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Publicly Provided Private Goods and Informal Labor Supply*

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Abstract

In this paper we investigate how households time allocations decisions between formal and informal sectors are related to publicly provided goods with and without market substitutes.A simple static public provision model motivates our analysis. Households consume a normal private good and a quasi-private (education) good. Household needs some public utility services to consume the private good and supply labor to formal and informal sectors. Using data from the PNAD (National Household Sample Survey) for the period 2007-2015 we construct indexes of access to three groups of publicly provided goods: (I) basic infrastructure or public utility services, (II) basic education and (III) higher education. Our logit results show a positive effect of access to public education (basic and higher) on the probability of evasion. Differently from public utility services, that affect negatively the probability of evasion, the consumption of these goods present substitute in the private sector. We observe a stronger effect of access to publicly provided basic education comparing with higher education. This result may be related to the different quality of publicly provision of higher and basic education. Tobit results suggest a positive and significant effect only in the case of publicly provided education, i.e., an increase in the access or use of publicly provided education increases the supply of informal labor hours.

Keywords: Education; Public Utility Services, Tax Evasion; Public Provision.

JEL Classification: J22; H26; H42.

Area: Public economics, political economy, institutions

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1 Introduction

In this paper we investigate the relation between households' time allocation between formal and informal sectors with publicly provided goods with and without market substitutes. Tax evasion reduces tax revenue and affects the provision of public goods. We consider a simple static formulation of public provision, inspired by e.g. Pirttila and Tuomala (2002) and Guler and Taskin (2013). Households consume two types of goods: a normal private good and a quasi-private good, i.e., a good that is both provided by the government and purchased by the household himself. In our model, the quasi-private good is education and its overall level for the household is a sum of the public provision of education and the private topped-up portion. We assume the household needs some public utility services, for instance, electricity, natural gas, water, sewage and garbage collection, to consume the private good.

Households supply labor to formal and informal sectors. Agents can work in the informal sector and still consume public goods. The supply of hours to the formal market then depends on their preferences - consumption versus leisure - and on the availability of private substitutes for public consumption. The relationship between time spent in the informal sector and the amount of public resources allocated to publicly provided private goods depends on the combination of factors, namely, the relative quality of private education *vis-à-vis* public education, the agent's non-labor income resources (wealth), the share of publicly provided utility services necessary for consumption of the private good and the amount of tax revenues allocated to publicly provided education.

Empirically, using data from the PNAD (National Household Sample Survey) for the period 2007-2015 is possible to identify the consumption of goods provided by the government and to estimate the role of these goods in the choice (intensive margin) of the working sector (formal versus informal). We sort goods into two groups according to whether or not the good has close substitutes being provided by the government. The first group of goods is comprised of all goods that have no private substitutes, for instance, street lighting, garbage collection, highway system and sewer systems. Other consumption goods, such as education and health, can be acquired either in the market or provided by the government. The dynamics and proprieties of labor supply become richer in the presence of market and publicly provided goods and informal activities because there are now three substitution margins: overall consumption versus leisure, market goods and publicly provided goods and public goods with and without substitutes. The PNAD allows us to observe households' access to some publicly provided goods. For all years, the survey provides information regarding households access to certain infrastructure goods, such as the public sewage system, running water, waste collection and electricity. Within each household, information is gathered regarding individuals who attend school or college and whether such individuals attend private or public schools. This information is used below to construct indexes of access to three groups of publicly provided goods: (I) basic infrastructure or public utility services, (II) basic education and (III) higher education.

Unlike traditional literature which analyzes the provision of public good, we observe the (realized) demand of these goods by individuals. We estimate a logit model for the probability of

being a evader, in which our interest variables are the "Access to public basic education index", "Access to public higher education index" and "Public utility services access Index". Our results show a positive effect of access to public education (basic and higher) on the probability of evasion. Differently from public utility services, that affect negatively the probability of evasion, the consumption of these goods present substitute in the private sector. Moreover, we observe a stronger effect of access to publicly provided basic education comparing with higher education. This result may be related to the different quality of publicly provision of higher and basic education.

Second, we use a Tobit model in order to estimate the marginal effects of publicly provided services on the ratio of informal hours. Our results of Tobit estimates show initially a strong and positive effect of access to publicly provided basic education and a strong and negative effect of access to public higher education and utility services. However, theses effects changes completely when we control for individual demographic characteristics, household characteristics and, finally, labor variables. Our final Tobit estimates suggest a positive and significant effect only in the case of publicly provided education, i.e., an increase in the access or use of publicly provided education increases the supply of informal labor hours.

Tax collection in the formal sector enables public spending on the provision of goods (Schneider (2005)). Furthermore, being in the formal sector represents access to fringe benefits guaranteed, in most of cases by law.[1] The worker in the informal sector, in turn, has no rights or any fringe benefits but the possibility of not paying taxes makes this an attractive sector. However, the larger the informal sector of the economy, the smaller the possibilities of tax collection by the government and hence the ability provision of public goods will be reduced. Fortin et al. (1997), Dessy and Pallage (2003) and Dijkstra (2011) use the ratio of taxes payment to the public provision of goods to explain the coexistence of formal and informal sectors.

Cowell and Gordon (1988) explores the impact of the provision of the public good on the decision to avoid tax payment. Their model assumes that the government offers an amount of public good that is proportional to the tax collection and find that the choices of individuals regarding tax payments depend on the size of the economy. If they are relevant (small economy) in terms of tax collection and might influence others contributors, then tax evasion decreases. Allingham and Sandmo (1972) is the first paper that relates the probability of detection and avoidance penalty imposed on withheld income instruments. Individuals choose the share of income that evades considering policy instruments where the larger the probability of detection (or penalties) the lower tax evasion is. Sandmo (1981) incorporates the decision of fiscal evasion to the choice of labor supply, imposing the restriction that only the income from informal work may be withheld. Thus, rather than choosing a portion of undeclared income, as in Allingham and Sandmo (1972), individuals choose an amount of working hours to offer in the informal sector. We relate this choice to the nature of public expenditures on the part of the government.[2]

[1]Brazilian Labor Law guarantees: weekly rest, wages paid in the fifth working day of the month, 30 days holiday, maximum discount of 6% of salary for mobility costs and maternity leave, a forced savings account (FGTS - Guarantee Fund for Time of Service), unemployment insurance, accident assistance and professional rehabilitation. Other fringe benefits include health insurance, life insurance, pension.

[2]See also Rauch (1991); Maloney (1999); Botelho and Ponczek (2011); Auriol and Warlters (2005) for a

Blomquist et al. (2016) point out that several contributions have highlighted how public provision of work complements can discourage people from lowering labor supply to diminish taxable income. They show how tax avoidance breaks the link between labor supply and reported income. An agent reducing his reported income to escape taxes might no longer forego a publicly provided labor complement, because he can now lower his income by avoiding more rather than working less. Pirttila and Suoniemi (2014) empirically examine, using Finnish consumption data, the relation between working hours, consumption demand, and the use of publicly provided day care. When labor income is controlled for in a non-parametric way, capital income and housing expenses are negatively associated with working hours, whereas the use of childcare is positively correlated with working hours. The authors argue that these results provide evidence for taxing capital income and housing, and for subsidizing day care. For other relevant paper regarding publicly provided private goods see, for instance, Aronsson and Granlund (2014), Fang and Norman (2014) and Pirttila and Tenhunen (2008).

The paper is divided as follows. Section 2 describes our model of formal and informal hours worked and three goods: market consumption, and two publicly provided good (with and without market substitute). We derive equilibrium allocations as functions of sets of parameters, preferences, technology and policy. In Section 3, we describe the relevant data and summarize their main features. Section 4 presents our methodology and empirical strategy and discuss our results. Concluding comments are offered in the last section.

2 Publicly Provided Education, Public Utilities and Labor Supply

We consider a simple static formulation of public provision, inspired by e.g. Pirttila and Tuomala (2002) and Guler and Taskin (2013). Households supply labor to formal and informal sectors and consume two types of goods: a normal private good, x, and a quasi-private good z, i.e., a good that is both provided by the government and purchased by the household itself. In our model, the good z is education and its overall level for the household is a sum of the public provision of education, denoted by g, and the private, topped-up portion, e.

The individuals enjoy utility from composite consumption good (c) and leisure (l) and the household utility function is denoted by $u(c, l)$. We assume that in order to consume the private good x the household needs some public utility services, for instance, electricity, natural gas, water, sewage and garbage collection. We denote these services, k. Hence, we assume that the composite consumption good function has the Cobb–Douglas form as follows:

$$c = C(k, x) = k^{\sigma} x^{1-\sigma} \tag{1}$$

where σ is the share of publicly provided utility services necessary for consumption of x.

We assume that all individuals work $\bar{n}$ given hours in the formal sector. Then, he decides whether and how much he works in the informal sector. Denote h the time spent in this sector.

discussion on labor market segmentation.

A worker's time constraint is

$$h + l + \bar{n} = 1 \tag{2}$$

Education affects household wages through its influence on productivity (Pirttila and Tuomala (2002)) and it itself does not enter the utility function. Let us denote the wage rate for a household as $\omega(\theta e, g)$, where θ is the relative quality of the private education e, and g is publicly provided education. Formal employed individuals pay income tax τ. Informal workers if detected pay a penalty and keep λ of their labor earnings. The tax-enforcement system leads to the following disposable income schedule:

$$y = Y\left(\omega(\theta e, g), h\right) = \omega(\theta e, g)\left[(1-\tau)\,\bar{n} + \lambda h\right] \tag{3}$$

and the household's budget constraint is given by $x + e = y + T$, where T represents non labor income (wealth).

Let G be the government's spending on education and public utilities. Publicly provided education is financed with a fraction β of total tax revenues, i.e., $g = \beta G$, while public utility services is funded with the remaining $(k = (1-\beta)G)$. Hence, the government budget is balanced such that tax revenues finance both publicly provided services:

$$\tau\bar{n} + (1-\lambda)h = g + k \tag{4}$$

Denoting $\bar{t} = 1 - \bar{n}$ as the total time available net of labor supply, we can derive the choice of (e, β, h) from the solution of the following problem:

$$\max_{\{e,\beta,h\}} u\left(C(k, Y\left(\omega(\theta e, g), h\right) + T - e), \bar{t} - h\right) \tag{5}$$

The first order conditions of this problem with respect to private education e, share of government's expenditures on education β and informal work time h are the following:

$$u_1(c,l)C_2(k,x)Y_1\left(\omega(\theta e, g), h\right)\omega_1(\theta e, g)\theta = u_1(c,l)C_2(k,x) \tag{6}$$

$$u_1(c,l)C_2(k,x)Y_1\left(\omega(\theta e, g), h\right)\omega_2(\theta e, g)G = u_1(c,l)C_1(k,x)G \tag{7}$$

$$u_1(c,l)C_2(k,x)Y_2\left(\omega(\theta e, g), h\right)\lambda = u_2(c,l) \tag{8}$$

where C_i denotes the derivative of the C function with respect to the ith item, and similarly for the functions u, Y and ω. The left-hand side (LHS) of equation (6) represents the marginal benefit of private education expenditures. As e increases incrementally, it increases labor productivity by $\omega_1(\theta e, g)\theta$ which, in turn, increases disposable income by $Y_1\left(\omega(\theta e, g), h\right)$ and composite good consumption by $C_2(k, x)$, which finally increases the utility by $u_1(c, l)$. The right-hand side (RHS) of this equation shows the marginal cost of such expenditures. An incremental increase in e decreases consumption of the composite good by $C_2(k, x)$, through a decrease in x, which decreases the utility by $u_1(c, l)$.

Similarly, the LHS of equation (7) shows the marginal benefit of increasing resources to

public education. As β increases incrementally, public education g increases by G, which then increases labor productivity by $\omega_2(\theta e, g)$, increasing disposable income by $Y_1\left(\omega(\theta e, g), h\right)$ and composite good consumption by $C_2(k, x)$, which finally increases the utility by $u_1(c, l)$. The RHS of the same equation shows the marginal cost of more resources to public education. An incremental increase in g decreases resources available to public utility, which decreases the consumption of the composite good by $C_1(k, x)$, which, in turn, decreases the agent's utility by $u_1(c, l)$.

Finally, the RHS of equation (8) represents the marginal cost of h, i.e., an incremental increase in h decreases the leisure by the same amount, which decreases the utility by $u_2(c, l)$. Lastly, the LHS of the same equation shows the marginal benefit of the time spent working in the informal sector. As h increases incrementally, disposable income increases by $Y_2\left(\omega(\theta e, g), h\right)\lambda$, which then increases composite good c by $C_2(k, x)$, which finally increases the utility by $u_1(c, l)$.

Combining equations (7) and (8), the optimal trade off between more resources to public education (β), and consequently less resources to public utilities, and hours worked in the informal sector h, is such that the relative decrease in the agent's utility due to incremental increases in β and h are equalized, as follows:

$$\frac{u_1(c, l)C_1(k, x)}{Y_1\left(\omega(\theta e, g), h\right)\omega_2(\theta e, g)} = \frac{u_2(c, l)}{Y_2\left(\omega(\theta e, g), h\right)} \tag{9}$$

The relationship between hours worked in the informal sector and the amount allocated to public education will depend on several variables, as suggested by equation (9). To illustrate such relationship, we assume standard functional forms of utility, $u(c, l) = \log c + \phi \log(\bar{t} - h)$, and productivity, $\omega(\theta e, g) = \theta e + g$, and evaluate equations $(6) - (8)$. From the solution of these first-order conditions, assuming $\lambda = 1$ and using the fact that $\bar{n}\tau = G = g + k$, we obtain

$$\frac{h}{\beta} = \frac{(g + k)\left[(1 - \theta\bar{n}) + \theta(g + k)\right]}{\theta\left[(1 - \sigma)(g + k) - \sigma T\theta\right]} \tag{10}$$

An important implication of equation (10) is that the relation between time spent in the informal sector and the share of government resources to the public education system depends on the combination of factors, namely, the relative quality θ of private education vis-a-vis public education, the agent's non-labor income resources (wealth) T, the share σ of publicly provided utility services necessary for consumption of the private good x, the amount of tax revenues allocated to publicly provided education (g) and public utility services (k). Note that this relation establishes that larger non-labor income descreases the share of infomral labor hours. Similarly for larger σ. We cannot sign the effects of other variables precisely, because they depend upon paramters values. However, for some reasonable parameter values, we expect that marginal increases in (g+k) would produce a reduction in the informal labor hours $\left({}^{1-\theta(\bar{n}-1)}/_{\theta(1-\sigma)}\right)$ relative to the share of the government's expenditure on education. Nevertheless, it is an empirical issue to better understand the role played by these variables on informal labor supply.

3 Hours Worked and Publicly Provided Goods Data

For our empirical analysis, we use the National Household Sample Survey (Pesquisa Nacional por Amostra de Domicilios - PNAD) from 2007 to 2015, conducted by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatistica - IBGE). This survey is conducted annually (except in Census years) and collects information on the socioeconomic, educational and labor market characteristics of Brazilian households. The individuals' labor characteristics available on the PNAD allow us to clearly identify formal and informal workers. In our analysis, domestic workers or workers with a formal labor contract (signed labor card or carteira assinada), civil servants and military personnel were considered formal workers.[3] Informal workers are, hence, those workers without a formal labor contract.

Using information from primary and secondary jobs, three groups of individuals were identified, namely, (i) non-evaders - workers with one or two formal jobs, (ii) evaders - workers with two jobs, one formal and one informal, and (iii) informal workers - those workers with one or two informal jobs. People with more than two jobs or people whose incomes from two jobs are zero were not considered in this sample. Also, only workers who have spent at least one year in the same job are considered in the analysis.[4] The purpose of these criteria is to avoid including individuals in the sample who are only temporarily working in a particular labor sector and, thus, obtain a more precise estimate of the relationship between (formal/informal) hours worked and the provision of public goods. To achieve greater homogeneity among workers, only workers who reside in urban areas, do not work in the agricultural or fishing industries and are between 24 and 64 years of age were included in the sample. A total of 335,577 self-employers, employers and unpaid workers were also excluded from our sample. Table I indicates the reduction in sample size that occurred after each cut-off point was applied. The cut-offs for age and time spent in a job generated the greatest sample loss. However, such cut-offs are necessary, and the final sample consists of 1,165,335 workers, taking all years into account. It is worth mentioning that the PNAD presents a complex survey design that is taken into account in all statistics and estimates.

Table II shows the final sample size, the number of workers in each group and some of the workers' characteristics. Regarding the groups specific characteristics, it is evident that informal workers are slightly older, with a lower proportion of men and a higher number of non-whites (black and mixed-race individuals), than other workers. Additionally, informal workers, who have on average 7.8 years of education, have less education than both non-evaders and evaders, who averages are 12.0 and 10.1 years of education, respectively. Workers with two jobs - one formal and the other is informal - in addition to having more education, work more hours per

[3]Self-employed workers were not considered in the analysis, due to the difficulty of defining a criterion for formality among these workers. Employers are also not considered, although this type of worker is identified in both years of the survey. Beginning in 2009, the PNAD reports on whether worker-employers are enrolled in the Corporate Taxpayers Registry (Cadastro Nacional da Pessoa Juridica - CNPJ), a criterion that could be used to define formal and informal workers. However, to maintain consistency of methodology in both years, employers are not considered in the analysis.

[4]This criterion is used only for workers' primary jobs, as information regarding the amount of time spent in a job is not available for secondary jobs.

Table I: Sample cut-offs and Final sample size

	2007	**2008**	**2009**	**2011**	**2012**	**2013**	**2014**	**2015**	**Total**
Total people	797,992	781,796	797,388	715,812	361,781	361,601	361,940	356,005	4,534,315
Working people	309,668	312,340	317,870	287,470	147,232	145,528	149,543	139,594	1,809,145
Workers Residing urban area	670,072	659,182	673,164	611,418	309,389	307,949	309,883	303,753	3,844,810
24-64 years old	246,132	249,502	256,052	235,468	120,612	120,306	123,111	116,909	1,468,092
Non-agricult. (main job)	232,722	236,394	242,860	223,996	115,364	115,043	117,624	112,087	1,396,090
More 1-year (same job)	197,358	195,314	203,472	191,266	97,811	97,486	100,779	97,346	1,180,832
Income higher than 0	194,944	193,286	201,486	189,890	97,133	96,964	100,044	96,764	1,170,511
With one or two jobs	193,860	192,178	200,468	189,180	96,817	96,657	99,673	96,502	1,165,335

week and have higher weekly wages than workers in the other groups.

Table II: Mean values of variables per group

	(1)	(2)	(3)	(4)
VARIABLES	Evaders	Non-Evaders	Informal	Total
Age	39.952***	39.134***	40.158***	39.383***
	(0.114)	(0.024)	(0.042)	(0.021)
Woman	0.616***	0.445***	0.584***	0.477***
	(0.006)	(0.001)	(0.002)	(0.001)
White	0.559***	0.544***	0.435***	0.521***
	(0.006)	(0.002)	(0.002)	(0.002)
Black	0.089***	0.088***	0.103***	0.091***
	(0.003)	(0.001)	(0.001)	(0.001)
Yellow	0.006***	0.006***	0.005***	0.006***
	(0.001)	(0.000)	(0.000)	(0.000)
Brown	0.343***	0.360***	0.454***	0.380***
	(0.006)	(0.002)	(0.002)	(0.002)
Years of Education	12.828***	10.090***	7.765***	9.663***
	(0.044)	(0.018)	(0.022)	(0.017)
Total hours working	54.645***	42.340***	37.903***	41.850***
	(0.193)	(0.027)	(0.058)	(0.026)
Hours working in informal sector	21.764***	0.000	37.903***	8.317***
	(0.131)	(0.000)	(0.058)	(0.042)
Contributes do Social Security? No	0.002***	0.005***	0.754***	0.162***
	(0.001)	(0.000)	(0.002)	(0.001)
Labor income - main job (monthly)	2,405.409***	2,132.661***	1,220.396***	1,949.841***
	(34.454)	(13.454)	(8.653)	(11.979)
Labor income - all jobs (monthly)	3,939.969***	2,147.460***	1,240.882***	2,014.414***
	(47.887)	(13.571)	(8.885)	(12.469)
Total income (monthly)	4,040.462***	2,232.476***	1,359.409***	2,107.333***
	(49.178)	(14.221)	(9.529)	(13.072)
Per capita household income	2,402.600***	1,482.400***	1,005.441***	1,411.118***
	(34.615)	(10.198)	(7.513)	(9.442)
Observations	13,278	592,504	169,126	789,608

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In addition, the PNAD allows us to observe households' access to some publicly provided goods. For all years, the survey provides information regarding households access to certain infrastructure goods, such as the public sewage system, running water, waste collection and electricity. Within each household, information is gathered regarding individuals who attend school or college and whether such individuals attend private or public schools. All this information is used below to construct indexes of access to three groups of publicly provided goods: (I) basic infrastructure or public utility services, (II) basic education and (III) higher education. Table III presents the results of principal component analysis for each of the three indexes of publicly provided goods. Note that the indexes are normalize to range from 0 to 1. The indexes are obtained separately for each year, but the weight assigned to each variable does not significantly change from one year to the next. In Brazil, the consumption of goods

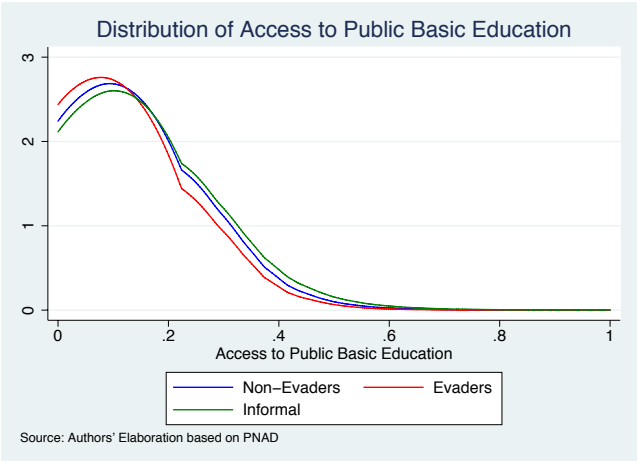


Figure 1: Distribution of Access to Public Basic Education

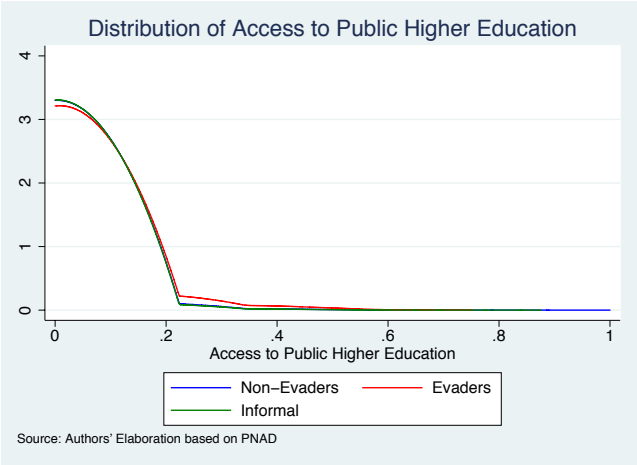


Figure 2: Distribution of Access to Public Higher Education

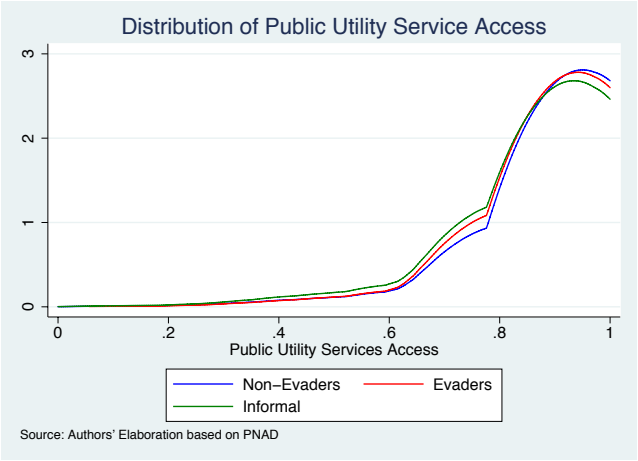


Figure 3: Distribution of Access to Publicly Infrastructure

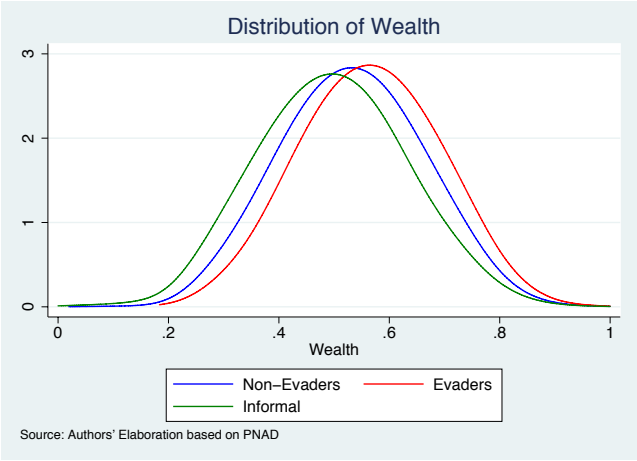


Figure 4: Distribution of Wealth Index

provided by the government is not restricted to formal workers, i.e., no proof of formal work or good standing with the tax authorities is needed for access to publicly provided goods.

Figures 1-3 present the distribution of access to the three publicly provided good considered in our analysis for each group of workers: evaders, non-evaders and informal workers. Concerning the publicly provided basic education, informal workers access it more than the non-evaders e evaders (Figure 1). The reverse occurs in the case of publicly provided higher education.. Figure 3 shows that informal workers have less access to public utility services. The upper tail of the distribution is higher for evaders and non-evaders workers. This may be an evidence that the informal workers are poorer than other workers, living in areas with worse basic infrastructure conditions.

In addition to the indexes of publicly provided goods, a variable of wealth was also constructed from a principal components analysis. Table IV shows the result for each year. In fact, the components are very similar along the years. The Figure 4 shows a comparative analysis of wealth index distribution between evaders, non-evaders and informal workers. It reinforces the evidence that informal workers are poorer that evaders and non-evaders. In fact, the evaders

Table III: Principal Component Analysis of Publicly provided Good

Variables	2007	2008	2009	2011	2012	2013	2014	2015
Panel A: Basic Education								
# of people in the household who attend a public:								
Elementary School	0.61	0.62	0.63	0.64	0.65	0.62	0.66	0.65
High School	0.24	0.30	0.31	0.34	0.33	0.38	0.40	0.42
Youth and Adult Elementary Education program	0.33	0.33	0.31	0.29	0.25	0.32	0.28	0.18
Youth and Adult High School Education program	0.20	0.19	0.20	0.23	0.20	0.24	0.21	0.20
Youth and Adult Literacy program	0.18	0.17	0.16	0.12	0.02	0.05	0.07	0.05
Daycare	0.29	0.25	0.30	0.27	0.37	0.34	0.34	0.36
Preschool - literacy	0.31	0.30	0.33	0.27	0.20	0.16	0.10	0.20
Preschool	0.46	0.44	0.37	0.41	0.43	0.40	0.39	0.39
Pre Entrance Exam	0.02	0.04	0.09	-0.03	-0.02	0.01	-0.04	0.03
Explained Variance	13.35	13.32	13.28	13.19	13.03	13.32	13.16	13.04
Observations	193,860	192,178	200,468	189,180	96,817	96,657	99,673	96,502
Panel B: Higher Education								
# of people in the household who attend a public:								
University of Graduate School	0.7071	0.7071	0.7071	0.7071	0.7071	0.7071	0.7071	0.7071
Master or PhD Program	0.7071	0.7071	0.7071	0.7071	0.7071	0.7071	0.7071	0.7071
Explained Variance	51.44	51.71	51.69	51.7	50.99	51.66	51.99	51.18
Observations	193,860	192,178	200,468	189,180	96,817	96,657	99,673	96,502
Panel C: Public Utility Services Index								
Dummy for								
Access to running water	0.6739	0.6804	0.6672	0.6614	0.6614	0.6735	0.6835	0.6879
Access to the sewage system	0.6776	0.685	0.6713	0.6656	0.6656	0.6585	0.6653	0.6835
Access to waste collection	0.2876	0.2535	0.3178	0.3401	0.3401	0.3209	0.2989	0.2426
Access to electricity (public network)	0.0633	0.0601	0.0571	0.0618	0.0618	0.0991	0.0283	0.0259
Explained Variance	30.79	30.81	31.01	31.81	31.99	31.99	31.70	31.67
Observations	188,208	187,416	196,020	185,356	95,184	95,027	98,197	95,287

Table IV: Principal Component Analysis of Wealth Index

Variables	2007	2008	2009	2011	2012	2013	2014	2015
There is								
a computer	0.37	0.37	0.38	0.38	0.39	0.38	0.39	0.39
internet access	0.37	0.37	0.38	0.39	0.39	0.39	0.39	0.40
a telephone	0.31	0.32	0.32	0.32	0.32	0.32	0.32	0.32
a washing machine	0.30	0.30	0.30	0.30	0.30	0.29	0.29	0.28
a freezer	0.22	0.22	0.21	0.20	0.20	0.19	0.18	0.18
a cellular	0.20	0.18	0.16	0.13	0.12	0.12	0.11	0.11
a toilet in the household	0.16	0.14	0.14	0.14	0.13	0.14	0.12	0.11
a refrigerator	0.14	0.14	0.13	0.11	0.09	0.09	0.08	0.08
a radio	0.14	0.15	0.13	0.13	0.13	0.12	0.11	0.11
a bathroom in the household	0.14	0.12	0.13	0.12	0.11	0.12	0.11	0.10
a water filter	0.12	0.13	0.13	0.15	0.15	0.16	0.17	0.17
a TV	0.09	0.08	0.08	0.06	0.06	0.06	0.05	0.06
gas installation	0.08	0.07	0.06	0.04	0.04	0.04	0.03	0.03
# of bathroom or toilets	0.36	0.36	0.36	0.37	0.37	0.37	0.37	0.37
# of rooms	0.36	0.37	0.37	0.38	0.38	0.38	0.39	0.39
# of rooms - dormitories	0.23	0.23	0.24	0.25	0.25	0.26	0.26	0.26
Own residence	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15
Wall material: masonry	0.11	0.11	0.10	0.11	0.10	0.10	0.10	0.09
Roof material: tile	0.05	0.04	0.03	0.04	0.04	0.04	0.04	0.03
Observations	192,988	191,304	199,628	188,552	96,508	96,306	99,241	96,225
Explained Variance (%)	20.95	20.7	20.1	19.3	18.53	18.31	18.02	17.86

workers seem to be wealthiest.

4 Empirical Analysis

The aim of the empirical analysis is to present new evidence about the correlation between tax evasion and publicly provided goods and services. First, we estimate a logit model for the probability of being a evader, in which our interest variables are the "Access to public basic education index", "Access to public higher education index" and "Public utility services access Index". Second, we use a Tobit model in order to estimate the marginal effects of publicly provided services on the ratio of informal hours, based on equation (10).

The results of our logit estimates are shown in Table V. The results show a positive effect of access to public education (basic and higher) on the probability of evasion. Differently from public utility services, that affect negatively the probability of evasion, the consumption of these goods present substitute in the private sector. Moreover, we observe a stronger effect of access to publicly provided basic education comparing with higher education. This result may be related to the different quality of publicly provision of higher and basic education. In the first case, there are several public institutions that provide undergraduate and graduate courses of high quality, whereas in the basic education, on average, the quality of publicly provision is very low and worse than the private one (see Bacalhau (2013)).

In other to better understand the results and evaluate the correlation between publicly

Table V: Logit Estimates - Probability of Being an Evader

		(1)	(2)	(3)	(4)
Variables	Access to public basic education	-1.848***	1.000***	3.931***	3.731***
		(0.190)	(0.177)	(0.178)	(0.193)
	Access to public higher education	3.231***	1.478***	1.301***	0.598***
		(0.191)	(0.202)	(0.210)	(0.216)
	Public Utility Services Access	0.112	-0.477***	-0.585***	-0.381***
		(0.115)	(0.110)	(0.112)	(0.120)
Individual Demographic Characteristics	Women		0.523***	0.552***	-0.257***
			(0.028)	(0.029)	(0.035)
	White		-0.436**	-0.415*	-0.272
			(0.221)	(0.225)	(0.252)
	Black		-0.118	-0.013	0.058
			(0.225)	(0.229)	(0.256)
	Yellow		-0.717**	-0.645**	-0.272
			(0.294)	(0.302)	(0.331)
	Brown		-0.312	-0.206	-0.120
			(0.221)	(0.226)	(0.252)
	Age		0.010***	0.005***	-0.013***
			(0.001)	(0.001)	(0.001)
	Spouse		-0.306***	-0.359***	-0.510***
			(0.030)	(0.032)	(0.034)
	Son		-0.559***	-0.521***	-0.732***
			(0.042)	(0.045)	(0.048)
	Other Relative		-0.586***	-0.581***	-0.737***
			(0.079)	(0.082)	(0.089)
	Aggregate		-0.438**	-0.496**	-0.965***
			(0.214)	(0.214)	(0.244)
	Guest		-0.371		
			(0.259)		
	Housekeeper		-1.098**		
			(0.542)		
	Years of Education		0.272***	0.197***	0.075***
			(0.007)	(0.007)	(0.008)
Household Characteristics	Wealth			-0.837***	0.323
				(0.186)	(0.199)
	Per capita household income			-0.000	0.000***
				(0.000)	(0.000)
Labor Variables	Contributes do Social security? No				-5.298***
					(0.965)
	Main job income				-0.000***
					(0.000)
	Dummies of Occupational Choice, Group of Occupation, Group of Activities				yes
	Year and State Dummies	yes	yes	yes	yes
	Constant	-4.019***	-7.026***	-5.025***	-4.102***
		(0.169)	(0.291)	(0.318)	(0.388)
	Observations	628,507	626,458	596,666	595,937

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

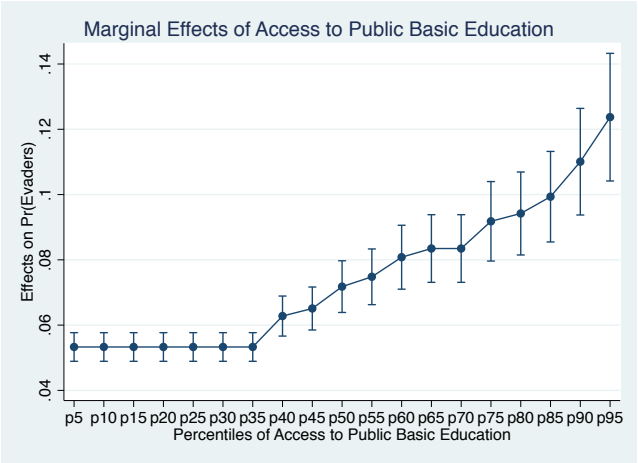


Figure 5: Marginal Effect of Access to Publicly Provided Basic Education

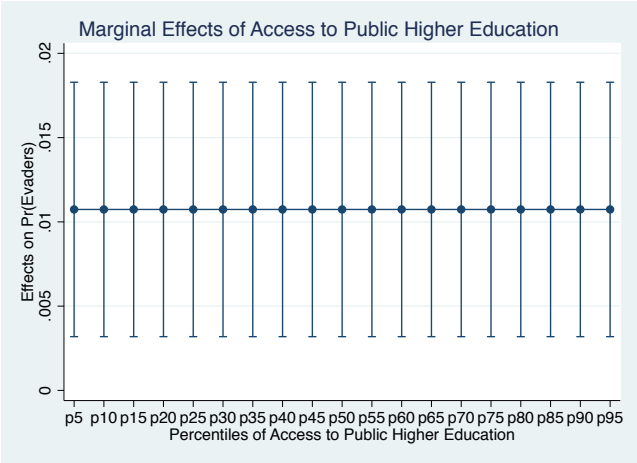


Figure 6: Marginal Effects of Access to Publicly Provided Higher Education

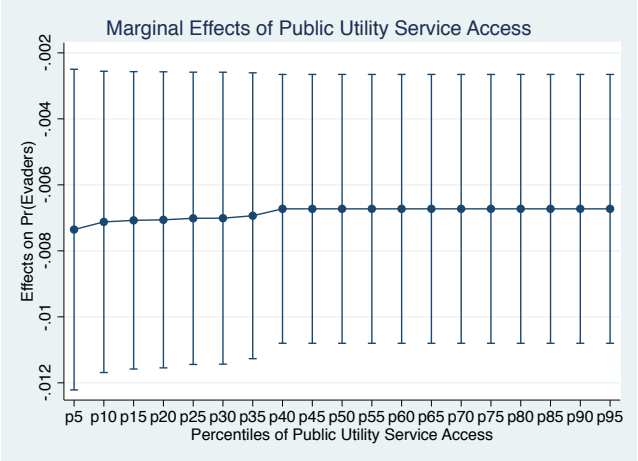


Figure 7: Marginal Effects of Public Utility Services

provided goods and tax evasion, Figures 5, 6 and 7 show the marginal effects of access to these goods and their confidence intervals. These graphs confirms a strong and increasing effect of access to publicly provided basic education for individuals with basic education index above the 40th quantile of the distribution, and constant positive effect for individuals with basic education index below the 35th quantile of distribution. Only in the case of basic education, the increases on access of publicly provided good increases the probability of being an evader. In the case of higher education the marginal effects are constant over the quantiles of the distribution of the indexes (Figure 6). For the public utility services access, the negative effect on the probability of being evader is slightly weaker above the 40th quantile.

Corner solution models, or Tobit models, are used in situations where the dependent variable is limited and thus assumes characteristics of both continuous and discrete variables. This analysis considers three types of individuals, with the dependent variable defined as the proportion of hours worked in the informal sector relative to the total number of hours worked. This variable, called the *ratio of informal hours*, is equal to one for informal workers and it assumes values between zero and one for evaders and is equal to zero for non-evaders. Thus, for individuals who are non-evaders, the optimal choice of hours worked in the informal sector

is zero, so that all working hours are allocated to the formal sector.

Formally, the *ratio of informal hours* variable is well characterized by a two-limit Tobit model. This model is most easily defined in terms of the latent variable y, which is the ratio of informal hours for each group. Let y^* be the ratio of informal hours of evaders, then:

$$\begin{aligned} y^* &= \mathbf{x}\boldsymbol{\beta} + u, \quad u \mid \mathbf{x} \sim \text{Normal}(0, \sigma^2) \\ y &= \begin{cases} 0 & if \quad y^* \leq 0 \\ y^* & if \quad 0 < y^* < 1 \\ 1 & if \quad y^* \geq 1 \end{cases} \end{aligned}$$

Note that $P(y = 0) > 0$ and $P(y = 1) > 0$, i.e., there are points in the distribution of y that occur with positive probability. The labor supply of formal and informal workers is located, respectively, at these points. For $0 < a < 1$, $P(y = a) = 0$. It is possible to show that, $P(y = 0|\mathbf{x}) = \boldsymbol{\Phi}((-\mathbf{x}\boldsymbol{\beta})/\sigma))$ and $P(y = 1|\mathbf{x}) = \boldsymbol{\Phi}(-(1 - \mathbf{x}\boldsymbol{\beta})/\sigma))$. Therefore, the conditional expectation of y is obtained as follows:

$$E[y|\mathbf{x}] = P(y = 0|\mathbf{x})0 + P(0 < y < 1\mathbf{x})E(y|\mathbf{x}, 0 < y < 1) + P(y = 1|\mathbf{x})1 \tag{11}$$

The model can be estimated via maximum likelihood, where the log-likelihood function is expressed as:

$$\begin{aligned} \log f(y_i|\mathbf{x_i}; \boldsymbol{\theta}) &= \mathbb{I}[y_i = 0] \log[\boldsymbol{\Phi}((-\mathbf{x}\boldsymbol{\beta})/\sigma] \\ &+ \mathbb{I}[y_i = 1] \log[\boldsymbol{\Phi}(-(1 - \mathbf{x}\boldsymbol{\beta})/\sigma] \\ &+ \mathbb{I}[0 < y_i < 1] \log[(1/\sigma\phi(y_i - \boldsymbol{\Phi}((\mathbf{x}\boldsymbol{\beta}))/\sigma] \end{aligned}$$

The vector of explanatory variables $\mathbf{x}$ contains two parts, such that: $\mathbf{x} = (\mathbf{x_j}; \mathbf{w_j})$, where $\mathbf{x_j}$ includes several individual characteristics, such as gender, age, education level, occupational choice, sector of activity, household income and others that affect the choice of the proportion of informal hours, while $\mathbf{w_j}$ contains variables that indicates access to publicly provided goods. The estimated model can then be rewritten as follows:

$$y^* = \mathbf{x_j}\boldsymbol{\beta_j} + \mathbf{w_j}\theta_j + u \tag{12}$$

The θ_j vector of coefficients, which expresses the effect of access to publicly provided goods on the informal labor supply, is of particular interest. Also of interest is the marginal effect of publicly provided goods. In the Tobit model, the marginal effect can be obtained by considering the expected value of y in equation (11) or the expectation conditional on $0 < y < 1$, i.e., $E[y|\mathbf{x}, 0 < y < 1]$. Given this conditional expectation, we can capture the effect of publicly provided goods exclusively on evaders, that is, individuals who access both labor markets. The computed marginal effect is, hence, $\partial E[y|\mathbf{x}, 0 < y < 1]/\partial w$. It is important to highlight that Tobit model estimates are useful to infer on correlation between formal/informal labor supply and publicly provided goods. Unfortunately this approach is not able to estimate causal effects.

Table VI reports the results of Tobit estimates for the effect of publicly provided goods on the ratio of informal hours. The first column shows a strong and positive effect of access to publicly provided basic education and a strong and negative effect of access to public higher education and utility services. But theses effects changes completely when we introduce individual demographic characteristics, household characteristics and, finally, labor variables. The final estimates in column (4) point to a positive and significant effect only in the case of publicly provided education. It means that an increase in the access or use of publicly provided education increases the supply of informal labor hours, that is related to tax evasion.

In order to complement the previous results, Table VII reports the conditional and the unconditional marginal effects of publicly provided goods on the ratio of informal labor hours. The marginal effect of access to publicly provided education, conditional on an individual work in both sectors, is always very small but significant, at least at 5 percent. Because of the small magnitude of these marginal effects, it is difficult to disentangle differences in the effects when examining different values for years of education and percentiles of wealth, as shown in Tables VIII-IX. The unconditional marginal effects of publicly provided education (basic and higher) are also significant and similar to the conditional one. We do not observe significant marginal effect of public utility services access on the ratio of informal labor hours. This result brings an evidence that access to basic infrastructure do not affect the intensive margin of labor supply in informal sector, although it is negatively correlated to the decision of being an evader, or better, to supply labor on both sector, formal and informal.

5 Conclusion

In this paper we study how households spend their time in the formal and informal sectors and evaluate how publicly provided goods with and without market substitutes affect their time allocation. Tax evasion reduces tax revenue and affects the provision of public goods. We consider a simple static formulation of public provision, where households consume two types of goods: a normal private good and a quasi-private good. In our model, the quasi-private good is education and its overall level for the household is a sum of the public provision of education and the private topped-up portion. Household needs some public utility services, for instance, electricity, natural gas, water, sewage and garbage collection, to consume the private good. Households supply labor to formal and informal sectors. Agents can work in the informal sector and still consume public goods. The relationship between time spent in the informal sector and the amount of public resources allocated to publicly provided private goods depends on the combination of factors, namely, the relative quality of private education *vis-à-vis* public education, the agent's non-labor income resources (wealth), the share of publicly provided utility services necessary for consumption of the private good and the amount of tax revenues allocated to publicly provided education. Empirically, using data from the PNAD (National Household Sample Survey) for the period 2007-2015 we construct indexes of access to three groups of publicly provided goods: (I) basic infrastructure or public utility services, (II) basic education and (III) higher education. Our logit results show a positive effect of

Table VI: Tobit Estimates Ratio of Informal Hours

		(1)	(2)	(3)	(4)
Variables	Access to public basic education	14.683***	5.999***	6.713***	0.116**
		(0.398)	(0.365)	(0.373)	(0.053)
	Access to public higher education	-8.061***	2.674***	6.507***	0.392***
		(0.918)	(0.846)	(0.851)	(0.091)
	Public Utility Services Access	-6.332***	-3.798***	-3.133***	0.023
		(0.325)	(0.299)	(0.294)	(0.035)
Individual	Women		4.763***	4.720***	-0.011
Demographic			(0.091)	(0.092)	(0.011)
Characteristics	white		-0.874	-0.539	-0.042
			(0.538)	(0.552)	(0.078)
	Black		-0.744	-0.710	0.028
			(0.545)	(0.558)	(0.079)
	Yellow		1.082	1.484**	-0.014
			(0.737)	(0.753)	(0.097)
	Brown		-0.496	-0.389	-0.013
			(0.540)	(0.553)	(0.078)
	Age		0.032***	0.064***	-0.002***
			(0.003)	(0.004)	(0.000)
	Spouse		0.099	0.426***	-0.060***
			(0.070)	(0.072)	(0.010)
	Son		1.480***	2.325***	-0.091***
			(0.095)	(0.101)	(0.013)
	Other Relative		1.190***	1.887***	-0.072***
			(0.143)	(0.149)	(0.020)
	Aggregate		2.194***	2.776***	-0.041
			(0.402)	(0.421)	(0.054)
	Guest		1.728**		
			(0.730)		
	Housekeeper		1.327**		
			(0.522)		
	Relative of Housekeeper		2.695		
			(5.615)		
	Years of Education		-0.824***	-0.695***	0.012***
			(0.014)	(0.013)	(0.002)
Household	Wealth			-17.477***	0.159***
Characteristics				(0.522)	(0.060)
	Per capita household income			0.000***	0.000***
				(0.000)	(0.000)
Labor Variables	Contributes do Social security? No				0.461***
					(0.019)
	Main job income				-0.000***
					(0.000)
	Dummies of Occupational Choice, Group of Occupation, Group of Activities				yes
	Year/State Dummies	yes	yes	yes	yes
Constant		-6.533***	-3.170***	2.008***	-2.287***
		(0.401)	(0.671)	(0.707)	(0.108)
Sigma		13.187***	12.471***	12.382***	0.843***
		(0.164)	(0.154)	(0.155)	(0.005)
Observations		814,250	811,461	772,469	772,469

Table VII: Marginal Effects of Publicly Provided Goods on the Ratio of Informal Labor Hours

	Conditional Marginal Effect E(ratio informal hours|0<ratio informal hours<1)						Unconditional Marginal Effects					
Access to	dy/dx	Std. Err.	t	P>t	[95% Conf.Int.]		dy/dx	Std. Err.	t	P>t	[95% Conf.Int.]	
Public basic education	0.011	0.005	2.180	0.029	0.001	0.021	0.014	0.006	2.18	0.029	0.001	0.026
Public higher education	0.037	0.008	4.320	0.000	0.020	0.053	0.046	0.011	4.32	0.000	0.025	0.067
Public utility services	0.002	0.003	0.640	0.523	-0.004	0.009	0.003	0.004	0.64	0.523	-0.006	0.011

Table VIII: Marginal Effects of Publicly Provided Goods on the Ratio of Informal Labor Hours - At Different Levels of Education

	Conditional Marginal Effect E(ratio informal hours|0<ratio informal hours<1)						Unconditional Marginal Effect					
Acess to	dy/dx	Std. Err.	t	P>t	[95% Conf.Int.]		dy/dx	Std. Err.	t	P>t	[95% Conf.Int.]	
Public basic education												
Years of Education												
1	0.008	0.055	0.15	0.879	-0.099	0.116	0.012	0.006	2.18	0.029	0.001	0.023
2	0.008	0.439	0.02	0.985	-0.851	0.868	0.013	0.006	2.18	0.029	0.001	0.025
3	0.009	0.006	1.31	0.190	-0.004	0.021	0.014	0.006	2.18	0.029	0.001	0.027
4	0.009	0.017	0.50	0.614	-0.025	0.042	0.015	0.007	2.18	0.030	0.002	0.029
Public higher education												
Years of Education												
1	0.036	0.008	4.32	0.000	0.020	0.052	0.041	0.010	4.28	0.000	0.022	0.059
2	0.036	0.008	4.32	0.000	0.020	0.053	0.045	0.010	4.31	0.000	0.024	0.065
3	0.037	0.008	4.32	0.000	0.020	0.053	0.048	0.011	4.33	0.000	0.026	0.069
4	0.037	0.009	4.32	0.000	0.020	0.054	0.052	0.012	4.33	0.000	0.028	0.075
Public utility services												
Years of Education												
1	0.002	0.003	0.64	0.523	-0.004	0.008	0.002	0.004	0.64	0.524	-0.005	0.010
2	0.002	0.003	0.64	0.523	-0.004	0.009	0.003	0.004	0.64	0.524	-0.005	0.010
3	0.002	0.003	0.64	0.523	-0.004	0.009	0.003	0.004	0.64	0.523	-0.006	0.011
4	0.002	0.003	0.64	0.523	-0.004	0.009	0.003	0.005	0.64	0.523	-0.006	0.012

Table IX: Marginal Effects of Publicly Provided Goods on the Ratio of Informal Labor Hours - At Different Quantiles of Wealth

	Conditional Marginal Effect E(ratio informal hours|0<ratio informal hours<1)						Unconditional Marginal Effect					
Acess to	dy/dx	Std. Err.	t	P>t	[95% Conf.Int.]		dy/dx	Std. Err.	t	P>t	[95% Conf.Int.]	
Public basic education												
Quantiles of Wealth												
1	0.011	0.005	2.18	0.029	0.001	0.020	0.013	0.006	2.18	0.029	0.001	0.025
2	0.011	0.005	2.18	0.029	0.001	0.021	0.013	0.006	2.18	0.029	0.001	0.026
3	0.011	0.005	2.18	0.029	0.001	0.021	0.014	0.006	2.18	0.029	0.001	0.026
4	0.011	0.005	2.18	0.029	0.001	0.021	0.014	0.006	2.18	0.029	0.001	0.027
5	0.011	0.005	2.18	0.029	0.001	0.021	0.014	0.007	2.18	0.029	0.001	0.027
Public higher education												
Quantiles of Wealth												
1	0.036	0.008	4.32	0.000	0.020	0.053	0.044	0.010	4.28	0.000	0.024	0.065
2	0.036	0.008	4.32	0.000	0.020	0.053	0.045	0.011	4.30	0.000	0.025	0.066
3	0.037	0.008	4.32	0.000	0.020	0.053	0.046	0.011	4.32	0.000	0.025	0.067
4	0.037	0.008	4.32	0.000	0.020	0.053	0.047	0.011	4.33	0.000	0.026	0.068
5	0.037	0.008	4.33	0.000	0.020	0.053	0.048	0.011	4.34	0.000	0.026	0.070
Public utility services												
Quantiles of Wealth												
1	0.002	0.003	0.64	0.523	-0.004	0.009	0.003	0.004	0.64	0.524	-0.005	0.010
2	0.002	0.003	0.64	0.523	-0.004	0.009	0.003	0.004	0.64	0.523	-0.005	0.011
3	0.002	0.003	0.64	0.523	-0.004	0.009	0.003	0.004	0.64	0.523	-0.006	0.011
4	0.002	0.003	0.64	0.523	-0.004	0.009	0.003	0.004	0.64	0.523	-0.006	0.011
5	0.002	0.003	0.64	0.523	-0.004	0.009	0.003	0.004	0.64	0.523	-0.006	0.011

access to public education (basic and higher) on the probability of evasion. Differently from public utility services, that affect negatively the probability of evasion, the consumption of these goods present substitute in the private sector. We observe a stronger effect of access to publicly provided basic education comparing with higher education. This result may be related to the different quality of publicly provision of higher and basic education. Tobit results suggest a positive and significant effect only in the case of publicly provided education, i.e., an increase in the access or use of publicly provided education increases the supply of informal labor hours.

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