Deficient Public Infrastructure and Private Costs:
Evidence from a Time-Use Survey for the Water Sector in India

by

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ABSTRACT

This paper presents new evidence on the links between public-infrastructure provisioning and time allocation related to the water sector in India. An analysis of time-use data reveals that worsening public infrastructure affects market work, with evident gender differentials. The results also suggest that access to public infrastructure can lead to substitution effects in time allocation between unpaid work and market work. The broad conclusion of the paper is that public-investment policy can redress intrahousehold inequalities, in terms of labor-supply decisions, by supporting initiatives that reduce the allocation of time in nonmarket work.

I. INTRODUCTION

As argued by Becker (1965) in his seminal paper on the theory of allocation of time, the allocation and efficiency of nonmarket working time may be more important to economic growth than market working time. Yet, the attention paid by economists to the market economy skews any paid to the other; nonmarket work continues to remain statistically invisible. Time-use data, in this context, are becoming increasingly important, as they capture the burden of unpaid work in addition to the market economy.

The time-use data challenged the existing theories on allocation of time where time was dichotomized into market time and nonmarket time, and also when nonmarket time aggregates leisure and work at home. The justification for aggregating leisure and unpaid work at home rests on two assumptions: (a) the two elements react similarly to changes in socioeconomic environment and, therefore, nothing is gained by studying them separately; and (b) the two elements satisfy the conditions of a composite input—that is, the relative price is constant and there is no interest in investigating the composition of the aggregate since it has no bearing on production and the price of the output (Gronou 1977). The time-budget findings did reveal that these two assumptions are wrong, as unpaid work at home and leisure are not affected in the same way by changes in socioeconomic variables and the composition of the aggregate affects many facets of the intrahousehold behavior. The findings from time-budget data—tricotomising the allocation of time into work in market, work at home, and leisure—can provide insights to integrate the nonmarket work into economic modeling and, in turn, in macroeconomic policy making. This is particularly relevant when public investment policy can redress intrahousehold inequalities in terms of household division of labor by supporting initiatives that reduce the time allocation of women in unpaid work. Examples of such public policy interventions are improved infrastructure in the water sector, rural electrification, roads, sanitation services, and better transport infrastructure.

Despite the growing recognition of implications of time-budget statistics for macroeconomic policy making, there have been relatively few examples of empirical literature on the topic. Bredie and Beehary (1998) revealed that easy accessibility to drinking water facilities might lead to an increase in school enrollment, particularly for

girls; in Madagascar, 83 percent of the girls who did not go to school spent their time collecting water, while only 58 percent of the girls who attended school spent time collecting water. Khandker (1998) showed that it was not the *patriarchy* per se that restricts women's time from market work in Bangladesh, but rather economic factors like low wages and low education. In the context of Pakistan, Ilahi and Grimard (2000) indicated that worsening water-gathering infrastructure caused an increase in the total work burden of women.

This paper aims to take on this rare gamut of literature by analyzing the first Time-Use Survey (TUS) conducted by the Central Statistical Organization (CSO), using a sample of 18,591 households spread over six major states of India, viz., Gujarat, Haryana, Madhya Pradesh, Meghalaya, Orissa, and Tamil Nadu. This major macro-level TUS is a first ever attempt, not only in South Asia, but also among developing countries. The paper attempts a nascent analysis of the time-budget data to explore the link between public infrastructure and time allocation in India. The hypothesis is to examine whether increased investment in water infrastructure will release rural women's allocation of time to market work. The paper is organized into four parts. Section II discusses the theoretical framework, while Section III interprets time-use data. Section IV discusses the econometric specification of the model and discusses the results. Section V summarizes the findings and draws conclusions.

II. THEORETICAL FRAMEWORK

The theoretical framework of the link between infrastructure investment and time allocation is drawn from Becker-Gronou models of time allocation. This framework is derived by refuting the assumption of *labor force exogeneity* in the treatment of the nonmarket economy, which is intrinsic to the neoclassical labor supply models of consumption and leisure. In other words, the model has incorporated the intrahousehold gender asymmetries in the allocation of time, as well as the choices and constraints regarding labor-force participation in the market and nonmarket economy. The improvised model recognizes the dynamic interaction between the dual sets of economic activity—that is, the statistically invisible nonmarket economy and market economy.

The model assumes that the household's utility function depends on the commodities consumed (z_i) and the leisure of its members (t_i^l) :

$$u_i = u_i (z_i , t_1^l, t_2^l)$$ (1)

Consumption is generated through a household production function:

$$z_i = z_i (W_i, x_i , t_1^e, t_2^e)$$ (2)

where W_i is the amount of water used by the household, x_i is a monetized input, and t_i^e denotes the time allocated to nonmarket work (e-SNA) by family members; i.= 1,2.

The water production function, in turn, is generated by:

$$W_i = f (t_i^w, \Omega_i)$$ (3)

where t_i^w is time allocated to fetch water and parameter Ω_i captures the access to water infrastructure.

The household agents maximize their welfare subject to budget and time constraints given by:

$$\max u_i = u_i (z_i , t_i^l)$$ (4)

subject to

$$t_i^w + t_i^m + t_i^e + t_i^l \geq T_0$$ (5)

and

$$x_i = w_1 t_1^m + w_2 t_2^m + v_i$$ (6)

where $t_i{}^m$ is the market time, T_0 is total time endowment, w_i is the market wage rate, and v_i is the unearned income.

Combining Equations (5) and (6), the full income constraint is obtained as follows:

$$x_{i+} w_i (t_i{}^w + t_i{}^e + t_i{}^l) = w_i T_0 + v_i \tag{7}$$

Solving for the first order conditions, a set of selected determinants of optimum time and commodity demand functions are derived a follows:

$$t^m = t^m(w, v, \Omega) \tag{8}$$

and

$$x^* = x(w, v, \Omega) \tag{9}$$

For econometric estimation, a reduced system of time equation is specified as follows:

$$t^m = t^m(w, v, \Omega) + \mu_i \tag{10}$$

III. STATISTICAL INVISIBILITY OF NONMARKET WORK: THE MAIN FINDINGS FROM TIME-USE DATA

Nonmarket work remains significantly invisible in national accounts. The attempt of the United Nations Statistical Division in extending the production boundary of the Systems of National Accounts (SNA) in 1993 has led to the inclusion of nonmarket work into the national accounting system as satellite accounts. Based on SNA 1993, the TUS classified the activities into SNA activities (that get included in GDP calculations), extended SNA activities (that do not get included in GDP, but should be included in the satellite

accounts), and residual non-SNA activities. This large-scale survey conducted by CSO during July 1998 to June 1999 polled 18,591 households in India, covering all members of the household aged six years and above, gives a better understanding of how time is allocated across gender in the economy and provides some insight into the extent of statistical invisibility of women's work in India.

The time-use data is generated usually on the basis of time-diary method, confined to a probability sample of all types of days (weekdays and weekends). Time diary is a retrospective method in which the respondents are asked to keep an account of a recent twenty-four hour chronology of the use of time and researchers code the responses to a standard list of activities. Time-use diaries are preferred over the other methods, for they tend to be more comprehensive, they enable respondents to report activities in their own terms, and they have some form of built-in check that increases the reliability of the data (Juster and Stafford 1985).

The time-diary method has certain deficiencies. The significant one is the presence of multitasking or omission of overlapping activities. This results from the imposition of a rigid constraint of time use, namely, no person has either more or less time available than twenty-four hours per day (time constraint) and the set of activities capable of being measured, described, and analyzed must add up to a fixed number of hours or days (Floro 1995). Theoretically, it can be solved by defining the new activity as a joint activity, but the codes for possible diary activities would explode in number. The practical way of solving this problem is to indicate one activity as primary and the other as "secondary." Yet another way to conceptualize secondary activities is to argue that there is really only one activity at any given time, but there are frequent switches between activities and if the time grid were fine enough, the issue of secondary activities would effectively disappear. Finally, it seems plausible that the issue of multiple or joint activities is the key source of the major failure of alternative recall methods. Recall accuracy falls when the respondents make primitive attempts to respond to questions about hours of an activity in the last week or month by engaging in a kind of *temporal double counting*—adding in periods when the activity was secondary to periods when it was central (Juster and Stafford 1985).

The time-use survey found that, in the production of own-account services that qualify for inclusion in the satellite accounts as per SNA 1993, on average, a female spent 34.6 hours per week compared to 3.6 hours by a male (Table 1). In these activities, females in Gujarat scored the most time spent (39.08 hours per week), followed by Madhya Pradesh (35.79 hours) and Orissa (35.70 hours).

Table 1: Time Allocation by Women and Men, Selected States of India (weekly average time in hours)

States	Female			Male			Total		
	SNA	Non-SNA		SNA	Non-SNA		SNA	Non-SNA	
	SNA	Ext-SNA	Residual Non-SNA	SNA	Ext-SNA	Residual Non-SNA	SNA	Ext-SNA	Residual Non-SNA
Haryana	21.26	31.06	115.67	37.72	1.99	128.23	30.19	15.24	122.52
Madhya Pradesh	19.85	35.79	112.38	42.07	4.43	121.47	31.54	19.22	117.19
Gujarat	17.60	39.08	111.36	43.63	3.19	121.12	31.24	20.27	116.44
Orissa	17.07	35.70	115.20	40.12	4.47	123.45	28.69	19.91	119.36
Tamil Nadu	18.97	30.46	118.61	42.54	3.19	122.27	30.68	16.87	120.45
Meghalaya	26.34	34.52	107.15	45.94	7.16	114.78	35.88	21.28	110.84
Combined States	18.72	34.63	114.58	41.96	3.65	122.42	30.75	18.69	118.62

Source: CSO, Time-use Survey (2000)

Time-use data of combined states suggest that women spent 50.52 percent of their time on unpaid work while men spent only 33.15 percent (Table 2). The interstate differences revealed that percent of time spent by females in unpaid activities was highest in Haryana (85.99 percent), followed by Meghalaya (76.39 percent) and Orissa (69.44 percent); the lowest time spent was in Tamil Nadu (32.45 percent).

Table 2: Distribution of Time Use in Paid and Unpaid SNA Activity in India (in percent)

States	Male			Female			Total		
	Paid	Unpaid	% of time use on unpaid activities	Paid	Unpaid	% of time use on unpaid activities	Paid	Unpaid	% of time use on unpaid activities
Haryana	33.09	18.12	*35.38*	4.13	25.34	*85.99*	20.60	21.37	*51.58*
Madhya Pradesh	29.41	23.34	*44.25*	14.31	15.75	*52.40*	22.99	20.12	*46.67*
Gujarat	44.37	14.17	*24.21*	17.18	13.87	*44.67*	33.26	14.05	*29.70*
Orissa	31.25	22.42	*41.77*	8.00	18.18	*69.44*	20.55	20.47	*49.90*
Tamil Nadu	41.42	13.36	*24.39*	21.80	10.32	*32.45*	32.74	12.04	*26.89*
Meghalaya	17.34	35.39	*67.12*	7.83	25.34	*76.39*	12.65	30.44	*70.64*
Combined States	36.54	18.12	*33.15*	14.87	15.18	*50.52*	27.16	16.85	*38.29*

Source: CSO, Time-use Survey (2000)

Imputing value to labor time spent on unpaid work, the contribution of nonmarket work was estimated across six states of India. District-wise data on wage rates for agricultural labor and wage rates for urban, unskilled manual labor have been used for valuing unpaid work in rural and urban areas, respectively. With this methodology, projecting the TUS results by age and district of the population, valuation of time spent on unpaid activities by females in Meghalaya and Madhya Pradesh indicates that the value of unpaid activities could be as much as 38–41 percent of the relevant State Domestic Product (SDP). For example, the total value of such activities by females was Rs 29,034 crore in Madhya Pradesh, relative to SDP of Rs. 70,832 crore (Table 3).

Table 3: Value of Nonmarket Work as Compared to State Domestic Product

States	Value of Nonmarket Work (Rs. Crores)			SDP (Rs. cr.)	'"Nonmarket Work" as a % of State Domestic Product		
	Male	Female	Total	1997–98	Male	Female	Total
Haryana	928.74	10,209.30	11,138.04	37,427	2.48	27.28	29.76
Madhya Pradesh	4,466.03	29,034.09	33,500.12	70,832	6.31	40.99	47.30
Gujarat	2,209.55	22,577.63	24,787.18	86,609	2.55	26.07	28.62
Orissa	1,463.78	11,343.88	12,807.65	32,669	4.48	34.72	39.20
Tamil Nadu	3,073.37	19,922.04	22,995.40	87,394	3.52	22.80	26.31
Meghalaya	260.45	862.97	1,123.42	2,250	11.58	38.35	49.93

Source: Pandey (2000)

Compared to females, the valuation of unpaid activities by males was limited to only about 2 percent of SDP in Gujarat and Haryana. The unpaid work, as a proportion of SDP, is as high as 49.93 percent in Meghalaya and 47.30 percent in Madhya Pradesh.

These results have significant policy implications. For instance, in terms of gender budgeting, it is often argued that mainstream public expenditure, such as infrastructure, is nonrival in nature and therefore applying a gender lens to these expenditures may not be feasible. This argument is refuted by the time-budget statistics. The time-budget data revealed that this argument is often flawed, as there is an intrinsic gender dimension to the nonrival expenditure. The time allocation in activities like fetching of water and fuel has significant gender differentials, therefore infrastructure investment with gender-sensitive water and energy policies can really benefit women. The gender disaggregated statistics of time use in the water sector across the six selected states in India clearly revealed that women spent more time in fetching water than men, except in Gujarat (Table 4).

Table 4: Time-Use Statistics of Water (weekly average time in hours)

States	RURAL			URBAN			TOTAL		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Haryana	3.20	5.54	5.38	3.08	4.79	4.71	3.19	5.48	5.33
Madhya Pradesh	3.21	5.40	5.03	1.21	2.96	2.76	3.11	5.22	4.88
Gujarat	14.00	0.00	14.00	0.00	0.00	0.00	14.00	0.00	14.00
Orissa	5.96	8.02	7.83	0.00	5.21	5.21	5.96	7.94	7.76
Tamil Nadu	3.85	4.79	4.69	2.56	4.62	4.26	3.33	4.74	4.57
Meghalaya	4.69	5.21	5.04	9.54	7.08	8.31	5.34	5.34	5.34
Combined States	3.83	5.11	4.97	3.02	4.63	4.35	3.61	5.02	4.85

Source: CSO, Time-use Survey (2000)

Apart from the time allocation in the activity, it is to be noted that the travel time for fetching water, fuel, etc. is also equally time consuming. The time-use data also revealed the gender differentials in travel time. There is thus a clear link between access to water and time allocation of women, who have a primary responsibility to ensure drinking water to their households, which suggest that changes in the availability of water infrastructure can lessen their burden in fetching the water, as well as release their time locked up in nonmarket work for the income-earning economic activities. In other words, investment in water infrastructure can help women in reallocating their labor time and reduce the stress related to walking long distances to fetch water.

In the next section, an illustrative empirical investigation of this hypothesis is undertaken using the data from the Time-use Survey for variables on time and finance accounts of selected states of India for the variable related to public infrastructure. Ideally, the empirical analysis requires comprehensive time-use data, either in terms of longitudinal surveys or across considerable cross-section units. However, within the data constraints of limited cross-section units of time-use data collected in rural and urban regions of selected states of India, an illustrative analysis is undertaken to examine the link between infrastructure and time allocation.

IV. EMPIRICAL ESTIMATION AND RESULTS

The hypothesis under investigation is whether better access to water infrastructure can help women to spend more time on market-oriented activities. The econometric specification is proposed as follows:

$$t_i^m = \alpha + \beta \, \text{infra}_i + \gamma \, \text{infrasq}_i + \lambda \, t_i^o + \delta \, t_i^c + \text{dummy} + \mu_i;$$

where t_i^m is time allocation in SNA activity (otherwise referred as market time). The variable infra_i denotes allocation and access to water infrastructure. The financial input variable of allocation is proxied by the log of public investment in infrastructure across cross-section units, while access to infrastructure or the distance variable is captured through the time-use budget of travel (ttim_i). The squared term of infrastructure reflects the plausible quadratic relationship between access to infrastructure and market time— that is, market time falls with fetching distance, but at a decreasing rate. The variable t_i^o denotes the opportunity cost of time, which is captured through market wage rate. Wage rates for agricultural labor and wage rates for urban, unskilled manual labor have been used for proxying the t_i^o in rural and urban areas, respectively. The unearned income is proxied by spouse's wage in selected models. As variables of opportunity cost of time and unearned income reported multicollinearity problems, estimations are done in separate models. The models are controlled for the nonmonetised work done in the *care economy* (t_i^c). A dummy is defined that takes the value of one if the unit of analysis is

rural and a value of zero otherwise. The parameters β and γ measure the effect of infrastructure on time variables; μ_i is a random error term. The econometric results are given in Table 5.

The results, though tentative due to data constraints, suggest that there is a quadratic relationship between access to infrastructure and market work; market time decreases with travel time to fetch water, but at a decreasing rate. The estimated coefficients suggest that the relationship between infrastructure access and time allocation in SNA activity is negative, which supports the hypothesis that better public infrastructure may release women's time to more market-oriented work. The financial input proxy for infrastructure also shows an initially decreasing and then increasing link with SNA activity, which needs a careful interpretation. The results indicate that higher infrastructural investment per se does not release time of women towards SNA activity. This points to the fact that higher budgetary allocation for infrastructure per se does not mean higher spending. Gender-budgeting studies showed that there is a significant deviation between what is budgeted and what is actually spent (Lahiri et al. 2002). The lag in the implementation of infrastructural projects may be a reason for the concave relationship. The results of linear models are not reported, as the quadratic models turned out to be the better fits.

Table 5: Econometric Results of Link between Infrastructure and SNA Activity

Dependent Variable↓	Female		Male	
	Model 1	Model 2	Model 3	Model 4
α	149.454 (2.468)*	-21.126 (-0.489)	174.714 (4.882)*	101.721 (5.988)
log pub infra$_i$	-27.466 (-1.947)*		-18.719 (-2.241)*	-
log pub infrasq$_i$	1.539 (1.859)		1.112 (2.262)*	-
ttim$_i$ (travel time)	-	-1.707 (-0.821)	-	-0.0009 (-0.002)
ttimsq$_i$ (travel time sq)	-	0.132 (0.579)	-	0.0003 (0.024)
t_i^o (male wage)	-	8.177 (1.024)	-12.81 (-4.459)*	-14.056 (-3.673)
t_i^o (female wage)	0.597 (0.157)		-	-
t_i^c (nonmonetised care economy)	-0.588 (-2.298)*	0.032 (0.072)	-1.419 (-3.663)*	-1.363 (-2.601)
Dummy	12.699 (7.631)*	16.308 (4.669)*	-0.081 (-0.079)	0.712 (0.463)
R^2	0.94	0.91	0.88	0.77
DW	1.85	2.15	2.05	1.95

Source: (Basic Data), Finance Accounts and Time-use Survey (2000)

Theoretically, a positive relationship between wages and market work is expected, which explains that as opportunity cost of time rises, women may allocate more time to market work. However, results revealed that wage is not a significant determinant of women's time in SNA activity. The labor-supply models predict an inverse relationship between unearned income and SNA activity. However, the estimated coefficient of spouse's wage is not found significant in determining women's time allocation in SNA activity. The model is controlled for the nonmonetised work in the care economy, inclusive of child care, care for sick, and geriatric care. The results showed that there is an inverse relationship between the work in the care economy and market economy, however, it was significant only for the models with financial input variable.

Broadly, the estimates suggest that there can be a link between deterioration in infrastructure and rural poverty, as worsening water infrastructure could lock-in the time of women in unpaid work that would otherwise be available for income-generating SNA activity. Time poverty affects income poverty, however, the aspects of *time poverty* are often surpassed when framing macro policies. The point to be noted here is that even with

the unit-record data, the analysis of the poverty-related aspects of time allocation and its implications for public investment may be severely restricted, as time-use data across income quintiles or monthly per captia consumer expenditure (mpce) quintiles is not available for India.

V. SUMMARY AND POLICY CONCLUSIONS

Using time-budget data, the paper provides new evidence on the link between public infrastructure and time allocation related to the water sector in India. The estimated coefficients suggest that worsening public infrastructure affects market work with evident gender differentials. The results, though tentative, indicate that access to public infrastructure can lead to substitution effects in time allocation between unpaid work and market work, which has implications for reducing the poverty in the household. The broad conclusion of the paper is that fiscal policies designed to redress income poverty can be partial if they do not take in to account aspects of *time poverty*.

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