# Public Infrastructure and Private Costs: Water Supply and Time Allocation of Women in Rural Pakistan*

Nadeem Ilahi
*International Monetary Fund*

Franque Grimard
*McGill University and Centre de Recherche et Développement en Économique*

## I. Introduction

The critical role that women play in alleviating poverty and promoting development has been receiving increasing recognition. In developing countries, for example, women's role is critical in improving the nutritional and educational levels of their children. In addition, women are major contributors to household production activities, both in monetary and nonmonetary ways.[1] Despite this, women's access to resources has been limited, especially in contrast to that of men. For instance, women receive less education than men do and thus their earning opportunities are often restricted.

A number of observers have argued that direct policy intervention to reduce this gender gap would help alleviate poverty.[2] One step in this direction would be to facilitate women's participation in market-oriented activities, which is expected to increase their contribution to household income. In addition, with greater control over household resources, women would be more likely to invest in their children's health, nutrition, and education. A significant long-term consequence of this policy is that better work opportunities for women induce households to invest in the education of their daughters as well as their sons. As a result, the vicious cycle of deprivation would be broken: women do not get formal education because their earnings are low, and their earnings are low because they possess little human capital.[3]

In developing countries, a woman's decision to allocate her time between market-oriented activities—such as work on the family farm or work for wages—and household chores—such as child care, food prepa-


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ration, and the collection of fuelwood and water—depends on a number of factors, including economic opportunities and constraints in addition to social, institutional, and religious reasons.[4] Despite the complexities of the labor allocation problem, some researchers have advocated the use of government intervention to alleviate the gender gap in the participation in income-generating activities. A World Bank study proposes that ''public policy can address inequalities in the household division of labor by supporting initiatives that reduce the amount of time women spend doing unpaid work. Examples of such intervention are improved water and sanitation services, rural electrification, and better transport infrastructure.''[5]

The role of infrastructure in promoting development is not new. Improvements in infrastructure increase the efficiency of production. H. Binswanger, S. Khandker, and M. Rosenzweig provide evidence that a better infrastructure improves the agricultural investment and output decisions of farmers in India.[6] But the positive benefits of infrastructure are not confined to production efficiency as infrastructure also contributes to improvements in living standards. V. Lavy et al. have documented the role of public infrastructure in improving the health of children in Ghana.[7] Similarly, D. Thomas and J. Strauss show that child height in Brazil is significantly affected by better availability of modern sewage disposal, piped water, and electricity.[8] A. Barrera finds that public health programs combined with maternal education improve the health of children in the Philippines, and H. Alderman and M. Garcia find that community services and infrastructure in Pakistan help to raise the nutritional status of rural children.[9]

In this article our aim is to investigate how the quality and quantity of infrastructure affect the time women allocate to their various activities. Our focus is on water infrastructure and how variations in its quality—at both the household and the community levels—relate to differences in time allocated by rural women to market-oriented activities (work for wages as well as work on the family farm or in the household's nonfarm enterprise), water collection, and leisure. We account for the fact that, faced with a deteriorating infrastructure, households may invest in access-improving technology.

Our case study concentrates on Pakistan, where a large proportion of the population lives in poverty and where there exists a significant gender gap in education as well as in labor force participation.[10] The government of Pakistan has enacted policies aimed at increasing living standards and alleviating poverty.[11] Yet, as S. Malik observes, these programs have not been adequate to bring a noticeable improvement at the country level.[12] Alderman and Garcia propose that other policies are needed in order to reduce poverty in general and to improve nutrition levels in particular. Their policy recommendation is that government programs should be aimed at providing community-level investments in infrastructure in conjunction with better education for women.[13]

Our results indicate that improvements in Pakistan's public water-supply infrastructure are negatively associated with the time women spend collecting water. There is some substitution between chores, such as water collection, and market work. We find that with improvements in the water-supply infrastructure, women increase the time that they allocate to income-generating activities. It is interesting, however, that our results also show that households that are driven to substitute for poor public infrastructure by investing in private time-saving water technology—more than half of the sample—do so not to increase the time their women allocate to market activities but, rather, to reduce the total work burden of female household members.

Finally, it should be noted that while our study analyzes the effects that changes in rural infrastructure may have on women's time allocation, improvements in public water-supply infrastructure can also have other consequences. Indeed, it is likely that in addition to affecting the time spent on collecting water, a public water-supply infrastructure system may also reduce the pathogen content of water, thereby improving its quality. This increase in quality will most likely bring health and sanitary benefits that our study does not consider. In addition, to the extent that children help their mothers in carrying water, the investment in infrastructure may free time for children to attend school or participate in labor activities. We do not consider the determinants of children's time use because of data limitations. Thus, our study should not be viewed as an exhaustive analysis of the consequences of public water-supply infrastructure.[14]

The remainder of the article is organized as follows. In Section II, we outline a theoretical model of the household that borrows from the frameworks suggested by G. S. Becker and R. Gronau.[15] Here we take water-collection activity as just another form of household chore, but one with explicit reliance on infrastructure—both at the household level and at the community level. In Section III, we discuss the data used and the econometric specification. In Section IV, we discuss the results, and in Section V, we draw conclusions.

## II. A Theoretical Framework

Most rural households in developing countries do not have direct (in-house) access to a water supply.[16] It is not uncommon for such households to derive their daily supply of water from natural sources, such as rivers, canals, and rain water, or from other open-access sources, such as community taps and wells. As the responsibility of water collection lies largely with women, our objective is to test whether a poor and deteriorating water-supply infrastructure, which makes household access to water increasingly difficult, affects women's time allocation, that is, their availability for market activities and for leisure.

To conceptualize the problem of access to infrastructure and how it affects women's time allocation, we use the home-production and time-allocation framework developed by Becker and, subsequently, by Gronau. This framework extends the conventional neoclassical labor supply model of consumption and leisure by incorporating home production as yet another activity that requires human labor. Women's work at home can be valued in a way similar to market work, and women's work at home is expected to respond to economic incentives, such as changes in market wages, unearned income, and productivity of work at home.

In our modification of the model, the representative individual in household *i* chooses optimal levels of consumption ($c_i$) and leisure ($t_i^l$).[17] Leisure here is to be understood as the time not spent in market and home production activities. As we show below, leisure defined this way includes several activities, including child rearing, that one could hardly characterize as recreational. Consumption is generated through a home production function:

$$c_i = c(W_i, x_i, t_i^h; \gamma_i), \tag{1}$$

where $x_i$ is a numeraire, market-purchased input, $t_i^h$ is time allocated to home production, and $\gamma_i$ is a home production technology parameter. Variable $W_i$ is the amount of water used by the household; it is, in turn, generated by a water production function given by

$$W_i = f(t_i^q; \theta_i, \phi_i), \tag{2}$$

where $t_i^q$ is time allocated to water collection. We make a distinction between a community-level water-collection infrastructure and one that is available to women at the household level. The parameter $\theta_i$ captures the quality of water-collection infrastructure and the community-level availability of water, and $\phi_i$ is the household-level counterpart, capturing the state of household water-generating technology.

The decision problem of the representative individual in the household with tastes denoted by $\alpha_i$ is then given by

$$\max_{c_i t_i^l} u_i = u_i(c_i, t_i^l; \alpha_i), \tag{3}$$

subject to time and budget constraints, given by

$$t_i^m + t_i^q + t_i^h + t_i^l \leq T, \tag{4}$$

and

$$x_i \leq w_i t_i^m + v_i, \tag{5}$$

where $t_i^m$ is time allocated to market-oriented activities, $T$ is time endowment, $w_i$ is market wage, and $v_i$ is unearned income. As is standard in the home production literature, equations (4) and (5) can be combined to obtain the full-income constraint:

$$x_i + w_i(t_i^h + t_i^q + t_i^l) = w_i T + v_i. \quad (6)$$

Ignoring subscripts $i$, the first-order conditions of the model are that time inputs are chosen so as to equate the marginal rate of substitution between leisure and consumption with the shadow wage of water collection, $c_W \cdot W_{t^2}$, the shadow wage of market time, $c_x \cdot w$, and the shadow wage of home time, $C_{t^h}$. Solving the first-order conditions yields a set of optimum time and goods demand functions:

$$t^{j^*} = t^{j^*}(w, v, \alpha, \theta, \phi, \gamma) \quad (7)$$

and

$$x^* = x^*(w, v, \alpha, \theta, \phi, \gamma), \quad (8)$$

where $j = m, q, h, l$.

Our interest is to investigate the influence of changes in community- and household-level access to infrastructure—θ and ϕ, respectively—on time allocated to water collection, market work, and leisure. There are two reasons why our economic model does not offer a straightforward answer to this question. First, the exact nature of the home production function (eq. [1]) and water production function (eq. [2]) are unknown a priori. In the absence of this knowledge, it is not possible to predict how changes in θ and ϕ affect time in water collection and in other activities.[18] Second, even if the specific form of the consumption and water-generating technologies is known, countervailing income and substitution effects of changes in θ or ϕ make the direction of the effects indeterminate.[19]

The relationships are further complicated by the fact that the propensity for and the level of household investments in time-saving water technology are themselves a function of, among other things, the opportunity cost of women's time, wealth, community availability of water access, improving technology, and so forth. Thus, whether poor and deteriorating access to infrastructure forces women to allocate more time to water collection and hence less to market-oriented activities is a question that can ultimately be answered only with data.

## III. Data and Empirical Specification

We use data from the 1991 Pakistan Integrated Household Survey (PIHS), which is based on the World Bank's Living Standards Measurement Study. The PIHS is a nationwide data set that contains information on 2,400 rural households (and an equal number of urban households). Information in the PIHS is available at the individual, household, and community levels. At the individual level, there is detailed information on age, education, number of children, and market and home activities of women (including time spent in water collection). At the household level, the PIHS provides information on ownership of assets, household size, land ownership, energy-use patterns, and access to electricity. At the community level, characteristics such as the distance to goods markets and the community's access to water are documented.

For our econometric estimation, we use a system of reduced-form time equations, denoted by:

$$t^{j^*} = t^{j^*}(w, v, \alpha, \theta, \phi, \gamma) + \epsilon, \qquad (9)$$

where $j = m, q, h, l$. Note that since all of the dependent time variables ($m, q, h,$ and $l$) must add to the total time constraint as per equation (4), we need only estimate equations for any three of the dependent variables. Thus we do not estimate an equation for time allocated to housework. The appendix (table A1) presents a description of all of the variables. We obtained information on the dependent variables from the time-use and employment files of the PIHS.

In devising a measure of time allocated to market activities, we were confronted with the choice of whether paid wage work should be considered as distinct from nonpaid work on the family farm or business. Our test on the data revealed that the determinants of the two types of activities are not significantly different.[20] This is in line with Khandker, who finds in Bangladesh no significant difference between the determinants of wage work and that of employment on the family farm or self-employment.[21] Thus, in computing $t^m$, we have lumped these two types of work together. Also, we do not explicitly use a measure of leisure, but rather we use its complement, total time spent working, which is defined in detail in the appendix.

Next we will attempt to determine what the appropriate measures of water infrastructure at the community ($\theta$) level and at the household ($\phi$) level are. Ideally, household-level access to water infrastructure ought to be measured as distinct from community-level access. One measure of $\theta$ we employ is the round-trip distance from home to the source of water. In the PIHS, this information was collected at the household level through a direct question. Women collecting water from outside of the house were asked how far the source of water was from the home. There can be two problems associated with a self-reported distance variable. First, it is censored as it is observed only for those households in which women collect water. Second, it can suffer from measurement problems. For example, a respondent's answers to the questions of how much time she spent in water collection ($t^q$) and the distance she has to travel for water (DIST) may be correlated owing to respondent-specific measurement error. We attempt to overcome these two problems by constructing what we term as the leave-out mean cluster distance to water source (H2ODIST). The H2ODIST for household *i*, in a cluster with *J* households that report collection distance (DIST), is calculated as:

$$\text{H2ODIST}_i = \frac{1}{J}\sum_{\substack{j=1 \\ j\neq 1}}^{J} \text{DIST}_j. \tag{10}$$

Thus, H2ODIST for household *i* is the distance to the source of water averaged over all *J* households in the community that report collection but not including the distance reported by household *i* itself. Note that such an indicator of access-to-water infrastructure helps to overcome both censoring and reporting measurement error problems. Another kind of community-level ($\theta$) indicator of water infrastructure can be obtained from the community files of the PIHS. Key informants in the cluster were asked about the primary source of water for households in the cluster. Based on this information, we define a dummy H2OINCOMU, which takes a value of one if in-house water supply is the primary source of water in the community and a value of zero otherwise.

The household may also have invested in water technology in the past, which can affect the current household-level access to water ($\phi$). For instance, if the household has installed an outdoor motor pump so that women now collect from the pump and not, say, from a community source, then the time allocated by women to water collection and market activities would be affected. We account for these types of investments by including dummy variables of the state of household water technology. In the PIHS there are 12 sources of water at the household level. An indicator of household water technology, H2OINHOME, is developed from these 12 dummies such that it takes a value of one if the household's water source was an in-house tap, outside private tap, an in-house hand pump, or an in-house motor pump, and a value of zero otherwise.

Note that H2OINCOME is an indicator of past investments made by the household. Since we are confined by cross-section data with no indication when these investments were made or what the determinants of such investments were at the time, it is difficult to model such investments as another jointly dependent variable in our econometric model.[22] In our estimation, we present two sets of results for each dependent variable used. One set includes H2OINHOME as a right-hand-side variable, while the other does not. The latter case is to account for the fact that H2OINHOME may be endogenous and is therefore excluded under the presumption that all determinants of such investments have already been included among the other right-hand-side variables.

Other determinants of women's time allocation are the opportunity cost of time (*w*) and unearned income (*v*). For those who participate in the market, the opportunity cost of time is exogenous and equal to the market wage. However, observed market wages do not take account of self-selection into market work. First, wages are not observed for those who do not work. Second, women who are observed working may command greater wages than a woman would who is randomly drawn from the population. We tackle these problems by predicting market wages (see definition of WAGE in the appendix) for those who participate in the labor market, using the technique pioneered by Heckman.[23] In addition, we employ the distance to the main market (DISTANCE2MKT) to capture the level of integration of the local farm economy and, hence, the demand for labor. We expect farm labor demand to be high in villages closer to agricultural markets. Since our definition of market work is ''market-oriented'' work, which includes both work for wages and work done on the household farm or in a business enterprise the output of which is marketed, we also include two variables that capture the labor demand emanating from such activities. One is the amount of land holdings of the household (LAND) and the other is the value as assets of the household's livestock and nonfarm holdings (PRODASSETS).[24]

Unearned income (*v*) is an integral part of a labor supply model. An increase in unearned income confers an income effect on leisure. We employ per capita nonwage income (NONWAGEINC) as one indicator. We also use indicators of permanent wealth. As proxies of unearned income or permanent wealth, we use the spouse's wage (SPOUSEWAGE) and the value of household assets such as financial assets and durable goods (HOMEASSETS).[25]

In order to control for the effects on time allocation of individual, household, and regional heterogeneity and of seasons, we also include other variables that do not directly arise from the theoretical model. The individual and household-specific control variables are age and the square of age (AGE and AGESQ in table 1), education (LITERATE), and the number of adult females in the household (ADULTFEMALES). The inclusion of such variables is standard in the literature on time allocation.[26] In addition, we include a dummy variable (ELECTRICITY) to control for household-level heterogeneity in the dependence on biofuels.

A related issue here is whether to include the number of children a woman has as determinants of her time allocation. This number may not be exogenous if the increasing demands on the woman's time owing to greater water scarcity are taken into consideration. In a related context, M. Nerlove argues that one manner in which poverty can worsen the state of the environment is when poor households, faced with severe fuelwood scarcity, choose to increase their total labor endowment by having more children.[27] The same argument could apply in the case of water collection. Even though the focus of this article is not on the influence of water scarcity on fertility, a relevant issue is whether it is appropriate to consider the number of children a woman has as exogenous to the system of reduced-form equations that we estimate.[28] One way to address the problem is to consider the number of children born to a woman as an endogenous variable in addition to the time variables. However such an exercise would take us beyond the objective of the article. We handle the problem of potential endogeneity of children by not including the number of young children as a right-hand-side variable.[29] We also exclude from the definition of housework, and thus of total work, the amount of time spent in child-care activities. Alderman and Chishti argue that child-care activities are likely to be joint with other primary activities, such as cooking or farming, and therefore are likely to be problematic in an econometric estimation.[30]

A number of regional and seasonal controls are also employed in our estimation to reduce the influence of unobserved heterogeneity. In order to control for regional heterogeneity, we classify the rural clusters in the PIHS into nine agroclimatic zones using the agroclimatic subdivision of Pakistan provided by T. Pinckney.[31] As the PIHS, unlike other time-allocation surveys, covered a large geographical area, the period of data collection exceeded 12 months. This means that some households were sampled during periods of peak labor demand, while others were interviewed during the lean labor season. Thus, there is likely to be a bias in the reported hours in the data, depending on when the interview was conducted.[32] We introduce time-of-interview dummies (APR–MAY, JUL–AUG, and OCT–NOV), which capture periods when labor demand is high.

## IV. Results and Discussion

A summary of the data is provided in table 1. In order to focus on the time allocation of working-age women, we restrict the sample to women who are older than 15 and who do nonzero work (i.e., $t^k > 0$, where $t^k = t^m + t^q + t^h$).[33] The total work (nonleisure) time of women ($t^k$) averages about 161 hours per month. For the case of rural Pakistan, Alderman and Chishti find average total work time to be 153 hours per month. The mean time spent in market work ($t^m$) is quite low (about 25 hours per month), but this is partly due to the large number of women in the full sample who do not work in the market at all (49%). Alderman and Chishti find average market time per month in their sample to be 31 hours. The average time allocated to water collection ($t^q$) is also quite small, only 11.4 hours per month, partly due to the fact that this variable is also censored (43% of the women in the sample reported some time spent in water collection). Again, for those who report any time in water collection, the average time spent collecting amounts to 27 hours per month, or about 15% of monthly work time.

It may be argued that in the data the average time women spend in

TABLE 1

SUMMARY STATISTICS

| | Full Sample | | Respondents with In-House Water Supply | | Respondents without In-House Water Supply | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| $t^q$ | 11.45 | 36.13 | 3.03 | 9.69 | 22.42 | 51.70 |
| $t^m$ | 24.75 | 50.28 | 23.60 | 45.08 | 26.24 | 56.33 |
| $t^k$ | 161.4 | 125.98 | 147.58 | 102.69 | 179.46 | 149.16 |
| AGE | 33.76 | 14.35 | 33.89 | 14.67 | 33.60 | 13.93 |
| ADULTFEMALES | 2.31 | 1.51 | 2.35 | 1.57 | 2.25 | 1.44 |
| LITERATE | .07 | . . . | .10 | . . . | .04 | . . . |
| WAGE | 1.84 | .27 | 1.86 | .28 | 1.82 | .25 |
| ELECTRICITY | .59 | . . . | .65 | . . . | .50 | . . . |
| PRODASSETS | 9.28 | 3.90 | 9.46 | 3.90 | 9.04 | 3.89 |
| HOMEASSETS | 5.40 | 4.51 | 5.84 | 4.53 | 4.84 | 4.42 |
| NONWAGENIC | 5.32 | 1.08 | 5.37 | 1.05 | 5.24 | 1.13 |
| LAND | .50 | 1.03 | .55 | 1.07 | .43 | .97 |
| SPOUSEWAGE | .50 | 1.00 | .46 | 1.00 | .55 | .99 |
| DISTANCE2MKT | 16.66 | 17.32 | 14.23 | 15.55 | 19.82 | 18.95 |
| H2ODIST | .56 | .64 | .39 | .42 | .79 | .79 |
| H2OINCOMU | .32 | . . . | .32 | . . . | .32 | . . . |
| H2OINHOME | .57 | . . . | 1.00 | . . . | .00 | . . . |
| APR–MAY | .18 | . . . | .16 | . . . | .21 | . . . |
| JUL–AUG | .27 | . . . | .23 | . . . | .20 | . . . |
| OCT–NOV | .27 | . . . | .27 | . . . | .28 | . . . |
| ZONE_BP | .08 | . . . | .04 | . . . | .13 | . . . |
| ZONE_MP | .11 | . . . | .15 | . . . | .05 | . . . |
| ZONE_LIP | .13 | . . . | .12 | . . . | .14 | . . . |
| ZONE_RWP | .09 | . . . | .15 | . . . | .03 | . . . |
| ZONE_CWP | .09 | . . . | .13 | . . . | .12 | . . . |
| ZONE_ROS | .13 | . . . | .14 | . . . | .12 | . . . |
| ZONE_CWS | .11 | . . . | .11 | . . . | .30 | . . . |
| ZONE_NWF | .19 | . . . | .11 | . . . | .11 | . . . |
| ZONE_BAL | .07 | . . . | .05 | . . . | . . . | . . . |
| CANAL | .61 | . . . | . . . | . . . | . . . | . . . |
| *N* | 2,505 | | 1,417 | | 1,088 | |

NOTE.—Definitions of variables are provided in table A1 in the appendix. $N$ = number of observations.

water collection is too small to warrant serious attention. Our objective in this article is not to convince the reader of the time-consuming nature of the problem but, rather, to explore how changes in infrastructure, on the margin, may influence time allocation to various activities. Note that 15% of total work time is by no means insignificant, given that water collection also can be physically taxing. Also, since the average number of adult women in the household is 3.3, the total household time in water collection is by no means insignificant.

At the community level, the mean round-trip distance to the water source faced by the household (H2ODIST), which is used here as one indicator of the community-level access to water infrastructure, is 0.6 kilometers.[34] The standard deviation of this variable is 0.64.[35] The dummy variable that captures the state of water access at the community level (H2OINCOMU) suggests that 31% of the women in our sample belong to clusters in which piped water is the primary or secondary source of water.

The dummy variable that captures whether the household has access to water inside the premises (H2OINCOME) has an average of 57% in the data, implying that 43% of the women in the sample derive their water from sources outside of the house. We also split the sample along the lines of whether the household had an in-house water supply or not. The summary statistics for the two subsamples are presented in table 1. It is clear that households that have in-house access to water are more affluent than those who do not. There is a significant difference in the average home (HOMEASSETS) and productive assets (PRODASSETS) and ownership of agricultural land (LAND) of the two types of households. The values of the dependent variables also are significantly different across the two groups. Thus, the average time allocated to water collection is only 3 hours per month for those who have in-house water supply, while others spend 22 hours per month in that activity. Also note that the average of H2ODIST is much smaller for those who collect water in-house rather than outside. It is interesting to note that for those who have access to an in-house water supply, the average of H2ODIST is still quite large at 0.38 kilometers, as compared with 0.78 kilometers for those who do not. One explanation for this is that in the clusters where many of the households have an in-house water supply, the state of public infrastructure may also be good, so that those who rely on outside sources for their water have to travel less distance.

Time-use survey data are notoriously inaccurate because of the inability of respondents to accurately recollect information on the components of their time use.[36] This may give rise to measurement error, specifically to an extreme value problem in the dependent variables. Inspection of time-use data in the PIHS reveals that some respondents overstated their time spent in all activities. We used transformation of the dependent variable to control for the extreme-value problem.[37] Our results were similar to those reported below.

### *A. Water Collection*

One of our objectives is to explore the determinants of women's time allocation to various activities, including water collection, and to investigate the association between the dependent hours variables and the various indicators of access to infrastructure at the community level and at the household level. The determinants of the decision to collect water may be different than those of the decision to allocate hours to water collection. This may be due to the fact that whether a woman collects water may be a function of the availability of in-house water, which, in turn, may be influenced by household wealth and the quality of water infrastructure at the community level. We expect the propensity to collect water to be lower for those who have in-house access. After controlling for access, the probability of collection should fall as distance to the source of water (H2ODIST) increases. The decision of how many hours to allocate to water collection is one that women take on the margin, following the optimal conditions stated in Section II, but only after the decision to collect water from outside the home has been taken. Here the hours allocated to collection are expected to increase as H2ODIST increases. Our intent here is to control for self-selection into water collection in the estimation of the hours in the water collection equation. We employ a Heckit procedure to obtain consistent estimates of the determinants of hours in water collection, which requires the calculation of a probit for the decision to collect water.[38] The inverse Mills ratio generated from this regression is then used as a right-hand-side variable in the hours in water collection equation to appropriately account for the self-selection discussed above.

As in any simultaneous equation estimation, the issue of identification is relevant here. We argue that having an in-house source of water at both the household level (H2OINHOME) and at the cluster level (H2OINCOME) will be a critical determinant of the decision to collect and that both variables will not affect the hours allocated to water collection once the decision to collect has been taken. Note, of course, that it is difficult to justify the inclusion of distance to water (H2ODIST) in this list as H2ODIST is expected to affect the decision to collect and the hours collected in the opposite manner—a greater distance to collection is likely to lower the probability of collection and, once that decision has been made, it is likely to increase the hours devoted to water collection for those who decide to collect. If this were indeed the case, then a tobit model, which assumes that determinants of the decision to collect are identical to determinants of the hours in collection, would be a misspecification.[39] Regardless, we provide results of the tobit estimation for illustration purposes.

The results are given in table 2. We focus on three variables: the leave-out community distance to water (H2ODIST), the indicator of the primary source of water at the community level (H2OINCOMU), and the indicator of in-house access to water (H2OINHOME). The probit estimation of the decision to collect reveals, not surprisingly, that in-house access to water significantly lowers the probability of collecting water from outside the home.[40] Women with in-house access to water are significantly less likely to collect water than those who do not have in-house water.[41] Another indicator of community-level infrastructure that we use is qualitative information about the main source of water in the cluster (H2OINCOMU), which is obtained from key informants in the cluster. The availability of water at the cluster level also significantly reduces the probability of collecting from outside of the home. A more interesting result can be obtained by focusing on the estimated coefficients of community distance to water (H2ODIST) and its square (H2ODISTSQ). The estimation results show a convex and downward sloping relationship between the probability of collecting water from outside of the home and H2ODIST; as distance to collection increases, the probability of collection falls, but at a decreasing rate.[42] At the sample average of H2ODIST in the data (0.56 kilometers), the relationship is negative, implying that the probability of collection is inversely correlated with community distance to water.[43]

The estimation results concerning hours spent in water collection are also provided in table 2. After controlling for the decision to collect and, hence, the self-selection into that activity, H2ODIST raises the time spent in water collection, but it does so at a decreasing rate. Putting the two results together, we show that as access to water deteriorates, there is a reduction in the probability of collection, but among those women who continue to collect water—perhaps because they have no alternatives—more time has to be allocated to water collection.

The third column in table 2 lists the results of the tobit estimation. The concave relationship between $t^q$ and H2ODIST found in the Heckit estimation also appears to hold here. However, since the Heckit results show that the determinants of the decision to collect water are different from the determinants of the number of hours allocated to water collection, a tobit specification may be inappropriate.[44]

Next we examine how our estimation performs with respect to the other exogenous variables. Wealth—as captured by the value of home assets (HOMEASSETS)—significantly reduces the probability of collection, but it does not reduce the hours spent collecting water after accounting for self-selection in that activity. The amount of agricultural land owned by the household (AGLAND) is negatively associated with time allocated to water collection. The question is whether this is because AGLAND is an indicator of the demand for labor on the family farm and when that demand is high—as may be the case with households that own land—time allocated to other activities may be low. Our estimation of the market-work equation discussed below reveals that this is not the case; the ownership of agricultural land significantly lowers the time spent in labor activities as well. Thus, we conclude that as far as water collection is concerned, land may be seen as an indicator of wealth and owning land has the effect of reducing time allocated to work activities in favor of leisure. In terms of capturing the demand for labor on the family farm, the value of productive assets (PRODASSETS) appears to be a better indicator—increases in PRODASSETS reduce time allocated to water collection and increase time allocated to market activities, including work on the family farm. The proxies for unearned in-

TABLE 2

DETERMINANTS OF TIME ALLOCATED TO WATER COLLECTION

| | PROBIT DECISION TO COLLECT | | HECKIT; HOURS DEVOTED TO COLLECTION | | TOBIT; HOURS DEVOTED TO COLLECTION | |
|---|---|---|---|---|---|---|
| | Estimated Coefficient | *t*-Ratio | Estimated Coefficient | *t*-Ratio | Estimated Coefficient | *t*-Ratio |
| AGE | . . . | . . . | .004 | .85 | −.009 | −1.00 |
| ADULTFEMALES | . . . | . . . | −.143 | −6.57 | −.326 | −7.29 |
| LITERATE | −.207 | −1.59 | −.070 | −.33 | −1.117 | −2.96 |
| WAGE | . . . | . . . | .221 | .60 | 1.206 | 1.89 |
| ELECTRICITY | . . . | . . . | −.351 | −5.45 | −.596 | −4.51 |
| HOMEASSETS | −.207 | −3.99 | .001 | .20 | .003 | .20 |
| PRODASSETS | .006 | .75 | .014 | 1.67 | −.062 | −4.50 |
| NONWAGENIC | . . . | . . . | −.012 | −.40 | −.204 | −3.21 |
| LAND | . . . | . . . | −.101 | −3.06 | −.033 | −.49 |
| SPOUSEWAGE | . . . | . . . | .040 | 1.38 | .014 | .24 |
| DISTANCE2MKT | . . . | . . . | .000 | .16 | .008 | 1.92 |
| H2ODIST | −.125 | −.73 | 1.031 | 5.51 | 1.589 | 4.66 |
| H2ODISTSQ | .79 | .06 | −.246 | −4.39 | −.263 | −2.42 |
| H2OINCOMU | −.151 | −2.10 | . . . | . . . | −.638 | −4.31 |
| H2OINHOME | −1.256 | −18.73 | . . . | . . . | . . . | . . . |

| | | | | | | |
|---|---|---|---|---|---|---|
| APR–MAY | .269 | .15 | .0145 | .08 | .942 | 2.62 |
| JUL–AUG | −.391 | −3.02 | .123 | .87 | −.463 | −1.68 |
| OCT–NOV | −.047 | −.37 | .033 | .22 | .290 | .99 |
| ZONE_BP | .737 | 4.62 | −.125 | −7.26 | 1.387 | 4.23 |
| ZONE_MP | −.309 | −2.19 | −1.041 | −5.49 | −1.500 | −5.01 |
| ZONE_RWP | −.535 | −3.12 | −1.505 | −6.29 | −1.861 | −5.25 |
| ZONE_CWP | −.109 | −.75 | −.686 | −3.48 | −.981 | −3.16 |
| ZONE_ROS | .920 | 7.71 | −1.281 | −8.81 | 1.381 | 5.33 |
| ZONE_CWS | 1.584 | 11.87 | −1.197 | −7.98 | 2.531 | 9.59 |
| ZONE_NWF | .761 | 6.43 | −.855 | −6.22 | 2.385 | 9.70 |
| ZONE_BAL | .671 | 4.65 | −.764 | −4.56 | 1.801 | 5.91 |
| CANAL | .238 | 1.90 | .181 | 1.40 | .530 | 2.09 |
| CANAL × APR–MAY | −.640 | −3.35 | −.113 | −.64 | −.936 | −2.57 |
| CANAL × JUL–AUG | .752 | 4.33 | −.265 | −1.54 | .992 | 2.90 |
| CANAL × OCT–NOV | .164 | 1.02 | −.354 | −2.08 | −.279 | −.84 |
| INTERCEPT | −.036 | −.22 | 3.368 | 3.71 | −1.495 | −.95 |
| $\lambda$ | . . . | | −.425 | | . . . | |
| *N* | 2,505 | | . . . | | 2,505 | |
| Log likelihood function | −2,540.05 | | . . . | | −3192.66 | |
| *P* value* | .00 | | . . . | | .00 | |

NOTE.—These are tobit regressions. Definitions of variables are provided in table A1 in the appendix.
* Likelihood ratio test statistic ($\chi^2$ with 2 df) for the joint null hypothesis: coefficients of H2ODIST and H2ODISTSQ are equal to zero.

come (SPOUSEWAGE and NONWAGEINC) do not appear statistically different from zero.

We expect that as the opportunity cost of time rises, women allocate less time to household chores, including water collection, and more to market activities. However, our results reveal that predicted wages (WAGE) are not significant in determining hours spent in water collection.

### *B. Market Work*

Table 3 gives the results of the hours spent in market work ($t^m$). Time allocated to market activities ($t^m$) is not observed for all women. Time use in market production is positive only for women who participate and zero for those who do not participate. Because of this censoring, we use the tobit technique to estimate the market-time equation and obtain consistent estimates of the parameters of interest.[45]

We first examine whether improvements in water infrastructure facilitate rural women's allocation of time to market activities, as has been suggested in the literature.[46] The results show that there is a quadratic relationship between H2ODIST and market time—market time falls with collection distance, but at a decreasing rate. The likelihood ratio test for the joint hypothesis that the coefficients of both the linear and quadratic terms of H2ODIST are zero was rejected at the 5% significance level. The estimated coefficients suggest that at the average of H2ODIST in the data, the relationship between cluster distance to water and time allocated to market activities is negative. The greater the distance to water collection, the less time women devote to market work, which would support the argument that a better infrastructure may, on the margin, allow women to engage in more market-oriented work. Further, the estimated coefficient of the other indicator of community-level access to water (H2OINCOMU), which comes from the community section of the PIHS data, is also positive but not statistically significant.

To determine how past household investments in time-saving water technology influence women's time allocation to market activities, we list the results of the tobit regression in which we included H2OINHOME as a right-hand-side variable (see table 3, the last two columns). The estimated coefficient of H2OINHOME is negative though not statistically significant. Households in which women can obtain water from time-saving private sources allocate less of their women's time to productive market activities. Note also that the results with respect to the estimated coefficient of H2ODIST and H2ODISTSQ are robust to the inclusion of H2OINHOME, implying that regardless of the nature of household water technology, increases in the distance to water reduce time allocated to market activities.

As for the performance of the other explanatory variables, the opportunity cost of time (WAGE) increases time allocated to market, with the estimated coefficient statistically different from zero at the 1% significance level.[47] The variables associated with the demand for labor yield mixed results. As noted earlier, the ownership of agricultural land (AGLAND) seems to have a greater wealth effect on time allocation than does a demand for labor effect. The proxies for labor demand on family farm also perform well. The value of productive assets (PRODASSETS), which includes the value of farm machinery, has a positive and significant effect on the time allocated to market and market-oriented activities, including farm work. The estimated coefficient of the community-level indicator of demand for labor (DISTANCE2MKT) is negative and significant, which implies that the farther the village is from a main market, the less active is the agricultural economy in the area, which, in turn, means the lower is the demand for labor.

As predicted by a labor supply model, nonwage income (NONWAGEINC) reduces the time allocated to market activities. Similarly, the wage of the spouse (SPOUSEWAGE), which is also used here as an indicator of exogenous unearned income, significantly lowers the supply of time to market activities. We used other indicators of wealth as well. The value of home assets (HOMEASST) does not appear to affect the supply of time to market activities.

Our results for the determinants of labor supply to market-oriented activities suggest that economic opportunities and constraints, which play an important role in labor supply behavior in other countries, also play an important role in the case of women in rural Pakistan. In this sense, our results corroborate those of Khandker, who finds social and religious factors are not sufficient to explain women's labor market behavior in rural Bangladesh. Our results also show that a worsening of water infrastructure imposes a time constraint on rural women, which, in turn, tends to reduce their time allocation to income-generating activities.

*C. Leisure*

The third dependent time variable, total nonleisure time ($t^k$), is not censored; we thus use least squares to estimate this regression, accounting for possible heteroscedasticity. The results of the estimation of the leisure equation are derived residually: the dependent variable is total work time ($t^k$), which, of course, is the difference between the time endowment and leisure. This $t^k$ includes $t^m$, $t^q$, and $t^h$, which consist of other household chores such as fetching fuelwood, animal care, overseeing grazing, herding, fodder collection, preparing dung cakes, milking animals, preparing *ghee,* taking meals to field workers, going to market, grinding flour, husking rice, cooking, baking bread, washing dishes, cleaning the house, doing laundry, ironing, stitching, and doing embroidery.[48] The results of this estimation are provided in table 4. One striking result is that there is a strong linear relationship between distance to water (H2ODIST) and total work time. A comparison of the linear and

TABLE 3

Determinants of Time Allocated to Market Activities

| | Regression 1 | | Regression 2 | | Regression 3 | |
|---|---|---|---|---|---|---|
| | Estimated Coefficient | *t*-Ratio | Estimated Coefficient | *t*-Ratio | Estimated Coefficient | *t*-Ratio |
| AGE | .183 | 7.66 | .182 | 7.60 | .182 | 7.59 |
| AGESQ | −.002 | −5.82 | −.002 | −5.75 | .002 | −5.74 |
| ADULTFEMALES | −.147 | −3.09 | −.149 | −3.13 | −.148 | −3.10 |
| LITERATE | −1.283 | −3.37 | −1.291 | −3.40 | −1.287 | −3.39 |
| WAGE | 2.438 | 3.73 | 2.452 | 3.76 | 2.448 | 3.75 |
| ELECTRICITY | −1.237 | −8.79 | −1.255 | −8.91 | −1.246 | −8.80 |
| HOMEASSETS | .004 | .24 | .004 | .28 | .005 | .33 |
| PRODASSETS | .217 | 10.39 | .218 | 10.42 | .218 | −10.44 |
| NONWAGEINC | −.169 | −2.50 | −.173 | −2.56 | −.170 | −2.50 |
| LAND | −.402 | −5.69 | −.390 | −5.51 | −.388 | −5.50 |
| SPOUSEWAGE | −.181 | −2.71 | −.181 | −2.72 | − .181 | −2.71 |
| DISTANCE2MKT | −.014 | −3.22 | −.013 | −2.93 | −.013 | −2.96 |
| H2ODIST | .179 | 1.32 | −.584 | −1.64 | −.621 | −1.71 |
| H2ODISTSQ | . . . | . . . | .271 | 2.32 | .280 | 2.37 |
| H2OINCOMU | . . . | .90 | .190 | 1.21 | .202 | 1.27 |
| H2OINHOME | . . . | . . . | . . . | . . . | −.078 | −.53 |

| | | | | | | |
|---|---|---|---|---|---|---|
| APR–MAY | .802 | 2.01 | .910 | 2.27 | .910 | 2.27 |
| JUL–AUG | .467 | 1.59 | .568 | 1.92 | .569 | 1.92 |
| OCT–NOV | .494 | 1.57 | .532 | 1.69 | .528 | 1.68 |
| ZONE_BP | .195 | .55 | .259 | .72 | .249 | .70 |
| ZONE_MP | .675 | 2.48 | .673 | 2.47 | .684 | 2.51 |
| ZONE_RWP | −.466 | −1.54 | −.534 | −1.76 | −.523 | −1.72 |
| ZONE_CWP | −.302 | −1.03 | −.306 | −1.04 | −.294 | −1.00 |
| ZONE_ROS | 1.556 | 5.84 | 1.640 | 6.11 | 1.638 | 6.10 |
| ZONE_CWS | 1.915 | 6.98 | 1.993 | 7.21 | 1.990 | 7.20 |
| ZONE_NWF | −.752 | −2.88 | −.798 | −3.05 | −.830 | −3.09 |
| ZONE_BAL | −1.226 | −3.57 | −1.211 | −3.52 | −1.231 | −3.56 |
| CANAL | −.151 | −.56 | −.141 | −.53 | −.142 | −.53 |
| CANAL × APR–MAY | .955 | 2.35 | .860 | 2.11 | .850 | 2.09 |
| CANAL × JUL–AUG | −.461 | −1.28 | −.580 | −1.59 | −.574 | −1.57 |
| CANAL × OCT–NOV | .589 | 1.68 | .568 | 1.62 | .580 | 1.65 |
| INTERCEPT | −8.031 | −5.09 | −7.849 | −4.99 | −7.808 | −4.96 |
| *N* | 2,505 | | 2,505 | | 2,505 | |
| Nonzero observations | 1,280 | | 1,280 | | 1,280 | |
| Log likelihood function | −3,914.97 | | −3,912.30 | | −3,912.16 | |
| *P* value* | . . . | | .04 | | .04 | |

NOTE.—These are tobit regressions. Dependent variable is log of hours in income-generating activities. $N$ = number of observations. Definitions of variables are provided in table A1 in the appendix.

* Likelihood ratio test statistic ($\chi^2$ with 2 df) for the joint null hypothesis: coefficients of H2ODIST and H2ODISTQ are equal to zero.

TABLE 4

DETERMINANTS OF TIME ALLOCATED AT ALL WORK ACTIVITIES

| | Regression 1 | | Regression 2 | | Regression 3 | |
|---|---|---|---|---|---|---|
| | Estimated Coefficient | *t*-Ratio | Estimated Coefficient | *t*-Ratio | Estimated Coefficient | *t*-Ratio |
| AGE | .040 | 3.77 | .040 | 3.77 | 0.40 | 3.71 |
| AGESQ | −.001 | −3.98 | −.001 | −3.98 | −.001 | −3.93 |
| ADULTFEMALES | −.151 | −11.56 | −.151 | −11.56 | −.149 | −11.34 |
| LITERATE | −.262 | −2.38 | −.262 | −2.38 | −.254 | −2.29 |
| WAGE | .449 | 2.15 | .449 | 2.15 | .435 | 2.06 |
| ELECTRICITY | −.203 | −6.15 | −.203 | −6.13 | −.188 | −5.70 |
| HOMEASSETS | −.000 | −.11 | −.000 | −.11 | −.001 | −.25 |
| PRODASSETS | .006 | 1.27 | .006 | 1.27 | .007 | 1.42 |
| NONWAGEINC | .004 | .27 | .004 | −.27 | .011 | .65 |
| LAND | .011 | .60 | .011 | .60 | .013 | .70 |
| SPOUSEWAGE | .018 | 1.09 | .018 | 1.09 | .019 | 1.18 |
| DISTANCE2MKT | −.001 | −1.48 | −.002 | −1.46 | −.002 | −1.95 |
| H2ODIST | .158 | 5.50 | .155 | 1.76 | .134 | 4.68 |
| H2ODISTSQ | . . . | . . . | .001 | .04 | . . . | . . . |
| H2OINCOMU | −.032 | −.84 | −.032 | . . . | −.012 | −.31 |
| H2OINHOME | . . . | . . . | . . . | . . . | −.146 | −3.99 |

| | | | | | | |
|---|---|---|---|---|---|---|
| APR–MAY | .263 | 2.82 | .263 | 2.81 | .252 | 2.70 |
| JUL–AUG | .027 | .38 | .028 | .37 | .022 | .30 |
| OCT–NOV | −.089 | −1.10 | −.089 | −1.09 | −.100 | −1.23 |
| ZONE_BP | −.134 | −1.74 | −.134 | −1.73 | −.159 | −2.09 |
| ZONE_MP | −.259 | −3.58 | −.259 | −3.57 | −.236 | −3.27 |
| ZONE_RWP | .048 | .68 | .048 | .67 | .072 | 1.01 |
| ZONE_CWP | −.144 | −2.06 | −.144 | −2.05 | −.124 | −1.77 |
| ZONE_ROS | .126 | 1.80 | .126 | 1.80 | .116 | 1.68 |
| ZONE_CWS | .294 | 4.28 | .294 | 4.26 | .282 | 4.15 |
| ZONE_NWF | −.157 | −2.42 | −.157 | −2.40 | −.214 | −3.26 |
| ZONE_BAL | −.155 | −1.88 | −.155 | −1.87 | −.191 | −2.29 |
| CANAL | .035 | .54 | .036 | .54 | .035 | .54 |
| CANAL × APR–MAY | −.089 | −.93 | −.089 | −.94 | −.098 | −1.02 |
| CANAL × JUL–AUG | −.064 | −.72 | −.064 | −.71 | −.046 | −.53 |
| CANAL × OCT–NOV | .076 | .93 | .076 | .92 | .098 | 1.18 |
| INTERCEPT | 3.787 | 8.50 | 3.787 | 8.50 | 3.867 | 8.62 |
| $N$ | 2,505 | | 2,505 | | 2,505 | |
| $R^2$ | .238 | | .238 | | .243 | |
| $P$ value* | . . . | | .00 | | . . . | |

NOTE.—These are least squares regressions. The dependent variable is log of time allocated to all work activities (housework and market). Standard errors have been corrected for heteroscedasticity. $N$ = number of observations. Definitions of variables are provided in table A1 in the appendix.

* $F$-test statistic (with 2 and 2,478 df) for the joint null hypothesis: coefficients of H2ODIST and H2ODISTSQ are equal to zero.

quadratic specifications between $t^k$ and H2ODIST reveals that the former has a better statistical fit. The results show that women's leisure is a cost of poor infrastructure, as captured by the distance that has to be traveled to collect water (H2ODIST).

Even after controlling for household investments in water technology (H2OINHOME), the relationship between $t^k$ and H2ODIST remains positive and statistically significant, with little change in the magnitude of the estimated coefficient (results are provided in the first two columns and the last two columns of table 4). The coefficient of H2OINHOME is negative and statistically significant; women in households that have invested in an in-house source of water tend to spend significantly less total time working. Thus, private investments in infrastructure are akin to ''buying'' leisure time for women, or to put it another way, they reduce the total work burden of women. This phenomenon is similar for communities where the major source is in-house water (H2OINCOMU). Indeed, women in such communities tend to spend less time in work activities (more time in leisure), though the estimated coefficient is not significantly different from zero.

Our results also have implications for the time women spend with children. Note that our measure of total work ($t^k$) does not include time women spend in child care as child care is likely to be joint with other activities. Thus, in our formulation, child-care activities are subsumed in leisure. As improvements in infrastructure have the effect of reducing women's work burden, one possible effect may be on the time available for child-care activities, such as teaching children and looking after their hygiene and nutrition. While it is not possible to test for this interaction directly, there is some evidence in our results that this connection may hold.

We now discuss our results with respect to the exogenous variables, that is, variables that do not directly arise from our theoretical framework but which we have used in our estimation largely to control for the influence of unobserved heterogeneity. Alderman et al. have analyzed the interaction of education, income, and cognitive development in rural Pakistan.[49] Given that our data only contain self-reported information on education levels and reading, counting, and writing abilities, the literacy variable we use is imprecisely measured and should be considered with caution. Nevertheless, we find that literacy significantly lowers time allocated to water collection and to market work. It raises leisure. While at first this effect may seem counterintuitive, it is not unusual to find similar patterns in other developing countries, especially those of south Asia.[50] Educational attainment among rural women in Pakistan is quite low—it is 7% in the data used herein (see table 1)—and women with education tend to belong to the richest households.[51] Given the negative association between household income or wealth and labor participation, it is not surprising to find a negative correlation between educational attainment—weakly captured by literacy—and leisure.

Another important type of infrastructure that may affect women's time allocation is the household's access to electricity, and we included the variable ELECTRICITY to account for this. Similar to what we find for water infrastructure, access to electricity significantly increases leisure (i.e., it lowers $t^k$). This variable appears to represent a strong wealth effect, since it tends to lower the time spent in all types of work activities.[52]

Seasonal control dummies are statistically significant in all regressions except in the regression for water collection, which suggests that household demand for time in water collection is such that it does not vary much over the cycle of the year, even in periods of peak labor demand. Regardless, our results with respect to seasonal dummies underscore that ignoring such controls is likely to bias the results of a time-allocation model in a rural setting.

Household structure influences the time allocation of women. The presence of other adult females in the household (ADULTFEMALES), which allows women to share work responsibilities, significantly lowers their water-collection burden, market-activity time, and the total work load (i.e., it increases leisure). There is a statistically significant concave relationship between age and total work hours. This suggests that over the life cycle, time spent working rises, reaches a maximum, and then falls again, with the maximum occurring at about 33 years of age. Time spent in market activities has a similar concave relationship with age (see table 3). Thus, early in the life cycle, women engage in arduous market work, which increases at a decreasing rate with age. Beyond the early thirties, total time spent working ($t^k$) falls, which suggests there is some movement toward leisure.

## V. Conclusion

Our objective in this article was to focus on the relationship between access to water—both at the community and household levels—and the time allocation of women, who have the primary responsibility for water collection. We found that changes in the availability of infrastructure affect time use at two levels—that of the household and that of the individual within the household.

At the household level, our results show that a poor infrastructure—as indicated by the state of water supply available to the household—induces women to reduce their market-oriented work and thus their contribution to household income. However, the relationship between infrastructure deterioration and household poverty cannot be directly established by the results in this article, because, although we assessed the impact of infrastructure on female time allocation, we have ignored the countervailing effects on the labor supply of male members of the household. There is some evidence that men's labor supply in rural areas of developing countries is often inelastic.[53] If this is indeed the case, then our results suggest that improvements in water-supply infrastructure will lower poverty through an increase in the participation of women in income-generating activities.

Our results also indicate that poor infrastructure causes an increase in the total work burden of women, that is, a decrease in their leisure. Thus, in as far as various measures of poverty are concerned, such as the welfare of women, there is an increase in the work burden of women as a consequence of worsening water-gathering infrastructure. It is not surprising, therefore, that households that are able to invest in private sources of water are able to prevent an increase in their women's work burden.

As for the implications that our analysis in this article may have for public policy in developing countries, our results show that improvements in water-supply infrastructure would lower the total time women spend in all activities, with a substitution of water collection for income-generating activities. Investments in such infrastructure would not only lower the total work burden of women, but it would also change the nature of women's contribution to the household—from performing everyday chores to doing income-generating work. In terms of women's time allocation in south Asia, our results compare well with those of Alderman and Chishti and those of Khandker. As in these studies, our conclusion is that while social and institutional factors may be important, economic opportunities and constraints should not be overlooked or ignored in explaining the time allocation of women in rural areas of developing countries. At the same time, even though we find that economic factors do matter in the labor supply decision of women, we do not intend to imply that rigidities do not exist in the labor market for women. It has been noted in the case of Pakistan by T. Ibraz and A. Fatima that social factors also affect the demand for female workers and that even though women would like to work in market-oriented activities, they may not find many opportunities to do so.[54]

## Appendix

TABLE A1

Description of Variables

| Variable | Description |
|---|---|
| $t^q$ | Hours (per month) spent in the collection of water. |
| $t^m$ | Hours (per month) spent in ''market-oriented'' activities. Market-oriented activities are work for wages, work on family farm, and employment in the family's nonfarm business. |
| $t^k$ | Hours (per month) in all nonleisure activities. Nonleisure activities include market work, water collection, and other household chores such as fetching fuelwood, animal care, overseeing, grazing, herding, fodder collection, preparing dung cakes, milking animals, preparing *ghee*, taking meals to field workers, going to market, grinding flour, husking rice, cooking, baking bread, washing dishes, cleaning the house, laundry, ironing, stitching, and doing embroidery. |
| AGE | Woman's age in years. |
| | The subsample used for estimation consists of women 15 years of age and older. |
| H2OINCOMU | Equals 1 if community has in-house supply of water, 0 otherwise. |
| DISTANCE2MKT | Community distance in kilometers to nearest wholesale market. |
| H2OINHOME | Equals 1 if household has in-house supply of water, 0 otherwise. In-house water supply is defined as (i) indoor tap, (ii) indoor hand-pump, or (iii) indoor electric-powered motor pump. |
| LAND | Log of number of acres of agricultural land owned by the household. |
| HOMEASSETS | Log of value of assets held by the household. Assets include rotating savings and credit association instruments (ROSCAS) due, bank balance, cash holding, amount lent by the household less amount borrowed, value of financial securities, and value of durable goods (measured in thousand rupees). |
| LITERATE | Equals 1 if woman can read, write, and count, 0 otherwise. |
| NONWAGENIC | Log of per capita nonwage income. |
| PRODASSETS | Log of value of assets of the household's self-employment enterprise. Assets include value of livestock and agricultural land owned and value of other nonfarm commercial assets (measured in thousand rupees). |
| SPOUSEWAGE | Log of wage of spouse. |
| H2ODIST | Average round-trip commuting distance to source of water excluding the household in question (kms). |
| H2ODISTSQ | Square of H2ODiST. |
| WAGE | Log of predicted wage of female. |
| ADULTFEMALES | Number of females in 15–45 age group in the household. |
| OCT–NOV | Equals 1 if month of interview was October (10) or November (11), 0 otherwise. |
| APR–MAY | Equals 1 if month of interview was April (4) or May (5), 0 otherwise. |
| JUL–AUG | Equals 1 if month of interview was July (7) or August (8), 0 otherwise. |
| ZONE_BP | Equals 1 if agro-climatic zone is Barani (rainfed) Punjab, 0 otherwise. |
| ZONE_MP | Equals 1 if agro-climatic zone is Mixed Punjab, 0 otherwise. |

TABLE A1 (*Continued*)

| Variable | Description |
|---|---|
| ZONE_CWP | Equals 1 if agro-climatic zone is Low-Intensity Punjab, 0 otherwise. |
| ZONE_LIP | Equals 1 if agro-climatic zone is Cotton-Wheat Punjab, 0 otherwise. |
| ZONE_ROS | Equals 1 if agro-climatic zone is Rice-Other Sindh, 0 otherwise. |
| ZONE_CWS | Equals 1 if agro-climatic zone is Cotton-Wheat Sindh, 0 otherwise. |
| ZONE_NWF | Equals 1 if agro-climatic zone is Northwest Frontier Province, 0 otherwise. |
| ZONE_BAL | Equals 1 if agro-climatic zone is Baluchistan, 0 otherwise. |
| ZONE_RWP | Equals 1 if agro-climatic zone is Rice-Wheat Punjab, 0 otherwise. |
| ZONE_RWS | Equals 1 if agro-climatic zone is Rice-Wheat Punjab, 0 otherwise. |
| ELECTRICITY | Equals 1 if the household uses electricity, 0 otherwise. |
| CANAL | Equals 1 if cluster has canal irrigation, 0 otherwise. |

## Notes

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1. For examples, see World Bank, *Recognizing the ''Invisible'' Woman in Development: The World Bank's Experience* (Washington, D.C.: World Bank, 1979); Lawrence H. Summers, ''Investing in All the People,'' *Pakistan Development Review* 31, no. 4 (1992): 367–93; and World Bank, *World Development Report, 1990* (Washington, D.C.: Oxford University Press, 1990).

2. See, e.g., World Bank, *Toward Gender Equality: The Role of Public Policy* (Washington, D.C.: World Bank, 1995).

3. For an interesting example of this vicious circle, see T. Ibraz and A. Fatima, ''Uneducated and Unhealthy: The Plight of Women in Pakistan,'' *The Pakistan Development Review* 32, no. 4 (1993): 905–15.

4. For an example of women's time allocation in Bangladesh, see Shahidur Khandker, ''Determinants of Women's Time Allocation in Rural Bangladesh,'' *Economic Development and Cultural Change* 37 (1988): 111–26.

5. See World Bank, *Toward Gender Equality: The Role of Public Policy,* p. 19.

6. Hans P. Binswanger, Shahidur R. Khandker, and Mark R. Rosenzweig, ''How Infrastructure and Financial Institutions Affect Agricultural Output and Investment in India,'' *Journal of Development Economics* 41 (1993): 337–66.

7. Victor Lavy, John Strauss, Duncan Thomas, and Philippe de Vreyer, ‘‘Quality of Health Care, Survival, and Health Outcomes in Ghana,’’ *Journal of Health Economics* 15 (1996): 333–57.

8. Duncan Thomas and John Strauss, ‘‘Prices, Infrastructure, and Household Characteristics and Child Height,’’ *Journal of Development Economics* 39 (1992): 301–31.

9. See Albino Barrera, ‘‘The Role of Maternal Schooling and Its Interaction with Public Health Programs in Child Health Production,’’ *Journal of Development Economics* 32 (1990): 69–92; and Harold Alderman and Marito Garcia, ‘‘Food Security and Health Security: Explaining the Levels of Nutritional Status in Pakistan,’’ *Economic Development and Cultural Change* 42, no. 3 (1994): 485–507.

10. See Sohail J. Malik, ‘‘Poverty in Pakistan, 1984–1985 to 1987–1988,’’ in *Including the Poor,* ed. M. Lipton and J. van der Gaag (Washington, D.C.: World Bank, 1993).

11. The government of Pakistan initiated in 1992–93 a Social Action Programme (SAP). The SAP is an integrated, multisectoral program involving primary education, primary health, family planning, and rural water supply and sanitation (Government of Pakistan, *Economic Survey, 1995–1996* [Islamabad: Government of Pakistan, 1996]). Its aim is ‘‘to provide relief to the target groups of the society, sponsor social services and community development projects, and ameliorate the condition of the destitute’’ (ibid., p. x).

12. Malik (‘‘Poverty in Pakistan, 1984–1985 to 1987–1988’’) observes that all development plans have explicitly taken into account poverty alleviation with measures such as minimum wage legislation, special rural development programs, subsidies on selected consumer goods and agricultural inputs, progressive income taxation, and higher public expenditures for the development of backward regions. However, he concludes that these policies have not achieved their objectives for several reasons. For instance, subsidies from the rural credit program intended for the poor did not reach them. Indeed, Malik presents evidence that small farm households have always had limited access to rural credit and that conditions worsened between 1973 and 1985. See Sohail J. Malik, *The Source, Structure, and Utilization Patterns of Rural Credit in Pakistan: Implications for Policy* (Washington, D.C.: International Food Policy Research Institute, 1993). Malik, in ‘‘Poverty in Pakistan, 1984–1985 to 1987–1988,’’ concludes that though conditions improved somewhat for the poor, the targeting of the programs left much to be desired, as urban areas and males were the recipients of programs, leaving rural areas and groups such as female-headed households even more disadvantaged.

13. Alderman and Garcia recommend that community-level investments be made in curative as well as preventive programs designed to improve health levels and reduce morbidity.

14. We thank an anonymous referee for drawing our attention to these points.

15. Gary S. Becker, ‘‘A Theory of Allocation of Time,’’ *Economic Journal* 75 (1965): 493–517; Reuben Gronau, ‘‘Leisure, Home Production, and Work: The Theory of the Allocation of Time Revisited,’’ *Journal of Political Economy* 85 (1977): 1099–1123.

16. It is estimated that about one billion people live without proper access to drinking water. See World Bank, *World Development Report, 1994* (Washington, D.C.: Oxford University Press, 1994), p. 1.

17. By choosing to define the model at the household level, we implicitly assume that there is no intrahousehold variation in the behavior of agents in the household. This may seem an overly restrictive assumption at first. In an earlier

version of the article, we conducted our empirical analysis at both the individual and household levels (Nadeem Ilahi and Franque Grimard, ''Public Infrastructure and Private Costs: Water Supply and Time Allocation of Women in Rural Pakistan'' [paper presented at the annual meeting of the Canadian Economic Society, St. John's, June 1997]). The results indicated that at least with respect to time allocation, there is no difference between the two specifications. We thus use the individual female as the unit of analysis and use the individual and the household interchangeably.

18. In general, two specifications of the water production function are possible. Depending on which one is used, the predictions of the model can be vastly different. For a discussion of this matter, see Reuben Gronau, ''Home Production—a Survey,'' in *Handbook of Labor Economics*, ed. O. Ashenfelter and R. Layard (Amsterdam: Elsevier, 1986), 1:28.

19. Ibid., pp. 273–304.

20. The test is based on three options that a woman can choose: (1) producing cash income from market employment; (2) participating in home production or in the family enterprise; and (3) not taking part in production (see Shahidur Khandker, ''Labor Market Participation of Married Women in Bangladesh,'' *Review of Economics and Statistics* 69 [1987]: 536–41). If one assumes that the errors are independently and identically distributed and that the independence of irrelevant alternatives (IIA) applies, then this model can be estimated using a multinomial logit. Another possibility is to follow Jerry Hausman and Daniel McFadden (''Specification Tests for the Multinomial Logit Model,'' *Econometrica* 52 [1984]: 1219–40) and relax the IIA assumption. Here one models the choice structure of a woman as sequential—that is, by assuming that first the woman decides on whether to produce or not (i.e., either cash income or home production). Then, once that decision is made, she chooses whether to produce in a home-production family enterprise or to produce cash income from employment outside of the family enterprise. This model can be estimated as a nested multinomial logit and can be used to test the IIA property of the multinomial logit. We estimated the nested multinomial logit and found that we could reject the IIA property. For determinants of the decisions to participate, we used literacy, age, husband's wage, distance to water, distance to water squared, in-house availability of water, community access to water, and 11 seasonal and regional dummies. As outlined by G. S. Maddala (*Limited-Dependent and Qualitative Variables in Econometrics* [Cambridge: Cambridge University Press, 1986]), the Hausman and McFadden test compares the coefficients of the determinants of one activity obtained with the multinomial logit with those obtained with the nested multinomial logit. If the null is true (i.e., IIA holds), then the difference in coefficients should be zero. The values of our tests of $\chi^2$ with 18 degrees of freedom are 902.3 and 723.4 for deleting the categories of market and leisure, respectively. As Khandker did in ''Labor Market Participation of Married Women in Bangladesh,'' we should point out that the rejection of the IIA may be indicative of a misspecification of the model we use. This result concerning the participation decision led us to take paid employment and family employment together as one category of time allocation.

21. See Khandker, ''Labor Market Participation of Married Women in Bangladesh.'' Also see A. Hill, ''Female Labor Force Participation in Developing and Developed Countries: Consideration of the Informal Sector,'' *Review of Economics and Statistics* 65 (1983): 459–68, for contradictory evidence from Japanese data.

22. Note that in our formulation of the econometric model, the dependent variables are times allocated to various activities today—i.e., they are flow variables—whereas H2OINHOME is an indicator of past investments in in-house

water supply—i.e., it is a stock variable. It is unlikely that the latter will cause a simultaneous-equation bias in the estimation equations of the former.

23. The probit for the decision to work had, as right-hand-side variables, number of children younger than 6, marital status, assets, wage of spouse, number of other adult females in the home, household size, and seasonal dummies. The second-stage wage equation was modeled as a function of age, its square, education, seasonal dummies, and the inverse Mills ratio from the probit regression. Assuming that wage workers do not differ from workers on the family farm, predicted wages for both types of workers were then predicted from the wage regression. Another approach to capture the opportunity cost of women's time is to use community-level (cluster) wage rates. See Khandker, ''Labor Market Participation of Married Women in Bangladesh.'' While this approach overcomes the self-selection issue, it raises another—it presumes women within a cluster are paid equally for each hour of market work. This translates to presuming that the returns to education or to tenure are zero. See William Greene, *Econometric Analysis*, 4th ed. (New York: Prentice Hall, 2000), pp. 928–30.

24. There is, of course, a potential problem in interpreting LAND and PRODASSETS as proxies for labor demand alone. These two variables may be indicators of wealth as well and, as a consequence, may influence the demand for leisure. Specifically, a higher value of these two variables may increase leisure at the expense of all or some types of work. The effect of these possible complications on our estimation is discussed below.

25. Note that we assume the husband's work decisions to be exogenous to that of the wife's and that while SPOUSEWAGE directly measures income, HOMEASSETS is a measure of wealth. Since it is reasonable to assume that wealth and income are positive correlates, the use of wealth variables as proxies of income may be justified.

26. See, e.g., P. Apps, ''Female Labour Supply, Housework, and Family Welfare,'' in *The Measurement of Household Welfare*, ed. R. Blundell, I. Preston, and I. Walker (Cambridge: Cambridge University Press, 1994); Khandker, ''Labor Market Participation of Married Women in Bangladesh''; and Hill.

27. This, Marc Nerlove argues, can lead to a perverse solution where the environmental resource in question is driven to zero. See ''Population and the Environment: A Parable of Firewood and Other Tales,'' *American Journal of Agricultural Economics* 73 (1991): 1334–47.

28. If Nerlove's (ibid.) argument is to hold, then we would expect women who face greater water scarcity to have more children (with a lag, of course).

29. Note that including the number of young children on the right-hand side does not alter our results.

30. Harold Alderman and Salim Chishti, ''Simultaneous Determination of Household and Market-Oriented Activities of Women in Rural Pakistan,'' *Research in Population Economics* 7 (1991): 245–65.

31. We believe that agroclimatic dummies provide more disaggregated information than do provincial dummies. Use of the former also allows us to control for the nature of the farm economy, which is not possible with provincial dummies. See Thomas C. Pinckney, *The Demand for Public Storage of Wheat in Pakistan*, Research Report no. 85 (International Food Policy Research Institute, Washington, D.C., 1989).

32. For instance, a woman is likely to report more time allocated to farm work and less time allocated to housework and water collection if she is interviewed in the peak labor season rather than in the lean labor season. This is consistent with Soussan et al., who observe that in Nepal, women's fuelwood collection activity winds down in the wet monsoon season because fuelwood supplies dwindle and there is a high demand for farm labor (J. Soussan, E. Gev-

ers, K. Ghimire, and P. O'Keefe, ''Planning for Sustainability: Access to Fuelwood in Dhanusha District, Nepal,'' *World Development* 19, no. 10 [1991]: 1299–314).

33. This is consistent with the subsample considered by Alderman and Chishti.

34. Self-reporting biases on distance to water source can affect the usefulness of this variable, especially if the number of observations within a cluster (on which this mean is calculated) is small. Essentially, for a given household *j,* it takes on a value that is the mean distance of all the other households (i.e., other than household *j*) in the cluster. Thus it takes different values for each household in the cluster.

35. The value of H2ODIST is ultimately obtained from household-level observations on distance to water. An analysis of this variable indicates a sizable intracluster variation. Note that clusters in which none of the households reported any collection distance were dropped from the analysis.

36. For a survey of the research on the use of time-use survey data, see Thomas Juster and Frank P. Stafford, ''The Allocation of Time: Empirical Findings, Behavioral Models, and Problems of Measurement,'' *Journal of Economic Literature* 29 (1991): 471–522.

37. In a separate set of estimations, we accounted for the extreme-value problem by employing an inverse hyperbolic sine (IHS) transformation of the dependent hours variables, as suggested by J. B. Burbidge, B. L. Magee, and A. L. Robb in ''Alternative Transformations to Handle Extreme Values of the Dependent Variable,'' *Journal of the American Statistical Association* 83 (1988): 123–27. The transformation can be expressed as: $\sinh^{-1}(y) = \ln\{y + (y^2 + 1)^{1/2}\}$.

38. The Heckit procedure is described in Greene (n. 23 above).

39. See Emmanuel Skoufias, ''Labor Market Opportunities and Intrafamily Time Allocation in Rural Households in South Asia,'' *Journal of Development Economics* 40 (1993): 277–310.

40. We also interacted time of interview dummies with H2OINHOME to capture the effect of interaction of seasonality and water availability on time use. The estimated coefficient of the interaction term was not statistically significant.

41. Note that having in-house access to water does not always mean zero time required to collect water. This would especially be the case for those women who collect from an outdoor pump situated within the household compound.

42. We also explored the joint effect of H2ODIST and nonwage income on the probability of collection. The estimated coefficient of the interaction term was not statistically significant.

43. Furthermore, we interacted nonwage income with distance to water in the probability equation. The estimated coefficient of the interaction term was statistically insignificant.

44. Recall that the tobit specification is based on the assumption that the determinants of the two equations are identical.

45. We do not use the Heckit procedure here because, unlike the case of water collection, it is difficult to find variables that only influence the decision to do market work and not the decision of how many hours to allocate to doing that activity. We thus use a tobit estimation procedure instead. This approach is consistent with that used by Khandker for ''Determinants of Women's Time Allocation in Rural Bangladesh'' (see n. 4 above).

46. See World Bank, *Recognizing the ''Invisible'' Woman in Development* (see n. 1 above).

47. We also interacted time of interview dummies with WAGE to capture

the joint effect of seasonality and wage on time use. The estimation yielded an insignificant coefficient estimate of the interaction term.

48. Since the number of children and the time spent in their care are likely to be choice variables, we have not included child-care time in women's time allocation. See Alderman and Chishti (see n. 30 above).

49. Since 1986, the International Food Policy Research Institute (IFPRI) has been administering a panel survey, the Pakistan Food Security Survey, in five districts in Pakistan. In the spring of 1989, a special human capital module was included in the survey, with tests of literacy and numeracy especially designed by the Educational Testing Service of Princeton, N.J. H. Alderman, H. J. Behrman, S. Khan, D. Ross, and R. Sabot (''The Income Gap in Cognitive Skills in Rural Pakistan,'' *Economic Development and Cultural Change* 46 [1997]: 97–122) use these data to analyze the effect of household income on cognitive achievement of individuals. Further, H. Alderman, H. J. Behrman, D. Ross, and R. Sabot (''Decomposing the Gender Gap in Cognitive Skills in a Poor Rural Economy,'' *Journal of Human Resources* 31, no. 1 [1996]: 229–54) examine the factors underlying the gender gap in cognitive skills in rural Pakistan.

50. See, e.g., Alderman and Chishti; and Khandker, ''Determinants of Women's Time Allocation in Rural Bangladesh.''

51. We define our literacy variable as the interaction of the self-reported answers concerning reading ability, writing ability, and counting ability. These values in the overall data set for adult females, including the villages where no one collects water, are respectively 10%, 8.3%, and 50%, for an average literacy figure of 8.2%. Our subset of women yields an average literacy rate of 7%. Furthermore, the proportion of women with any primary school attendance is 4%. It would appear that even though the Pakistani government claims a rate of 15% for women, this does not appear to apply to those rural women sampled in our data set. Including girls below the age of 15 increases our average literacy rate and our primary-school attendance rate in the sample, but these figures are still lower than the overall figures provided by the government. Readers interested in finding more about education in rural Pakistan should refer to Alderman, Behrman, Ross, and Sabot; and Alderman, Behrman, Khan, Ross, and Sabot.

52. Our results indicate that different types of infrastructure may have different effects on time allocation. Whereas both types of infrastructure variables (water and electricity) allow women to increase their leisure, access to electricity is associated with a decline in market work.

53. E. King and Robert E. Evenson, ''Time Allocation and Home Production in Philippine Rural Households,'' in *Women and Poverty in the Third World*, ed. M. Buvinic, M. A. Lycette, and W. P. McGreevey (Baltimore: Johns Hopkins University Press, 1983).

54. See Ibraz and Fatima (n. 3 above).