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IMPACT OF INFRASTRUCTURES ON PAID WORK OPPORTUNITIES AND UNPAID WORK BURDENS ON RURAL WOMEN IN BANGLADESH

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Abstract: This study deals with two questions: what role infrastructures can play in promoting paid work opportunities for women and what specific type of infrastructure can reduce women's time burden? The study brings empirical evidence on these two questions in a specific country context. Findings from an econometric model that endogenises women's paid and unpaid work show that the impacts of infrastructure on women's work and total time burden depend on the type of a particular infrastructure and availability of other infrastructures. While hard infrastructure shows significant influence on women's work with a lag, a rise in paid work outside home has not been equally compensated by a decline in unpaid work at home. The findings have important policy implications in infrastructure policy design and provision. Copyright © 2009 John Wiley & Sons, Ltd.

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1 INTRODUCTION

The questions of what role infrastructures can play in promoting economic opportunities for women and what specific type of infrastructure can reduce women's time burden are some basic concerns of policy makers and development practitioners.[1] In this study, these two questions are dealt with in the specific context of a developing country. The study brings empirical evidence on what differences infrastructures make and how much

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[1]For instance, on the UN millennium development goal of gender equality and the empowerment of women, the task force on gender equality has identified seven strategic priorities; among them the third is the infrastructure: 'invest in infrastructure to reduce women's and girls' time burdens' (UN Millennium Project, 2005, p. 29).

difference they make for women living in rural areas. The evidences presented here are based on quantitative studies where information was collected from a representative household survey, as well as a time-use survey where married couples reported their time allocations between different activities and leisure within a day.

The present study was conducted in the rural areas of the northwest (NW) region of Bangladesh. In developed countries, researchers are mostly concerned in understanding the gender-based discriminations within the workplace (Altonji and Blank, 1999), whereas, in developing countries such as Bangladesh, freeing women out of unpaid family labour to participate in formal labour force or to engage in self-employment activities remains of general concern. Gender gaps in wages and other discriminatory practices (e.g. occupational segregation), against women in workplaces, although important and studied (Foster and Rosenzweig, 1996), are relevant mostly for a fraction of women those who participate in the formal labour force. For the majority of women living particularly in rural areas, reducing their unpaid work burden at home and increasing their paid work[2] opportunities outside home remain overwhelmingly important.

In a well-functioning competitive labour market, woman's participation in the paid labour force depends on the opportunity cost of her time and the relative strength of income and substitution effects. While a rise in the wage rate will pull her to the labour market to substitute leisure for work, a rise in accompanying earnings, either by her or by her husband will push her to consume more leisure. However, in a situation where a woman has to divide her time between paid labour outside the home and unpaid labour for household work and care, the actual labour supply decision is no longer a labour-leisure tradeoff. While the substitution effect due to an increase in work opportunity outside the home will be positive for paid labour supply decision, it will be negative for leisure. The effect on unpaid labour and care works could be either positive or negative.[3] The usual income effect will still prevail both for paid and unpaid work.

Infrastructure can bring changes in both paid work opportunities and unpaid work burdens for women as well as for men. The role of public infrastructures in women's paid work can come into play in two ways: first, by a change in labour demand due to a change in production composition towards activities that are more gender neutral such as non-farm and tertiary activities.[4] Infrastructure can have both substitution and complementary effects; it can be a cheaper substitute of other inputs and can have positive complementarities with other inputs.[5] This can shift the production composition towards activities that can use infrastructural services. Such activities are usually in secondary and

[2]Unless otherwise mentioned, by paid work opportunities, we mean the paid non-farm work and non-farm work for profits. Paid farm work has not been considered as a part of paid work here. Paid work connected to the farm sector is appropriately accounted for in the total work burden.

[3]Unlike Gronau (1977) and the literature that immediately followed in the tradition of neoclassical time use model *a la* Becker (1965), imperfect substitutability between home-produced goods and market-purchased goods is assumed here.

[4]Non-farm work considered for the current purpose such as work in industrial enterprises, cottage industries, self-employed professions and services gives opportunities for cash income for women and income diversification for households. One of the public policies prescribed for poor households living in rural areas of Bangladesh and many other developing countries has been to diversify to non-farm activities. In Bangladesh, farm activities, particularly of cash crops are seen as part of the male domain. In contrast, participation of women in non-farm activities does not depart from social customs (Feder and Lanjouw, 2000). In addition, targeted credit and training programs of microfinance institutions that encourage non-farm activities also have made them more attractive to females.

[5]For instance, electricity can be a cheaper substitute of diesel, telephone can be a cheaper substitute of currier service and paved road can be a complement to motorised transportations. Therefore infrastructure can reduce the production cost as substitutes, and increase the productivity of other inputs as complements.

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tertiary sectors and are more gender neutral in nature. Second, by integrating fragmented markets, infrastructure can cause an outward shift in the production frontier and an increase in labour demand as a result. By reducing information asymmetries, time and energy cost of distance and transportation costs between rural and urban areas, and within rural areas, infrastructure can therefore integrate fragmented markets.

Three types of infrastructure considered in this study are: paved roads, telephony and electricity. Respectively providing transportation, telecommunications and power—they belong to the so-called hard-core category of public infrastructure.[6] Since the mid-1980s, the Bangladesh government has embarked on a planned development of linking rural roads to growth centres[7] and markets, and rural markets to regional and national highways, which can contribute to the spatial market integration. A rural electrification program, starting from the second half of the 1970s has similarly contributed to the availability of electricity in rural areas—a critical input in many non-farm developments. In the case of telecommunications, a highly significant change has taken place with the privatisation of rural fixed telephony in the late 1980s and mobile telephony in the mid-1990s. After 2001, more private companies have been granted licenses for fixed telephony to operate both in urban as well as rural areas.[8] It can be expected that the telecommunication services increase information availability and reduce communication costs.

Since Aschauer's (1989a,b) pioneering works on the role of public infrastructure on productivity, a diverse body of literature has emerged that looks at the impact of infrastructures at aggregate level. The approach followed in most macroeconomic studies are to augment an aggregated production function to include the public capital stock.[9] There are also sector specific studies that utilised cost function (e.g. Morrison and Schwartz, 1996), and infrastructure specific studies (e.g. Röller and Waverman, 2001) that determined the demand and supply of a specific infrastructure simultaneously. Despite the proliferation of studies on impact evaluation of infrastructures, the literature has not focused on the impact of specific infrastructures on women's work and time burden.

This study makes two contributions. Firstly, it looks infrastructure accessibility at household-level. Though studies such as Ahmed and Hossian (1990) or Dong (2000) examined the impact of infrastructure on household production, they did not focus on women.[10] In addition, their infrastructure variable was aggregated at village level. Though access at village level could be a sufficient condition for some infrastructure such as paved roads and access to public telephone, it is not necessarily the case for all infrastructures. For instance, a government policy of mosque/church electrification may ensure electricity connection to the mosque/church of a village leaving households without any electricity. Such connection at village level has limited benefits for women's work and leisure. Therefore, considering the access at individual household level can elicit the exact benefits that women and men derive from infrastructure.

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[6]Hirschman (1959) made a distinction between 'hardcore' public infrastructure, limited to transportation and power and a wider concept of social overhead capital.

[7]Growth centres are places where market infrastructures were built.

[8]A recent review of changes in infrastructure can be found in Ali and Jahan (2005).

[9]See Gramlich (1994) for a review of such studies. In a Cobb–Douglas production function written in logs would be: $\ln Q = \ln A + a \ln K + b \ln L + c \ln G$, where aggregate output Q is a function of private capital K, labour force L and public capital stock G. Here A is total factor productivity. Assuming $a + b = 1$ and finding c to be positive is an indication of increasing returns to scale. Alternatively, assuming $a + b + c = 1$ and finding c to be positive is an indication of unpaid public factor and existence of private factor rents.

[10]However, Khandker *et al*. (2006) is a notable exception who estimated the income-consumption benefits of road investment by using a fixed-effects quintile estimation approach.

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The second contribution is in the use of methods. A number of econometric problems are identified in the first-generation studies that employed a macroeconomic time series method of estimating production functions, e.g. the direction of causality, common trends in infrastructure and output and omitted variables. In micro econometric studies such as Ahmed and Hossian (1990), the obvious shortcoming of their measurement is the construction of an arbitrary index combining different infrastructure, both hardcore and social, into a single number. In the current study, a structural model has been developed that endogenises women's paid and unpaid work and household's demand for infrastructure services, the details of which is described in Section 2.

The remainder of this paper proceeds as follows: Section 2 builds an econometric model of link between infrastructure and women's paid and unpaid work. It also describes the empirical implementation of the model. Section 3 describes the data used and summary statistics of the variables used in the next section. Section 4 describes the empirical results on the impact of infrastructure on women's paid and unpaid work, and total work burden. Section 5 concludes the paper with some possible policy implications.

2 AN ECONOMETRIC MODEL OF INFRASTRUCTURE AND WOMEN'S PAID AND UNPAID WORK

2.1 Econometric Model

This section develops a structural model that endogenises women's paid and unpaid work and household's demand for infrastructure services. At community level, it assumes the supply of infrastructures is externally determined and therefore exogenous to households' decision. At household level, some of the variables such as the number of children, though could be influenced by women's labour market participation decision, are assumed to be exogenous.

It relates paid work opportunity for a woman within a community to her own human capital (HK), physical capital of the family (K) and infrastructure capital (INFRA) of the community. For two identical communities, it seems plausible to assume that differences in infrastructure capital can make differences in entrepreneurial ventures and hence work opportunities for women as well as men. Given the paid work opportunities, the actual work decision of a woman depends on the market wage rate and her reservation wage determined by household characteristics (HH) such as the number of children, unearned income, etc. What follows is that the paid work opportunity for a woman i (i refers to the woman and j refers to her husband) living in a community k with a wage rate W can be expressed as:

$$\text{PAIDWORK}_{ik} = f(\text{HK}_{ik}, K_{ik}, \text{HH}_{ik}, \text{INFRA}_k, W_k) \tag{1}$$

While an individual household cannot determine the supply of infrastructure at the community, it can decide the supply of household specific infrastructural services at its own household. Therefore, access to some infrastructural services could be endogenous where the demand for such services depends primarily on the price of the service and income of the households:

$$\text{INFRA}_{ik} = f(\text{PRICE}_k, \text{INCOME}_{ik}) \tag{2}$$

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However, unlike paid work, unpaid work performed by women within the household does not depend on their human capital directly or on the physical capital of the family. It is a kind of residual work performed after completing the paid work.[11] Being residual in nature, the actual hours spent on it decreases at unpaid work performed by the other spouse j (husband in the current case). Finally, unpaid work also depends on infrastructures available at household (INFRA_{ik}) and household characteristics (HH_i). Therefore, the unpaid work of the spouse i can be written as follows:[12]

$$\text{UNPAIDWORK}_{ik} = f(\text{PAIDWORK}_{ik}, \text{UNPAIDWORK}_{jk}, \text{INFRA}_{ik}, \text{HH}_i);\ i \neq j \quad (3)$$

Given the time constraint the total work burden of spouse i (WORKTOTAL_{ik}) depends on paid and unpaid work and can be written as follows:

$$\text{WORKTOTAL}_{ik} = f(\text{PAIDWORK}_{ik}, \text{UNPAIDWORK}_{ik}) \quad (4)$$

Note that the Equation (4) is not an identity. As defined in the next section, it includes, in addition to paid non-farm works and unpaid care works, time spent on paid and unpaid farm works.

2.2 Empirical Implementation

The empirical implementation of the above model described in Equations (1–4) involves estimation of the following system of equations:

$$\text{PAIDWORK}_{ik} = a_0 + a_1\text{HK}_{ik} + a_2K_{ik} + a_3\text{HH}_{ik} + a_4\text{INFRA}_k + a_5W_k + \varepsilon_i^1 \quad (1')$$

$$\text{INFRA}_{ik} = b_0 + b_1\text{PRICE}_i + b_2\text{INCOME}_{ik} + \varepsilon_i^2 \quad (2')$$

$$\begin{aligned}\text{UNPAIDWORK}_{ik} = {} & c_0 + c_1\text{PAIDWORK}_{ik} + c_2\text{UNPAIDWORK}_{jk} + c_3\text{INFRA}_{ik} \\ & + c_4\text{HH}_{ik} + \varepsilon_i^3;\ i \neq j;\end{aligned} \quad (3')$$

$$\text{WORKTOTAL}_{ik} = d_0 + d_1\text{PAIDWORK}_{ik} + d_2\text{UNPAIDWORK}_{ik} + \varepsilon_i^4 \quad (4')$$

For the paid work, only non-farm work is considered. That means, farm wage labour and farm work is not included here.[13] Two outcome measures for paid work taken here are: first, the participation in non-farm work, and second, the total hours spent on non-farm work. A probit model for the participation in non-farm work, and an ordinary least-square regression for the total number of works are estimated. To check the robustness of the results, a Poisson regression[14] for the incidence of non-farm work, and Heckman's two-stage selection model for total hours spent on non-farm work once participated are also employed.

Human capital indicators such as years of formal schooling and age have been included as explanatory variables. For the market wage of women, community female wage rate is

[11]A sequential decision making process is assumed, where unpaid work is preceded by paid work in the sequence. However, due to the imperfect substitutability between home- and market-produced goods, unpaid work does not fall to zero at full-time paid work.

[12]It has been assumed that unlike paid work, unpaid work is not influenced by human capital. This is due to the residual nature of unpaid jobs.

[13]Paid farm work has not been considered as a part of paid work here. This is because the focus of current paper is on non-farm work opportunities for women that are associated with access to public infrastructures.

[14]The use of Poisson is to keep maximum possible information.

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included. For the reservation wage, husband's income proxied by age, years of schooling, community male wage rate are considered. In addition, household's wealth proxied by ownership of business enterprise and expenditure on capital goods are also considered. These, along with the number of children should be a good predictor of women's reservation wage. In the presence of labour market imperfections, the actual incidence of non-farm work depends on initial capital stock of the household in addition to public capital. The appropriate proxy should be the value of non-farm capital. In the absence of such information, a non-farm business dummy—if a household owns any enterprise, and expenditure on capital goods—can be used. Therefore, the ownership of business enterprise and expenditure on capital goods are serving dual purposes in the current case.

Infrastructures that households possess and are considered here are tube well for water and electricity for lighting.[15] Sources of drinking water among the surveyed households were mostly tube wells (above 96 per cent) subsidised and installed by a public authority. The actual location of such a publicly provided tube well is determined by villagers, their elected representatives and government officials among others. Private tube wells were very negligible in the study area. Electricity connection at households is determined by the household demand given that a village is connected to an electricity grid—which in turn is an aggregation of individual household demand for electricity. Ordinary least square regression for partial demand estimation is employed and a fitted value of electricity demand is included here.[16]

For time spent on unpaid work, time spent on household labour and care work is included. In addition, time that the male spouse allocates on unpaid work is also considered assuming the residual nature of unpaid work. The time spent on non-farm work of a male spouse is instrumented using the variables that determine non-farm work and described in Equation (1). Here again, the sequential decision process is assumed. Assuming a certain degree of substitutability between labours for unpaid work and infrastructure capital available at household, tube well and electricity at home is included ($INFRA_i$), in addition to household characteristics (HH_i). A two-stage least square regression is used in the estimation.

For the total work burden, paid non-farm work, and non-farm work for profit and unpaid care work at home are considered. Work done at own-farm or as wage labour is also included in the total work burden. That means, this measure takes the total actual work burden of women into account. Both paid and unpaid works are instrumented and estimated simultaneously using a three-stage least square regression.

In estimating the above Equations (1–4), there are few important econometric issues to note: first, we are assuming that placement of public infrastructures considered here is associated with observed community characteristics. Therefore adding community specific characteristics and clustering the standard errors at community level should take care of the nonrandom placement of infrastructures. However, if infrastructure placement is nonrandom and if placement decision is correlated with unobserved community characteristics, then the estimated impact of infrastructure on labour allocation would be biased. For this, in addition to regional dummies, we have added the altitude collected in our GPS survey as additional control.

[15]Households that use electricity for irrigation only are not considered here.
[16]In estimating household demand for electricity, we have considered land instead of income. However, the results remain unchanged.

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Second, we are also aware of possible correlation between household level unobserved characteristics and benefits that individual households accrue from infrastructure investments. For this, we make use of the panel characteristics of the infrastructure variables. However, as the outcome variables come from a cross-sectional survey, the unobserved household specific fixed effects cannot be differenced out. For this, we have added additional observed household characteristics as additional controls as much as possible.

3 DATA AND SUMMARY STATISTICS

Data used in this study come from a time use survey and a household survey conducted between December 2004 and January 2005[17] by International Food Policy Research Institute (henceforth, IFPRI survey 2004–2005) in the NW region of Bangladesh. In its survey, IFPRI surveyed the same households that the Bangladesh Bureau of Statistics (BBS's) surveyed for its Household Income and Expenditure Survey (HIES) in 2000. However, with few exceptions, the data resulted from these two surveys—IFPRI and BBS, has not formed a two-point panel data set for the research questions in hand. The geographic location of the villages of households surveyed is shown in Figure A1 in Appendix. They were drawn from 78 villages in 67 Upziallas[18] of the 16 districts of Rajshahi Division. The details of the survey can be found in Chowdhury *et al*. (2005). Overall, the sample is representative of the NW region, and the sample is large enough to allow for generalisations from the survey results.

For all the households and communities, two structured questionnaires were conducted—one at the household level and one at the village level. In the time use survey, the respondents were asked to describe how they spent the last day (previous 24 h) by hours that restricted them to report sequentially all their previous day activities. Though the best way to collect such information would be to obtain time-dairy information recorded by the respondents without any lag, the short recall period followed in the current survey should minimise the recall bias.[19]

In addition, a geo-referenced database from the Local Government Engineering Department (LGED) of Bangladesh on infrastructure and market places in the NW region was obtained. The LGED database contained information on public infrastructures and services. This information was combined with exact household locations (latitude, longitude and altitude), which allowed to calculate access to specific forms of infrastructure.

Table 1 provides the summary statistics of data that is restricted to married couples only. The total number of households of such married couples is 1147, which constitutes around 79 per cent of the surveyed households.

Unpaid work consists primarily of housework, cooking, cleaning, caring for children, the elderly, the sick or disabled. It also includes fetching water and collecting firewood. It does not however include work in family farms or agricultural wage labour. Paid work considered here consists of non-farm (off-farm) work such as non-agricultural wage labour, work in industrial enterprises, cottage industries, construction, transportation,

[17]December and January fall in the same cropping season in the Northwest region of Bangladesh.
[18]Upzillas/thanas are administrative units and used interchangeably here.
[19]Among the different alternatives of time use survey, Hammermesh *et al*. (2005) consider that the 24 h recall period followed here is the second best to time-diary and better than the retrospective reports.

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Table 1. Summary statistics

Variables	Mean	Std. errors
Total hours wife spent on non-farm paid works (paidwork)	0.436	0.049
Total hours wife spent on unpaid works (unpaidwork)	7.927	0.074
Total work burden of wife in hours (worktotal)	9.688	0.068
Total hours husband spent on unpaid works (unpaidwork)	0.207	0.024
Human capital and household characteristics		
Age of wife	34.313	0.238
Years of education of wife	1.927	0.091
Age of husband	42.287	0.263
Years of education of husband	2.978	0.121
Number of girls children	0.916	0.028
Number of boys children	0.924	0.026
Household size	4.956	0.051
Monthly total household expenditure in local currency (Tk.)	5050.684	105.968
Financial capital		
Expenditure on capital goods in the last 12 months (in Tk.)	904.865	372.134
Household owns an enterprise (0,1)	0.421	0.015
Infrastructure capital at household		
Access to tube well water within the house precinct (0,1)	0.967	0.005
Household has electricity connection (0,1)	0.235	0.013
Community wages		
Average female wage in Tk.	45.280	0.307
Average male wage in Tk.	70.307	0.329
Population of the village	3574.027	80.651
Infrastructure capital at village		
Paved road ran through the village in 2000 (0,1)	0.255	0.013
Village had access to electricity in 2000 (0,1)	0.605	0.014
Village had public telephone in 2000 (0,1)	0.103	0.009
No public phone in 2000, phone in 2004 (0,1)	0.623	0.014
No electricity in 2000, electricity in 2004 (0,1)	0.220	0.012
No road in 2000, road in 2004 (0,1)	0.154	0.011
Public phone and road in 2004 (0,1)	0.127	0.010
Public phone and electricity in 2004 (0,1)	0.121	0.010
Electricity and road in 2004 (0,1)	0.051	0.006
Time required to reach the nearest growth centre in 2004 (in minutes)	20.483	0.393

trade, self-employed professions and services.[20] The total work burden consists of paid non-farm work, unpaid work and paid or unpaid on-farm work.

Two infrastructures considered at the household level are tube well water and electricity connection. While an overwhelming majority had access to tube well water, less than a quarter of the households had electricity connection at home. Among the surveyed households, none reported any access to piped water at home or no community was found with access to piped water. While tube well for drinking water is highly subsidised and widely available, electricity is not. Even in villages connected to electricity grid, not all households had electricity connection.

[20]This is not to say that farm production is not influenced by infrastructures considered here. In fact, evidence shows that infrastructure such as roads enhance farm productivity through increasing inputs availability and reducing inputs costs (e.g. Binswanger *et al*., 1993). The logic behind the exclusion of unpaid farm work from the total unpaid work, and paid farm work from the total paid work is based on the assumption of no direct use of infrastructures considered here in farm production.

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Infrastructures considered at the community level are roads, electricity and telephone. Road measures access to a paved road at village while phone measures access to public phone or publicly accessible phone at villages. Electricity is if a village is connected to an electricity grid or not. The distance to the nearest market (growth centre) is also considered as a control.

Table 2 provides the distribution of infrastructural variables aggregated at village level and associated allocation of working hours of women and their husbands' unpaid work hours. Women living in villages that had paved road or electricity or public telephone in 2000 had allocated substantially more hours on non-farm paid works. However, this has not happened in villages that got road or electricity in 2004. In case of the time required to reach the nearest growth centre, it seems obvious that women who live closer to a growth centre allocate more of their time to non-farm paid works and women living more than 1 h distance from such centres do not participate in non-farm paid works at all.

Variables used for household characteristics are self-explanatory.

4 RESULTS AND INTERPRETATIONS

4.1 Paid Work

Equation (1) is estimated via probit regression where the participation in paid work of women is regressed on infrastructure capital, controlling for human and physical capital, market and reservation wage. Village and regional fixed effects[21] are included to control for systematic differences in market and economic conditions. The days of the week are also included to control for any day-to-day variation of work availability. The state of the three infrastructures under study: road at village, public telephone at village and electricity at village is put for two time periods—2000 and 2004. Estimation results are reported in Table 3.

Results indicate that infrastructure variables have, in general, positively influenced the incidence of paid work for women. However, there is a lag between infrastructure provision and the creation of non-farm employment for women (and for men).[22] Availability of public phone and electricity in 2000 has large and statistically significant influence on women's paid work in 2004–2005. The effect of paved road 2000 dummy, though positive, is not statistically significant. Having said that, the impact of road in market integration has been partly captured by the variable titled 'time required to reach the nearest growth centre', which is significant.[23] Women who live in villages that got access to paved road only in 2004 have not experienced any increase in non-farm paid works. Though statistically insignificant, the impact is negative.

The results indicate that employment opportunities created by rural infrastructures are indirect in nature. For example, the demand created for women workers in the paved road construction in a village is less important than that of the demand created in other sectors due to the availability of the road. This supports the emergence of tertiary sector as a major contributor of income and employment in Bangladesh. The not significant influence of road

[21]Following the Bangladesh Bureau of Statistics, classification, the NW is subdivided into five sub-regions.
[22]Similar results, not reported here, are found for men too.
[23]We have run separate regressions with only distance to the nearest growth centre and with the 2000 roads dummy. However, the results remain unchanged—road dummy is positive but statistically not significant and distance dummy is significant.

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Table 2. Access to infrastructures and allocation of working hours

	Number of house holds	Number of villages	Total hours wife spent on non-farm paid works	Total hours wife spent on unpaid works	Total work burden of wife in hours	Total hours husband spent on unpaid works
Paved road ran through the village in 2000						
Yes	293	20	0.57	7.68	9.44	0.09
			(0.11)	(0.14)	(0.12)	(0.02)
No	854	58	0.39	8.01	9.77	0.25
			(0.05)	(0.09)	(0.08)	(0.03)
Village had access to electricity in 2000						
Yes	694	42	0.52	7.88	9.68	0.24
			(0.07)	(0.10)	(0.09)	(0.04)
No	453	36	0.31	7.99	9.70	0.16
			(0.07)	(0.11)	(0.11)	(0.03)
Village had public telephone in 2000						
Yes	118	9	0.63	9.04	10.78	0.45
			(0.16)	(0.26)	(0.24)	(0.14)
No	1029	69	0.41	7.80	9.56	0.18
			(0.05)	(0.08)	(0.07)	(0.02)
No road in 2000, road in 2004						
Yes	177	12	0.39	7.99	9.79	0.23
			(0.12)	(0.19)	(0.17)	(0.05)
No	970	66	0.44	7.91	9.67	0.20
			(0.05)	(0.08)	(0.07)	(0.03)
No electricity in 2000, electricity in 2004						
Yes	252	18	0.35	7.83	9.63	0.17
			(0.09)	(0.14)	(0.13)	(0.04)
No	895	60	0.46	7.95	9.71	0.22
			(0.06)	(0.08)	(0.08)	(0.03)
No public phone in 2000, phone in 2004						
Yes	715	47	0.55	7.88	9.78	0.20
			(0.07)	(0.09)	(0.09)	(0.03)
No	432	31	0.25	8.00	9.53	0.21
			(0.05)	(0.12)	(0.11)	(0.04)
Time required to reach the nearest growth centre in 2004 (in minutes)[1]						
$\leq$10 min	236	38	0.64	7.83	9.55	0.12
			(0.13)	(0.16)	(0.14)	(0.02)
$>$10 and $\leq$ 30 min	712	66	0.42	8.05	9.79	0.24
			(0.06)	(0.09)	(0.09)	(0.04)
$>$30 and $\leq$ 60 min	190	25	0.26	7.65	9.46	0.14
			(0.10)	(0.18)	(0.18)	(0.04)
$>$60 min	9	3	0.00	6.67	9.67	0.89
			(0)	(1.13)	(1.27)	(0.45)

[1]The total number of villages is more than the total number of surveyed villages due to the fact that households located in the same village may require different time to reach the nearest growth centre. Numbers in the parentheses are standard errors.

in Table 3 needs to be read along with the coefficient of the time required to reach to the nearest growth centre variable, which is perhaps a better proxy for access to market via road.

Among different human capital variables, the age has the expected sign while schooling has negative effects. This implies that while the likelihood of non-farm jobs increases with experience, the jobs created in rural areas are low-skilled in nature and do not attract

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Table 3. Infrastructure and paid works. Dependent variable: participation in non-farm works by wife

	Probit		Poisson	
	Coeff.	SE	Coeff.	SE
Human capital				
Age of wife in years	0.083	(0.061)	0.152	(0.100)
Wife age squared	−0.002	(0.001)**	−0.003	(0.001)**
Schooling of wife in years	−0.168	(0.050)***	−0.243	(0.084)***
Wife's schooling squared	0.021	(0.005)***	0.027	(0.007)***
Market and reservation wage				
Community female wage	0.025	(0.012)**	0.044	(0.021)**
Number of girls 14 years or below	−0.091	(0.078)	−0.108	(0.140)
Number of boys 14 years or below	−0.152	(0.074)**	−0.257	(0.130)**
Age of husband in years	0.047	(0.015)***	0.068	(0.021)***
Schooling of husband in years	−0.035	(0.017)*	−0.044	(0.028)
Community male wage	−0.012	(0.010)	−0.021	(0.017)
Physical capital				
Expenditure in capital goods in last 12 months (in Tk) $\times 10^3$	0.000	(0.000)	0.024	(0.028)
Household owns an enterprise (0,1)	0.190	(0.140)	0.175	(0.230)
Infrastructure capital				
Paved road ran through the village in 2000 (0,1)	0.184	(0.210)	0.282	(0.320)
Village had access to electricity in 2000 (0,1)	0.493	(0.260)*	0.867	(0.430)**
Village had public telephone in 2000 (0,1)	1.127	(0.290)***	2.110	(0.550)***
No public phone in 2000, phone in 2004 (0,1)	0.567	(0.290)**	0.991	(0.530)*
No electricity in 2000, electricity in 2004 (0,1)	0.100	(0.310)	−0.075	(0.590)
No road in 2000, road in 2004 (0,1)	−0.914	(0.670)	−1.854	(1.000)*
Public phone and road in 2004 (0,1)	0.614	(0.690)	1.361	(1.060)
Public phone and electricity in 2004 (0,1)	0.212	(0.500)	0.938	(0.990)
Electricity and road in 2004 (0,1)	0.649	(0.460)	0.653	(0.800)
Time required to reach the nearest growth centre $\times 10^3$	0.000	(0.000)***	−0.537	(0.170)***
Other controls				
Total population of the village in 2004 $\times 10^3$	0.000	(0.000)*	0.567	(0.040)
Altitude	0.001	−0.0024	0.002	(0.004)
Constant	−5.354	(1.050)***	−9.340	−1.83***
Number of Observations	1147		1147	
Pseudo R-squared	0.172			

Robust standard errors clustered at village level are in parentheses.
Other controls include five sub-regions dummies and days of the week. There coefficients are not reported to conserve space.
*Significant at 10%; **Significant at 5%; ***Significant at 1%.

women with schooling. It could also be the case that the average returns from such jobs are lower than the reservation wage of women with schooling, or social norms prevent such women from performing jobs that are currently available. The support of this can also be found in husband's education and potential wealth effects that deter women from participating in labour market for wage or profit. Similarly, the number of children, particularly the number of boys 14 years or below, restricts women's entry into non-farm jobs.

Though positive, influence of family enterprise on women's paid work is not statistically significant. This means women are not necessarily restricted to the family owned businesses such as petty trade and cottage industries.

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A similar set of variables is used in OLS estimation where women's total paid work hours have been regressed (Table A1 in Appendix) and results are similar to probit regression.

Since hours spent on paid work is preceded by labour market participation decision, there may be self-selection by women. One observes the incidence of paid work or hours spent on paid work for women whose market wage exceeds home wage at zero hours of work. However, if the unobservable part of the decision to participate in paid work is correlated with the unobservable part of the hours spent on paid work, then there is a problem of self-selection. In this case, the fitted regression function confounds the behavioural parameters of interest with parameters of the function determining the probability of participating in paid work (Heckman, 1979). One can theoretically correct for this problem by modelling the ways in which the sample selection occurs. It is possible to model the participation decision as a first stage based on observable characteristics and use the probability of participation into the second stage.

Estimation results of Heckman selection model are presented in Table A2 in Appendix. For identification purposes (with the exception of women human capital), female market wage, number of children and infrastructure variables, the set of variables included in the selection equation has not been included in the outcome equation. The selection equation has included human capital, physical capital, proxies for reservation wage and household's income proxied by expenditure, in addition to fixed effects. In the outcome equation, hours women spent on unpaid works is included to account for the trade-off between paid and unpaid work and the total time constraint.

Results indicate that the availability of public infrastructures in villages has a significant impact on women's participation decision in paid work in general, as can be seen from the selection part of Table A2. Women living in villages endowed with publicly accessible telephone, paved roads and electricity are more likely to participate in the non-farm labour market. However, as found in the single equation estimation, there is a lag between infrastructure availability and the creation of non-farm work opportunities and the participation of women in such works.

Table A2 also reports the effects of public infrastructures on women's total hours spent on paid work correcting for sample selection. Once participated, the total hours allocated to paid work depend largely on hours allocated to unpaid work. This implies that the substitution effect between paid and unpaid work is very strong and freeing women from unpaid care works at home is critical to increase their labour supply to paid work outside home.

Once corrected, it is only the publicly accessible telephone that remains significant. Why this is so? Barring the *palli phone* of Grameen Bank[24], it is unlikely that telephone creates direct employment opportunities for women. One plausible explanation of the effect of telephone on hours of work is market integration between rural and urban areas. The presence of a publicly accessible telephone helps, as well as indicates market integration.

Results found so far indicate that women's entry into non-traditional jobs is partly influenced by a positive change in rural infrastructure. Infrastructures such as public phone and paved roads in villages might have influenced the incidence of non-farm work by expanding the size of the market and by giving access to other services that enhance labour

[24]Under this program, the Grameen Bank provides a cellular telephone and credit support to its female members so they can operate their own mobile telephone businesses.

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quality. The expansion came mostly from increasing spatial integration among rural labour markets and between rural and urban areas in goods markets. Similarly, for self-employed women, giving access to skill training to improve labour quality was also important.[25]

4.2 Unpaid Work

Given the findings that infrastructure enhances women's paid work and employment opportunities, how does it influence women's unpaid work at home? To examine this, Equation (3′) is estimated via two-stage least square regression where the total hours a wife spends on unpaid work is regressed on infrastructure availability controlling for the household's income and demographic characteristics. Here, the hours a wife spends on paid work is instrumented by village level infrastructure variables among others. Electricity available at the household is the fitted value (Equation 2) that corrects for possible endogeneity between the demand for infrastructure and women's unpaid work hours.

Table 4 shows the regression results where the time the wife spends on unpaid works is regressed on the household's access to infrastructures among others. The results show that the time a woman spends on unpaid work declines with the time she spends on paid work, household size and access to electricity and tube wells; it increases with household expenditure and the number of children 14 years or younger. The time a woman spends on unpaid work is not significantly correlated with the time her husband spends on unpaid work.

Access to electricity and water (tube well) at home reduces the wife's unpaid work burden and the effect of water is relatively large. Their availability reduces the time spent on household-related labour. While the majority of households in Bangladesh

Table 4. Infrastructure and unpaid work. Dependent variable: total hours wife spends on unpaid works. Method: IV (two-stage least square) regression

	Coefficient	Std. error
Hours wife spent for paid work	−0.246	(0.109)**
Hours husband spent for unpaid work	0.061	(0.078)
Household size	−0.312	(0.055)***
Monthly total household expenditure in taka (cash + imputed) × 10^3	0.172	(0.052)***
Number of girls (≤14 years)	0.518	(0.084)***
Number of boys (≤14 years)	0.592	(0.090)***
Access to tube well water within the house (0,1)	−0.580	(0.361)*
Household has electricity connection[1] (0,1)	−0.016	(0.005)***
Constant	8.989	(0.435)***
Observations	1147	
Adjusted *R*-squared	0.31	

Instrumented: hours wife spent on paid work. Instruments: age, education, community female wage, road 2000, electricity 2000, public phone in 2000, public phone in 2004, electricity in 2004, paved road in 2004, road and electricity in 2004, phone and electricity in 2004, phone and road in 2004, distance to the growth centre, population, regions and days.
Robust standard errors clustered at village level are in parentheses.
[1]Fitted values of electricity.
*Significant at 10%; **Significant at 5%; ***Significant at 1%.

[25]It is found in both qualitative and quantitative studies that better access to infrastructure is associated with increased income generating activity training offered by non-governmental organisations.

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have access to tube well water, households without a tube well spend more time on activities that require water. Similarly, the availability of electricity reduces time spent on activities related to lighting and cooking such as collecting firewood or drying cow dung.

The time spent by women on unpaid work is positively related to household income. Given the availability of maid services in rural areas in Bangladesh, this is a surprising finding. One possible explanation is that relatively poor rural women participate in paid work, while wealthier women have more time to spend on unpaid work. Further to this, new opportunities for women in the rural labour market may have reduced the supply of domestic labour, a hypothesis supported in informal discussions with urban women in Bangladesh.

Though not reported here, unpaid work reduces time spent on leisure activities. An ordinary least-square regression of leisure on unpaid work, controlling for individual and household characteristics, shows that a one–hour increase in unpaid work reduces leisure activities by around seven minutes and the effect is statistically significant. Turning to the effect of public infrastructures on women's leisure, the availability of electricity at village and good road connection affect leisure time and household expenditure on recreational activities positively. Results from radius matching ($r = 0.05$) on the impact of electricity at home on women's leisure time also shows that the electricity at home has increased the leisure time by about 20 min per day (average treatment effect on the treated is 0.328 h per day) and the effect is significant.

4.3 Total Work Burden

For the total work burden, Equation ($4'$) was estimated via three-stage least square regression, where the total hours wife spends on paid work, unpaid care work and paid and unpaid farm work combined is regressed on the instrumented value of the paid non-farm, and unpaid care work. Here the effect of public infrastructures is accounted through their effect on increasing paid works and decreasing unpaid works.

Table 5 reports the results. As expected, the total work burden of women is largely determined by the unpaid care works and paid non-farm work. Since access to public infrastructure increases the likelihood of women's participation in paid work outside home, unless it is compensated by a concurrent reduction in their unpaid work at home, the overall work burden of women due to public infrastructure might have increased. There may be some degree of substitutability between paid and unpaid work. Increase in one may decrease the other.

To examine women's overall work burden due to the relevant forms of infrastructure, a control group was constructed based on matching method, whereby a relevant control woman (one without access to infrastructure) is assigned to each treated woman (one with access to infrastructure). The predicted values from a standard probit model were used to estimate the propensity score for each observation in the treatment and the control group samples. The idea was to search from a large group of control women for those that were similar to the treated women in all relevant pretreatment characteristics. The differences in the total work burden (hours) between the treatment and control groups could then be attributed to infrastructure access. Among the several ways of constructing estimators based on the propensity score, the radius matching method was used, whereby treatment household was matched with a weighted average of control households based on a score

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Table 5. Infrastructure and total work burden on females. Dependent variable: total work burden of wife (paid and unpaid combined). Method: three-stage least square regression

	Coefficient	Std. error
Total work burden of wife (paid and unpaid combined)		
Total hours worked in non-farm activities by wife	0.876	(0.105)***
Time wife spends on unpaid works	1.094	(0.053)***
Constant	0.635	(0.434)***
Total hours wife spends on unpaid works		
Hours husband spent for unpaid work	0.036	(0.076)
Household size	−0.269	(0.054)***
Monthly total household expenditure in taka (cash + imputed) $\times 10^3$	0.190	(0.055)***
Number of girls ($\leq$14 years)	0.466	(0.088)***
Number of boys ($\leq$14 years)	0.522	(0.093)***
Access to tube well water within the house (0,1)	−0.387	(0.348)
Household has electricity connection[1] (0,1)	−0.019	(0.006)**
Constant	8.268	(0.405)***
Total hours wife spends on paid works		
Age of wife	0.045	(0.044)**
Wife age squared $\times 10^3$	−1.226	(0.573)**
Years of education of wife	−0.133	(0.043)***
Wife education squared	0.018	(0.005)***
Community female wage	0.012	(0.006)
Number of girls 14 years and below	−0.026	(0.053)
Number of boys 14 years and below	−0.058	(0.057)
Age of husband in years	0.038	(0.013)
Schooling of husband in years	−0.028	(0.014)
Community male wage	−0.017	(0.006)
Expenditure in Capital Goods in last 12 months (in Tk) $\times 10^5$	−0.005	(0.349)
Household owns an enterprise (0,1)	0.065	(0.089)
Paved road ran through the village in 2000 (0,1)	−0.087	(0.120)
Village had access to electricity in 2000 (0,1)	0.368	(0.146)*
Village had public telephone in 2000 (0,1)	0.741	(0.180)***
No public phone in 2000, phone in 2004 (0,1)	0.368	(0.140)***
No electricity in 2000, electricity in 2004 (0,1)	0.203	(0.199)
No road in 2000, road in 2004 (0,1)	−0.664	(0.330)*
Public phone and road in 2004 (0,1)	0.412	(0.346)
Public phone and electricity in 2004 (0,1)	0.133	(0.255)
Electricity and road in 2004 (0,1)	0.034	(0.298)
Total population of the village in 2004 $\times 10^3$	−0.027	(0.020)
Time required to reach the nearest growth centre $\times 10^3$	−0.183	(0.063)***
Constant	−1.188	(0.819)**
Adjusted *R*-squared	0.279	

Endogenous variables: total hours worked in non-farm activities by wife, time wife spends on unpaid works. Exogenous variables: access to tube well water within the house, age of wife, age of husband, community female wage, community male wage, days of the week, electricity, road, telephone, expenditure in capital goods, hours husband spent for unpaid work, household has electricity connection, household owns an enterprise, household size, monthly total household expenditure, number of boys, number of girls, regions, schooling of husband in years, time required to reach the nearest growth centre, total population of the village, years of education of wife. Other controls include five sub-regions dummies and days of the week. The coefficients are not reported to conserve space.

[1]Fitted values of electricity. Robust standard errors clustered at village level are in parentheses.

*Significant at 10%; **Significant at 5%; ***Significant at 1%.

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not larger than a radius of 0.05. The estimated treatment effect is the average of the difference in work burden between treated and control women. The results (Table A3 in Appendix) show that the availability of public infrastructures for a sustained period (phone and electricity, or phone and road, or all of them together) has increased women's total work burden on an average by 1 hour.

5 CONCLUSIONS AND POLICY IMPLICATIONS

In this paper, we have examined how hard infrastructures, namely road, electricity and telephone affect paid work opportunities in non-farm sector for women and how electricity and water at home affect their unpaid work burden. Estimation results indicate that infrastructures expand the paid work opportunities for women in the non-farm sector. There is however, a lag between infrastructure provision and the creation of non-farm work opportunities. This implies infrastructure's greater role in the creation of indirect employment as a cheaper substitute of other inputs and its role as a complement to other inputs in the production process. Indirect employment creation might also have happened due to infrastructure's role in the integration of labour markets and access to services that enhance labour quality.

In addition to paid work opportunities, results also confirm the role of electricity and water at home in reducing women's unpaid work burden by reducing the time women spent on household-related labour. This reduction may, in turn, discharge women's time and allows one to allocate more of her labour to paid works or to spend on leisure.

The positive benefits of hard infrastructure, however, have not come without any negative costs. The results show that the negative is a rise of women's total work burden. In addition, though infrastructures have played an important role in non-farm development, the jobs that have been generated for women are unskilled in nature and do not necessarily attract women with higher years of schooling.

While it would be rational to expect that the employment opportunities due to infrastructures will induce spatial labour mobility, it would, however, be unlikely to assume that such labour mobility will eliminate spatial wage differentials and achieve spatial labour market equilibrium for female labour market. Local proximity will still matter, particularly for employment. The creation of jobs within one's own community will remain important for women in the short-run. While men may migrate or commute for jobs, social norms, family and children's needs may rule out such mobility for women. Given the finding that hard infrastructures facilitate non-farm job creation for women (as well as men) and reduce women's labour hours allocated to unpaid care work, their provision should be a high policy priority. However, how to reduce the overall work burden of women without reducing their paid work opportunities outside home remains an important question not answered here. The finding that paid work outside home has not been equally compensated by a reduction in unpaid work at home raises the question of whether women's overall welfare due to infrastructures has improved.

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APPENDIX

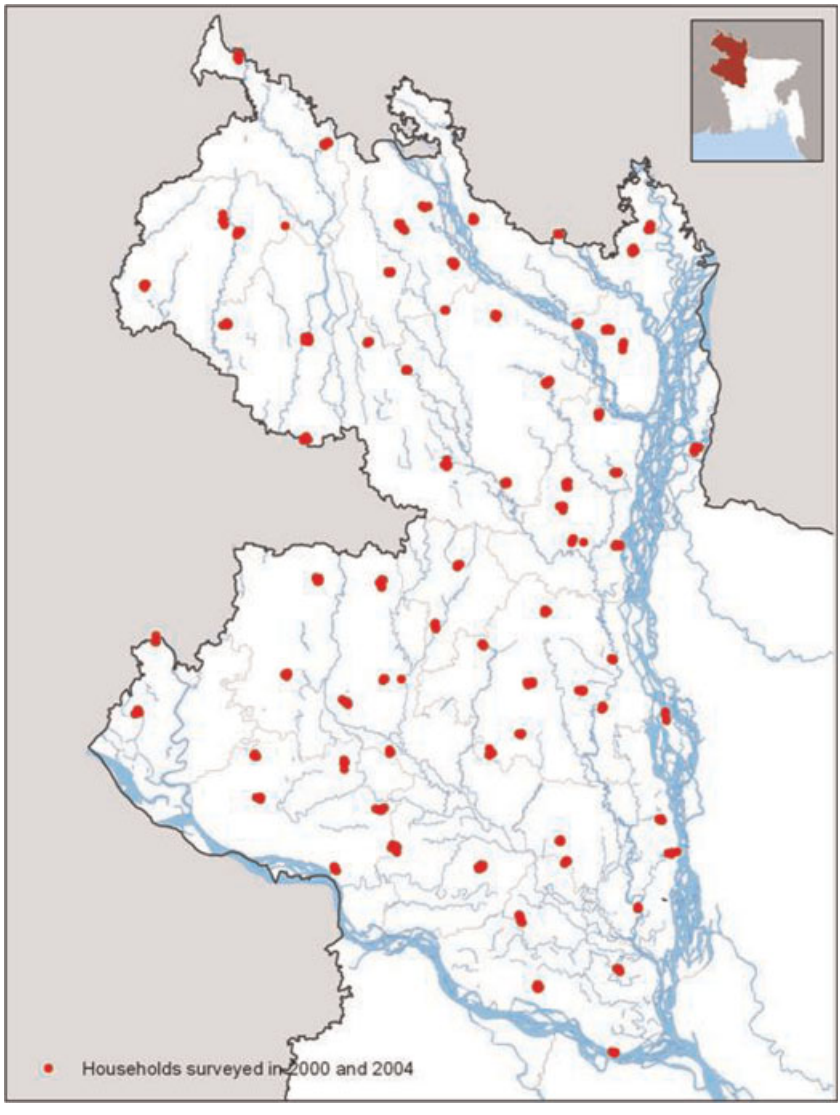

Figure A1. Location of villages (mouza) from where households are surveyed

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Table A1. Infrastructure and paid works. Dependent variable: total hours worked in non-farm activities by wife. Method: OLS regression

Human capital	Coefficient	Std. error
Age of wife in years	0.064	(0.049)
Wife age squared	−0.001	(0.001)**
Schooling of wife in years	−0.169	(0.047)***
Wife schooling squared	0.022	(0.005)***
Market and reservation wage		
Community female wage	0.014	(0.007)**
Number of girls 14 years or below	−0.010	(0.054)
Number of boys 14 years or below	−0.032	(0.058)
Age of husband in years	0.046	(0.014)***
Schooling of husband in years	−0.037	(0.015)**
Community male wage	−0.006	(0.006)
Physical capital		
Expenditure in capital goods in last 12 months (in Tk) × 103	−0.002	(0.004)
Household owns an enterprise (0,1)	0.016	(0.099)
Infrastructure capital		
Paved road ran through the village in 2000 (0,1)	0.107	(0.133)
Village had access to electricity in 2000 (0,1)	0.163	(0.156)
Village had public telephone in 2000 (0,1)	0.489	(0.200)**
No public phone in 2000, phone in 2004 (0,1)	0.408	(0.156)***
No electricity in 2000, electricity in 2004 (0,1)	0.077	(0.217)
No road in 2000, road in 2004 (0,1)	−0.566	(0.367)
Public phone and road in 2004 (0,1)	0.258	(0.385)
Public phone and electricity in 2004 (0,1)	0.074	(0.284)
Electricity and road in 2004 (0,1)	0.280	(0.331)
Time required to reach the nearest growth centre × 103	−0.186	(0.070)***
Other controls		
Total population of the village in 2004 × 103	−0.026	(0.022)
Constant	−2.527	(0.906)***
No. of Observations	1147	
Adjusted *R*-squared	0.09	

***, **, *—Significant at 1, 5 and 10%, respectively. Robust standard errors are in parentheses. Other controls include five sub-regions dummies and days of the week. There coefficients are not reported to conserve space.

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Table A2. Infrastructure and paid works. Dependent variable: total hours worked in non-farm activities by wife. Method: two-stage selection model

Second-stage	Coefficient	Std. error
Hours spent on unpaid works	−0.764	(0.090)***
Age of wife in years	0.004	(0.036)
Schooling of wife in years	0.033	(0.071)
Community female wage	−0.017	(0.032)
Number of girls 14 years or below	0.487	(0.262)*
Number of boys 14 years or below	0.301	(0.265)
Paved road ran through the village in 2000 (0,1)	0.371	(0.577)
Village had access to electricity in 2000 (0,1)	−0.969	(0.850)
Village had public telephone in 2000 (0,1)	2.335	(1.270)**
No public phone in 2000, phone in 2004 (0,1)	2.810	(1.017)***
No electricity in 2000, electricity in 2004 (0,1)	−0.196	(1.260)
No road in 2000, road in 2004 (0,1)	−0.416	(1.407)
Public phone and road in 2004 (0,1)	0.130	(1.511)
Public phone and electricity in 2004 (0,1)	−1.269	(1.315)
Electricity and road in 2004 (0,1)	−1.092	(1.550)
Total population of the village in 2004 $\times 10^3$	0.028	(0.107)
Constant	5.087	(4.082)
Selection		
Age of wife in years	−0.043	(0.017)***
Schooling of wife in years	0.005	(0.025)
Community female wage	0.019	(0.010)**
Age of husband in years	0.045	(0.017)***
Schooling of husband in years	−0.025	(0.018)
Community male wage	−0.003	(0.009)
Number of girls 14 years or below	−0.091	(0.067)
Number of boys 14 years or below	−0.104	(0.072)
Paved road ran through the village in 2000 (0,1)	0.234	(0.156)
Village had access to electricity in 2000 (0,1)	0.409	(0.219)**
Village had public telephone in 2000 (0,1)	1.054	(0.246)***
No public phone in 2000, phone in 2004 (0,1)	0.543	(0.235)**
No electricity in 2000, electricity in 2004 (0,1)	0.009	(0.312)
No road in 2000, road in 2004 (0,1)	−0.742	(0.417)*
Public phone and road in 2004 (0,1)	0.540	(0.460)
Public phone and electricity in 2004 (0,1)	0.066	(0.397)
Electricity and road in 2004 (0,1)	0.708	(0.412)**
Expenditure in Capital Goods in last 12 months (in Tk) $\times 10^3$	−0.016	(0.023)
Household owns an enterprise (0,1)	0.257	(0.115)**
Monthly total household expenditure in taka (cash + imputed) $\times 10^3$	0.026	(0.027)
Constant	−3.725	(0.748)***
Number of observations	1147	
Number of censored observations	1049	
Prob $> \chi^2$	0.000	

Other controls include five sub-regions dummies and days of the week. There coefficients are not reported to conserve space.
*Significant at 10%; **Significant at 5%; ***Significant at 1%.

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Table A3. Impact of infrastructure on women's total work burden, radius matching ($r = 0.05$)

	# of treatment	# of control	ATT	St. error
Electricity and phone in village in 2000	70	866	1.157	(0.299)**
Electricity and road in village in 2000	201	910	−0.278	(0.197)
Phone and road in village in 2000	25	356	1.581	(0.384)**
Electricity, phone, and road in village in 2000	13	298	1.086	(0.533)*
Electricity and phone in village in 2004	139	826	0.055	(0.210)
Electricity and road in village in 2004	54	603	−0.217	(0.238)
Phone and road in village in 2004	132	886	0.422	(0.198)*
Electricity, phone, and road in village in 2004	36	578	0.019	(0.291)

ATT indicates average treatment effect on the treated.
*Significant at 10%; **Significant at 5%; Significant at 1%.

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