
GLOBALIZATION AND WATER RESOURCES MANAGEMENT: THE CHANGING VALUE OF WATER

AUGUST 6-8 AWRA/IWLRI-UNIVERSITY OF DUNDEE INTERNATIONAL SPECIALTY CONFERENCE 2001

WATER MARKET PARTICIPATION AND EFFECTIVE WATER PRICES IN JORDAN

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ABSTRACT: Public piped water prices and effective water prices paid by households may differ widely. Particularly in countries where households not only rely on water from the piped system, but also on water from vendors or have considerable indirect expenditures for water. When evaluating water pricing, this needs to be taken into account. Jordan is one of the most water scarce countries in the developing world and public water supply is rationed through intermittent supply. People are compelled to invest in storage tanks and to buy additional water from private vendors in order to satisfy their water needs and to improve supply reliability. The study analysis the parameters that determine the demand for water from the private water market in Jordan. Moreover, it will evaluate the effective price paid for water by including expenditures for private water sources and indirect water-related expenditures such as investments in storage and expenditures for treating water. Within this analysis geographical and seasonal variation will be considered. The results are based on a household survey conducted in eastern Amman and in 14 villages in northern Jordan in the summer of 1999.

KEY TERMS: water price, water market, water demand, Jordan

INTRODUCTION

Water scarcity is considered to be one of the most important constraints to Jordan's agricultural and overall economic development. The country draws its water supply from both, surface (approximately 40%) and groundwater sources (EL-Naser, 1999). In order to satisfy the water demand of all sectors the available water resources are already overexploited, i.e. the abstraction of groundwater exceeds the safe yield of the aquifer system. Thus, the country's water needs already cannot be satisfied in a sustainable manner leading to increasing uncertainty over sufficient freshwater availability for drinking water. This situation is particularly precarious as the population in the country is rapidly increasing. Jordan had a population of about 5 million in 2000. Seventy-eight percent of the population lives in urban areas, in particular in the capital city of Amman with about 38% of the total population. The estimated population growth rate is about 3.4% per year, which is one of the world's highest (DOS, 2000).

Already now domestic water supply is rationed through intermittent supply, particularly in the summer season. People are compelled to invest in storage tanks and buy additional water from private vendors for example at high prices in order to satisfy their water needs and improve supply reliability. Only little is known about peoples demand behavior in such a supply environment, and how much they effectively pay for water.

Study Area

The Hashemite Kingdom of Jordan is among those countries of the world least endowed with water resources. The country faces a series of water supply constraints, due to water scarcity, infrastructure deficits, and increasing demand. The Jordanian water supply system is quite diverse and includes public and private water sources. For the study 200 household in Jordan were surveyed - 100 urban (East-Amman) and 100 rural (northern

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Jordan). The households were selected randomly according to a statistical sampling procedure. Standardized in depth household interviews were conducted with the person responsible for intra-household water provision and usage and the household head respectively.

Methods

The Jordanian household water sector is quite diverse in its sources, means of supply, and costs for the individual household. Nearly 100% of the households are connected to the piped water system. In the summer season, the public supply is characterized by rationing through interruption (water is supplied only once or twice a week for 12-24 hours), due to water scarcity, infrastructural deficits (~ 58% of unaccounted for water losses - UFW in 1998) and increasing demand due to population growth. But even during the winter season household water supply is not 24 hours a day and 7 days a week, although interruptions are less frequent (supply of 4-6 days a week). Water rationing compels households to invest in storage tanks. Tanks are usually situated on the roof and have a volume of 1-2 m³. In rural areas, some households have underground tanks or cisterns in addition to store piped water or collected rain water. Other alternatives are water purchases from public or private tankers. Water supply from public tankers (run by the Water Authority) is considered unreliable due to long response times, and limited volume and numbers. In addition, informal water exchange between neighboring households on a small scale can be observed. Here, water is typically exchanged without monetary compensation as a neighborly service. Moreover, in rural areas, some villages have access to surface/spring water from which they fetch water. Sometimes, this water is the preferred source for drinking, particularly for preparing tea.

Water Market Participation

About 30% of the households in Amman, decide to obtain additional water from the private market because accessible piped quantities are not sufficient. The choice to purchase on the open market is assumed to be a rational choice reflecting the environment and household characteristics. A Probit approach has been chosen to model this decision behavior (Maddalla ,1983). It estimates the probability that a household in Amman purchases water on the private market with the dependent variable being 1 if the household purchases water from the privately operating water vendor and 0 otherwise:

$$Pr_m = a + \beta_1 PRICEVEN + \beta_2 FITLNPIP + \beta_3 INCOMEPC + \beta_4 SATPIP + \beta_5 LNSTORE$$

where

- Pr_m = a dummy variable that is 1 if the household i purchases from the privately operating water vendor and 0 otherwise
- PRICEVEN = Price per m³ from the private vendor (JD);
- FITLNPIP = Instrumental variable explaining the logarithm of piped water rationing amount of household i per household member per month (m³);
- INCOMEPC = Monthly income per household member (JD);
- SATPIP = Dummy variable defined as 1 if household i perceives quality of water from the piped system as good and 0 otherwise;
- LNSTORE = Logarithm of storage capacity of household i per household member (m³).

As piped water is the main water source for most households, access to and consumption of piped water is a strong determinant of the likelihood that additional water sources are used and that water purchases at a higher price are carried out on the private market. However, piped water consumption would be endogenous in the model, since it is determined by the rationing intensity, the water storage capacity, and other household characteristics related to the rationing environment the individual household faces. Therefore, an instrumental variable explaining piped water consumption should be included in order to obtain consistent estimates for the effective rationing amount (Deaton, 1997). The instrumental variable is formulated as:

$$C_p = f(\text{No_SHARE}, \text{LNRAT}, \text{LNSTORE}, \text{REUSE}, \text{EDU_HEAD}, \text{HHMEM})$$

where C_p is the amount of piped water consumed per household member per month (in m^3) in Amman. No_SHARE is the number of households sharing one connection. It is assumed that with a growing number of households sharing a single connection per capita consumption decreases due to lower flow to the individual tap. This fact particularly becomes relevant when considering the limitation of supply hours in the Jordanian water rationing environment. When water is supplied all households open their taps to fill their storage tanks, with households sharing a connection having proportionally less access to piped water. Moreover, when households share a connection, the likelihood that they fall under a higher tariff block under the increasing block tariff structure is higher. Increased water prices could result in a reduced per capita consumption by households. $LNRAT$ is the logarithm of the number of hours the household is supplied per month. It is expected that with increasing length of supply –lower rationing intensity - consumption increases. $LNSTORE$ is the logarithm of the storage capacity per household member (in liters). In order to overcome estimation problems due to high variance and skewness the logarithm was used for C_p , $LNRAT$, and $LNSTORE$. $REUSE$ is a dummy variable indicating, whether the household reuses water within the household, with 1 indicating reuse and 0 otherwise. EDU_HEAD indicates number of years of schooling of the household head. It is expected that the educational level of the person responsible for household water management – the household head – negatively affects household water consumption as higher education increases the sensitivity towards and awareness of a water scarce environment. $HHMEM$ is the number of household members. The fitted values (FITLNPIP) of the regression model are then included as an instrumental variable into the Probit model.

The next step is the estimation of water demand from the open market—here the water purchased from privately operating vendors. The determinants for the decision on the amount of water purchased from the market are of particular interest here. The estimation approach chosen is the two-stage Heckman approach (Heckman, 1976). The conditional demand equation is formulated as following:

$$Q_m = a + \beta_1 PRICEVEN + \beta_2 FITLNPIP + \beta_3 ALTPC + \beta_4 INCOMEPC + \beta_5 HHMEM + \beta_m LAMBDA$$

where

- PRICEVEN = Price per m^3 from the private vendor (JD);
- FITLNPIP = Instrumental variable explaining the logarithm of piped water rationing amount of household i per household member per month (m^3);
- ALTPC = Quantity of water used by household i per household member (m^3) from neighbors, bottled water, or water from a public tanker;
- INCOMEPC = Monthly income per household member (JD);
- HHMEM = Number of household members;
- LAMBDA = Invers Mills ration.

Table 1. Conditional Water Demand Model for Water from the Private Market

| +-----+ | | | | | | |
|--|------------------|----------------|----------|----------|-----------|--|
| Binomial Probit Model | | | | | | |
| Maximum Likelihood Estimates | | | | | | |
| Dependent variable | | | | | VENDOR | |
| Weighting variable | | | | | ONE | |
| Number of observations | | | | | 72 | |
| Log likelihood function | | | | | -39.14210 | |
| Restricted log likelihood | | | | | -43.46188 | |
| Chi-squared | | | | | 8.639573 | |
| Degrees of freedom | | | | | 5 | |
| Significance level | | | | | .1243332 | |
| +-----+ | | | | | | |
| Variable | Coefficient | Standard Error | b/St.Er. | P[Z >z] | Mean of X | |
| +-----+ | | | | | | |
| Index function for probability | | | | | | |
| Constant | -.8389856986 | .66645269 | -1.259 | .2081 | | |
| PRICEVEN | .1162621308 | .22861263 | .509 | .6111 | 1.7931944 | |
| FITLNPIP | -.3381409976 | .16233511 | -2.083 | .0373 | .51098940 | |
| SATPIP | -.2238075280 | .11984350 | -1.867 | .0618 | .70833333 | |
| LNSTORE | .1282548125 | .83931808E-01 | 1.528 | .1265 | 6.2223414 | |
| INCOMEPC | -.5035871146E-03 | .81707938E-03 | -.616 | .5377 | 71.905715 | |
| +-----+ | | | | | | |
| Sample Selection Model | | | | | | |
| Two stage least squares regression Weighting variable = none | | | | | | |
| Dep. var. = VEN_PC Mean= 1.372185883 , S.D.= 2.049792599 | | | | | | |
| Model size: Observations = 21, Parameters = 7, Deg.Fr.= 14 | | | | | | |
| Residuals: Sum of squares= 30.08856563 , Std.Dev.= 1.46601 | | | | | | |
| Fit: R-squared= .462915, Adjusted R-squared = .23274 | | | | | | |
| Model test: F[6, 14] = 2.01, Prob value = .13201 | | | | | | |
| Diagnostic: Log-L = -33.5737, Restricted(b=0) Log-L = -44.3579 | | | | | | |
| Standard error corrected for selection..... 1.5798 | | | | | | |
| Correlation of disturbance in regression | | | | | | |
| and Selection Criterion (Rho)..... .44858 | | | | | | |
| +-----+ | | | | | | |
| Variable | Coefficient | Standard Error | b/St.Er. | P[Z >z] | Mean of X | |
| +-----+ | | | | | | |
| Constant | 7.665980862 | 2.9505787 | 2.598 | .0094 | | |
| PRICEVEN | -2.577233011 | 1.0916095 | -2.361 | .0182 | 1.8028571 | |
| FITLNPIP | -1.404784882 | 1.3149349 | -1.068 | .2854 | .37006317 | |
| ALTPC | -.7529278573 | .50576860 | -1.489 | .1366 | .27465321 | |
| INCOMEPC | .1105550359E-01 | .87899506E-02 | 1.258 | .2085 | 61.490014 | |
| HHMEM | -.3285573168 | .13660209 | -2.405 | .0162 | 7.1428571 | |
| LAMBDA | .7086934722 | 1.5453293 | .459 | .6465 | 1.0530308 | |

Results from the Probit model show that the water price of private vendors does not significantly determine the decision to purchase water. This does in turn lead to the conclusion that the demand is price inelastic as water is a vital good; when households are short of water their willingness to pay for water on the open market is very high. The same seems to hold true for income as a determining factor for private market participation. The probability of purchasing water from a vendor is hypothesized to rise with increasing income as the price of vendor water is relatively higher and only households with higher income may be able to afford purchases in the open market. However, the sign of the income variable in both models is negative, which may hint to the fact that the demand for relatively high priced water is income inelastic as it is the poor who tend to buy water from the private market, whereas the rich may have better access to public tanker water from the Water Authority at lower prices. As expected, the amount of piped water consumption and satisfaction with piped water negatively affect the likelihood of market participation.

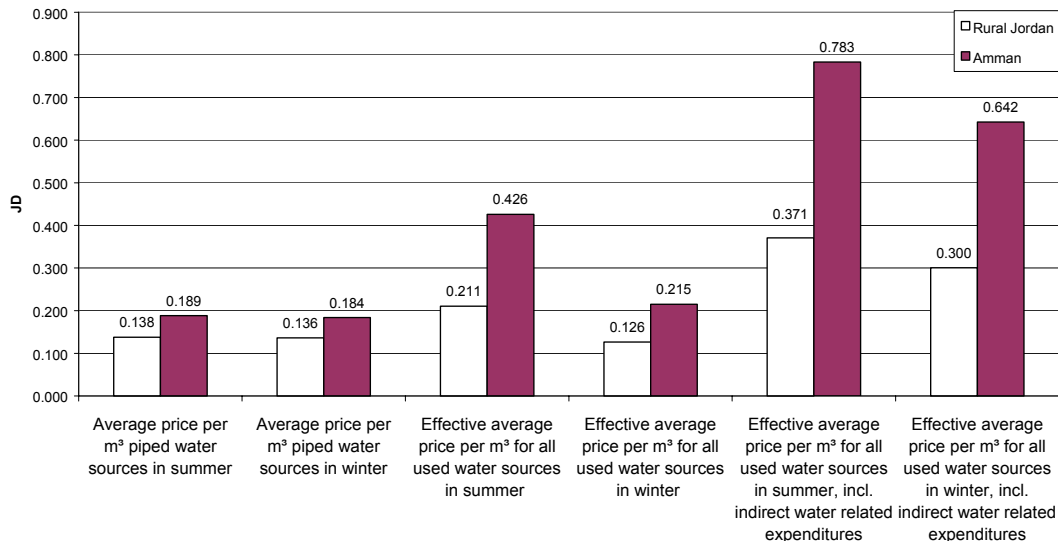
The conditional demand estimates show that although demand is price inelastic regarding the decision to participate, because water is a vital good, demand is highly price elastic regarding the additional quantity purchased. Furthermore the number of household members significantly affects the per capita demand of water from vendors. As the results show, per capita consumption decreases with an increasing number of household members. This indicates economies of scale in water demand from the private market.

Effective Water Price

The Jordanian water sector not only has a highly diverse formal and informal supply system, but also features a wide variety in water related costs and pricing structures, as well as differences in expenditure patterns between urban and rural households. Expenditures for water are not only determined by demand, but also, to a great extent, by the level of rationing households are experiencing. This is due to Jordan's water scarcity problems and its infrastructural and managerial challenges. This is also the main reason why indirect expenditures account for a large share of overall water related expenditures. These costs need therefore be taken into account, when assessing "water pricing" in Jordan. Expenditures for water include **direct monetary expenditures** for public piped water, water from public and private vendors, and bottled water. In addition, **water-related (indirect) expenditures** emerge which include the connection fee in the case of public supplies (0.3 JD; 1JD~1,41\$), investment cost in storage facilities, pumping expenditure to pump water into the storage tanks and water treatment cost.

The sum of all expenditures for water over the amount of water consumed yields the effective average price paid for one m³ of water. The effective average price per unit of water varies significantly by season and region. In Amman, the effectively paid average price more than doubles in the summer season when including expenditures for other (than piped) water sources into the price calculation (see Figure 1).

Figure 1: Effective average price per m³ of water (in JD)



If furthermore indirect expenditures (storage, treatment, pumping) are included, the effective price increases by an additional 84%. Since households in Amman rarely purchase water from the vendor during winter, as water scarcity is lower, the effective price also declines. In general, in the northern rural region the price per unit of water is lower than in Amman. The average price difference is between 23% and 53% depending on whether the purchase of other water resources or indirect expenditures are included. The difference can be explained with the lower price for piped water outside of Amman; the need for Amman households to rely on vendor water (or bottled water) as only alternative source compared to rural households, which have additional alternatives such as rain water or spring water or surface water; and the expenditures of Amman households on treating piped water for drinking purposes, compared to rural households, which often prefer (untreated) rain water for drinking.

Further research is necessary to determine whether the savings from eliminating indirect and private vendor water costs through increasing public tariffs and coverage would improve equity, reliability, and economic efficiency of water supply. This question not only relates to the cost structure of water supply companies, but also to the political feasibility of increased coverage, improved supply, and increased reliability. That consumers could pay and would be willing to pay to the public supply system, could be seen from survey results. Currently households spend on average 1-3% of household income on water (depending on the season), which is still comparatively low to other countries.

ACKNOWLEDGEMENTS

The following individuals and institutions provided technical support for this study: Dr. Shafiq El-Atoum, Dr. Ahmad Malkawi, GTZ in Amman and the Jordan Water Authority. I would also like to thank those who reviewed this paper for AWRA.

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