# Deficient Public Infrastructure and Private Costs: Evidence for the Water Sector

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

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As argued by Becker (1965) in his seminal paper on the theory of allocation of time, the allocation and efficiency of non-market working time may be more important to economic growth than market working time. Yet, the attention paid by economists to the market economy skews scrutiny of the other; and the non-market work continues to remain statistically invisible. Time-use data, in this context, is increasingly getting important as it captures 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 dichotomised into market time and non-market time and also when non-market 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 socio-economic 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 [Gronau 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 socio-economic variables and the composition of the aggregate affects many facets of intra-household behaviour. The findings from time budget data – trichotomising the allocation of time into work in market, work at home and leisure – can provide insights to integrate the non-market work into economic modelling and in turn in macroeconomic policymaking. This is particularly relevant when public investment policy can redress intra-household inequalities in terms of household division of labour by supporting initiatives that reduce the time allocation of women in unpaid work. Examples of such public policy interventions are improved infrastructure in water sector, rural electrification, roads, sanitation services and better transport infrastructure.

Despite the growing recognition of implications of time budget statistics for macroeconomic policymaking, there has been relatively less empirical literature on the topic. Bredie and Beehary (1998) revealed that easy accessibility to drinking water facilities might lead to an increase in school enrolment particularly girls; in Madagascar, 83 per cent of the girls who did not go to school spent their time collecting water, while only 58 per cent of the girls who attended school spent time collecting water. Khandker (1988) showed that it was not the patriarchy per se that restricts women's time from market work in Bangladesh, but 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 analysing the first Time Use Survey (TUS) conducted by the Central Statistical Organisation (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 releases rural women's allocation of time to market work. The paper is organised into four parts. Section 1 discusses the theoretical framework while Section 2 interprets time use data. Section 3 discusses the econometric specification of the model and discusses the results. Section 4 summarises the findings and draws conclusions.

NOTES

## 1 Theoretical Framework

The theoretical framework of the link between infrastructure investment and time allocation is drawn from Becker-Gronau models of time allocation. This framework is derived by refuting the assumption of labour force exogeneity in the treatment of the non-market economy, which is intrinsic to the neoclassical labour supply models of consumption and leisure. In other words, the model has incorporated the intra-household gender asymmetries in the allocation of time and the choices and constraints regarding labour force participation in the market and non-market economy. The improvised model recognises the dynamic interaction between the dual sets of economic activity – that is, the statistically invisible non-market 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 ($t_i^l$):

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

Consumption is generated through a household production function:

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

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

Water production function in turn is generated by

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

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

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

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

subject to

$$t_i^w + t_i^m + t_i^e + t_i^l \geq T_o \quad ...(5)$$

and

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

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

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

$$x_{i+} w_i (t_i^w + t_i^e + t_i^l ) = w_i T_o + v_i \quad ...(7)$$

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

$$t^m = t^m ( w, v, \Omega ) \quad ...(8)$$

and

$$x^* = x (w, v, \Omega ) \quad ...(9)$$

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

$$t^m = t^m ( w, v, \Omega ) + \mu_i \quad ...(10)$$

## 2 Main Findings

Non-market work remains significantly invisible in national accounts. The attempt of United Nations Statistical Division in extending the production boundary of the Systems of National Accounts (SNA), 1993, has led to the inclusion of non-market 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 of 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 recent 24-hour chronology of the use of time and the 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, enable respondents to report activities in their own terms, and have some form of built-in check that increases the reliability of the data [Juster and Stanford 1991].

The time diary method has certain deficiencies. The significant one is the presence of multitasking or omission of overlapping of activities. This results from the imposition of a rigid constraint of time use, namely, no person has either more or less time available than 24 hours per day (time constraint) and the set of activities capable of being measured, described, and analysed must add up to a fixed number of hours or days [Floro 1995]. Theoretically, it can be solved by defining the new activity as 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 conceptualise 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 then 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.

The TUS 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, p 67). In these activities, females in Gujarat scored the highest time spent (39.08 hours per week) on such activities, followed by Madhya Pradesh (35.79 hours) and Orissa (35.70 hours).

Time-use data of combined states suggest that women spent 50.52 per cent of time on unpaid work while men spent only 33.15 per cent (Table 2, p 67). The inter-state differences revealed that per cent of time spent by females in unpaid activities was highest in Haryana (85.99 per cent) followed by Meghalaya (76.39 per cent) and Orissa (69.44 per cent) and lowest was in Tamil Nadu (32.45 per cent).

Imputing value to labour time spent on unpaid work, the contribution of non-market work was estimated across six

states of India. District-wise data on wage rates for agricultural labour and wage rate for urban unskilled manual labour have been used for valuing unpaid work in rural and urban areas respectively. With this methodology, projecting the TUS results by age-wise district-wise 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 per cent 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).

Compared to females, the valuation of unpaid activities by males was limited to only about 2 per cent of SDP in Gujarat and Haryana. The unpaid work, as a proportion of SDP, is as high as 49.93 per cent in Meghalaya and 47.30 per cent 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 non-rival in nature and therefore applying gender lens to this expenditure 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 intrinsic gender dimension to the non-rival expenditure. The time allocation in activities like fetching of water and fuel has significant gender differentials and infrastructure investment with gender-sensitive water polices and energy policies can really benefit women. The gender disaggregated statistics of time use in water sector across selected six states in India clearly revealed that women spent more time in fetching water than men, except in Gujarat (Table 4). Apart from 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 primary responsibility to ensure drinking water to their households, which suggests that changes in the availability of water infrastructure can lessen their burden in fetching water as well as release their time locked up in non-market work for the income-earning economic activities. In other words, investment in water infrastructure can help women in reallocating their labour time and reduce the stress related to walking long distances to fetch water.

**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 | |
| | | Ext-SNA | Residual Non-SNA | | Ext-SNA | Residual Non-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 (2000).

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

| 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 | 20.6 | 21.37 | 51.58 |
| Madhya Pradesh | 29.41 | 23.34 | 44.25 | 14.31 | 15.75 | 52.4 | 22.99 | 20.12 | 46.67 |
| Gujarat | 44.37 | 14.17 | 24.21 | 17.18 | 13.87 | 44.67 | 33.26 | 14.05 | 29.7 |
| Orissa | 31.25 | 22.42 | 41.77 | 8 | 18.18 | 69.44 | 20.55 | 20.47 | 49.9 |
| Tamil Nadu | 41.42 | 13.36 | 24.39 | 21.8 | 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 (2000).

**Table 3: Value of Non-Market Work as Compared to State Domestic Product**

| States | Value of Non-Market Work (Rs Crore) | | | SDP (Rs Crore) | 'Non-Market Work' as % of State Domestic Product | | |
|---|---|---|---|---|---|---|---|
| | Male | Female | Total | 1997-98 | Male | Female | Total |
| Haryana | 928.74 | 10,209.3 | 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 | 22,995.4 | 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: NIPFP (2000).

**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 (2000).

In the next section, an illustrative empirical investigation of this hypothesis is undertaken using the data of TUS 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 conducted for rural and urban regions of selected states of India, an illustrative analysis is undertaken to examine the link between infrastructure and time allocation.

## 3 Estimation and Results

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

$$t_i^m = \alpha + \beta\, infra_i + \gamma\, infrasq_i + \lambda\, t_i^o + \delta\, t_i^c + dummy + \mu_i;$$

EPWRF

where $t_i^m$ is time allocation in SNA activity which is 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 labour and wage rate for urban unskilled manual labour have been used for proxying the $t_i^o$ in rural and urban areas respectively. The unearned income is proxied by spouse 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 non-monetised work done in care economy ($t_i^c$). A dummy is defined which takes the value of one if the unit of analysis is rural and a value of zero otherwise. The parameter $\beta$ and $\gamma$ measure the effect of infrastructure on time variables. $\mu_i$ is a random error term. The econometric results are given in Table 5.

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

| Dependent Variable↓ | Female | | Male | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 |
| $\alpha$ | 149.454 | -21.126 | 174.714 | 101.721 |
| | (2.468)* | (-0.489) | (4.882)* | (5.988) |
| log pub $infra_i$ | -27.466 | | -18.719 | – |
| | (-1.947)* | | (-2.241)* | |
| log pub $infrasq_i$ | 1.539 | | 1.112 | – |
| | (1.859) | | (2.262)* | |
| $ttim_i$ (travel time) | – | -1.707 | – | -0.0009 |
| | | (-0.821) | | (-0.002) |
| $ttimsq_i$ (travel time sq) | – | 0.132 | – | 0.0003 |
| | | (0.579) | | (0.024) |
| $t_i^o$ (male wage) | – | 8.177 | -12.81 | -14.056 |
| | | (1.024) | (-4.459)* | (-3.673) |
| $t_i^o$ (female wage) | 0.597 | | – | – |
| | (0.157) | | | |
| $t_i^c$(non-monetised | -0.588 | 0.032 | -1.419 | -1.363 |
| care economy) | (-2.298)* | (0.072) | (-3.663)* | (-2.601) |
| Dummy | 12.699 | 16.308 | -0.081 | 0.712 |
| | (7.631)* | (4.669)* | (-0.079) | (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.

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 actual spending [Lahiri et al 2002]. The lag in the implementation of infrastructural projects may be a reason beneath the concave relationship. The results of linear models are not reported, as quadratic models turned out to be the better fits.

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 labour supply models predict an inverse relationship between unearned income and SNA activity. However, the estimated coefficient of spouse wage is not found significant in determining women's time allocation in SNA activity. The model is controlled for the non-monetised work in the care economy, inclusive of childcare, 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, 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, which is otherwise available for income generating SNA activity. Time poverty affects income poverty. However, the aspects of time poverty are often surpassed while 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 capita expenditure (mpce) quintiles is not available for India.

## 4 Conclusions

Using time budget data, this paper provides new evidence on the link between public infrastructure and time allocation related to 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 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 into account aspects of time poverty.

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