans from international agencies or by private donations. MEAT (1997) estimated that 87% of the total Tunisian population had access to safe drinking water in 1994. INS (1997) estimated that 68% of the rural population had access to safe drinking water in 1996 (see also Table 1 for comparison with world status). Obviously, a large share of the rural population in Tunisia still lacks access to safe water resources.

The supply of drinking water in rural Tunisia is provided by two organisations: the Société Nationale d'Exploitation et de Distribution des Eaux (SONEDE) and the Associations of Collective Interests (ACI). The SONEDE is a public company that is responsible for supplying drinking water, mainly in urban areas, where it supplies 90% of the water quantity to 87% of the customers (and thus, exercises monopolistic power in the urban sector). An ACI is an association of joint use of a water resource. The ACIs are assisted by the public authorities (as part of the Agriculture Ministry, General Board of Rural Engineering-GBRE) with a bureau of ACIs at the national level as well as local ACIs. These organisations operate when there is no common or private safe and reliable water resource in a rural community to satisfy human needs.

In addition to these services, many families in rural areas have their private sources such as storage tanks to store rainfall water that is harvested from the roof or wells of the house. Harvested water is usually used only for drinking purposes. The other needs of the families are generally satisfied by alternative water sources of lesser quality, which are not suitable for drinking. The quality of the water supplied by SONEDE and GBRE/ACI in rural areas varies according to local conditions. Water quality is one of the most important variables contributing to the success/failure of the GBRE/ACI service.

3.1. The costs of water supply in rural Tunisia

There is a great disparity between the cost of water supply in rural Tunisia that is borne by both SONEDE and ACI, and the revenue these providers collect from users. The difference between the per unit cost of service and the fee reflect, to a certain extent, the hidden consumer benefits. To understand better the nature and extent of the cost-price difference, in this section we employ various sources of data on water provision costs in rural Tunisia. Table 2 presents data on various components of the cost of water supply to (urban and

[3] One reviewer suggested correctly that this comparison is valid only under the assumption that the suppliers are not natural monopolies. While 'alternative' supply is usually of a competitive nature, public supply is more likely to be natural monopoly. In the case of Tunisia, this is not the case in the rural sector since consumer associations can select the service provider (either SONEDE, ACI, or GBRE, as is explained in the next section). In fact, the public authorities do decide which is the best scheme to implement after a study by a private consultancy.

Table 2
Cost of water for SONEDE (all customers) and ACI (million 1996 TD)

Item	SONEDE	ACI
Total operating and maintenance expenses (*A*)	55146	2327648
Depreciation (*B*)	24043	5213320
Financial fees (*C*)	6698	
Total assistance cost (*D*)		218210
Financial exchange fees (*E*)	10443	
Total cost ($A + B + C + D + E$)	96331	7781075
Volume of water (million m^3)	228509	8378382
Total cost per unit of water (TD/m^3)	0.422	0.929
Operating and maintenance cost per unit of water (TD/m^3)	0.241	0.278
Staff cost per unit of water (TD/m^3)	0.128	
Depreciation cost per unit of water (TD/m^3)	0.105	0.625
Financial cost per unit of water (TD/m^3)	0.075	

Source: Zekri (1999).

rural without distinction) SONEDE customers and to ACI customers in 1996.

Scrutiny of Table 2 shows that the total cost of one cubic meter (m^3) of water to SONEDE customers in 1996 was 0.425 TD/m^3 (in 1996, 1 TD = US$ 1). The operating and maintenance cost was calculated as the sum of the expenditures on consumable materials, chemicals, fuel, energy, staff, water purchased and others. The numbers in Table 2 represent the cost of water supplied by SONEDE to rural and urban areas of Tunisia. There are substantial regional differences in costs (not shown, see Zekri, 1999), arising from remoteness and the number of service connections in the rural community. For example, in 1996 the total unit cost ranged from 0.229 TD/m^3 in the district of Tunis to 0.533 TD/m^3 in the district of Mahdia (SONEDE, 1997). Because of the unified prices applied to customers at the national level, it is clear that a substantial cross-subsidisation between districts or regions takes place. Besides, a tiered pricing method is applied for SONEDE customers, with consumers using less than 20 m^3 per quarter paying less than the total costs, which implies additional cross subsidies between users (Zekri et al., 1997). Therefore, one can expect variation also in consumer surplus among the various regions.

3.2. Estimating SONEDE water costs in rural areas

A breakdown of SONEDE cost data into rural and urban area is not available. To grasp the magnitude of the total cost of SONEDE water in rural areas, a detailed example of one rural locality is considered. Table 3 presents the total cost of supplying water to the rural locality of Hichria in the district of Sidi Bouzid (SB), as well as the total cost for the district of SB (rural and urban) in 1996. Hichria is a small rural community with 328 customers subscribed to SONEDE service. The network for water distribution extends over 20 km. The total cost for Hichria is 1.042 TD/m^3, whereas the total cost (rural and urban) in the district of SB is 0.464 TD/m^3 (SONEDE, 1998). The situation described for Hichria may be typical for other rural communities, namely remoteness that necessitates extension of the pipe system and service to a small number of customers. This translates into per unit cost in rural areas that are about three to four times higher than those in urban areas.

Table 3
Water costs in the rural locality of Hichria serviced by SONEDE (1996 TD)

	Hichria	District SIDI BOUZID
Consumables	1172	10221
Chemicals	538	12777
Fuel	1746	10221
Power	1706	71552
Water purchase	0	128285
Staff cost (*A*)	10893	495283
Overhead costs (*B*)	3203	98311
Others (*C*)	937	59163
Depreciation (*D*)	13578	299910
Total expenses ($A + B + C + D = T$)	33773	1185723
Volume of water serviced (*V*, million m^3)	32401	2555436
Total cost (T/V, TD/m^3)	1.042	0.464
Operating and maintenance cost ($(T - D)/V$, TD/m^3)	0.623	0.347
Staff cost (A/V, TD/m^3)	0.336	0.194
Overhead cost (B/V, TD/m^3)	0.099	0.038
Depreciation (D/V, TD/m^3)	0.419	0.117
Operating and maintenance cost/total cost (%)	59.8	74.7
Staff cost/total cost (%)	32.3	41.8
Overhead costs/total cost (%)	9.5	8.3
Depreciation/total cost (%)	40.2	25.3

Source: Zekri (1999).

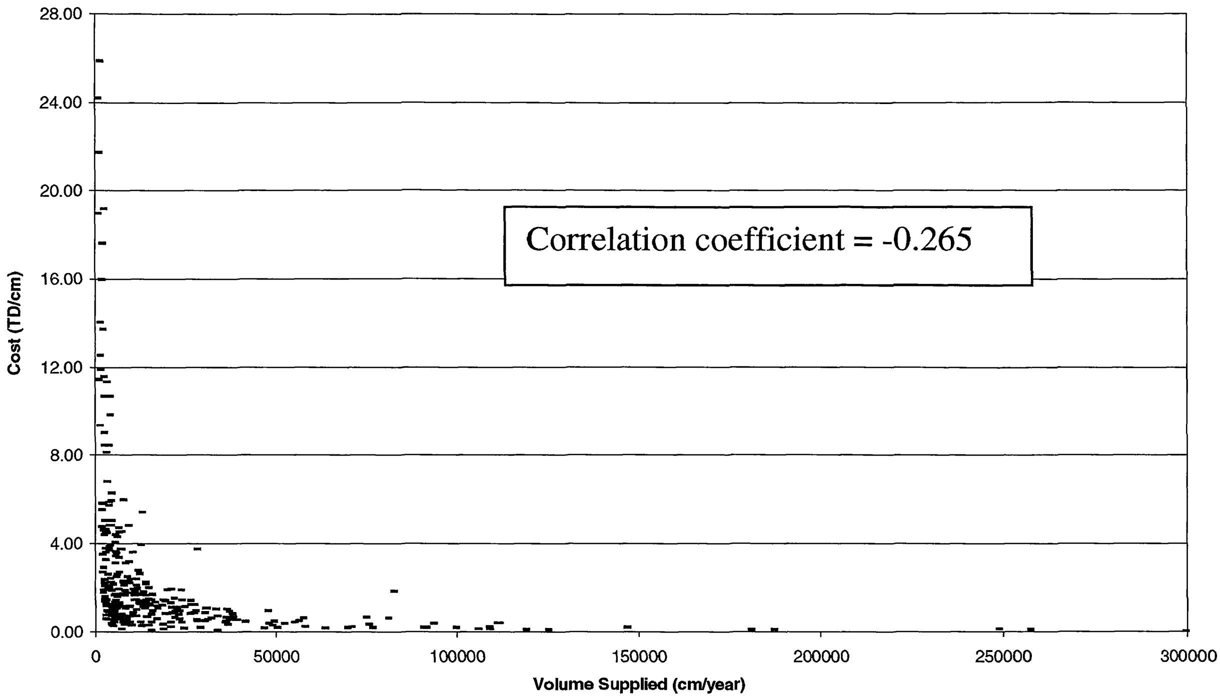

Fig. 2. Cost vs. volume supplied by ACI.

Lahouel et al. (1993) estimate the long-term marginal cost (LTMC) per unit of water for SONEDE in urban and rural areas. The estimates for the urban areas vary between 0.430 TD/m^3 in 1993 and 0.485 TD/m^3 in 1996. However, the estimates for the rural area ranged between 0.810 TD/m^3 in 1993 and 0.893 TD/m^3 in 1996. These figures show that rural LTMC is almost twice as high as urban LTMC.

3.3. The ACIs' water costs

The costs for the ACIs have been determined on the basis of available information for 637 ACIs in 14 districts of Tunisia in 1996. The information comes from the database of the Special Assistance for Project Implementation (SAPI, 1998) and the German firm IGIP. Cost information includes the following expenditures:[4] maintenance, operating and preparation costs, association management expenditures, payment of the annual instalment/annuity and expected expenditures.

The average operating cost for the 637 ACIs was 0.148 TD/m^3 in 1996. This cost varies considerably within regions with a maximum of 0.469 TD/m^3 for Sfax and a minimum of 0.084 TD/m^3 for Kasserine. The reasons for these variations are similar to those mentioned above for SONEDE supplies in rural areas. The average operating and maintenance cost in 1996 for the 637 ACIs was 0.278 TD/m^3. This is the cost that the ACI water users should have normally borne. Operating and maintenance costs also vary considerably among districts, ranging from a maximum of 0.796 TD/m^3 in Mahdia to a minimum of 0.147 TD/m^3 in Kasserine.

Where data was available, a detailed analysis of water supply costs in individual ACIs was also conducted. Of the 637 ACIs in the sample, we used only 405 because of missing data. The information reveals costs ranging between 0.041 and 25.88 TD/m^3. The distribution of per unit cost is plotted against the volume supplied in Fig. 2. About 72% of the ACIs

[4] Based on Decree no. 87-261 enacted on 27 October 1987, concerning the organisation and management of the ACIs.

Table 4
Comparison of total charges per consumer for SONEDE and ACI

	SONEDE & ONAS[a]	SONEDE only	ACI
Water consumption (m^3 per year)	137	137	68
Water services			
Water price (TD/m^3)	0.19	0.19	0.195
Fixed charges SONEDE (TD)	11.764	11.764	
Wastewater treatment			
Fixed charges ONAS (TD)	5.64		
Price (TD/m^3) (block 1 = 0–20 m^3)	0.006	0.006	
Price (TD/m^3) (block 2 = 20–40 m^3)	0.0078	0.078	
Value added tax (%)	18	18	
Total of the bill tax included (TD)	57.1	44.6	13
Total (TD/m^3)	0.417	0.326	0.195
Average cost of water (TD/m^3)	0.422	0.422	0.148
Price-to-cost ratio (%)	45	45	132

[a] ONAS stands for Office National Assainissement, and is the organisation in charge of wastewater management.

fall in the ranges of 0–40,000 m^3 per year and 0.04–6.0 TD/m^3.

To be able to compare SONEDEs and ACIs per unit rural water costs, depreciation costs as well as central administrative and regional specific charges should be added to the ACI cost structure. The reason is that ACI customers do not pay for these fixed costs. Therefore, total cost was estimated by adding depreciation costs and administrative and maintenance costs to the operating costs. Administrative costs are staff expenses, travelling expenses and the budget allocated to the ACI administrative by the public authority GBRE. These assistance costs have been estimated for the GBRE bureau of assistance to ACIs on national and local levels. Total administrative cost was divided in proportion to the total number of ACIs. The average total cost of water amounted to 0.929 TD/m^3 for the 637 ACIs. The District of Mahdia recorded the highest total cost (2.871 TD/m^3), whereas in Kasserine total costs reached only 0.457 TD/m^3.

3.4. Price-to-cost ratio

The price-to-cost ratio indicates the cost recovery rate of the supply agency or the level of subsidy provided to consumers. To measure the price-to-cost ratios for customers in rural SONEDE and for the members of ACIs, we first compare the prices paid by each of the two types of consumers. This comparison is presented in Table 4 and is based on the actual costs and prices borne by the consumers.[5] Table 4 highlights a big difference between ACI and SONEDE in regard to the cost of providing water services and the derived price-to-cost ratio. Because the two agencies' prices of water to consumers are quite similar (0.19 TD/m^3), SONEDE recovers only 45% of its costs, while the ACIs recover 132% of their costs, on average. Rates vary between 107 and 170% at the district level.

4. Estimating rural water demand and supply elasticities

In 1996 the number of people with access to drinking water in rural Tunisia was estimated at 2.39 million. About 1.4 million people were served by the ACIs (about 200,000 families), and the rest (974,000) by SONEDE (139,000 families). About 1400 ACIs operated in 1996. The average calculated consumption was 137 m^3 per year per family served by SONEDE and 68 m^3 per year per family served by the ACIs. The average price paid by ACI customers was 0.195 TD/m^3, and the average price paid by SONEDE customers was 0.190 TD/m^3 (or 0.326 TD/m^3 if fixed costs are included). A mean minimum salary of 155 TD per month prevailed in rural Tunisia in 1996.

[5] We use the average consumption of 68 and 137 m^3 per year for a subscriber family of ACI and SONEDE, respectively (SONEDE, 1997). A detailed discussion can be found in Appendix A.

Table 5
Demand and supply estimates for ACI and SONEDE (log–log specification)

	ACI				SONEDE	
	Demand		Supply		Demand	Supply
Equations	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	3.32 (7.33)	8.11 (39.94)	4.45 (12.23)	6.47 (32.55)	3.2 ([a])	2.72 (51.21)
Cost			−0.42 (−5.37)	−0.78 (−23.64)		−1.42 (−4.59)
Price	−1.29 (−10.23)	−1.30 (−6.18)			−0.24 (−0.95)	
Number of families connected				0.513 (11.30)		
Length of pipe system				0.055 (9.16)		
Water quality		−0.48 (−2.08)				
Minimum salary number					−0.08 (−0.25)	
Number of observations	405	223	369	369	40	10
R-square	0.24	0.19	0.20	0.77	0.85	0.70
Adjusted R-square	0.17	0.18	0.19	0.76	[a]	0.53
D-W	–	–	–	–	1.92	2.37
Breusch-Pagan	20.43	25.81	28.53	34.12	[a]	17.12
F-test	27.43	26.25	401.75	408.84	[a]	10.35
Source					Lahouel et al. (1993)	Zekri (1999)

The t-values are in parenthesis.
[a] Not reported.

Based on the available data for 405 ACIs (Zekri, 1999), demand and supply functions for ACIs were estimated. Several specifications were considered, including various sets of explanatory variables in addition to the conventional variables of the price paid by consumers and the cost of producing the water. Various functional forms were tested but only the log–log form yielded reasonable and comparable results. The estimated demand and supply functions are presented in Table 5. Due to missing values for some of the variables, the number of observations for each specification of the demand or supply functions differs. Descriptive statistics of these variables are not presented but available from the authors upon request.

Water quality is one of the explanatory variables in the demand function. It is measured in ranges of salinity values (0–1.5; 1.6–2.5; >2.5 g/l) with higher salinity values representing lower quality. It is expected that lower quality will be negatively correlated with the volume consumers are willing to pay for.

The number of families connected to the ACI supply system is one of the explanatory variables of the ACI supply function. We expect that the volume of water supplied will increase as the number of families connected increases. The length of the pipe system is another explanatory variable in the supply function. Longer pipe systems may represent larger supply systems and thus be correlated with higher values of volume supplied.

Scrutiny of Fig. 2 suggests that although most of the observations are below both 6 TD/m^3 and 40,000 m^3 per year, it is clear that some ACIs are characterised by higher values and these observations affect the trend of the estimated supply curve to reflect economies of scale.

A demand function for SONEDE customers in rural areas based on Lahouel et al. (1993) is used. The demand function considers the low revenue population and is based on quarterly data for the period 1983–1992. Based on data in Zekri (1999), a supply function for SONEDE was estimated using long-term marginal cost data for rural areas (Table 5).

Our purpose in estimating supply and demand functions for SONEDE and the ACIs was to prepare tools for the calculation of welfare measures of water supply in rural Tunisia. Prior to launching the welfare analysis, however, we can gain several interesting observations from scrutiny of the results in Table 5. Focusing first on the price elasticity of demand, one can see that the range is −0.24 to −1.3, for both supply arrangements. This range of price elasticity values is quite reasonable in developing countries, both in rural (e.g. Briscoe and de Ferrenti, 1988; World Bank Water Demand Research Team, 1993) and in urban areas (e.g. Boland and Whittington, 2000). In this respect, the demand functions used in our analysis are quite representative.

Comparing estimated coefficients of the ACI and SONEDE demand functions in Table 5 suggests that the intercepts are quite similar, but the price elasticity for ACI is higher than for SONEDE. This difference reflects the fact that ACI customers have different characteristics than those served by SONEDE. We suspect that ACI connections reach the poorest rural population. This is reflected in the higher absolute elasticity values for ACI customers compared with those for SONEDE rural customers, and is in accordance with the actual volumes demanded by ACI customers (68 m^3 per year) and SONEDE customers (137 m^3 per year).

Another issue to pay attention to is the sign of the cost elasticity of supply in both the ACI and SONEDE functions. The negative sign of the cost elasticity means that in both cases production is on the declining part of the marginal cost function. This indicates that the systems are operating inefficiently, reflecting the fact that both SONEDE and the ACIs reach small and remote communities and, therefore, volumes delivered are much smaller and production costs much higher than in urban areas. When we calculate social welfare under these declining marginal cost functions, we will use the difference between the consumer and (negative) producer surplus (instead of the sum of consumer and producer surpluses as in the case of a positively sloped supply function).

Other interesting results in Table 5 are the negative coefficient of the water quality variable in the ACI demand function. The results suggest that the quality of the water (salinity) is an important determinant in the demand. The higher the salinity the lower the quantity demanded. We are not aware of previous studies of residential water supply that include water salinity as a determinant of demand. However, as we indicate later, water quality can be seen as a service provided by the supply agency. Improved quality reflects a higher service level and should be considered by the agency. The ACI supply estimates also include variables indicating the number of connections and the length of the system. More connections and longer pipe systems affect the volume supplied positively.

4.1. Welfare implications of SONEDE and ACI water services

Inserting the mean values of the variables in the estimated supply and demand functions, one can obtain a comparable measure of social welfare for SONEDE and ACI water supply services, using the framework

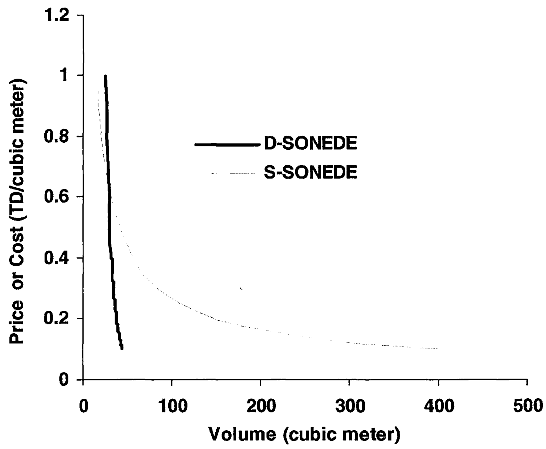

Fig. 3. Supply and demand curves for SONEDE water.

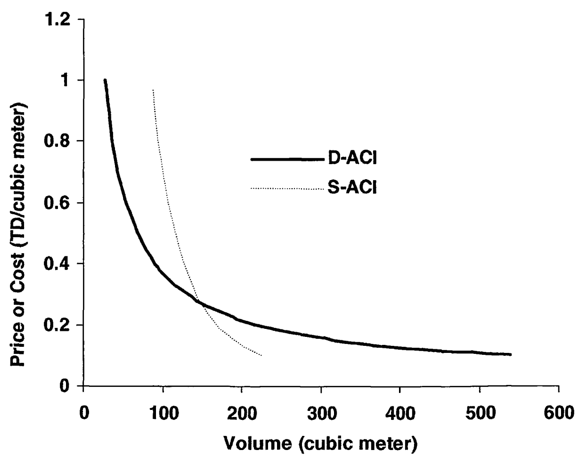

Fig. 4. Supply and demand curves for ACI water.

Table 6
Welfare calculation for ACI and SONEDE water supply in rural Tunisia

	ACI			SONEDE		
	Consumer surplus	Producer surplus	Social welfare	Consumer surplus	Producer surplus	Social welfare
Based on the estimated supply and demand curves						
Per family (TD)	25.2	−53.2	−28.00	17.64 (21.29[a])	−13.72	3.92 (7.57[a])
Total (million TD)	5.04	−10.64	−5.60	2.45	−1.91	0.54
Based on the observed values of mean volumes and prices						
Per family (TD)	11.27	−56.98	−45.71	14.19	−7.85	6.34
Total (million TD)	2.25	−11.99	−9.74	1.97	1.09	0.88

[a] Value obtained with $\varepsilon_D = -0.5$ for SONEDE.

suggested earlier. This can be done, under the assumption that the populations currently served by ACI and SONEDE are characterised by similar intercept and price elasticity values. However, if we accept the explanation in the previous section regarding the differences between the populations served by SONEDE and the ACIs, we can rest assure that the welfare benefit comparison can be conducted on the ground that the population remains the same when the water supply provider changes (say from SONEDE to ACI).

We elected to use the demand and supply functions for SONEDE and ACI that include only the unit price and cost variables (columns 1, 3, 5 and 6 in Table 5) in order to comply with the simple model presented in Section 2. These functions are plotted in Figs. 3 and 4.

One immediate observation is that the intersection values (volume and price of water) in Figs. 3 and 4 differ from those reported above. Using the intersection values from Figs. 3 and 4, the annual volume per family served by SONEDE is 49 m^3 and the price is 0.64 TD/m^3. In the case of the ACIs, annual water consumption per family is 140 m^3 and the price is 0.24 TD/m^3. These estimates are very interesting to contrast to the actual prices and volumes reported in Table 4. First, the average water price across ACIs and for SONEDE is 0.19 TD/m^3. Second, the actual water consumption for ACI and SONEDE families is 68 and 137 m^3 per year, respectively, which is reciprocal to the intersection values of 140 and 49 m^3 per year. These differences arise from the nature of the basic data available for our analysis. One possible explanation is the fact that the supply and demand equations for SONEDE were imported from other studies. We address these values in the welfare calculations conducted below.

The social surplus is computed using both the observed mean prices and volumes of water consumed as well as the values obtained from the intersections of the demand and supply functions in Figs. 3 and 4. Calculation of welfare values is presented in Table 6 using both the procedure suggested in the analytical framework and linear approximation of the curves in Figs. 3 and 4. The per family surplus is then multiplied by the number of families served to obtain total social values.

The calculated consumer and producer surplus values suggest that in the case of the ACIs there is a small social welfare loss (5.60–9.74 million TD per year, depending on the data source). In the case of SONEDE there is a small social welfare gain (0.54–0.88 million TD, depending on the data source). In both cases the producer surplus is negative, due to the fact that the marginal cost curve is above the equilibrium price. This implies that both agencies produce in a non-optimal zone of the production function. Because the estimated demand function for SONEDE does not have a statistically significant price coefficient, we conducted a sensitivity analysis for the demand elasticity. With $\varepsilon_D = -0.5$, consumer surplus and social welfare increase and are closer to the estimates based on the observed values in Table 6.

In the case of the ACIs it was also possible to calculate a proxy welfare index that provides an alternative estimate of social welfare.[6] Because information

[6] This idea was provided by one of our reviewers and we acknowledge it with much appreciation.

is available on the individual ACIs, we calculated for each ACI (with available data) the consumer surplus minus the sum of supply cost and subsidy, where subsidy was calculated as the difference (if any) between the supply cost and revenue. To calculate the consumer surplus, we inserted the actual price and volume consumed by each ACI into the estimated demand functions (column 1 in Table 5). Since not all ACIs in the database have a water price figure, we conducted this analysis on a subset of ACIs. This subset included 231 ACIs with a total of 30,408 families (out of 200,000). Total consumer surplus is 1.47 million TD and total supply cost is 1.76 million TD. The resulting social welfare is thus, −0.29 million TD. Although it is hard to compare this result with those in Table 6, one underlying outcome is clear: the social welfare figures are negative. Scrutiny of the individual ACI results suggests that the proceeds from water sales covered the supply costs in only 25 of the 231 cases in this data subset.

5. Conclusion

SONEDE is a public monopolistic enterprise with a responsibility for providing water to urban communities in Tunisia. SONEDE's service has been extended to rural areas as well. In 1990 the ACIs were established and started providing rural communities with safe water. Our cost analysis shows that when considering the total cost of water supply, the ACIs are more efficient than SONEDE. Rural customers of SONEDE paid only 18% of the total cost of water, while ACI members paid 21% of the total cost. In addition, the total bill for a SONEDE customer is four times higher than the bill for an ACI member. This is due to differences in the volume of water consumed as well as in fixed charges: the average ACI member uses only half the water quantity of a SONEDE customer and pays neither fixed charges nor added value tax.

Currently, the ACI members pay just the operating costs of water supply. There is a need to include at least the maintenance costs in order to insure the reliability and continuity of the service. SONEDE customers are cross-subsidised. The subsidies come from other customers and/or other urban or rural districts.

Even if there are differences between the efficiencies of SONEDE and ACI, both still operate in an inefficient zone of the production function. These inefficiencies may result from the fact that there are economies of scale in water supply that are not realised due to small plants or low demand (small and remote communities).

From a public policy perspective, both SONEDE and ACI receive substantial public subsidies. In the case of ACI this is a government subsidy in the form of 'assistance', and in the case of SONEDE this is cross-subsidisation among regions (recall that the price is unified across regions). Our analysis suggests that the subsidy to both SONEDE and ACI is provided because both operate in a sub-optimal manner (declining marginal cost). The relatively high consumer surplus measures indicate that the value of the water supplied to consumers is much higher than the price they are charged for it. This implies that there may be scope for additional steps to be taken, such as improving the quality of service so as to provide justification for price increases and/or expand demand to increase the level of supply and cover operating and maintenance and even investment costs. From a welfare point of view, the results of our analysis suggest that in heavily subsidised water supply systems, positive consumer surplus may override negative producer surplus and create an overall positive social welfare effect.

Acknowledgements

The authors would like to thank two anonymous reviewers for an excellent set of comments and dedication through the review process. The views expressed in this paper should not be attributed to the World Bank.

Appendix A. Price-to-cost ratio calculations

The calculation of SONEDE costs takes into account (given the nature of the data) the national average total cost for rural and urban areas together. This cost was 0.422 TD/m^3 in 1996. The average operating cost actually borne by ACI members or consumers was 0.142 TD/m^3 in the same year. The price structure for a SONEDE customer includes several components: a fixed water charge, two variable block prices, a wastewater fixed charge and a value added tax (Table 4). The figures for 1996 show that a family served by SONEDE & ONAS pays 57.1 TD per year. A family served by SONEDE alone pays 44.6 TD per year and a family served by an ACI pays only 13 TD per year on average. Thus, ACI members pay only 23 and 30% of the amount paid by those subscribing to SONEDE & ONAS and SONEDE, respectively. These figures show that it is decisive to take into consideration the standard of living of rural families in the choice of the intervention mode for the provision of drinking water when estimating their willingness to pay.

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