Economics Bulletin

Volume 36, Issue 2

A Multi-Level Housing Hedonic Analysis of Water and Sanitation Access

Johanna Choumert
Economic Development Initiatives (E.D.I.)

N. Eric Kéré
African Development Bank

Amandine Loyal Laré-Dondarini
Centre d''Etudes et de Recherches sur le Développement International (CERDI-CNRS)

Abstract

Poor access to safe water and sanitation remains one of the most important development issues in Sub-Saharan African countries, causing significant morbidity and mortality. Development practitioners often cite the paradox of some projects where the improvement of the living conditions of populations –such as water and sanitation access– leads to increased housing prices, forcing the eviction of the poorest. In this context, the purpose of the present study is to examine, in the context of an African city, the impact of housing characteristics on housing values using the hedonic price method with a focus on water and sanitation. Using primary data collected in Togo, we show that households pay a premium for these essential amenities. Such results call for further analysis in African countries to investigate the impact of basic infrastructures on populations through housing markets.

The authors are grateful to the Editor and anonymous referees for their helpful comments. They also thank participants at the Journées de Microéconomie Appliquée (JMA) in June 2014. The usual disclaimers apply.
Citation: Johanna Choumert and N. Eric Kéré and Amandine Loyal Laré-Dondarini, (2016) "A Multi-Level Housing Hedonic Analysis of Water and Sanitation Access", *Economics Bulletin*, Volume 36, Issue 2, pages 1010-1037
Contact: Johanna Choumert - j.choumert.nkolo@surveybe.com, N. Eric Kéré - e.kere@afdb.org, Amandine Loyal Laré-Dondarini - loyallare@gmail.com.
Submitted: January 18, 2016. **Published:** June 11, 2016.

1. Introduction

Access to safe water and sanitation is a critical issue in most urban and rural areas in Sub-Saharan African countries. The health and economic impacts of improved access to water and sanitation are well documented in the literature (Galiani et al., 2005; Jenkins and Curtis, 2005; Hutton et al., 2007; Pattanayak et al., 2010; Olivier, 2010; Briand et al., 2010; Roushdy et al., 2012).[1] In sub-Saharan Africa, one dollar invested in the water sector yields 2.8 dollars of returns, whereas a similar investment in the sanitation sector yields a return of 6.6 dollars (Hutton et al., 2007). Togo, like many Sub-Saharan African countries, lags behind the other developing and emerging countries (DHS, 2015). Only 62% (86% urban, 47% rural) of the population has access to improved water, and very few have it within their dwelling (5%); Only 13.5% of the population has access to improved sanitation facilities (DHS, 2015).

Expanding the access to improved water and sanitation is particularly sensitive in African countries in the current context of rapid urbanization and constant extension of cities (Sy et al., 2014). This strong urbanization generates increased need for housing, bringing along a proliferation of irregular neighbourhoods that have a deficit of urban basic services (Jaglin, 2001). In particular, an increasing share of the population lacks access to safe water (Baron, 2006). In this context, it is a research imperative to analyze the formation of housing values and to determine how utilities are capitalized into these values.

Recent studies put forward the considerable cost of extending the water network in developing countries (Nauges and Van Den Berg, 2009; Onjala et al., 2013; Stage and Uwera, 2012). As pointed out by Stage and Uwera (2012), massive water investment programs are still a long way off in poorer countries. What is more, if new connections are established, households may be required to pay the entire investment cost. For liquidity-constrained households, such expenditure is unrealistic. One way to secure a water connection and sanitation is to buy or rent a dwelling that is already connected to these basic services. As a consequence, the real estate market is expected to reflect the value of water and sanitation access. More research is needed to understand households' willingness-to-pay for water and sanitation. This is especially important as evidence suggests the paradoxical effect of some development projects, when urban projects improve living conditions but lead to the eviction of the poorest, who were the intended beneficiaries of the program (Josse and Pacaud, NA; Rakodi, 1992).

In this paper, we estimate the costs incurred by households to access water and sanitation in the city of Dapaong in Togo, which is a good example of a growing African city. The structure of this paper is as follows. Section 2 discusses the literature on the use of the hedonic price method applied to water and sanitation in the African context. Data collection is presented in Section 3. Section 4 covers the empirical strategy. Results and policy implications are discussed in Section 5 before we conclude.

[1] The impact of health is striking, with 0.4% of children under 5 passing away due to poor water, sanitation or hygiene in 2004 in Togo (0.287 in developing countries) (UNDP, 2016).

2. Literature Review

Revealed preferences methods such as the Hedonic Pricing Method (HPM) have drawn attention from scholars for several decades, but not in African countries, due to the lack of real estate data. Existing studies provide contrasted results on the value of water and sanitation access. Asabere (1981) and Asabere (2004) analyzed housing values in Ghana and found a significant impact of a package of services that includes piped water. However, access to water was not studied separately. Megbolugbe (1989) investigated property values in Jos, Nigeria and found that access to water mattered for the valuation of single-household dwellings but not for multi-household dwellings. Arimah (1992) did not find a significant impact of access to piped water or of having a water-operated lavatory when analyzing the rental housing in Ibadan (Nigeria). Knight et al. (2004) studied rental prices in Uganda. They found a positive effect of piped water and flush toilets on rents. Gulyani and Talukdar (2008) found that access to piped water and "reasonable access to toilet"[2] were determinants of monthly rent in Nairobi slum areas in Kenya. In a study on sale prices in South Africa, Els and Von Fintel (2010) found that the number of bathrooms did matter. Finally, Choumert et al. (2014) found a strong positive impact of piped water and sanitation access on rental values in Kigali, Rwanda. It is therefore difficult to draw conclusions from this still embryonic literature.

3. Data Collection

3.1. Dapaong city

Dapaong city in Northern Togo is in the constituency of Tone, in the Savannah region (the poorest region of the country). It is located 650 km away from Lomé, the capital city of Togo, and 300 km from Ouagadougou, the capital city of Burkina Faso. It is divided into 26 districts and its population is estimated at 68,650 inhabitants (Direction Régionale de la Statistique, 2010) (See Figure 1).

3.2. Investigation and data collected

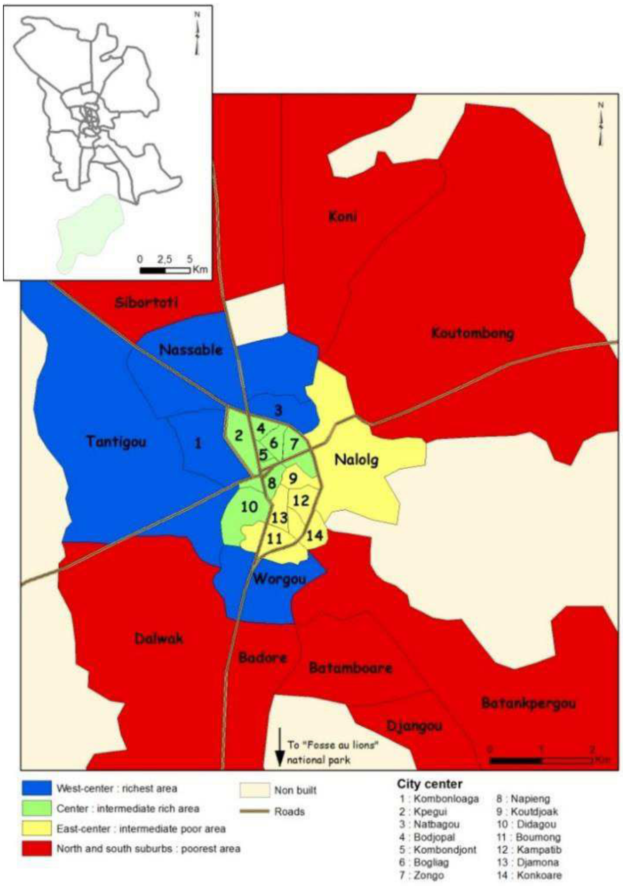
A household survey was conducted in 2010 from April to June[3] (see appendix A for more details on the survey). Our data set contains information for 277 households who own their dwelling and live in a celibatorium (dwelling composed of several housing units, but different from an apartment building). One household was interviewed in each celibatorium.

Housing values were self-reported by households.[4] The extent to which self-reported housing values approximate market values is, of course, a critical issue for the hedonic analysis. There are, however, several convincing arguments validating this proxy. First, we can postulate that

[2] "Defined as those where the renter shares a toilet facility with less than ten households."
[3] The questionnaire was administered before the start of a project of the NGO EAST (Eau Agriculture Santé en Milieu Tropical) funded by the SEDIF (Syndicat des Eaux d'Ile de France) and the city of Issy-Les-Moulineaux (France). The purpose was to study a front project for the extension of the public water network by the TDE (Togolaise des Eaux, the public company for water supply in Togo), and the promoting of family and public latrines.
[4] The question asked was: Valeur de la maison (estimation): ... FCFA (Translation: What is the estimated value of the dwelling in CFA Francs?)

owners are the best informed on the various attributes of their housing because it is a dominant asset for them. Second, respondents did not have an incentive to misreport the value of their home, as the scope of the survey was access to water, hygiene and sanitation. Third, previous studies suggest that self-reported housing values are suitable for hedonic analysis (Cheshire and Sheppard, 1995, 1989; Gravel et al., 2006; Henneberry, 1998; Herath et al., 2014; Orford, 2000; Shultz and King, 2001). Freeman (1979) stressed that using self-reported housing values will not bias the estimates of the hedonic model except if the errors are correlated with the explanatory variables of the model. This point is further discussed in section 4.5.

Figure 1. The city of Dapaong



3.3. Access to water and sanitation in Dapaong

In our sample, 93% of households are not connected to the water network (cf. Table I). The low share of households connected to the water network, and particularly the absence of tap connection in the Northern and Southern peripheries of Dapaong, can be explained by the lack of water network in these areas. For drinking water, households mainly resort to retailers and wells that may or may not be protected. Among households that do not have access to tap water, 73% are not satisfied with their current conditions of water access. The main reason given is the difficulty to collect water.

The sanitation situation is more alarming. According to our survey, 28% of households still defecate in the fields and 49% use traditional latrines (cf. Table I). In the Northern and

Southern suburbs, 64% do not have latrines compared with 19% in the Center. 58% of households are not satisfied with those practices of sanitation, mainly because of the lack of intimacy and hygiene. The most dissatisfied are on the outskirts of the city. And having a latrine is in itself a reason for satisfaction.

Table I. Access to water and sanitation in Dapaong (% of households)

	Access to piped water	Ventilated improved pit latrine	Ecological latrine	Manual flush latrine	Modern flush latrine	Public latrine	Traditional latrine	Nature (no latrine)
All City	7.2	11.2	1.4	6.1	1.0	2.5	49.4	28.1
North and South Suburbs	0	4	8	4	0	0	20	64
West-Center	9.5	8.3	0	4.7	2.3	0	59.5	25
East-Center	7.8	18.7	3.1	7.8	0	0	37.5	32.8
Center	6.7	10.5	0	6.7	1	6.7	55.7	19.2

N=277

4. Empirical Analysis

4.1. Variables

The dataset includes 277 housing units, the so-called “celibatoriums”. The description and descriptive statistics of housing and households characteristics are provided in Table II. Households have better access to sanitation than water. Access to tap water relies on water provision, which implies major investments costs, which depend on public policies; whereas households can more easily install latrine facilities in their dwelling. Average house prices are the highest in the central districts, which have better access to amenities (Figure 1 and Figure 2). Most of the better-off households are concentrated in these areas. Conversely, the poorest populations are concentrated in neighborhoods where house prices are the lowest, on average.

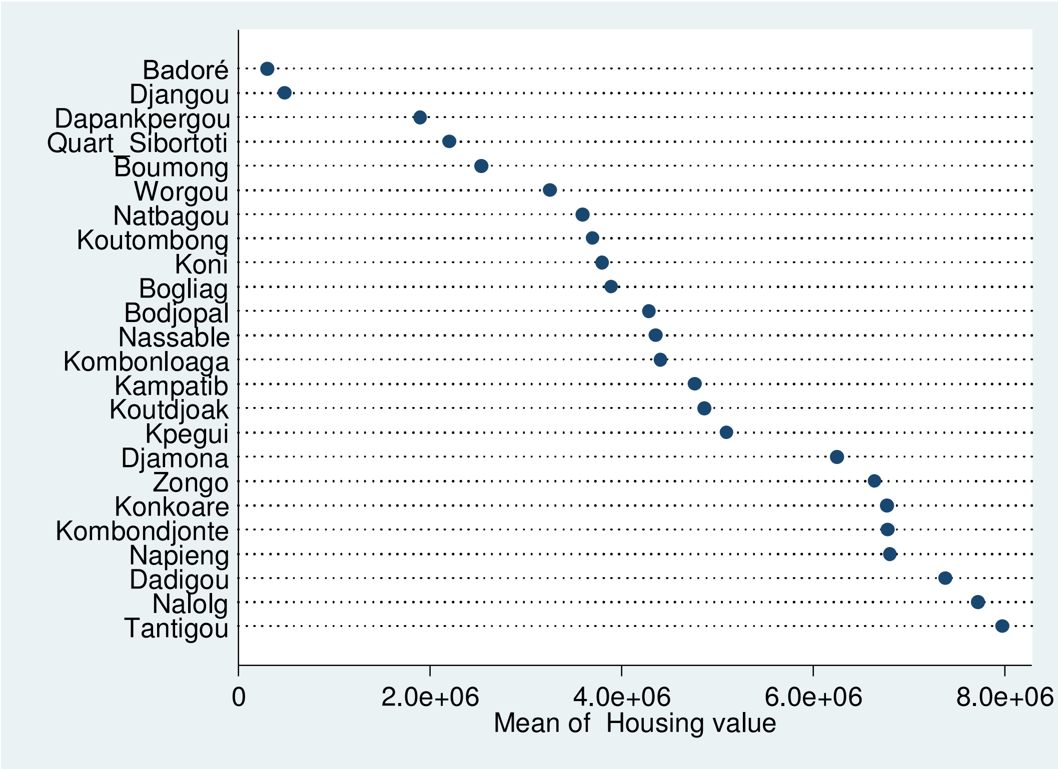
Table II. Descriptive statistics

VARIABLES	Description	mean	sd	min	max
Housing_value	Reported value in CFA Francs	5,166,227	5,218,260	300,000	3,500,000
LnHousing_value	Log of the Housing_value	15.15	0.77	12.61	17.37
Room	Number of rooms (bedrooms and living rooms, excluding: bathrooms, kitchens and toilets)	8.77	5.02	2	37
LnRoom	Log of Room	2.03	0.52	0.69	3.61
Latrine_VIP	= 1 if Ventilated Improved Pit latrine	0.11	0.32	0	1
Latrine_Ecosan	= 1 if Ecological latrine	0.01	0.12	0	1
Latrine_TMC	= 1 if Manuel flush latrine	0.06	0.24	0	1
Latrine_Moderne	= 1 if Modern latrine	0.01	0.10	0	1
Latrine_Publique	= 1 if Public latrine	0.03	0.16	0	1
Latrine_Tradition	= 1 if Traditional latrine	0.50	0.50	0	1
Latrine_Nature	= 1 if Nature (No latrine)	0.28	0.45	0	1
Latrine_MDG	= 1 if Improved latrine, as defined in the MDGs[5]	0.10	0.14	0	1
Elec_water	= 1 if both electricity and water	0.07	0.26	0	1
Elec_only	= 1 if electricity only	0.47	0.50	0	1
Water_only	= 1 if water only	0	0	0	0
Cement_wall	= 1 if the construction material of walls is cement	0.85	0.36	0	1
Adobe_wall	= 1 if the construction material of walls is adobe	0.15	0.36	0	1
Adobe2_wall	= 1 if the construction material of walls is improved adobe	0.00	0.06	0	1
Cement_floor	= 1 if the construction material of the floor is cement	0.96	0.19	0	1
Sand_floor	= 1 if the construction material of the floor is sand	0.02	0.13	0	1
Clay_floor	= 1 if the construction material of the floor is clay	0.02	0.13	0	1
HHH_age	Age of the head of household	46.53	12.46	18	80

[5]Improved latrines as defined in the Millennium Development Goals (MDGs) are Ventilated improved pit latrines, Ecological latrines, Manual flush latrines and Modern flush latrines.

HH_size	Size of the household	7.75	4.30	1	26
Marital_status *(N=275)*	=1 if head of household is married	0.79	0.40	0	1
Income *(N=276)*	Household income (per month)	7,3044.48	8,2709.92	11,250	1,000,000
HHH_edu	=1 if head of household is illiterate	0.30	0.45	0	1
HHH_woman	= 1 if the head of household is a woman	0.17	0.38	0	1
Number_Household	Number of households in the celibatorium	1.82	1.69	1	13
Association_sanitation	=1 if household is an association member before their sanitation technology choice	0.05	0.23	0	1
Children	Number of children aged 3 to 15 years	4.13	2.80	2	16
N			277		

Figure 2. Average value of homes based on districts



4.2. Fixed effects models versus random effects models

According to Jones and Bullen (1994) and Orford (2000), the hedonic price function applied to the housing market can be written as follows:

$$P_i = \beta_0 + \sum_{k=1}^{K} \beta_k X_{ki} + \varepsilon_i \quad (1)$$

where: $i = 1, \ldots, N$; P_i : the price of the housing; X_{ki} : its attributes; and $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$: the random error term.

The City of Dapaong is divided into 26 districts. To take into account the effect of belonging to a neighborhood, we can use either a fixed effects model (FEM) or a random effects model (REM). In the FEM, belonging to a neighborhood is taken into account by a dummy variable = 1 for residents of the district and = 0 otherwise, such that:

$$P_i = \beta_0 + \sum_{k=1}^{K} \beta_k X_{ki} + \sum_{j=1}^{J-1} \alpha_j Q_{ij} + \varepsilon_i \quad (2)$$

where $j = 1, \ldots,$ J designates the district where the owner lives and α_j the fixed effect linked to belonging to district j.

According to Jones (1991), this model assumes that "*all the relevant variation is at one scale, that there is no auto-correlation, and that there is a single general relationship across space* *and time … [T]his model denies geography and history; everywhere and anytime is basically the same*."

The REM (called variance components model or multi-level model) allows taking into account the spatial correlation of house prices in the inner districts (Jones, 1991; Jones and Bullen, 1994; Orford, 2000). In this case, the hedonic price function is written as follows:

$$P_{ij} = \beta_{0j} + \sum_{k=1}^{K} \beta_k X_{ki} + \varepsilon_i \qquad (3)$$

With $\beta_{0j} = \beta_0 + u_j$ and $u_j \sim N(0, \sigma_u^2)$ as the same random effect for all the houses in the same district, it can capture the effect of context related to membership in a neighborhood. Therefore, the error term of the model is composed of two parts. The first component is the unobserved heterogeneity $u_j \sim N(0, \sigma_u^2)$, which is specific to each district and constant between households in the same district. The second component $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$ is the usual error term that varies between households and between districts.

In this study, the REM is more relevant. Indeed, according to the localization of districts (proximity to the city center) and the level of amenities (markets, schools, etc.), quality of life will be different from one area to another. In fact, as can be seen in Figure 2, house prices generally tend to be higher in areas where the quality of life is high. Home prices vary, therefore, at two distinct geographical levels, the individual one (housing unit) and at the neighborhood one. Furthermore, according to Orford (2000), "*inferential errors are likely to occur when inappropriate single-level models are used, and when multilevel data are modelled using techniques designed for a random sample, such as OLS regression. These problems can be overcome by specifying the model, not as varying at a single level, but as varying simultaneously over a number of levels*." In addition, according to Anselin (2002) and Wendland et al. (2011), the decomposition of the error term of the REM into its nesting components allows taking into account the spatial correlation of the error term in districts. Finally, the Hausman test allows us to accept the null hypothesis of independence between errors and explanatory variables (in the linear, lin-log, log-lin models). We therefore opt for an REM.

The model to be estimated can be written in the following reduced form:

$$P_{ij} = \beta_0 + u_j + \sum_{k=1}^{K} \beta_k X_{ki} + \varepsilon_i \quad (4)$$

4.3. Estimation strategy

Using the maximum likelihood estimator, we first estimate models without explanatory variables in order to calculate the contribution of each level (individual and district) to the total variance of house prices. We then calculate the intra-district correlation $\rho = \frac{\sigma^2{}_u}{\sigma^2{}_\varepsilon + \sigma^2{}_u}$. According to our results (cf. Table III), house prices are correlated within neighborhoods. 3.1% to 16.5% of the total variance in house prices is explained by membership in a district. Having a significant correlation corroborates the idea that house values are not independent within a district.

Table III. Hedonic price models without explanatory variables

	Celibatoriums	
VARIABLES	Housing_value	lnHousing_value
σ_u	1010225**	0.3197***
	-460,783	(0.0885)
σ_ε	5110922***	0.7108***
	-224,648	(0.0321)
ρ	0.0376	0.1682
Constant	5064852***	15.0863***
Observations	277	277
Number of Districts	24	24

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

We then estimate the full model with all explanatory variables (cf. Table IV and Table V). We estimate four functional forms, i.e. linear, lin-log, log-lin, and log-log models. In order to select the appropriate model, we use the J-test[6] and PE-test (cf. Appendix B). Tests indicate that the log-lin model is the best specification.

Table IV. Hedonic price models for celibatoriums

VARIABLES	Model A Lin_lin	Model B Lin_log	Model C Log_lin	Model D Log_log
Room	608,580***		0.0654***	
	(49,900)		(0.0078)	
lnRoom		4,645,678***		0.5704***
		(529,833)		(0.0783)
Cement_wall	1,121,781*	941,172	0.3167***	0.2962***
	(670,985)	(736,786)	(0.1045)	(0.1070)
Cement_floor	904,593	1,144,894	0.4007**	0.4085**
	(1,268,041)	(1,391,986)	(0.1973)	(0.2020)
Elec_water	3,853,869***	4,753,430***	0.3859**	0.4524***
	(990,494)	(1,080,030)	(0.1545)	(0.1572)
Elec_only	23,892	122,364	0.1200	0.1079
	(535,700)	(594,350)	(0.0844)	(0.0873)

[6] The J-test performs the Davidson-MacKinnon J test for comparing non-nested models. Following the J-test, if the first model is correctly specified, then including the fitted values of the second model into the set of regressors should provide no significant improvement. But if it does, it can be concluded that model 1 is not correctly specified. PE-test performs the MacKinnon-White-Davidson PE test for comparing linear vs. log-linear specifications. Following the PE-test, if the linear specification is correctly specified then adding an auxiliary regressor with the difference of the log-fitted values from both models should be non-significant. Conversely, if the log-linear specification is correct, then adding an auxiliary regressor with the difference of fitted values in levels should be non-significant. (For further details, see: Davidson and MacKinnon (1981); MacKinnon et al. (1983); and Greene (2003)).

Latrine_VIP	932,778	957,939	0.2627**	0.2677**
	(856,808)	(941,362)	(0.1333)	(0.1365)
Latrine_Ecosan	574,572	1,528,904	-0.3423	-0.2468
	(1,968,848)	(2,159,612)	(0.3067)	(0.3137)
Latrine_TMC	789,305	1,487,035	0.1153	0.1704
	(1,068,197)	(1,170,388)	(0.1656)	(0.1690)
Latrine_Moderne	-2,413,461	-3,069,680	-0.4075	-0.4854
	(2,260,966)	(2,484,055)	(0.3508)	(0.3589)
Latrine_Publique	-692,876	-288,942	0.0110	0.0543
	(1,529,647)	(1,674,783)	(0.2357)	(0.2412)
Latrine_Tradition	693,881	818,598	0.1972**	0.2076**
	(586,041)	(643,295)	(0.0914)	(0.0935)
σ_u	805,306**	839,475**	0.2113***	0.2240***
	(337,279)	(367,745)	(0.0708)	(0.0708)
σ_ε	3,718,400***	4,086,410***	0.5719***	0.5850***
	(163,790)	(179,733)	(0.0260)	(0.0265)
ρ	0.0448	0.0404	0.1201	0.1278
R^2	0.4666	0.3588	0.3880	0.3540
Constant	-2,809,902**	-7,236,451***	13.6782***	13.0891***
	(1,285,820)	(1,620,292)	(0.2035)	(0.2385)
Observations	277	277	277	277
Number of Districts	24	24	24	24

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

Table V. Implicit marginal prices for Model C

VARIABLES	Implicit marginal price
Room	337,871***
Cement_wall	1,636,144***
Cement_floor	2,070,107**
Elec_water	1,993,646**
Elec_only	619,947
Latrine_VIP	1,357,167**
Latrine_Ecosan	-1,768,399
Latrine_TMC	595,665
Latrine_Moderne	-2,105,237
Latrine_Publique	56,828
Latrine_Tradition	1,018,779**

*** p<0.01, ** p<0.05, * p<0.1

Moreover, it is necessary to take into account the potential endogeneity between the price of the dwellings and the quantities of characteristics. Indeed, buyers can simultaneously choose the price and some characteristics. As we suspect the number of rooms to be endogenous, we define two instruments: the number of households in the celibatorium and the number of individuals. These are correlated with the number of rooms but not with the housing value. The test of over-identifying restrictions suggests that we cannot reject the null hypothesis that the instruments are uncorrelated with the error term in the structural model. However, conducting the Hausman test for endogeneity leads to a high p-value for all models (Models A, B, C and D). Hence, we cannot reject the null hypothesis that the number of rooms is exogenous in all specifications.

Finally, we estimate all models, i.e. linear, lin-log, log-lin, and log-log models, with districts fixed effects. Ours results are similar to those obtained by REM (Appendix C).

4.4. Results

The results corroborate the importance of intrinsic characteristics of dwellings such as the number of rooms. Our estimates also stress the importance of access to piped water and electricity. They suggest that having electricity and water jointly is highly capitalized in house values. Our results are in line with existing studies in African countries (Gulyani and Talukdar, 2008; Choumert et al., 2014). However, one should be aware that the utility dummies may capture the presence of unobserved amenities. Therefore, our results should be interpreted as upper bound values.

Regarding latrines, our results highlight the capitalization of VIP and traditional latrines compared to not having latrines. Such results are in line with expected results. Previous studies have highlighted the importance of having latrines to explain house/rental values (e.g. Knight et al., 2004, in Uganda; and Gulyani and Talukdar, 2008, in Kenya).

4.5. Robustness check

We perform two robustness checks, which we expose according to different potential concerns. The first is related to the hypothetical nature of housing prices (self-reported). Indeed, although the characteristics used above explain largely the price of houses, our estimate could be biased if the potential measurement errors of housing prices are not random. Following Vásquez (2013a), we include socio-economic and demographic variables in our best specification (log-lin) to control for this problem. The results reported in Table VI show that no socio-demographic characteristics significantly affect housing prices. This suggests that there is no self-declaration bias related to the households' characteristics.

Table VI. Hedonic price models: self-reported hypothesis

VARIABLES	Log_lin lnHousing_value
Room	0.067***
	(0.008)
Cement_wall	0.321***
	(0.105)
Cement_floor	0.502**
	(0.206)
Elec_water	0.388**
	(0.158)
Elec_only	0.141
	(0.086)
Latrine_VIP	0.268**
	(0.137)
Latrine_Ecosan	-0.329
	(0.307)
Latrine_TMC	0.164
	(0.168)
Latrine_Moderne	-0.409
	(0.352)
Latrine_Publique	0.006
	(0.236)
Latrine_Tradition	0.209**
	(0.093)
HHH_age	0.001
	(0.003)
HH_size	-0.014
	(0.009)
Marital_status	-0.261
	(0.169)
Income	-0.000
	(0.000)
HHH_edu	0.028
	(0.089)
HHH_woman	-0.285
	(0.185)
σ_u	0.183***
	(0.068)
σ_ϵ	0.571***
	(0.026)
Constant	13.876***
	(0.291)
Observations	274
Number of Districts	24

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

Second, studies have shown that water and sanitation variables may be endogenous (Nauges et al. 2009; Vásquez 2013b). For this purpose, we need variables that explain the access to water (sanitation) and have no direct effect on the value of houses and sanitation (access to drinking water).

Because it is difficult to find an instrumental variable for each type of sanitation, we build one sanitation variable (*latrine_MDG*) equal to one if the household uses improved latrines as defined in the MDGs. We use households' membership in an association before their latrine choice as an instrumental variable. In Dapaong city, most property owners who haven't inherited their dwelling, often buy land and build their own house, which enables them to choose the kind of latrine they desire. This variable $Association\_sanitation$ can be interpreted as a proxy of their social network. We assume that households who belong to an association are more likely to hear information about the direct and indirect benefits of the different types of latrines (Laré-Dondarini, 2015).

For access to water, we use the number of children aged 3 to 15 years in the household as an instrumental variable. Indeed, children of this age usually help their parents in collecting water; this will tend to reduce the probability of connection to the drinking water network. In their study of Bamako, Briand and Laré-Dondarini (2016) showed that when a child carries the main responsibility for collecting water, the household is more inclined to choose a stand post at the expense of access in the dwelling. These children are usually between 3 and 15 years.

Therefore, the hedonic price function is rewritten as follows:

$$\begin{cases} \log(Housing\_value_{ij}) = \beta_0 + u_j + \beta_1 X_i + \varepsilon_{1i} \\ Elec\_water_i = \beta_{20} + \beta_{21} X_i + \beta_{22} SD_i + \beta_{23} Children_i + \varepsilon_{2i} \\ Latrine\_MDG_i = \beta_{30} + \beta_{31} X_i + \beta_{32} SD_i + \beta_{33}\, Association\_sanitation_i + \varepsilon_{3i} \end{cases} \quad (5)$$

where *SD* is the vector of households socio-demographic variables, $Children$ the number of children between 3 and 15 years and $Association\_sanitation$ the membership in an association before their latrine choice.

This model is estimated using the conditional mixed process estimator with multilevel random effects and coefficients (cmp) developed by Roodman (2011) and available on Stata software. This estimator allows estimating the model as three simultaneous and recursive equation systems and at the same time, taking into account the random effects. This estimator also allows considering the house price equation as a continuous variable and water and sanitation as discrete (probit model). The results presented in Table VII confirm the capitalization of access to water and electricity in the value of the house; in contrast, the presence of sanitation has a non-significant positive effect. The two types of latrines that were significant

(Latrine_VIP and Latrine_Tradition) in Table IV, are not significant when taking into account sanitation endogeneity.

Table VII. Hedonic price models: endogeneity

VARIABLES	Robustness 2			Robustness 3			Robustness 4		
	lnHousing	Elec_water	Latrine_MDG	lnHousing	Elec_water	Latrine_VIP	lnHousing	Elec_water	Latrine_Tradition
Elec_water	0.525**		1.428***	0.530**		1.179***	0.845***		1.025***
	(0.242)		(0.346)	(0.237)		(0.438)	(0.215)		(0.271)
Latrine_MDG	0.101	1.907***							
	(0.143)	(0.379)							
Latrine_VIP				0.233	3.200***				
				(0.179)	(0.849)				
Latrine_Tradition							-0.171	2.229***	
							(0.131)	(0.323)	
Room	0.064***	0.090*	-0.000	0.065***	0.134***	-0.030	0.061***	0.126***	-0.009
	(0.013)	(0.053)	(0.020)	(0.012)	(0.033)	(0.025)	(0.013)	(0.041)	(0.016)
Cement_wall	0.301*	0.764	0.221	0.298*	1.110	0.158	0.292*	0.976	0.071
	(0.161)	(0.716)	(0.299)	(0.160)	(0.681)	(0.374)	(0.176)	(0.626)	(0.225)
Cement_floor		-			-	-		-	
Elec_only		-			-			-	
Cement_floor	0.428		0.136	0.413			0.438		0.199
	(0.336)		(0.630)	(0.333)			(0.373)		(0.433)
Elec_only	0.199		0.487**	0.192		0.635**	0.280*		0.557***
	(0.124)		(0.202)	(0.128)		(0.259)	(0.148)		(0.169)
HHH_age		0.029	0.014*		0.041*	0.021**		0.047***	-0.008
		(0.026)	(0.008)		(0.024)	(0.010)		(0.014)	(0.007)

HH_size		0.046	-0.039		0.073	-0.042		-0.059*	0.047**
		(0.057)	(0.025)		(0.061)	(0.030)		(0.032)	(0.020)
Marital_status		-0.308	-0.126		-0.394	-0.588		-0.084	-0.117
		(0.925)	(0.443)		(0.992)	(0.489)		(0.687)	(0.356)
Income		0.000***	0.000		0.000***	0.000		0.000**	0.000
		(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.000)
HHH_edu		-0.950	-0.260		-1.519**	-0.095		-0.910***	-0.148
		(0.662)	(0.243)		(0.714)	(0.298)		(0.241)	(0.190)
HHH_woman		0.265	-0.241		0.375	-0.747		0.012	0.026
		(0.919)	(0.489)		(0.984)	(0.562)		(0.696)	(0.389)
Children		-1.349**			-1.622***			-1.592***	
		(0.559)			(0.555)			(0.344)	
Association_sanitation			0.935***			1.236***			-0.756**
			(0.324)			(0.343)			(0.354)
σ_u	0.1981***			0.194***			0.224***		
	(0.054)			(0.066)			(0.067)		
σ_ϵ	0.589***			0.587***			0.604***		
	(0.026)			(0.026)			(0.029)		

N = 277

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

5. Discussion

Despite considerable efforts, water, sanitation and hygiene remain striking issues in developing countries, especially in Sub-Saharan Africa. Our analysis supports the idea that the presence of water and sanitation utilities in dwellings is positively capitalized in their value. This can cause two related effects: (i) house prices will be higher due to a premium related to the presence of water and latrines. Thus, only one category of households, probably better-off, will be able to afford these dwellings; (ii) on the rental market, we may expect this premium to increase rental values and thus affect poorer households. This argument is supported by existing studies that find a positive relationship between rents and the presence of toilets, e.g. in Uganda (Knight et al., 2004) and in Kenya (Gulyani and Talukdar, 2008).

As observed by Malpezzi et al. (1985), information on the functioning of housing markets in developing countries remains relatively scarce compared to that in developed countries, although necessary for policy makers when addressing urban policies. What is more, "*in developing countries, only a small number of studies have been done, and these are only linked to policy applications*" (Malpezzi et al., 1985). Water and sanitation policies are part of the wider problem of land management in African cities. The crucial question raised by development actors is whether projects that are intended to help the most disadvantaged populations really benefit them. And more generally, to what extent do they contribute to the fight against poverty? Further research should investigate the question within a relevant framework such as an impact evaluation or the use of panel data. More precisely, further research could investigate whether one consequence of a positive relationship between house values, water and sanitation could be the eviction of the poorest people in these neighborhoods (risk of counter—redistributive dynamic effects). Rakodi (1992) refers to the "*…'hijacking' of housing or plots intended for the poor by higher income groups*" and emphasizes the "*realization that housing for the urban poor must be considered within the context of the housing sector as a whole*." These people will most often move a little further out, most commonly to areas lacking basic services. This is partly responsible for the constant expansion of cities to the periphery and the development of many poor and informal neighborhoods (Jaglin, 2001).

What is more, cost-benefit analyses of urban amenities in African cities should be considered. Even if studies find that tap water and sanitation increase housing values or rental prices, tap water is often less costly than private vendors, as noted, for instance, by Gulyani and Bassett (2007). One should also take into account the premium households pay when given access to tap water or private latrines, in order to fully capture the cost of access. Indeed, as argued by Malpezzi (1999), intervention in the housing market or infrastructure should be accompanied by an analysis of how the intervention changes prices.

Finally, the results of the current study indicate that the HPM is a useful tool to analyze the development of a city in the developing world. In the context of studying the growth and financing of the "African city", water policy meets a vital need of the population -whether through public or private provision, and whether funded domestically or through international funding-. What is more, the provision of drinking water and sanitation cannot be reduced to a vector of development and differentiation of a neighborhood or a city through the promotion of a pleasant lifestyle. Beyond the immediate effects on health, access to water and sanitation has a considerable impact on households in developing countries. In fact, decent housing, for example, would increase women's access to the labor market (Malpezzi, 1999; Collier and Venables, 2013), as they would have less work to do at home, such as collecting water. The revealed importance of sanitation in the issue of urban development contributes to rendering public decision-making even more complex—not only do households have to pay for their water consumption, but they also have to pay a premium to have access to sanitation in their homes. In this context, the implementation of a second step would be to assess the actual cost to households of accessing these sanitation services, with a view toward using such cost-benefit analysis to streamline public decisions and international funding.

6. References

Anselin, L. (2002) Under the hood: Issues in the specification and interpretation of spatial regression models. *Agricultural Economics* **2**(27), 247–267.

Arimah, B. (1992) Hedonic Prices and the Demand for Housing Attributes in a Third World City: The Case of Ibadan, Nigeria. *Urban Studies* **29**, 639–651.

Asabere, P.K. (2004) The Pricing of the Emergent Leasehold (Possessory) Estates of Ghana. *Real Estate Economics* **32**, 673–694.

Asabere, P.K. (1981) The Determinants of Land Values in an African City: The Case of Accra, Ghana. *Land Economics* **57**, 385.

Baron, C. (2006) *Mutations institutionnelles et recompositions des territoires urbains en Afrique : une analyse à travers la problématique de l'accès à l'eau*. Développement durable et territoires, Dossier n°6, Les territoires de l'eau. https://developpementdurable.revues.org/2940.

Briand A., Laré-Dondarini A.L. (2016) La demande pour des services améliorés en eau potable : une analyse du consentement à payer des ménages bamakois et de quartiers précaires de Ouagadougou. Forthcoming, *Revue d'Economie Régionale et Urbaine*.

Briand, A., Nauges, C., Travers, M. (2009) Les déterminants du choix d'approvisionnement en eau des ménages de Dakar. *Revue d'économie du développement* **17**, 83–108.

Briand, A., Nauges, C., Strang, J., Travers, M. (2010) The Impact of Tap Connection on Water Consumption Patterns: The Case of Household Water Use in Dakar, Senegal. *Environment and Development Economics* **15**(1), p. 107-126.

Cheshire, P., Sheppard, S. (1995) On the Price of Land and the Value of Amenities. *Economica* **62**, 247–267.

Cheshire, P., Sheppard, S. (1989) British Planning Policy and Access to Housing: Some Empirical Estimates. *Urban Studies* **26**, 469–485.

Choumert, J., Stage, J., Uwera, C. (2014) Access to water as determinant of rental values: a housing hedonic analysis in Rwanda. *Journal of Housing Economics* **26**, 8–54.

Collier, P., Venables, A.J. (2013) *Logement et urbanisation en Afrique: Libérer le développement du marché formel*. UKP WORKING PAPER.

Cubula, B. (2009) Recomendações do desenho da amostra do estudo sobre acesso a agua – Bairros Perifericos das Cidades de Maputo e Matola. INE

Davidson, R., MacKinnon, J.G. (1981) Several Tests for Model Specification in the Presence of Alternative Hypotheses. *Econometrica* **49**, 781–793.

DHS (2015) Enquête Démographique et de Santé au Togo 2013-2014, Ministère de la Planification, du Développement et de l'Aménagement du Territoire (MPDAT), Ministère de la Santé (MS) et ICF International, 2015. Enquête Démographique et de

Santé au Togo 2013-2014. Rockville, Maryland, USA : MPDAT, MS et ICF International.

Els, M., Von Fintel, D. (2010) Residential property prices in a submarket of South Africa: Separating real returns from attribute growth. *South African Journal of Economics* **78**, 418–436.

Freeman, A.M. (1979) Hedonic Prices, Property Values and Measuring Environmental Benefits: A Survey of the Issues. *The Scandinavian Journal of Economics* **81**, 154.

Galiani, S., Gertler, P., Schargrodsky, E. (2005) Water for Life: The Impact of the Privatization of Water Services on Child Mortality. *Journal of Political Economy* **113**.

Gravel, N., Michelangeli, A., Trannoy, A. (2006) Measuring the social value of local public goods: an empirical analysis within Paris metropolitan area. *Applied Economics* **38**, 1945–1961.

Greene, W.H. (2003) *Econometric Analysis*. Pearson Education.

Gulyani, S., Bassett, E.M. (2007) Retrieving the baby from the bathwater: slum upgrading in Sub-Saharan Africa. *Environment and Planning C: Government and Policy* **25**, 486–515.

Gulyani, S., Talukdar, D. (2008) Slum Real Estate: The Low-Quality High-Price Puzzle in Nairobi's Slum Rental Market and its Implications for Theory and Practice. *World Development* **36**, 1916–1937.

Henneberry, J. (1998) Transport investment and house prices. *Jnl of Property Val & Invest* **16**, 144–158.

Herath, S., Choumert, J., Maier, G. (2014) The value of the greenbelt in Vienna: a spatial hedonic analysis. *The Annals of Regional Science* **54**, 349-374.

Hutton, G., Haller, L., Bartram J. (2007) *Economic and health effects of increasing coverage of low cost household drinking-water supply and sanitation interventions to countries off-track to meet MDG target 10*. WHO Press

Jaglin, S. (2001) L'eau potable dans les villes en développement: les modèles marchands face à la pauvreté. *Revue Tiers Monde* **42**, 275–303.

Jenkins, M.W., Curtis, V. (2005) Achieving the "good life": Why some people want latrines in rural Benin. *Social Science & Medicine* **61**, 2446–2459.

Jones, K. (1991) *Multi-level models for geographical research, Concepts and techniques in modern geography*. Order from Environmental Publications, University of East Anglia, Norwich.

Jones, K., Bullen, N. (1994) Contextual models of urban house prices: a comparison of fixed- and random-coefficient models developed by expansion. *Economic Geography* 252–272.

Josse, G., Pacaud, P.-A., NA. *Améliorer les quartiers précaires : Approches suivies au Burkina, Djibouti et Haïti*. French Agency for Development (AFD).

Knight, J.R., Herrin, W.E., Balihuta, A.M. (2004) Housing prices and maturing real estate markets: Evidence from Uganda. *The Journal of Real Estate Finance and Economics* **28**, 5–18.

Laré-Dondarini, A.L. (2015) Analysis of household demand for improved sanitation: the case of green latrines in Dapaong city in Northern Togo. *Canadian Journal of Development Studies/Revue canadienne d'études du développement* **36**, 555–572.

MacKinnon, J.G., White, H., Davidson, R. (1983) Tests for model specification in the presence of alternative hypotheses: Some further results. *Journal of Econometrics* **21**, 53–70.

Malpezzi, S. (1999) Chapter 44 *Economic analysis of housing markets in developing and transition economies*, in: Handbook of Regional and Urban Economics. Elsevier, pp. 1791–1864.

Malpezzi, S., Mayo, S.K., Gross (1985) *Housing demand in developing countries*. World Bank, Washington, D.C., U.S.A.

Megbolugbe, I. (1989) A Hedonic Index Model: The Housing Market of Jos, Nigeria. *Urban Studies* **26**, 486–494.

Nauges, C., Strand, J., Walker, I. (2009) The value of water connections in Central American cities: a revealed preference study. *Environment and Development Economics* **14**, 349.

Nauges, C., Van Den Berg, C. (2009) Demand for piped and non-piped water supply services: Evidence from southwest Sri Lanka. *Environmental and Resource Economics* **42**, 535–549.

Olivier, A. (2010) Universalité de l'accès à l'eau en milieu urbain et impact des politiques tarifaires : Analyse distributive dans les métropoles de Manaus (Brésil) et Casablanca (Maroc). Doctoral dissertation, Ecole des Hautes Etudes en Sciences Sociales.

Onjala, J., Wagura Ndiritu, S., Stage, J. (2013) *Risk Perception, Choice of Drinking Water, and Water Treatment Evidence from Kenyan Towns*. EfD Discussion Paper EfD.

Orford, S. (2000) Modelling spatial structures in local housing market dynamics: a multilevel perspective. *Urban Studies* **37**, 1643–1671.

Pattanayak, S.K, Poulos, C., Yang, J-C., Patil S. (2010) *How valuable are environmental health interventions? Evaluation of water and sanitation programmes in India*. Bulletin of the World Health Organization 2010; 88: p.535-542.

Rakodi, C. (1992) Housing markets in third world cities: Research and policy into the 1990s. *World Development* **20**, 39–55.

Roodman, D. (2011) Fitting fully observed recursive mixed-process models with cmp. *The Stata Journal* **11**, Number 2, pp. 159–206.

Roushdy, R., Sieverding M., Radwan, H. (2012) *The Impact of water supply and sanitation on child Health: evidence from Egypt*. Population Council, Poverty, Gender and Youth Working Paper N°24.

Shultz, S.D., King, D.A. (2001) The Use of Census Data for Hedonic Price Estimates of Open-Space Amenities and Land Use. *The Journal of Real Estate Finance and Economics* **22**, 239–252.

Stage, J., Uwera, C. (2012) Water management and pricing in the urban areas of Rwanda: the case of Kigali city. *Water Utility Management International* **7**, 13–17.

Sy, I., Keita, M., Traoré, D., Koné, B., Ba, K., Wedadi, O.B., Fayomi, B., Bonfoh, B., Tanner, M ., Cissé, G. (2014) *Eau, hygiène, assainissement et santé dans les quartiers précaires à Nouakchott (Mauritanie) : contribution à l'approche écosanté à Hay Saken*. VertigO Hors-série 19, août. https://vertigo.revues.org/14999.

UNDP (2016) *Human development report 2015*. United Nations.

Vásquez, W.F. (2013a) An economic valuation of water connections under different approaches of service governance. *Water Resources and Economics* **2–3**, 17–29.

Vásquez, W.F. (2013b) A Hedonic Valuation of Residential Water Services. *Applied Economic Perspectives and Policy* **35**(4), 661-678.

Wendland, Kelly J., Lewis, D. J., Alix-Garcia, J., Ozdogan, M., Baumann, M., & Radeloff, V. C. (2011) Regional- and district-level drivers of timber harvesting in European Russia after the collapse of the Soviet Union. *Global Environmental Change* **21**(4), 1290–1300.

Appendix A. Sampling procedure[7]

Sampling

The sample was constructed on the basis of data provided by the Regional Office of Statistics (Direction Régionale de la Statistique, 2010 estimation). The following definitions were used:

- Household: A group of individuals having or not having a relationship, living in the same dwelling, taking meals together and having the same family budget (Cubula, 2009). In some cases, we may find a group of individuals who live in the same house without sharing the same budget. In this case, we consider each person as an independent household. Military barracks, residential schools, colleges, hospitals, and prisons are considered as "collective" households, so voluntarily excluded from our study.

- The head of household: Person (male or female) recognized as such by other household members. This person assumes responsibility for the family. Each household necessarily has a leader. This individual may or may not be present at the time of the survey (Cubula, 2009).

- Household member: Individual living (eating and sleeping) in the household. He/she may be present or absent at the time of the interview. Note: Included in this category are employees who live (eat and sleep) in the household and long-term visitors located in the household (Cubula, 2009).

Sampling: two-stage sampling

The survey was conducted in the form of a stratified, simple, random sampling. The first level consisted of, first, cutting the city into small geographic areas. Four areas have been established. The second level was a second, random drawing but this time from the households in the four areas above, ensuring there were interviews in each district.

Regarding the selection of households: there was systematic selection with only the first household randomly selected. The subsequent households were selected by counting "steps" (the value of "steps" differed depending on the neighborhood, since all districts did not have the same sample size) from the first randomly selected household. After arriving in a district, each investigator started from the center, each taking a different direction (north, south, east, or west) respecting the step value—this, to better disperse the sample and to comply with the random selection of households. If someone refused to answer the questionnaire, the investigator would go to the first neighbor.

Sample Size

The sampling unit is the household. Specific factors have been taken into account in determining the size of the sample: (i) ensure the statistical power of the sample to conduct statistical and econometric analyses and (ii) have a handy sample to ensure a proper system of quality control at all stages. Calculating the sample size was made in three steps:

(1) Calculation of the sample size base. Three factors were decisive for the calculation of the sample size in this study: The estimated prevalence of the studied variables (i.e. rate of access

---

[7] Note that the current study focuses on "celibatorium" housing, hence reducing the sample size used for the analysis.

to water or sanitation), namely, the rate of access to improved sanitation: p; the confidence level under T; and the acceptable margin of error: m. In this case, the rate of access to improved sanitation was 13% in 2010 (JMP, 2012), which gave us the following parameters: P = 13%, m = 5%, and T = 1.96 (for a confidence level of 95%). The central limit theorem states that if a random sample of size n (n> 30) is taken from a population in which the average frequency of the population is f, then the sampling distribution (or law of the estimator p of f) approximately follows a normal distribution N of mean p and standard deviation σ (f) with:

$$\sigma(f) = \sqrt{p\frac{1-p}{n}}$$

With the assumption of a sample with replacement, one must choose n such that T*σ (p) ≤m with T (random variable) = 1.96, which gives

$$n = \frac{T^2 p(1-p)}{m^2}$$

Therefore, the minimum size required for the sample is given by the latter. After calculation, the value of the sample found was 173 households or units of observations.

(2) Correction of clustering effects due to the choice of distribution units. The sample is based on a selection of 6 districts. To correct this, we multiplied the sample size by this effect, often called the cluster effect (D). It is assumed, in general, that this cluster is equal to 2 (D = 2). With the correction, n is equal to 347 households (Z * 2).

(3) We added to this figure a margin of 10% to account for non-responses or recording errors. This brought our value to 382 households, a figure that we rounded to 400 households.

Distribution of households to investigate by region

A sample of 400 households (according to calculations) was considered relevant. Given the high number of districts (26), we raised the number of households to 556 in order to have more households per district. This was distributed in proportion to the size of each of the four study areas, as described in the following table:

Table A.I: Breakdown of the city into 4 zones and sample size

Areas	**Districts concerned**	**Total population[8]**	**Sample size**	**celibatoriums**
Periphery (north and south)	Sibortoti, Koni, Koutombong, Dalwak, Dapankpergou, Badore, Batamboare, Djangou	9 651	86	25
West-central	Worgou, Tantigou,	18 395	169	84

[8] Data obtained from the Direction Régionale de la Statistique (estimation for 2010)

	Nassable, Kombonloaga, Natbagou			
Est-central	Boumong, Kounkoire, Nalolg, Koutdjoak, Kampatib, Djamona	13 266	107	64
Centre	Dadigou, Napieng, Kombondjonte, Zongo, Bogliag, Kpegui, Bodjopal	27 338	194	104
Total	26 districts	68 650	556	277

Appendix B. J-test for model comparison - Comparison between models A, B, C and D for celibatoriums

	Lin-lin (Model A)	Lin-log (Model B)	Log-lin (Model C)	Log-log (Model D)
Lin-lin (Model A)		*J* test *A≈B* -1.268021 (0.000) 1.930453 (0.000)	*PE* test *C>A* 2437773 (0.000) -1.78e-08 (0.567)	*PE* test *A≈D* 2607413 (0.000) 1.31e-07 (0.005)
Lin-log (Model B)			*PE* test *C>B* 4200940 (0.000) -1.23e-08 (0.526)	*PE* test *B≈D* 4150370 (0.000) -2.96e-07 (0.000)
Log-lin (Model C)				*J* test *C>D* -.1749877 (0.614) 1.144295 (0.000)
Log-log (Model D)				

P-value in parentheses

Appendix C. Estimation results of fixed effects models

VARIABLES	Model A Lin_lin	Model B Lin_log	Model C Log_lin	Model D Log_log
Room	633,173***		0.0660***	
	(54,761)		(0.0081)	
lnRoom		4,892,558***		0.5812***
		(594,931)		(0.0822)
Cement_wall	1,127,542	965,898	0.2751**	0.2549**
	(718,435)	(791,833)	(0.1064)	(0.1094)
Cement_floor	748,297	1,001,040	0.3952**	0.4022**
	(1,333,054)	(1,469,540)	(0.1974)	(0.2029)
Elec_water	3,807,981***	4,786,562***	0.3407**	0.4114**
	(1,064,452)	(1,163,734)	(0.1576)	(0.1607)
Elec_only	-32,349	21,731	0.0638	0.0522
	(574,039)	(637,661)	(0.0850)	(0.0881)
Latrine_VIP	1,061,012	1,173,976	0.2647*	0.2729*
	(915,481)	(1,008,285)	(0.1356)	(0.1392)
Latrine_Ecosan	153,189	993,042	-0.2960	-0.2153
	(2,131,179)	(2,344,935)	(0.3156)	(0.3238)
Latrine_TMC	522,376	1,137,285	0.0915	0.1433
	(1,118,525)	(1,228,515)	(0.1656)	(0.1697)
Latrine_Moderne	-2,817,832	-3,689,558	-0.4231	-0.5096
	(2,366,325)	(2,604,443)	(0.3504)	(0.3597)
Latrine_Publique	-109,429	239,156	0.0076	0.0499
	(1,596,083)	(1,758,821)	(0.2363)	(0.2429)
Latrine_Tradition	835,882	992,488	0.2256**	0.2348**
	(626,237)	(689,641)	(0.0927)	(0.0952)
Quart_Sibortoti	3,271,724	3,352,607	2.3343***	2.3435***
	(4,495,189)	(4,951,557)	(0.6657)	(0.6838)
Quart_Koni	3,280,594	2,918,583	2.5749***	2.5071***
	(4,443,883)	(4,898,791)	(0.6581)	(0.6765)
Quart_Nassable	3,423,432	3,363,524	2.5050***	2.4871***
	(3,926,696)	(4,325,860)	(0.5815)	(0.5974)
Quart_Natbagou	1,383,167	774,291	2.0730***	1.9797***
	(3,953,349)	(4,359,655)	(0.5854)	(0.6021)
Quart_Koutombong	557,364	-28,035	2.1977***	2.0766***
	(4,079,505)	(4,508,922)	(0.6041)	(0.6227)
Quart_Kombonloaga	1,738,050	1,604,317	2.1073***	2.0504***
	(3,918,262)	(4,322,593)	(0.5802)	(0.5969)
Quart_Kpegui	1,820,614	1,332,467	2.3735***	2.2834***
	(3,888,923)	(4,291,065)	(0.5759)	(0.5926)
Quart_Bodjopal	2,773,996	2,332,445	2.4593***	2.3880***
	(4,022,714)	(4,434,419)	(0.5957)	(0.6124)
Quart_Bogliag	687,935	375,703	2.1946***	2.1146***
	(3,997,000)	(4,411,627)	(0.5919)	(0.6092)
Quart_Zongo	1,992,392	2,038,959	2.4006***	2.3488***

	(3,976,153)	(4,389,257)	(0.5888)	(0.6061)
Quart_Tantigou	3,433,411	3,667,173	2.4394***	2.4199***
	(3,959,941)	(4,366,359)	(0.5864)	(0.6030)
Quart_Napieng	-162,545	327,579	2.2948***	2.2716***
	(4,023,558)	(4,443,368)	(0.5958)	(0.6136)
Quart_Koutdjoak	3,003,886	2,650,504	2.4422***	2.3656***
	(4,019,885)	(4,434,628)	(0.5953)	(0.6124)
Quart_Kampatib	1,429,948	813,818	2.3141***	2.2268***
	(4,221,193)	(4,652,802)	(0.6251)	(0.6425)
Quart_Nalolg	4,331,142	4,322,919	2.6183***	2.5694***
	(3,949,704)	(4,357,861)	(0.5849)	(0.6018)
Quart_Djamona	4,935,803	4,297,950	2.8145***	2.7126***
	(4,727,785)	(5,213,324)	(0.7001)	(0.7200)
Quart_Dadigou	1,965,038	757,541	2.4904***	2.3315***
	(4,313,250)	(4,758,067)	(0.6387)	(0.6571)
Quart_Konkoare	3,948,906	3,612,510	2.5512***	2.4793***
	(4,005,661)	(4,418,092)	(0.5932)	(0.6101)
Quart_Boumong	400,862	-356,681	1.8316***	1.7381***
	(4,000,993)	(4,408,795)	(0.5925)	(0.6088)
o.Quart_Dalwak	-	-	-	-
Quart_Worgou	1,520,790	1,259,198	2.1833***	2.1452***
	(4,021,159)	(4,430,088)	(0.5955)	(0.6118)
Quart_Dapankpergou	-274,534	-649,861	1.6174***	1.5214**
	(4,073,199)	(4,499,190)	(0.6032)	(0.6213)
o.Quart_Badori	-	-	-	-
o.Quart_Batamboare	-	-	-	-
Quart_Kombondjonte	1,566,941	1,456,006	2.5608***	2.4910***
	(4,072,958)	(4,497,441)	(0.6031)	(0.6211)
Quart_Djangou	-4,188,304	-3,990,830	0.3110	0.2316
	(5,498,207)	(6,076,425)	(0.8142)	(0.8391)
Constant	-4,944,413	-9,441,952**	11.4517***	10.9140***
	(4,072,307)	(4,522,507)	(0.6030)	(0.6246)
Observations	277	277	277	277
R-squared	0.5330	0.4334	0.5240	0.4977

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