Improving Gender Outcomes in the course of Development: Revisiting the Role of Basic Infrastructure

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Abstract

The paper investigates the role of basic infrastructure in improving gender outcomes in the course of development. We first model an environment where social norms impose that women most care about the quality of the household environment more than men. Our theoretical results show that access to infrastructure increases the potential return on market activities, and thus the opportunity cost of domestic chores socially-imposed on women. Theoretical results show declining leisure and household chores time and increasing labour supply in response to infrastructure access. The empirical analysis involves a propensity scores matching and inverse probability of treatment weighting using household data from Senegal for the year 2011. Our empirical results show that access to infrastructure induces a substitution of market activities to leisure amongst uneducated men and women, but has limited impact on educated people. We find that women leverage multiple infrastructure access better than men but also find no credible scenario where access to infrastructure significantly improves women's income. These findings are consistent with working poverty, time poverty and persistent gender-based, wage discrimination unfavorable to uneducated women. Addressing these barriers to women's economic empowerment is essential for gender outcomes to improve comprehensively as infrastructure improves in the course of development.

Keywords: Economic Empowerment; Gender; Development.
JEL Classification : D13, J78, O12.

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We are thankful to the National Agency for Statistics and Demography in Senegal - ANSD - for graciously providing the data used in this paper. We are also thankful to participants to the UNU-WIDER Gender and Development workshop of Nov. 2015 at Namur University, Belgium, and to Williams Ahouakan for excellent research assistance.

Introduction

The paper investigates the role of basic infrastructure in reducing barriers to women's economic empowerment in the course of development. Basic infrastructure includes social infrastructure such as schools, hospitals, bus terminals, parks, etc. It also includes economic infrastructure such as utilities and amenities, including energy, water, transport, roads, dams, etc. In a 2015 report on spanning Africa's Infrastructure Gap, The Economist Corporate Network analyzes that while Africa's economic growth rate in the last few years has been significantly higher than the global economic average, the region is still faced with many developmental challenges including a *yawning infrastructure gap*. The report estimates that development capital funding alone for African infrastructure totaled approximately USD328 billion between 2009 and 2014. These figures raise the question of whether these massive investments enable all segments of the population to share in the benefits of economic growth.

The paper adds to the economic literature on the interplay of economic growth and gender inequality, and specifically how economic growth may promote gender equality. While economic growth may not be sufficient to promote gender equality, the outcomes of growth may nevertheless have a positive impact on gender outcomes through better access to basic infrastructure. However, our empirical results show that more deliberate efforts aimed at addressing specific barriers to women's economic empowerment – which we identify in the paper, are necessary for gender outcomes to improve comprehensively as infrastructure improves in the course of development.

The African Union Commission (2015) reports that in spite of disparities between countries Africa has performed better than other developing regions with respect to women's participation in the labour force, which stood at 61 per cent in 2010, relative to 52 per cent worldwide. In line with the World Development Report (2012) the Commission also analyzes that limited access to inputs, such as infrastructure, finance, land and water significantly impedes women's productivity estimated to be 30 per cent lower than that of men in agriculture. On the other hand African women are reported to be performing a disproportionately higher share of unpaid or unproductive labour including fetching water, an activity which takes valuable time away from income-generating activities (African Union Commission 2015).

The study seeks to contribute to the growing body of evidence on the role of basic infrastructure as a driver for economic inclusion. The study's main hypothesis to be tested is that access to basic infrastructure such as quality roads, marketplaces, safe water, health centers and electricity play a key role in improving gender outcomes in the course of development. Central to the analysis is the substitution of market activities to housework as more and better infrastructure becomes available. As basic infrastructure improves the opportunity cost of housework increases and women increasingly leverage existing opportunities by allocating more time to market activities. This should ultimately contribute to narrowing down the economic gap between men and women in the course of development.

In a recent survey of the literature Kabeer (2012) finds that most micro level studies approach gender inequalities in terms of labour market outcomes with a focus on individual choices or on structural constraints. The survey points to three broad classes of work. One strand explains gender-differentiated labour market outcomes in terms of gender differential investments in human capital endowments, reflecting women's role in biological reproduction and weaker attachment to the labour market (Polachek, 1981). A second strand of work that suggests that gender inequalities in labour market outcomes reflect a 'taste for discrimination' on the part of individual employers but that such taste are viable only as long as markets are not competitive (Becker, 1971). A third strand focuses on 'statistical discrimination', suggesting that, given imperfect information, employers use aggregate group characteristics, such as group averages in education, to make judgements about the suitability of all members of that group for particular jobs. This means that individuals belonging to different social groups can be treated very differently even if they are identical in every other way (Arrow, 1973).

This study builds on the assumption that social norms that assign domestic chores primarily to women bear the blame for women taking less advantage of market-based opportunities than men, hence a potential explanation for the economic gender gap. Quality infrastructure can make market opportunities appealing enough for culturally-driven constraints to women's economic engagement to gradually fade away, setting

women free to create and seize income-generating opportunities.[1] Kabeer (2012) survey shows that most studies use econometric models to show how providers and suppliers of labour make decisions in the face of market forces. That has helped to identify and measure gender discrimination but it has not provided an understanding of the processes that give rise to it.

The study differs from Agénor and Alpaslan (2013) who study how lack of access to infrastructure may lead to child labor for girls and ultimately explain gender income differentials based on women's lower human capital relative to men's. Our study provides some theoretical ground to the growing country-specific evidence on the interplay of infrastructure access and women's time allocation (see, e.g. Koolwal and van de Walle, 2010; Ghani et al., 2013; and Dinkelman, 2011). Unlike most of the other contributions, we show that access to infrastructure actually plays out differently for non-educated and for educated women in Senegal.

We first model an environment where social norms impose that women must care more about the quality of the household environment than men, and therefore, must take care of domestic chores. Access to basic infrastructure increases the potential return on market activities, and thus, the opportunity cost of domestic chores socially-imposed on women. In the absence of gender-based discrimination in the labour market, the substitution of market activities to housework should improve the economic situation of women, thus reducing the gap with their male counterparts.

Next, we implement a propensity score matching estimation on household data from Senegal for the year 2011. We find evidence in support of our theoretical prediction at the aggregate level and for the uneducated, i.e. the most vulnerable. We find that the effects of specific basic infrastructure on domestic chores' time is gender-sensitive but also varies with education. Access to transport in particular tends to reduce domestic chores' time more than other basic infrastructure.

However access to infrastructure appears to have little effect on the labour supply of educated people. A noticeable exception is access to health which boosts labour supply amongst highly educated women. Amongst uneducated people those with simultaneous

[1] Agénor and Canuto (2012) provide an overview of the evidence on how constraints on women's time allocation - specifically, lack of access to infrastructure - affect their ability to engage in market work and how, in turn, policy-induced changes in such allocation affect growth.

access to many infrastructure supply more labour on the market compared to those with access to fewer or no infrastructure at all. Market access in particular boosts labour supply amongst men and women with minimum education. However, while there is some evidence that men's income increases with access to infrastructure, we find no credible scenario where infrastructure access significantly impacts women's income. We reconcile these findings with persistent gender-based wage discrimination against women and conclude that addressing such discrimination is essential for gender outcomes to improve comprehensively as infrastructure improves in the course of development.

The paper is structured as follows. Section 1 presents a simple theoretical model showing the substitution away from domestic chores as infrastructure improves. Section 2 presents the empirical framework and the data used for the analysis. Section 3 presents estimations' results and discussion. Section 4 contains some concluding remarks.

1- A simple theory of time allocation with gender-biased social norms

We consider an environment with individuals each endowed with one unit of time. Individuals can allocate their time endowment to market activities, domestic chores, leisure or any combination of the three alternatives. The time constraint is thus given by $t_c + t_d + l \leq 1$, where l stands for leisure, and t_c (respectively, t_d) for time spent on market / commercial (respectively, domestic) activities.

Individuals in this environment value the return, *R*, on market activities. That return depends on time, t_c, allocated to such activities, education level, *h*, as well as the market price of time, *w,* according to a simple linear relationship of the form $R = wht_c$. We shall assume that the return on market activities is the only source of income in this environment. Individuals also value domestic chores through which they improve the quality, *q*, of their home's environment according to $q = t_d$.

Individual preferences can be summarized using a utility function *U(l, q, R; λ, g)*, where *U(.)* is strictly increasing and concave in *l*, *q* and *R*. *g* stands for the quality of public infrastructure which impacts the return on market activities as illustrated below. λ is a positive, gender-specific parameter differentiating the extent to which men and women value the quality of the household environment. This parameter captures the important fact that in many developing economies social norms place the prime responsibility for

the quality of the household environment on women. The resulting social pressure leads women to attach more value to the quality of the household environment, so that this parameter can be assumed to take higher values for women compared to men, *i.e.* $\lambda^f > \lambda^m > 1$, where *f* stands for women and *m* for men.

Using a logarithmic specification for simplicity the maximization program facing each individual can thus be expressed as follows:[2]

$$Max_{l,t_c,t_d} U(l,q,R;\lambda,g) = \lambda \ln q + \theta \ln l + g \ln R. \quad (1)$$

By way of substitution of the expressions for *q*, *R* and the time constraints in *Eq.*(1) for interior solutions, the maximization program reduces to:

$$Max_{l,t_d} V(t_d,l;\lambda,\theta,h,g,w) = \lambda \ln t_d + \theta \ln l + g \ln(1-l-t_d) + g \ln wh, \quad (2)$$

and the solutions follow:

$$t_d^* = \lambda/(\theta+\lambda+\lambda g). \quad (3)$$

$$l^* = \theta/(\theta+\lambda+\lambda g). \quad (4)$$

Proposition 1: *All else equal,*

(i) Whenever social norms impose that women should value the quality of the household environment more than men, i.e. $\lambda^f > \lambda^m > 1$, *women devote a higher share of their time endowment to domestic chores compared to men.*

(ii) Whenever social norms impose that women should value the quality of the household environment more than men, i.e. $\lambda^f > \lambda^m > 1$, *women afford less leisure time than men.*

(iii) Men and women afford less leisure time when public infrastructure improves.

Proof: The proof follows by differentiating Eqs.(3) and (4) with respect to λ and g.

The result in Proposition 1 is consistent with most available evidence, including for developed economies. The World Bank estimates that women devote 1 to 3 hours more a day to housework than men; 2 to 10 times the amount of time a day to care (for children, elderly, and the sick), and 1 to 4 hours less a day to market activities.[3] The result shows that if the society does not impose that women should value the quality of the household environment more than men, *i.e.* if $\lambda^f = \lambda^m = \lambda$ in Eq. (3), then men and women would devote the same amount of time to housework.

[2] This specification implies decreasing absolute risk aversion and constant relative risk aversion.
[3] World Bank, World Development Report 2012, p. 80.

The second part of Proposition 1 shows that in the absence of any social norms imposing that women should value the household environment more than men, *i.e.* $\lambda^f = \lambda^m = \lambda$, men and women would afford the same amount of leisure time.

Given the optimal allocation of domestic chores time and leisure time in Eqs.(3) and (4), the optimal allocation of time for market activities follows from the time endowment constraint for an interior solution $t_c + t_d + l = 1$. Clearly,

$$t_c^* = \lambda g / (\theta + \lambda + \lambda g). \tag{5}$$

The next result follows:

Proposition 2: *All else equal,*

(i) Whenever social norms dictate that women should care about the quality of the household environment more than men, i.e. $\lambda^f > \lambda^m > 1$, *women devote a higher share of their time endowment to market activities compared to men.*

(ii) Men and women devote a higher share of their time endowment to market activities when basic infrastructure improves.

Proof: The proof follows by way of differentiation of Eq.(5) with respect to λ and g respectively**.**

Although the first part of Proposition 2 seems counter-intuitive it may reflect social pressure on women who are expected to take care of the house, and to contribute to the household income with little leisure time. We interpret this as the manifestation of the *women's time poverty* phenomenon largely documented in the literature (see, e.g. Asian Development Bank, 2015).

We interpret the second part of proposition 2 as follows. On the one hand, as the economy grows available evidence suggests that it typically also expands its infrastructure basis. On the other hand consumption needs expand to include a wider range of goods which can hardly be supplied through household production solely. In a market economy this underlies the need for increased household's income. Thus the man-as-the-breadwinner model of a subsistence economy can increasingly be challenged as women are expected to step out of the house and contribute to the household's income.[4]

[4] Coen-Pirani *et al*. (2010), for instance use micro-level data from the 1960 and 1970 US Censuses to show that the diffusion of household appliances contributed significantly to the increase of the labor force participation rate of married women during the 1960s.

Whether the impact of infrastructure on leisure time and labour supply is stronger for men or for women is an empirical issue that we shall investigate in the next section. However, there is evidence that women still devote more time to domestic chores than men even in more developed economies (See, *e.g*., Schaffnit-Chatterjee, 2009 for Germany, and the American 2013 Bureau of Labour Statistics' Time Use Survey). This may suggest some inertia built into old time social norms and leading women to work longer hours than men even when female labour market participation increases significantly (see, *e.g*., N. Kabeer, 2014; Agénor and Canuto, 2012).

Given the expression for the return to market activities $R = wht_c$, substituting in the optimal time allocation for market activities gives the equilibrium level of income:

$$R^* = whg/(\theta + \lambda + \lambda g). \quad (6)$$

Equation (6) shows that individual income in this environment depends on institutional parameters *w* and *g,* as well as individual preference parameters θ and λ. This expression also shows that in the absence of any social norms imposing that women should care about the quality of the household environment more than men, only differences in human capital levels and / or gender-based wage discrimination can explain the economic gap between men and women as largely documented in the economic literature. Our contribution therefore stems from showing that the interplay of gender-biased social norms and emerging infrastructure introduces an additional layer of complexity.

Proposition 3: *All else equal,*

(i) Whenever social norms impose that women should care about the quality of the household environment more than men, i.e. $\lambda^f > \lambda^m > 1$*, women's income is lower than that of men.*

(ii) Individual income is higher the better basic infrastructure.

(iii) Individual income is lower the higher individual preference for leisure.

Proof: The proof follows by way of differentiation of *Eq.*(6) with respect to λ, g, and θ respectively.

2- Empirical Analysis

In this section we present the data used in our empirical analysis. We also present our approach to estimating the effects of infrastructure access on our variables of interest.

2.1- Data

Our empirical analysis uses data from the Poverty and Family Structure survey of 2011 carried out by the National Agency of Statistics and Demography in Senegal. One of the primary objectives of the data collection was to revisit the concept of household in an African context where many families live under the same roof and report to the same household head. A related goal was to document the interplay of individual poverty and family structure by documenting how the distance to the household head impacts individual wellbeing. Distance was defined by the relation to the household head, i.e. spouse, biological child, fostered child, family in law, etc.

Data were collected in 3 strata, including the urban environment of the city capital Dakar, other cities and rural areas. The Census Districts considered are geographic units formed on the basis of the 1988 Census. Twelve (12) households per Census District were surveyed. Data collection followed a two-tier draw with the Census Districts as primary sampling units and households as secondary sampling units. The Census Districts were drawn independently in each strata. The sample was chosen with a probability proportional to the size of the Census District. Then, the household sample was drawn at random according to the size of the Census District. Overall, a representative sample of 1,800 urban and rural households was selected, spreading over 86 primary units (census districts) in urban areas and 64 in rural areas. In addition, 280 'secondary' households, *i.e*. those of the spouses of sample households heads were also interviewed. This resulted in a sample of 2,953 urban and rural households, and a sample population size of 15,288 out of a total of 12,528,558.

The distribution of the Senegalese population by sex shows a predominance of women with 53 per cent against 47 per cent for men. Although the proportion of women is higher both in rural areas (53.4 per cent against 46.6 per cent for men), and in urban areas (52.6 per cent against 47.4 for men), more women live in rural than in urban areas.
At the national level, 43.2 per cent of people aged 13 and over are married, including 28.9 per cent monogamous and 14.3 per cent polygamous. Single people represent 49.65

per cent, with more single men (61.9 per cent) than women (52.5 per cent). Widows and divorced people represent respectively 4.4 per cent and 2.2 per cent. Marriage and polygamy are more prevalent in rural areas (47.5 and 18.4 per cent) than in urban areas (38.7 and 10 per cent). The data show that extended poly-nuclear family remains the dominant model in Senegal with an average of 9 people per household. Large majority of the population is Muslim (94.8 per cent).

In order to shed light on the relation of living conditions and household characteristics, the survey collected information on household's members' property, income, expenditure or consumption, indicators related to demography, education, health, employment, housing and household equipment, as well as access to basic social services, including access to public transport, access to clean water, access to garbage collection system, distance to marketplace, distance to health facilities, etc.[5]

Following Kotsadam and Tolonen (2015) we use an indicator variable for access to marketplace, health centres, and public transport. An individual is coded as treated or having access if infrastructure is within walking distance, i.e. 15 minutes or less.

Our goal in this paper is to assess the impact of three types of infrastructure on adults' labour supply, leisure time, time allocated to domestic chores, and income in Senegal. This allows us to assess the extent to which economic growth, through facilitated access to basic infrastructure, may or may not improve gender outcomes in the course of development. Treated individuals in this environment are those with access to a health centre, a market place, or to public transport, i.e. service within 15 minutes of walking distance.

Table 1 summarizes the descriptive statistics used in our empirical analysis.

[5] In 2003 for instance, the Programme of Drinking Water and Sanitation for the Millennium, a well programme implemented jointly by the United Nations Development Programme (UNDP) and the Government of Senegal was designed to ensure a sustainable supply of drinking water for 2.3 million people in Senegal's rural areas. It aimed to raise households' rate of access to clean drinking water from 64 percent in 2004 to 82 percent by 2015 – the deadline for achievement of the Millennium Development Goals (MDGs). By 2009, 74 percent of rural residents in Senegal had access to potable drinking water, thanks to programme initiatives such as the drilling of a well. The programme allowed villagers to have pipes laid down that connect their homes to the well for just a small fee, which they pay in addition to their regular monthly utilities fees. It also aimed to provide millions more people with an independent system for disposing waste water, in addition to establishing latrines for schools, clinics, bus stops and weekly markets in rural communities.

Table 1: Descriptive statistics

VARIABLE	MEAN	OBS.
TREATMENT VARIABLES (1 if the individual spent less than 15 minutes to access infrastructure and 0 otherwise)		
Health centre	0.54 (0.49)	15751
Market	0.49 (0.50)	15717
Transport	0.73 (0.44)	15700
DEPENDANT VARIABLES		
Time spent in domestic chores (Average number of hours per week)	15.06 (15.64)	5753
Leisure (average number of hours per week)	132.65 23.58	9658
Labour supply (average number of hours per week)	40.50 (15.90)	6089
Professional Income (thousands of CFA francs)	359.75 (7063.20)	12762
EXPLANATORY VARIABLES (PROBIT)		
Age	35.36 (16.50)	15979
Sex (1=male and 0=female)	0.44 (0.49)	16141
Education		
Educated	40.43	3,772
Non educated	59.57	5,558
Matrimonial status		
Married	32.37	5,068
Cohabitation	0.13	21
Single	62.26	9,748
Widowed	3.38	530
Divorcee	1.74	272
Separated	0.12	19
Place of residence		
Dakar	28.73	4,599
Other urban areas	25.06	53.79
Rural areas	46.21	7,397
Nationality		
Senegalese	99.35	15,808
B. Guinean	0.10	16
Guinean	0.30	48
Mauritanian	0.07	11
Malian	0.02	3
Ivorian	0.02	3
Burkinabè	0.02	3
Gambian	0.02	3
Other African	0.09	15
Non-African	0.01	1

2.2- Single infrastructure access and propensity scores matching

To measure the impact of infrastructure access on leisure time, time devoted to domestic chores and labour supply, one would ideally want to observe the same individual in multiple states of the world: one state in which the individual has access to infrastructure, let us call labour supply in this state Y_1; and another state in which the same individual does not have access to infrastructure; we call labour supply in this state Y_0. If this were possible, we could easily measure the impact that access to infrastructure has on an individual labour supply as $Y_1 - Y_0$. However, it is not always possible to observe the same individual in two states of the world at the same time, *i.e.* the ideal counterfactual is not available.

Simply subtracting the outcome of untreated individuals from the outcome of treated individuals and averaging over the sample, *i.e.* approximating $E[\,Y_1 - Y_0\,]$, is not an acceptable practice as it is likely that there are unobservable characteristics that simultaneously affect access to infrastructure and labour supply. Such confounding variables cause endogeneity, and thus bias the estimated impact of infrastructure access. If there is an unobserved variable that increases access to infrastructure and at the same time increases labour supply, we cannot be sure if it is truly access to infrastructure that is increasing labour supply, or if it is the unobserved variable. Individuals hardly access basic infrastructure at random. It is possible that those who have easy access are those who are in employment and hence have enough resources to leverage such services to improve their situation. This suggests that there is potential for reverse causality in the empirical relationships to be estimated. Another potential source of endogeneity stems from the fact that households with access to basic infrastructure may have elected to settle in areas with easy access to infrastructure possibly because of the activities they are involved in (selection problem).

Propensity score matching is a methodology that is often used to reduce or eliminate bias from endogeneity.

In this paper we use a propensity scores matching approach to infer the causal link between infrastructure access and our outcome variables while accounting for endogeneity issues. Propensity scores matching builds on the notion that one can assess

the effect of a given policy, program or intervention by pairing treated individuals with untreated individuals based on observable characteristics, *i.e.* by considering individuals who had the same probability to experience the policy / program / intervention given their observable characteristics, except that some did experience it and others did not. In the light of such probability the assignment to policy / program / intervention is considered exogenous and the effect unbiased.

The conditional independence assumption states that outcome is independent of the treatment assignment mechanism, conditional on pre-treatment observable characteristics. Formally,

$$Y_0, Y_1 \perp D \big| X = x, \qquad \forall x \in \chi \tag{7}$$

where D is the treatment status such that $D = 1$ for treated individuals, and X is a set of observable pre-treatment characteristics in characteristic space χ.

If the conditional independence assumption holds, matching untreated individuals to treated individuals that have the same pre-treatment observable characteristics ensures that unobservable characteristics between the treated and untreated individuals are also similar. Then estimating $E[Y_1 - Y_0]$ of the matched individuals will give the impact of treatment.

In this paper we estimate propensity scores for treated and non-treated individuals using standard Probit models. Using the estimated propensity scores, $\hat{P}(x)$, matched-pairs are constructed using the nearest-neighbors approach.

Nearest neighbors approach

We implement the nearest-neighbor matching technique when matching treated individuals to untreated individuals, using the nearest-neighbors as the counterfactual. The Nearest-neighbor matching approach matches untreated individual(s) to the treated individual with the closest propensity score. The nearest neighbor to the treated individual i^{th} is defined as the non-treated individual j that minimizes $[p(x_i) - p(x_j)]^2$ over all j in the set of non-participants, where $p(x_k)$ is the predicted odds ratio for observation k, i.e. $p(x_k) = \hat{P}(x_k)/[1 - \hat{P}(x_k)]$

Caliper Specification

When implementing the propensity scores matching approach it is possible for two individuals with very different propensity scores to be matched if no closer match exists. This is because the nearest-neighbor matching strategy matches individuals with the closest propensity scores. To avoid matching two dissimilar individuals, a matching caliper must be specified, i.e. the maximum distance between propensity scores that is acceptable for any match. The caliper specification involves a trade-off between a potentially high bias on the one hand, and decreased efficiency of the estimates on the other hand. If the value of the caliper is too large, two dissimilar individuals may be matched, increasing the bias. If the value is too small, a large number of observations may be dropped from the sample, reducing the scope of inference, and decreasing the efficiency of the estimates.

In this paper, we only retain matches with significance level of tests balancing property of 0.001.

Assuming that the common support and overlap condition requirements are met the treatment effect can be written as follows (see, for e.g. Heckman, Ichimura and Todd, 1997; Smith and Todd, 2005):

$$ATT = \frac{1}{N_T}\left[\sum_{i\in T} Y_i^T - \sum_{j\in C} \omega(i,j) Y_j^C\right], \tag{7}$$

Where Y_i^T and Y_j^C stand for treated and non-treated individuals respectively, N_T is the number of treated individuals *i* and $\omega(i,j)$ is the weight used to aggregate outcomes for the non-treated individuals *j* matched with the treated ones.

2.3- Multiple infrastructure access and inverse probability of treatment weighting

This section accounts for simultaneous access to various combinations of basic infrastructure. In experimental studies, one can analyse the outcomes for multivalued treatments by simply regressing the outcome on a set of indicator variables representing each treatment, followed by contrasts between the treatment variables to estimate treatment effects. This basic setup is deemed sufficient to provide unbiased treatment effect estimates when subjects are randomized. However, in the case of observational data, the estimation of treatment effects requires causal-inferential methods to control for

confounders. Since Lechner (2001) extended Rosenbaum and Rubin's (1983) propensity score framework for binary treatments to multivalued treatments, many techniques designed for binary treatments – including regression, matching, weighting, sub-classification on covariates and stratification – have been modified to account for multivalued treatments (see, for e.g. Novak L., 2014).

In the binary treatment case, matching on the propensity score serves a similar purpose to that of weighting and stratification. However, matching has unique challenges when extended to the multiple treatment case. This is because multiple treatment matching either attempts binary treatment matching for all pairwise comparisons or it searches for triplets (or multiplets) that match across the multiple treatment arms. The all-pairwise case is complicated by the potentially different supports of the pairwise comparisons. The matched multiplets case suffers from the 'curse of dimensionality' that can make finding enough matched sets difficult unless the available dataset is very large.
In light of these considerations we resort to the Inverse Probability Weighting method to assess the impact of multiple infrastructure access on our variables of interests, including labour supply, time spent on domestic chores, leisure time and income.

We start out by constructing a categorical variable of access, T_i. The categorical variable takes the value 0 when the individual has no access to any type of infrastructure, 1 when in case of access only to a health centre, 2 if access only to the market, 3 if access to transport only, 4 in case of access to market and centre health centre, 5 if access to transport and health centre, 6 in case of access to transport and market, and 7 if access to transport, market and health centre (i.e., all 3 basic infrastructure under consideration).

For each individual *i*, *i = 1,…, N* in the sample, the triplet (Y_i, T_i, X_i) is observed, where Y_i is the outcome variable, T_i is the categorical variable of infrastructure access, and X_i the vector of pre-treatment covariates. $D_{it}(T_i)$ the indicator of treatment *t,* i.e. having access for individual *i* is defined as follows:

$$D_{it}(T_i) = \begin{cases} 1 & if \quad T_i = t \\ 0 & otherwise. \end{cases}$$

For each individual, there is a set of potential outcomes $(Y_{i0}, \ldots, Y_{i7})$. Y_{it} denotes the potential outcome for each individual *i*, for which $T_i = t$ where t ∈ Ω = {0,…,7}. Only

one of the potential outcomes is observed, depending on the treatment status. The observed outcome, Y_i, can be written in terms of treatment indicator, $D_{it}(T_i)$, and the potential outcomes, Y_{it}:

$$Y_i = \sum_0^7 D_{it}(T_i) Y_{it}. \tag{8}$$

Thus, at the individual level the effect of configuration *m* versus configuration *l* infrastructure access is given by the difference of these two potential outcomes, $Y_{im} - Y_{il}$. The population average treatment effect in turn is given by the difference in the means of the two potential outcomes:

$$\Delta_{ml} = E[Y_{im} - Y_{il}] = \mu_m - \mu_l. \tag{9}$$

Assuming the common support and overlap condition as well as the conditional independence condition are met as before, the unconditional means can be estimated by averaging these conditional means, that is, $\mu_t \equiv E[Y_{it}] = E[E[Y_{it} \big| X_i]]$.

The average treatment effect can then be estimated as follows:

$$\hat{\Delta}_{ml} = \frac{1}{N} \sum_{i-1}^{N} \frac{Y_i D_{im}(T_i)}{\hat{r}(m, X_i)} - \frac{1}{N} \sum_{i=1}^{N} \frac{Y_i D_{il}(T_i)}{\hat{r}(l, X_i)} = \hat{\mu}_m - \hat{\mu}_l, \tag{10}$$

where $\hat{r}(t, X_i)$ is the estimated generalized propensity score defined as the conditional probability of having access to a particular basic infrastructure given the pre-treatment variables, that is,

$$r(t, x) \equiv P[T = t \big| X_i = x] = E[D_{it}(T_i) \big| X_i = x]. \tag{11}$$

Identification of potential outcomes' means is possible as in the single infrastructure access case by weighting observed outcomes by the conditional probability of access to a particular basic infrastructure:

$$E[\frac{Y_i D_{it}(T_i)}{r(t, X_i)}] = E[Y_{it}]. \tag{12}$$

The next section presents our empirical results with a discussion of the key findings.

3- Results and discussion

3.1- Single infrastructure access and propensity score matching results

We start our empirical analysis with a set of estimations based on the whole sample (FS), the sample of women only (WS), and the sample of men only (MS).

Full sample results and gender-disaggregated sub-samples:

We consider two economic infrastructure (market place and public transport) as well as one social infrastructure (health center). We consider as treated, individuals living in a household within walking distance to a given basic infrastructure, i.e. 15 minutes or less. We estimate the probability for a given individual to have access to the basic infrastructure under consideration using a Probit model. Explanatory variables used in the estimation include age, age squared, gender, education, intersect of age with education, matrimonial status, place of residence (Dakar, other urban area and rural areas) and nationality (Senegalese, B. Guinean, Guinean, Mauritanian, Malian, Ivorian, Burkinabè, Gambian, other African and Non-African).

Using the propensity scores, non-treated individuals are matched to a treated individual using the nearest neighbor matching technique which was detailed earlier. The average treatment effect on the treated (ATT) is then estimated based on those matches. Table 2 shows the results.

Table 2:
Impact of access to infrastructure on labour supply, leisure, income and domestic chores (full sample)

TREATMENT VARIABLE	TREATMENT EFFECT (TOTAL)											
	DOMESTIC CHORES			LEISURE			LABOR SUPPLY			INCOME		
	FS	WS	MS	FS	WS	MS	FS	WS	MS	FS	WS	MS
HEALTH CENTRE	-1.58*** (0.47)	-1.90*** (0.61)	-2.39*** (0.72)	0.11 (0.72)	1.97** (0.97)	0.35 (1.08)	1.63*** (0.49)	1.24** (0.62)	1.54** (0.76)	302.68 (201.59)	435.88 (375.12)	115.02*** (38.05)
MARKET	0.22 (0.45)	0.12 (0.59)	0.27 (0.68)	-1.75*** (1.58)	-2.95*** (0.90)	-1.98* (1.02)	2.10*** (0.47)	2.64*** (0.62)	2.31*** (0.72)	296.21 (207.68)	440.10 (384.73)	136.98*** (39.89)
TRANSPORT	-3.01*** (0.60)	-3.13*** (0.76)	-3.32*** (1.08)	1.53 (0.98)	2.48** (1.27)	0.56 (1.69)	1.12* (0.61)	1.48** (0.74)	0.67 (0.94)	227.83 (169.14)	291.48 (304.17)	163.36*** (44.85)

Note:
* Significant at 10%; ** Significant respectively at 5%; *** Significant at 1%
FS: Full sample; WS: Women's sample; MS: Men's sample
Income expressed in thousands of franc CFA
The values in brackets are standard errors
Age variable crossed with education,
Squared value of age included in the Probit with other explanatory variables to explain the probability to be treated.

The results from Table 2 show that the impact of infrastructure on individual income and behaviour, including labour supply varies quantitatively and qualitatively from one basic infrastructure to the other, but also varies with gender.

Access to a health centre and access to public transport appear to reduce time spent on domestic chores and to boost labour supply[6]. These results are consistent with a care economy where active adults, in addition to supplying labour in the market, take care of their dependent relatives. This can include taking the elderly or children to the health centre possibly using public transport in an environment where few people have their own means of transport (car, cart, etc.). This is further corroborated by the finding that access to public transport reduces domestic chores more than it increases labour supply. The case of access to health which increases labour supply more than it reduces domestic chores suggests that the benefits may be twofold: Not only is it easier for active individuals to take care of their sick relatives, but it also enhances their human capital in a way that enables them to supply more labour.

The results show that no type of basic infrastructure seems to significantly impact incomes at the aggregate level, i.e. full sample. This may suggest that the basic infrastructure under consideration have not triggered a structural transformation of the economy which would enable active individuals to earn far more above subsistence levels of income if working more hours. These results are consistent with a working poverty scenario whereby individuals who have access to basic infrastructure work more hours but the impact on their income is marginal or insignificant. This is corroborated by the finding that access to a market place leads individuals to work more hours in the labour market while affording less leisure, with no significant change to the amount of time spent on domestic chores. This result may suggest that individuals are leveraging the market place to either start a small business (e.g. open a shop), or work as a vendor, commercial aid, etc.

An analysis of the results in Table 2 also points to significant variations across gender. The results provide evidence in support of two major claims: gender-based

[6] That access to public transport positively impacts labour supply suggests that basic infrastructure increases the productivity of market activities, and as such, the opportunity cost of domestic chores. Similar results were obtained for the Rural Roads and Markets Improvement and Maintenance Program in Bangladesh. The programme was shown to have boosted employment and wages in agricultural and non-agricultural activities, as well as aggregate harvest outputs.

discrimination at the household level, and discrimination in the labour market. At the household level each of the basic infrastructure under consideration benefits men more than women in that it reduces the time spent on domestic chores more for men than for women. This is possibly the manifestation of gender-based social norms unfavourable to women and according to which domestic chores are mainly the responsibility of women.

With regard to the labour market the results point to women generally increasing their labour supply in the market almost in the same proportion as men (and sometimes more as is the case with access to public transport). However, the impact on women's incomes is consistently insignificant whereas there is evidence of strong and positive impact on men's income. Whether this stems from women being less educated than men or self-selecting into less remunerating activities / jobs is an issue that we investigate further in the next sub-section.

Altogether, the results in Table 2 show that the type of basic infrastructure does matter when analysing its impact on the allocation of individual time endowment between domestic chores, leisure and labour supply. This is consistent with the findings of the Asian Development Bank (2015) desk review of women's time poverty and infrastructure in Asia and the Pacific.

Notwithstanding the above, access to basic infrastructure may also impact sub-groups of men or sub-groups of women differently depending on their specific characteristics. It is unlikely that access to a market place can impact educated and uneducated women the same way with regard to leisure time for instance as it may seem from Table 2. In the next subsection we discuss the propensity score matching results across various sub groups of the population disaggregated by gender and by level of education.

Propensity score matching results by gender and education level:

We refine our analysis by further disaggregating the empirical analysis taking into account the level of education in addition to gender. Tables 3, 4 and 5 in the Appendix section show estimation results for uneducated individuals, individuals with primary level of education, and individuals with secondary and higher level of education.

The results show that access to basic infrastructure plays out differently for educated people and for those with no education. Table 3 shows that access to basic

infrastructure generally has a sizable impact on individuals with no education, especially with regard to labour supply.

The case of access to a market place is of particular interest. The results suggest that access to a market place leads men and women with no education to substitute labour supply to leisure. However, there is also some indication that gender-based social norms may be playing out as well. This is because the substitution away from leisure fully benefits labour supply in the case of men, whereas women combine increased labour supply with increased time spent on domestic chores. This situation is consistent with the *women's time poverty* phenomenon documented in the literature. Thus, basic infrastructure in this case enables uneducated people to increase their labour supply, but this does not change the internal dynamics of poor households where women tend to take care of most, if not all of the domestic chores.

Table 4 and 5 provide some indication that each of the three basic infrastructure under consideration tends to reduce the amount of time that educated people spent on domestic chores, although the results are not always statistically robust. The substitution away from domestic chores for educated people might explain increased labour supply by the uneducated who in some instances work as domestic aids.

The limited impact of access to public transport on educated individuals may reflect the fact that on average such individuals are more likely to have their own means of transportation. Access to a market place also seems to have a limited impact on educated people because the more educated are likely to have a blue collar job and to be employing uneducated individuals for the market commissions.

The significant impact of market place access on the labour supply of men and women with primary level of education may illustrate the fact that people in this group tend to leverage their literacy and access to a market place to venture into some forms of business, either alongside the uneducated or by employing them as commercial aids.

Of the three types of basic infrastructure being considered, access to a health centre seems to be the more relevant one for the most educated people, *i.e.* those with high education level or more, and especially amongst women. Not only does access to a health centre induce a sharp reduction in the amount of time spent on domestic chores, it also boosts female labour supply. This may be due to the fact that access to a health centre

enables educated women to meet the socially-driven expectations of caregiving at a minimum time cost.

Table 3 also illustrates the important point that as much as women with no education generally increase their labour supply in proportion to that of men when they have access to basic infrastructure, the impact on their income remains insignificant whereas men's income increases sharply. With both men and women in this category having no education, this result can hardly be explained by the fact that men might be taking relatively higher paying jobs compared to women. Most likely, women are being paid less than men in this category for similar jobs, i.e. unskilled jobs.

Table 3 also shows that in spite of the positive impact on labour supply, access to each of the basic infrastructure under consideration does not generally boost the income of people with no education, i.e. full sample of uneducated individuals. This may be a reflection of the fact that those infrastructure are failing to raise the return on unskilled labour supply. Reason for that could be that unskilled labour supply is matched with low paying jobs whose productivity remains unchanged. This makes the uneducated working poor although they have access to some basic infrastructure such as health centres, public transport or market places.

An important implication of this analysis is that access to basic infrastructure may still not be enough to address the rich – poor divide. This contrasts with the findings from the Rural Development Program and the Rural Roads and Markets Improvement and Maintenance Program in Bangladesh which are reported to have boosted employment and wages in agricultural and non-agricultural activities, as well as aggregate harvest outputs, with per capita annual spending across households in the program areas rising by about 10 percent.

The next section presents the results for the multiple access case and the related discussion.

3.2- Multiple infrastructure access and inverse probability of treatment weighting results

As before we start our empirical analysis with a set of estimations using the whole sample (FS), the sample of women only (WS), and the sample of men only (MS).

IPTW: Full sample and gender-disaggregated sub-samples results

We first consider the case of labour supply as influenced by a simultaneous access to various basic infrastructure. The results in Table 6 (in the Appendix section) show that having access to many infrastructure at the same time does not boost labour supply compared to the baseline case of single infrastructure access. This may be because each individual has a fixed time endowment, and values leisure and domestic chores in addition to labour income. We obtain similar results for leisure and domestic chores.[7]

However, with regard to income, the results from Table 7 (in the Appendix section) show that having access to one or many other infrastructure in addition to a market place significantly boosts income. For instance, having access to transport and health centre in addition to market place increases income by 441.37 monetary units. A potential intuition for this result is that access to other infrastructure in addition to a market place increases productivity more than otherwise possibly because of improved health and less commuting time.

Table 7 also confirms that transport is key for improving incomes. Any combination of infrastructure access that involves transport is shown to increase income relative to market access. This may be because access to transport gives access to virtually any other infrastructure, including market place and health centre.

Upon breaking down the full sample across gender lines most of the results above remain. Moreover, results show that women leverage basic infrastructure more than men. This is evident from the estimation results for income and which show that any combination of infrastructure access increases women's income compared to market access only (Table 8 and Table 9).

IPTW: Results by gender and education level

Disaggregating the multiple access case by level of education and gender, it turned out that the empirical analysis could not be implemented for the sub-samples of individuals with secondary education level or more. The underlying scenarios were discarded because of the violation of the overlap condition due to the limited number of data points for treated individuals.

[7] Estimation results available upon request from the authors.

We first consider the whole sample of uneducated individuals on the one hand, and the whole sample of individuals with primary education on the other hand. The results suggest that individuals can better leverage basic infrastructure to improve income provided that they have a minimum level of education. This can be seen from Table 10 and Table 11. Table 11 shows that compared to individuals who only have access to a market place, individuals with primary education who in addition have access to at least one other infrastructure experience a positive impact on income. This contrasts with the case of uneducated individuals (Table 10) where having access to more infrastructure has no impact on income. These results obtain while other outcomes of interest, including domestic chores time, labour supply and leisure time are shown to be robust to the number of basic infrastructure accessible to the individual.

Considering various sub-samples by gender and education level, the findings are consistent with the above. Unlike non-educated men, men with primary level of educated can leverage access to additional infrastructure beyond access to market place to increase income. Women on the other hand leverage access to additional infrastructure to increase income no matter their level of education, i.e. with primary level of education or with no education. However, unlike women, the additional income associated with multiple access is accompanied by increased labour supply in the case of men with primary level of education. This shows that women generally leverage multiple access to increase income better than men (see Table 12 in the Appendix section for uneducated women).[8]
Reconciling the findings from the multiple access case with those of the single access scenario one can infer significant institutional and structural barriers to women's economic empowerment. Women leverage multiple infrastructure access better than men to increase income. However, infrastructure access somehow has negligible impact on women's income.

4- **Concluding remarks**

In a context where many African countries are striving to upgrade existing infrastructure we developed a simple model of time allocation between three competing claims. The model enables us to first derive some theoretical predictions regarding the

[8] Other estimation results relating to this section are available upon request.

impact of infrastructure access on various variables of interest. These include time spent on domestic chores, leisure time, labour supply and individual income. Our empirical results show that the surge in African infrastructure may bring about new sources of vulnerability, especially among the poor. These include time poverty and working poverty especially for uneducated women.

Overall, our results point to the need to imbed a deliberate strategy to reach out to the most vulnerable or uneducated people in the design of infrastructure development programs. For instance, adopting an unskilled-labour intensive approach to the implementation of such programs could contribute to boosting the demand for unskilled labour in a way that positively impacts the income of uneducated people. Such strategy should also have a clear gender strategy to ensure that uneducated women can benefit as much as uneducated men from such initiatives. At the aggregate level it might be worth enacting and enforcing laws promoting equal pay for equal work across gender.

References

African Union Commission, 2015. *Invest in Africa.* London UK: News Desk Media.

Agénor, P.-R. and B. Alpaslan, 2013. *Child Labor, Intra-Household Bargaining and Economic Growth*. Working Paper No. 181, Centre for Growth and Business Cycle Research, University of Manchester, Manchester.

Agénor, P.-R. and O. Canuto, 2012. *Access to Infrastructure and Women's Time Allocation: Evidence and a Framework for Policy Analysis*. Working paper No. P45, Fondation pour les Études et Recherches sur le Développement International.

Arrow, K., 1973. The theory of discrimination' in O. Ashenfelter and A. Rees (eds) *Discrimination in Labor Markets*. Princeton NJ: Princeton University Press.

Asian Development Bank, 2015. *Desk review of women's time poverty and infrastructure in Asia and the Pacific*. Mandaluyong City, Philippines: Asian Development Bank.

Becker, G., 1971. *The economics of discrimination*. Chicago: University of Chicago Press.

Coen-Pirani, D., A. León, and S. Lugauer, 2010. The Effect of Household Appliances on Female Labor Force Participation: Evidence from Microdata. *Labour Economics*, 17, 503-13.

Dinkelman, T., 2011. The Effects of Rural Electrification on Employment: New Evidence from South Africa. *The American Economic Review*, 101, Dec., 3078-108.

Ghani, E., W. Kerr, and S. D. O'Connell, 2013. Promoting Women's Economic Participation in India. *Economic Premise* No. 107, World Bank.

Heckman, J., J.; H. Ichimura and P. E. Todd, 1997. Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Programme. *The Review of Economic Studies*, Vol. 64 (4), Special Issue: Evaluation of Training and Other Social Programmes (Oct., 1997), pp. 605-654.

Kabeer, N., 2010. *Gender & Social Protection Strategies in the Informal Economy*. New Delhi: Rootledge.

Kabeer, N., 2012. Women's economic empowerment and inclusive growth: labour markets and enterprise development. *SIG WORKING PAPER 2012/1*. International Development Research Centre and Department for International Development.

Koolwal G., and D. van de Walle, 2010. *Access to Water, Women's Work and Child Outcomes*. Policy Research Working Paper No. 5302, World Bank.

Kotsadam A. and A. Tolonen, 2015. African Mining, Gender, and Local Employment. *Policy Research Working Paper 7251.* The World Bank Group.

Lechner, M., (2001). *Identification and estimation of causal effects of multiple treatments under the conditional independence assumption*. In ``Econometric Evaluation of Labour Market Policies,'' Lechner M., Pfeiffer F. (eds). Physica: Heidelberg, 43–58.

Novak, L., 2014. The Impact of Access to Water on Child Health in Senegal. *Review of Development Economics*, Vol. 18(3), 431–444.

Polachek, S. W., 1981. Occupational self-selection: a human capital approach to sex differences in the occupational structure. *The Review of Economics and Statistics* Vol. 63 (1), 60-69.

Rosenbaum P.R., and D.B. Rubin, 1983. The central role of the propensity score in observational studies for causal effects. Biometrika Vol. 70 (1), 41–55.

Schaffnit-Chatterjee, C., 2009. *Who is Washing the Dishes Tonight? The Gender Gap in Household Work: Causes and Effects*. Unpublished Manuscript, Deustche Bank Research.

Smith, J. A., and P.E. Todd, 2005. Does Matching Overcome Lalonde's Critique of Nonexperimental Estimators? *Journal of Econometrics*, Vol 125 (1-2), pp 305-353.

The Economist Corporate Network, 2015. *Spanning Africa's infrastructure gap: How development capital is transforming Africa's project build-out*. The Economist Group: London.

The World Bank, 2012. *World Development Report 2012: Gender Equality and Development*. Washington D.C.: The World Bank.

Appendix:

Table 3:

Impact of basic infrastructure access on domestic chores, leisure, labour supply and income (non-educated people)

TREATMENT VARIABLE	TREATMENT EFFECT (TOTAL)											
	DOMESTIC CHORES			LEISURE			LABOUR SUPPLY			INCOME		
	FS	WS	MS	FS	WS	MS	FS	WS	MS	FS	WS	MS
HEALTH CENTRE	-0.63 (0.58)	-0.28 (0.73)	-1.53* (0.89)	-0.14 (0.89)	0.84 (1.13)	-1.01 (1.34)	2.08*** (0.57)	1.72*** (0.72)	3.07*** (0.87)	43.86 (97.16)	-3.66 (167.20)	113.28** (48.92)
MARKET	2.05*** (0.55)	2.34*** (0.72)	0.94 (0.86)	-2.74*** (0.84)	-3.32*** (1.11)	-2.66** (1.31)	2.44*** (0.54)	2.16*** (0.66)	2.78*** (0.90)	26.57 (90.80)	-37.64 (164.43)	122.03*** (48.04)
TRANSPORT	- 2.75*** (0.63)	-1.04 (0.73)	-3.55*** (1.17)	1.57 (1.03)	0.35 (1.14)	4.02** (1.92)	0.96 (0.61)	2.52*** (0.67)	-1.44 (1.00)	93.41 (120.73)	65.12 (180.49)	102.36** (51.65)

Note:

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

FS: Full sample; WS: Women's sample; MS: Men's sample

Income expressed in thousands of franc CFA

The values in brackets are standard errors

Age variable crossed with education,

Squared value of age included in the Probit with other explanatory variables to explain the probability to be treated.

Table 4:

Impact of basic infrastructure access on domestic chores, leisure, labour supply and income (Primary education)

TREATMENT VARIABLE	TREATMENT EFFECT (TOTAL)											
	DOMESTIC CHORES			LEISURE			LABOUR SUPPLY			INCOME		
	FS	WS	MS	FS	WS	MS	FS	WS	MS	FS	WS	MS
HEALTH CENTRE	-1.44 (1.07)	-1.32 (1.52)	0.66 (1.45)	-0.26 (1.59)	0.64 (2.30)	-3.83* (2.15)	0.69 (1.20)	-0.67 (1.63)	2.09 (1.64)	41.79 (48.83)	-28.80 (72.19)	25.00 (60.48)
MARKET	-1.00 (1.05)	-2.84* (1.60)	0.91 (1.30)	-0.95 (1.44)	-0.54 (2.01)	-2.90 (2.01)	2.78*** (1.07)	2.62* (1.39)	3.01** (1.49)	25.89 (47.65)	1.48 (68.96)	37.85 (62.25)
TRANSPORT	-2.83 (1.91)	-8.14*** (2.53)	0.21 (2.33)	2.15 (2.34)	10.82*** (3.60)	-2.24 (2.86)	-0.23 (1.57)	-3.69 (2.54)	0.58 (2.08)	6.13 (71.24)	-355.9*** (109.48)	67.73 (92.78)

Note:

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

FS: Full sample; WS: Women's sample; MS: Men's sample

Income expressed in thousands of franc CFA

The values in brackets are standard errors

Age variable crossed with education,

Squared value of age included in the Probit with other explanatory variables to explain the probability to be treated.

Table 5:

Impact of basic infrastructure access on domestic chores, leisure, labour supply and income

(High education and more)

TREATMENT VARIABLE	TREATMENT EFFECT (TOTAL)											
	DOMESTIC CHORES			LEISURE			LABOUR SUPPLY			INCOME		
	FS	WS	MS	FS	WS	MS	FS	WS	MS	FS	WS	MS
HEALTH CENTRE	-9.05*** (1.86)	-5.63** (2.46)	-4.57* (2.56)	6.61*** (2.41)	-0.46 (3.32)	4.06 (3.46)	1.26 (1.80)	6.24*** (2.14)	-1.82 (2.75)	1376.4 (975.66)	2353.0 (1861.3)	354.73*** (137.38)
MARKET	-2.97* (1.54)	-3.10 (1.91)	-2.89 (2.46)	0.87 (2.23)	-1.30 (1.77)	1.36 (3.46)	-1.40 (1.79)	1.58 (2.21)	0.27 (2.69)	1438.7 (1044.1)	2502.4 (1957.2)	198.06 (159.74)
TRANSPORT	-5.54** (2.69)	-1.75 (4.33)	-2.44 (3.76)	-3.06 (3.72)	-1.07 (5.17)	-7.13 (5.91)	3.24 (3.09)	3.69 (3.80)	2.25 (6.47)	1291.7* (783.5)	1935.2 (1496.1)	391.50*** (124.39)

Note:

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

FS: Full sample; WS: Women's sample; MS: Men's sample

Income expressed in thousands of franc CFA

The values in brackets are standard errors

Age variable crossed with education,

Squared value of age included in the Probit with other explanatory variables to explain the probability to be treated.

Table 6:

Multiple infrastructure access and labour supply – Full Sample

	NONE	HEALTH CENTRE	MARKET	TRANSPORT	M. & H. C.	TR. & H. C.	TR. & M.
HEALTH CENTRE	-1.85 (1.75)	-	-	-	-	-	-
MARKET	3.86 (4.79)	5.71 (4.94)	-	-	-	-	-
TRANSPORT	-0.23 (1.11)	1.61 (1.66)	-4.10 (4.76)	-	-	-	-
M. & H. C.	-1.04 (1.63)	0.80 (2.05)	-4.91 (4.90)	-0.80 (1.53)	-	-	-
TR. & H. C.	0.18 (1.36)	2.04 (1.84)	-3.67 (4.82)	0.42 (1.24)	1.23 (1.72)	-	-
TR. & M.	-1.20 (1.26)	0.64 (1.77)	-5.07 (4.79)	-0.97 (1.13)	-0.16 (1.65)	-1.39 (1.38)	-
TR. & M. & H. C.	1.28 (1.01)	3.13** (1.60)	-2.58 (4.73)	1.51* (0.84)	2.32 (1.46)	1.09 (1.15)	2.48** (1.03)
OBS.							**3735**

Note:

M. & H. C.: Access to a market and health centre; TR & H. C.: Access to transport and health centre; TR & M.: Access to transport and market; TR & M. & H.C.: Access to transport and market and health centre

*;**; ***, significant respectively at 10%, 5% and 1%

Table 7:

Multiple infrastructure access and income – Full Sample

	NONE	HEALTH CENTRE	MARKET	TRANSPORT	M. & H. C.	TR. & H. C.	TR. & M.
HEALTH CENTRE	-39.34 (64.58)	-	-	-	-	-	-
MARKET	-123.08** (61.21)	-83.74 (64.90)	-	-	-	-	-
TRANSPORT	141.72 (100.93)	181.07* (103.22)	264.81*** (101.14)	-	-	-	-
M. & H. C.	-31.39 (63.47)	7.95 (67.00)	91.69 (63.78)	-173.11* (102.51)	-	-	-
TR. & H. C.	52.36 (65.03)	91.71 (68.49)	175.45*** (65.33)	-89.35 (103.49)	83.76 (67.47)	-	-
TR. & M.	48.42 (53.26)	87.77 (57.44)	171.51*** (53.65)	-93.30 (96.54)	79.81 (56.20)	-3.94 (57.94)	-
TR. & M. & H. C.	318.28 (212.77)	357.63* (213.85)	441.37** (212.88)	176.56 (227.48)	349.67 (213.50)	265.91 (214.01)	269.86 (201.72)
OBS.							**7122**

Note:

M. & H. C.: Access to a market and health centre; TR & H. C.: Access to transport and health centre; TR & M.: Access to transport and market; TR & M. & H.C.: Access to transport and market and health centre.

*,**; ***, significant respectively at 10%, 5% and 1%

Table 8:

Multiple infrastructure access and income – Women Sample

	NONE	HEALTH CENTRE	MARKET	TRANSPORT	M. & H. C.	TR. & H. C.	TR. & M.
HEALTH CENTRE	-114.54 (116.62)	-	-	-	-	-	-
MARKET	-273.32*** (76.77)	-158.78* (91.06)	-	-	-	-	-
TRANSPORT	92.17 (160.44)	206.71 (167.76)	365.50** (143.06)	-	-	-	-
M. & H. C.	-75.84 (99.27)	38.69 (110.67)	197.47*** (67.61)	-168.02 (156.24)	-	-	-
TR. & H. C.	-59.18 (91.91)	55.36 (104.17)	214.14*** (56.24)	-151.35 (151.65)	-16.66 (84.26)	-	-
TR. & M.	-65.02 (79.91)	49.51 (93.71)	208.30*** (33.13)	-157.20 (144.71)	-5.84 (60.21)	5.84 (60.21)	-
TR. & M. & H. C.	445.02 (426.66)	559.56 (429.47)	718.35* (420.40)	352.85 (443.40)	504.20 (423.45)	510.05 (420.96)	-510.05 (420.96)
OBS.							**3861**

Note:

M. & H. C.: Access to a market and health centre; TR & H. C.: Access to transport and health centre; TR & M.: Access to transport and market; TR & M. & H.C.: Access to transport and market and health centre.

*,**; ***, significant respectively at 10%, 5% and 1%

Table 9:

Multiple infrastructure access and income – Men Sample

	NONE	HEALTH CENTRE	MARKET	TRANSPORT	M. & H. C.	TR. & H. C.	TR. & M.
HEALTH CENTRE	58.20 (69.41)	-	-	-	-	-	-
MARKET	23.31 (88.20)	-34.89 (104.11)	-	-	-	-	-
TRANSPORT	205.05* (112.35)	146.84 (125.27)	181.73 (124.47)	-	-	-	-
M. & H. C.	17.92 (67.30)	-40.28 (87.10)	-5.39 (86.07)	-187.13 (124.06)	-	-	-
TR. & H. C.	163.16* (85.23)	104.95 (101.62)	139.84 (100.76)	-41.89 (134.72)	145.23 (96.98)	-	-
TR. & M.	185.04*** (65.69)	126.84 (86.02)	161.73* (84.76)	-20.00 (123.32)	167.12** (80.37)	21.88 (99.14)	-
TR. & M. & H. C.	228.72*** (60.02)	170.52** (81.69)	205.41** (80.52)	23.67 (120.28)	210.80*** (75.60)	65.56 (95.47)	43.67 (78.68)
OBS							**3261**

Note:

M. & H. C.: Access to a market and health centre; TR & H. C.: Access to transport and health centre; TR & M.: Access to transport and market; TR & M. & H.C.: Access to transport and market and health centre.

*;**; ***, significant respectively at 10%, 5% and 1%

Table 10:

Multiple infrastructure access and income – Full Sample

(No education)

	NONE	HEALTH CENTRE	MARKET	TRANSPORT	M. & H. C.	TR. & H. C.	TR. & M.
HEALTH CENTRE	-3.35 (70.64)	-	-	-	-	-	-
MARKET	-14.44 (75.24)	-11.09 (72.08)	-	-	-	-	-
TRANSPORT	155.56 (134.18)	158.91 (132.48)	170.01 (135.02)	-	-	-	-
M. & H. C.	-18.50 (67.49)	-15.15 (63.97)	-4.06 (69.01)	-174.07 (130.81)	-	-	-
TR. & H. C.	123.74 (103.02)	127.10 (100.73)	138.19 (104.01)	-31.81 (152.23)	142.25 (98.58)	-	-
TR. & M.	53.02 (76.30)	56.37 (73.14)	67.46 (77.52)	-102.54 (135.61)	71.52 (70.18)	-70.72 (104.72)	-
TR. & M. & H. C.	86.05 (64.43)	89.40 (60.66)	100.49 (65.92)	-69.51 (129.27)	104.56* (57.02)	-37.69 (96.48)	33.03 (67.15)
OBS							**4182**

Note:

M. & H. C.: Access to a market and health centre; TR & H. C.: Access to transport and health centre; TR & M.: Access to transport and market; TR & M. & H.C.: Access to transport and market and health centre.

*;**; ***, significant respectively at 10%, 5% and 1%

Table 11:

Multiple infrastructure access and income – Full Sample

(Primary education)

	NONE	HEALTH CENTRE	MARKET	TRANSPORT	M. & H. C.	TR. & H. C.	TR. & M.
HEALTH CENTRE	-18.54 (138.85)	-	-	-	-	-	-
MARKET	-289.08*** (76.09)	-270.53** (117.90)	-	-	-	-	-
TRANSPORT	225.66 (221.87)	244.21 (239.43)	514.75** (209.38)	-	-	-	-
M. & H. C.	-108.52 (95.70)	-89.97 (131.24)	180.55*** (61.47)	-334.19 (217.39)	-	-	-
TR. & H. C.	-79.43 (81.90)	-60.88 (121.71)	209.64*** (36.22)	-305.10 (211.51)	29.09 (68.47)	-	-
TR. & M.	-4.67 (85.65)	13.87 (124.21)	284.41*** (43.97)	-230.33 (213.08)	103.85 (72.86)	74.76 (53.47)	-
TR. & M. & H. C.	8.76 (79.42)	27.31 (119.95)	297.84*** (29.81)	-216.90 (210.48)	117.29* (65.36)	88.19** (42.45)	13.43 (49.43)
OBS							**1846**

Note:

M. & H. C.: Access to a market and health centre; TR & H. C.: Access to transport and health centre; TR & M.: Access to transport and market; TR & M. & H.C.: Access to transport and market and health centre.

*;**; ***, significant respectively at 10%, 5% and 1%

Table 12:

Multiple infrastructure access and income – Women Sample

(No education)

	NONE	HEALTH CENTRE	MARKET	TRANSPORT	M. & H. C.	TR. & H. C.	TR. & M.
HEALTH CENTRE	-124.59 (108.84)	-	-	-	-	-	-
MARKET	-206.83* (108.13)	-82.24*** (30.87)	-	-	-	-	-
TRANSPORT	198.66 (263.44)	323.25 (242.35)	405.49* (242.06)	-	-	-	-
M. & H. C.	-71.10 (120.63)	53.48 (61.76)	135.72** (60.50)	-269.76 (247.92)	-	-	-
TR. & H. C.	24.44 (136.28)	149.03* (88.50)	231.28*** (87.65)	-174.21 (255.86)	95.55 (102.68)	-	-
TR. & M.	-68.31 (111.79)	56.27 (41.80)	138.51*** (39.88)	-266.97 (243.71)	2.78 (66.82)	-92.76 (91.94)	-
TR. & M. & H. C.	-11.00 (110.82)	113.58*** (39.22)	195.82*** (37.06)	-209.67 (243.25)	60.09 (65.12)	-35.45 (90.86)	57.30 (46.62)
OBS							**2337**

Note:

M. & H. C.: Access to a market and health centre; TR & H. C.: Access to transport and health centre; TR & M.: Access to transport and market; TR & M. & H.C.: Access to transport and market and health centre.

*;**; ***, significant respectively at 10%, 5% and 1%