Disparities in public service provision in Niger: cross-department evidence on primary schools and healthcare

Stefano Mainardi
Dept. of Economics, University of Botswana, Gaborone, and
Dept. of Informatics and Econometrics, UKSW – Card. S. Wyszyński University
Warsaw (s.mainardi@uksw.edu.pl)

Abstract

In developing countries, the provision of public services for education and healthcare continues to fall short of demand. Under severe infrastructure backlogs, marginal benefit theory envisages that measures aimed at maximising average access rates, unlike outright redistributive measures, can have contradictory impacts in the medium term: depending on sector characteristics and infrastructure needs, geographical disparities may decline in some sectors, and persist or widen in others. Relative to expected outcomes, Tobit models with/without eligibility and spatial effects suggest mixed evidence for primary schools and healthcare across districts (*départements*) in Niger. With strict eligibility thresholds, these effects turn out to be more relevant for healthcare. Once local population size is accounted for, (in-between) Sahelian-zone districts appear to systematically lag behind others in school access improvements. In both sectors, no additional gains accrue to worse off administrative departments, relative to targeted departments randomly chosen. This implies no selectivity bias in models with exogenous eligibility, and points to a need for strengthening social service delivery and better targeting poverty in poorer districts of Niger.

Keywords: public services, marginal benefit, eligibility, spatial Tobit, Niger.

JEL classification: C21/24, H54, I18/28.

1. Introduction

For many developing countries, geographical disparities in delivery of education, healthcare and other public services have not been investigated in detail. Yet, these services play a crucial role for attaining better quality of life (www.un.org/millenniumgoals). Higher levels of education are instrumental for public health improvements, and better health and nutrition can indirectly foster children's education. For schools, healthcare and social safety nets, transfers in-kind are especially important where cash transfers and fiscal policy may be less effective. In sub-Saharan Africa, many governments have not sufficiently targeted the poor through public expenditures in these services (Davoodi *et al.*, 2003). The consequences are especially serious in countries with weak infrastructure and stagnant growth, such as Niger (apart from the 1975-82 uranium boom, when its economy grew at 7.5% per year; World Bank 2008b). Recurrent droughts, demographic pressures, soil degradation and desertification, and insufficient provision of facilities for education, healthcare, and agricultural market support, undermine Niger's development, particularly in remote rural areas.

A developing country's geographical distribution of public infrastructures can be expected to depend on its social utility function(s), with intervention priorities based on socioeconomic, demographic, and location characteristics of demand in each sector. If a budget-constrained maximum average access to a service is pursued with no *a priori* social and regional distribution targeting, the marginal impact of public expenditure and related service expansion path will reflect eligibility criteria and spatial effects which are consistent with the above goal, and will vary across sectors. In sectors with lagging infrastructure development, residents in better off districts tend to live closer to pre-existing infrastructure networks. As long as there is no adequate coverage, the marginal benefit is therefore likely to be higher for those districts. In sectors with more widespread public coverage and no large investment requirements, the opposite is more likely to occur. Hence, with successive improvements in average access rates, cross-district disparities can be envisaged to increase for healthcare (as a sector with features largely complying with the first case outlined here), and to decline for primary schools (as a sector fitting in the second case). In an alternative scenario, the allocation of improved or newly established public services may follow a different objective function, such as redistribution in favour of poorer districts.

This analysis aims at assessing shortcomings in geographical allocation of public service delivery, based on the case of two sectors in Niger. The estimation approach can serve as an analytical tool for regional development and poverty targeting, of potential help also for other developing economies and sectors. The paper is structured as follows. The next section examines marginal expansion paths of public services across target areas, and related issues of econometric estimation and modelling. In the third section, results (relative to Niger's administrative areas or *départements*) of Tobit regressions with/without eligibility and spatial effects are assessed in light of marginal benefit expectations. These results are also compared with previous evidence and hypotheses from selected country studies, including Niger, which are reviewed in the Appendix. The last section draws concluding remarks.

2. Theoretical background and estimation problems

2.1 Theoretical background

Standards and accessibility of public services can be explained by three types of determinants, which vary across (and within) target areas: (i) valuation of and willingness to pay for services by residents, (ii) distribution weights in the social welfare objective function of central and local governments, and (iii) costs of public service delivery. Relative to the first point, some households will be reluctant to settle in remote areas due to inadequate access to public utilities. In a developing country with limited scope for internal migration, issues related to (ii) and (iii) are probably more relevant factors, while the link with (i) can be envisaged to be indirect, with government perceptions of consumer preferences partly reflected by weights attached to gains/losses of social groups. In the absence of *a priori* pro-poor/pro-non-poor interventions, one can assume that planning authorities strive to maximise the *average* access to a public service subject to a binding cost constraint. Hence, public sector allocation will vary according to type of service and infrastructure needs (Ajwad and Wodon 2002). Different marginal benefit paths can be tested on small area units, such as municipalities within a national territory or within administrative regions in a decentralised system. Since longitudinal data are usually unavailable, public service beneficiaries have been predicted from cross-section data by assuming that an area's changing average access is reflected by geographical variation across areas (for education and basic infrastructures in Bolivia, see Ajwad and Wodon 2007). However, statistical inference of time dynamics from cross-section patterns fails to distinguish 'between' from 'within' variation. As an alternative approach, in this analysis marginal incidence effects are modelled as a censored variable, relative to a medium-term time span.[1]

Whenever they require substantial infrastructure and severely fall short of universal coverage, public utilities expand first more easily in and around districts (or administrative *departments* in Niger: henceforth used interchangeably) which are already partly endowed with the needed infrastructure (unless equalisation of service provision is striven for as an urgent priority). Therefore in the medium term, service improvements may turn out to remain skewed in favour of the non-poor, even though social policies are not openly biased against the poor. Maximising local service access is less costly when delivery expansion is close to pre-existing infrastructure, where residents exercise pressure for adequate service coverage and quality. By contrast, costly coping mechanisms are often the only option for many residents in areas with less political influence (e.g., water from trucks supplementing piped water supply; Walker *et al.* 2000). This typically concerns basic services such as telephone, water and electricity, and has been regarded as evidence against no or low user charges by studies arguing that rationing of excess demand risks limiting subsidised services to richer households, and can be redressed by adopting high user charges coupled with discriminatory pricing (Thobani 1984; among counterarguments raised in recent years, see Fredriksen 2009). Healthcare is likely to follow this pattern to some extent, with sparsely populated, poor districts often benefiting marginally from public investment. Services which register relatively higher average access rates and are less dependent on a pre-existing infrastructure grid can instead be envisaged to follow a more balanced diffusion process

[1] Niger's district-level data are mostly limited to few non-consecutive survey years, thus making panel data models not applicable. Even when time series are available, comparability is often limited by changes in survey design (Davis, 2003: p. 39). Moreover, a medium-term framework is justified in view of the assumption that the budgetary constraint cannot be remarkably expanded with additional taxes or expenditure cuts in other sectors.

and be largely pro-poor even in the absence of outright pro-poor policies, except if public authorities pursue anti-egalitarian strategies. This can be illustrated by primary schools, which do not require substantial infrastructure investment in remote districts.[2]

In terms of marginal incidence within a reference period (e.g. three-four years), each sector can be assumed (as in the studies quoted above) to face a separate, exogenously set budget, which reflects the above determinants and is allocated between districts with relatively better off and worse off socioeconomic conditions and infrastructure coverage ($E = E_b + E_w$). In each district, average access rate to a public service (S_i, with $i = b, w$) is a function of allocated expenditure, i.e. $S_i = f_i(E_i)$, which is increasing and strictly concave for both district groups, thus being $f_i' > 0$ and $f_i'' < 0$. Prior to reaching optimal delivery with universal access, for any given level of expenditure E_z ($0 < E_z < E_{max}$), worse off districts will lag behind in access coverage ($f_w(E_z) < f_b(E_z)$). In the long-term, starting from a non-uniform spatial distribution of assets, people in better off districts are largely net contributors to social infrastructure projects, while people in poorer districts are mostly receivers of net transfers (Lessmann 2009). However in the medium term and assuming budget-constrained maximisation of average access rates, marginal improvements in access rates ($f_i'(E_i)$) will reflect the above patterns, i.e. $f_w'(E_w) < f_b'(E_b)$ for healthcare (as long as a sufficient infrastructure network is not in place), and $f_w'(E_w) > f_b'(E_b)$ for primary schools. With the marginal impact of spending in poorer districts being relatively lower for healthcare, and higher for schools, public authorities will target points on the production possibility frontiers (Fig. 1) to the left of the 45º line (where $S_w=S_b$) in the former sector, and to the right in the latter (transformation curves are elongated in the direction of respective returns on investment, given different infrastructure requirements).

Of two potential outcomes for each district over a period concerned, namely progress ($\Delta S_i>0$) or lack thereof ($\Delta S_i=0$, including possible reversals –which can be spuriously inflated by changes in annual survey design–), only one is observed. The observed gain (in square brackets in eq. (1) below), or its absence, can be modelled linearly in terms of a constant, a component of observable characteristics (expressed in a vector of variables X_i; see Appendix), and another component of non-observables (which may be partly observable for the policy-maker). Relative to the two groups and given an eligibility binary variable r_i based on an average threshold ($r_i = 0$ for $S_i>S_{av}$ [$\rightarrow i = b$], $r_i = 1$ for $S_i<S_{av}$ [$\rightarrow i = w$]), the outcome variable can be specified as in equation (1), and rewritten as equation (2) (where $\delta = \alpha_w - \alpha_b$, $\gamma = \beta_w - \beta_b$ and $\varepsilon_i = (1 - r_i)\varepsilon_b + r_i\varepsilon_w$):[3]

---

[2] One should notice that, without detailed information at micro level (public facilities/households) marginal incidence theory is subject to some limitations. The proxy for access to primary school services does not account for disparities in quality of access, such as the presence of community schools with large class sizes in (often poor and remote) rural areas where teachers' salaries are at least partly financed by parents (in the early 2000s, this concerned 4% of primary school teachers in Niger; Fredriksen 2009). Similarly, a physical distance-related indicator of access to healthcare is an inadequate measure for areas with severe transport deficiencies (in extreme cases, mule-drawn carts as 'local ambulances': Ridde *et al.* 2011). Moreover, the analysis ignores indirect long-term beneficial effects across and within districts: for instance, as a consequence of expanding education, the 'compression effect' on wage gaps between skilled and unskilled labour (Thobani 1984).

[3] In the presence of underdeveloped infrastructure facilities, marginal incidence theory implicitly assumes that the scope for 'general interdependence' (i.e. including psychic benefit from supporting welfare programmes in favour of poorer residents, as in Orr 1976) in social group utility functions of taxpayers in better off districts would mainly concern only recipients in the same districts. Also, given the absence of information reflecting marginal social values of different types of public expenditure, public spending can be assumed to be optimally allocated (i.e. the social value of the last unit of resources spent on health, education, public transport, etc., is the same; Brent 1990: p. 47). In this respect, bivariate spatial Tobit models estimated by FIML (simultaneously estimating regressions C4 [Table 4] and G1 [Table 5, with/without agro-climatic

$$\Delta S_i = \alpha_b + \beta_b X_i + \varepsilon_b + r_i[(\alpha_w - \alpha_b) + (\beta_w - \beta_b)X_i + (\varepsilon_w - \varepsilon_b)] \qquad (1)$$

$$\Delta S_i = \alpha_b + \beta_b X_i + \delta r_i + \gamma(r_i X_i) + \varepsilon_i \qquad (2)$$

The eligibility criterion reflects a set of intervention priorities across districts, which is largely unknown to individuals not involved in public investment decisions, and is thus interpreted as a latent variable in a Probit model (from equation (3), with $r_i = 1$ if $r_i^* > 0$, and 0 otherwise; Z_i is a vector of variables influencing the subdivision of districts between better off and worse off and their ranking, which may include some of the explanatory and control variables in equation (2)):

$$r_i^* = \zeta_i Z_i + \eta_i \qquad (3)$$

Assume $\eta_i \sim NID(0,1)$, and $(\varepsilon_b, \varepsilon_w, \eta_i) \sim$ trivariate $N(0,0,0,\sigma_0^2,\sigma_1^2,1,\sigma_{ij})$, and define σ_{02} ($=\rho_{02}\sigma_0$) and σ_{12} ($=\rho_{12}\sigma_1$) as covariances of ε_b and ε_w with η_i, respectively. Equation (2) can then be estimated as a Tobit regression with treatment effects, with residual conditional expectation given by equation (4) (where φ is the density function, Φ the cumulative distribution function, and the last term in brackets is Heckman's lambda –$\lambda_i(\zeta_i Z_i)$=inverse Mill's ratio–; Greene 2003, Wooldridge 2002):

$$E(\varepsilon_i \mid Z_i, r_i) = \sigma_{02}E(\eta_i \mid Z_i, \eta_i \leq -\zeta_i Z_i) + \sigma_{12}E(\eta_i \mid Z_i, \eta_i > -\zeta_i Z_i) =$$

$$\sigma_{02}(1 - r_i)[-\varphi(\zeta_i Z_i)/(1 - \Phi(\zeta_i Z_i)] + \sigma_{12} r_i[\varphi(\zeta_i Z_i)/\Phi(\zeta_i Z_i)] =$$

$$\sigma_{02}(1 - r_i)[\lambda_b(\zeta_i Z_i)|r_i=0] + \sigma_{12} r_i[\lambda_w(\zeta_i Z_i)|r_i=1] \qquad (4)$$

Hence, equation (2) is consistently estimated only if the interaction of the eligibility dummy with the generalised Probit residuals from (3) is accounted for (a consistent estimate of ρ_{ij} is not a standard sample correlation coefficient, and it can fall outside the [0, 1] range in finite samples; for details, see Greene 1981). Under assumption of budget-constrained and distribution-'neutral' access rate maximisation, and imposing a zero restriction on γ in (2) to avoid identification problems (i.e. $\beta_w = \beta_b = \beta$; Verbeek 2004: pp. 243-44), the model will indicate improvements in school access rates of worse off districts if (i) $\delta>0$ (expected gain for these districts), and (ii) $\delta r_i + E(\varepsilon_i \mid Z_i, r_i) = \delta r_i + (\sigma_{12} - \sigma_{02})[\lambda_i(\zeta_i Z_i)] > \delta r_i$. Condition (ii) implies that the average treatment effect for eligible districts (ETE) exceeds the average treatment effect relative to all districts (ATE). The latter measures the impact if districts targeted for delivery improvements are chosen randomly (which also implies, in this context, that $(\Delta S_i=0|r_i^*<0) = (\Delta S_i=0)$, and the respective observations are 'missing randomly'; Heckman 1979: 155). If $\sigma_{02} = \sigma_{12}$, then ATE and ETE are identical. However, the lack of suitably located schools can be envisaged to pose greater problems in poorer than wealthier districts, thus entailing higher potential gain (access increase) with the same amount of investment. Hence, inequality condition (ii) should hold true even without leakages in public investment programmes, that is even if *ex post* $\Delta S_i>0 \leftrightarrow r_i=1$ and $\Delta S_i=0 \leftrightarrow r_i=0$.[4]

---

dummies]), yield residuals which are statistically uncorrelated across regressions.

[4] Likewise, as a microeconomic illustration, 'the wages of migrants do not, in general, afford a reliable estimate of what non-migrants would have earned had they migrated' (Heckman 1979: 153). Pure random sampling would require a 'stable unit treatment value' assumption, namely that the impact of a treatment of one unit has no influence on other units' outcomes

With the same social utility objective function, different outcomes can be expected for healthcare. As long as infrastructure cost constraints remain an inhibiting factor for health sector development, requests for improved population coverage from better off districts will overshadow those from poorer districts, thus possibly causing $\delta<0$ and ETE $\cong$ ATE. In both sectors, location characteristics will influence the scope for service access improvements, by fostering it in districts with location advantages, and hampering it otherwise. Local residents will benefit from public expenditures targeting neighbouring districts, with varying strength and modalities of spillover effects depending on institutional and productivity interactions (Brueckner 2003). In line with the hypothesised expansion paths, the impact is likely to differ, with spatial diffusion being possibly stronger (albeit more concentrated) for healthcare, weaker and diffuse for schooling.

2.2 Econometric estimation problems

An analysis of geographical disparities and marginal changes in the spatial distribution of public utilities faces various problems and constraints. Since variables reflect political and socioeconomic conditions influencing placement decisions on public utilities, OLS estimates are likely to be biased due to simultaneity, sample selection and eligibility/treatment effects (considered above), hidden explanatory variables, and unobserved effects (Kutengule *et al.* 2006: p. 427). Endogeneity arises from blurred distinctions between indicators of *status* (structural conditions of a population) and *outcome* (standards achieved in these conditions; Deichmann 1999; Henninger and Snel 2002). For instance, the number of medical visits per capita can be seen as a measure of affordability of health services (after controlling for health status and epidemics), or inadequacy of these services to effectively cure patients' ailments (with numerous visits by and admissions of the same individuals). Similarly, access to basic services can be regarded as a factor influencing health status, education and income, among others (thus being used a status indicator), but conversely insufficient access to these services can originate from lack of stable and sufficient sources of income (which may be proxied by health and nutrition indicators, among others).[5]

High correlation between variables may also not allow a clear identification of the influence of different factors (ethno-linguistic homogeneity vs. latitude zones, early presence of missionaries vs. proximity to coasts and rivers, mothers' education vs. transport in rural areas; Alabi 2008). Census income data often cannot be relied on at a district level, due to insufficient representativeness and large shares of non-cash income, particularly for rural households with high vulnerability to climatic shocks. In the absence of disaggregate information on income (/consumption) and physical distances from main markets, approximate indicators can be used. For given demographic and environmental

---

(Wooldridge 2002: 604). With spatial spillover effects (as also in a general-equilibrium dynamic treatment effects framework: Heckman *et al.* 1998), this assumption is partly relaxed.

[5] Due to likely measurement errors and simultaneity, the number of medical visits per resident (Table 2: *lnvispc*) is not included in the regressions (moreover, it is weakly correlated with healthcare access [*lnhca*, with $\rho\cong0.12$], which by definition influences eligibility for new public investment). While allowing parsimony and smoothing measurement errors, principal components should be interpreted with caution in small samples (Mertler and Vannatta 2001; Lattin *et al.* 2003). Among other regression results not reported here, based on semi-elasticity parameter estimate and mean healthcare access, and after accounting for local health personnel, a doubling of accessibility to healthcare could contribute to decrease infant mortality by nearly 20% on average across departments.

conditions (including size and urban-rural distribution of the local population, and agricultural cropland per producer), relatively lower yields of major staple food crops are likely to be associated with higher transport and commercialisation costs and/or high incidence of poverty (with reduced access to agricultural inputs, including fertilisers; Stifel *et al.* 2003). Therefore, while also reflecting different degrees of soil erosion, crop yields may indirectly explain backlogs in access to education and healthcare.

Unobserved effects can be modelled with spatially lagged exogenous variables. Unlike the *global* case (captured by a spatial [endogenous variable] lag specification), *local* spatial dependence implies a limited range in spatial multiplier effects, and, in the absence of additional problems, OLS estimation of the resulting spatial ('cross-regressive') specification yields unbiased and consistent parameters (Anselin 2002 and 2003b).[6] Analogously, in a spatial Tobit accounting for endogenous eligibility and local spatial spillovers, Heckman's two-step procedure maintains these properties, even if it is less efficient than a maximum likelihood (ML) estimator. If errors are heteroscedastic and non-Gaussian, Tobit estimators are inconsistent. Powell's censored least absolute deviations (CLAD) method avoids this problem, but its efficiency loss often outweighs the consistency gain relative to misspecified Gaussian ML (Amemiya 1984; Khan and Powell 2001). Semi-parametric Probit estimation by maximum score (where the binary variable is interpreted as a predictor of the median, instead of the mean as in the parametric approach) is also robust to extreme observations. Estimates can be relied on to compute a pseudo-inverse Mill's ratio, for outcome equations based on asymmetric and/or leptokurtic distributions (Heckman *et al.* 2000; Chay and Powell 2001; Powell 2008).[7]

3. Econometric application

3.1 Variables and descriptive statistics

Administratively, Niger consists of seven regions (plus the capital Niamey, which forms a separate administrative unit), subdivided into thirty six administrative units (*départements*). To keep data consistency for this analysis, relative to four of these units (Kollo, Madarounfa, Tahoua and Mirriah) some indicators were re-estimated based on population weights of the respective urban communes (namely Niamey, Maradi, Tahoua and Zinder) within their administrative boundaries. The same applies to Abalak, which was treated jointly with the department of Tchintabaraden as one administrative unit (in the mainly Sahelo-Saharan north of the region of Tahoua). Similarly, for consistency with geo-coded UN-SALB GIS files (sub-national administrative local boundaries; www.fao.org), in the south-eastern departments of Diffa and Nguigmi separate information was maintained for major urban

[6] In global spatial dependence, off-diagonal non-zero elements of the residual variance-covariance matrix create bands of ever larger reach around each location, with declining strength at higher orders of contiguity. This can be modelled with a spatial lag specification, and estimated by ML or GMM. Relative to sample selection in the presence of spatial error dependence (which induces heteroscedasticity), Flores-Lagunes and Schnier's (2010) heteroscedasticity-consistent GMM relies on the same distributional assumptions as Heckman's and ML estimators.

[7] The maximum score $Z'\zeta_{MS}$ vector (equation (3)) was rescaled by dividing it by the ratio $Z'\zeta_{ML}/IMR_{ML}$ estimated by parametric Probit (Tables 4-5: D2 and H2). The semi-parametric inverse Mill's ratio thus obtained was then used as a regressor for the outcome equation (D4 and H5, for schools and healthcare respectively), based on the logistic distribution. This distribution turned out to slightly outperform other densities (normal and Weibull), in terms of predictive power and standard error of regression, thus implying thicker tails than the Gaussian (results not shown).

communes versus the remaining district area. In summary, the analysis is focused on thirty seven spatial unit observations, which coincide with the thirty six administrative departments except for two sub-departmental units within Diffa and Nguigmi, and one aggregate unit comprising two departments (Abalak and Tschintabaraden). Descriptions of variables, statistical sources and summary statistics are provided in Table 2.

To partly remove data asymmetries and directly estimate semi-elasticity parameters (in Tobit models), some variables have been log-transformed (the variable *lnnetgap* remains skewed and leptokurtic [m_4=3 for mesokurtosis]). Local characteristics of the agricultural sector are captured by indicators of cultivated area per producer, importance of farming for local employment, diffusion and kind (nomadic versus sedentary) of livestock husbandry, annual yields of major traditional food crops (nationally-adjusted weighted average yield for sorghum, millet and *niebé* [cowpea]), and agro-climatic conditions. The latter are modelled with isohyets-delimited zone dummies, with (Sahelo)-Saharan areas as implicit category (as distinct from Sahelian and Sahelo-Sudanian areas). Relative to health status/care, statistical information on infant mortality and medical personnel is only available at a regional level. Gross primary school enrolment rates are calculated as the ratio of the total number of students (independently of age) to the school age population: this exceeds 100% in Bilma (Agadez region, 2004-05) and Madarounfa (Maradi, 2006-07). The net rates are given by the ratio of primary school-aged pupils to primary school-aged population (aged between 7 and 12 years).

Healthcare exhibited wider cross-department disparities in service delivery than the education sector: in 2004-05 average terms, the respective coefficient of variation is 0.38 for percent shares of residents within 5 km from a medical centre, and 0.32 and 0.3 for gross and net primary school enrolment rates. Lower and upper extreme district-level figures range from 16% in Dakoro (region of Tahoua) to 79% in Kollo (including the city of Niamey; 74% in Bilma) for healthcare access, and from 22% (/26%) in Tchirozérine (Agadez) to 93% (/119%) in Bilma for net (/gross) primary school enrolment (68% [/82%] in Kollo). Based on percentile maps (not shown), some departments structurally lag behind others in both public sectors: Tchintabaraden and Madaoua (north and south of the region of Tahoua, bordering with Mali and Nigeria respectively), Say (along the border with Burkina Faso, in the Tillaberi region), and Gouré (Zinder). Others lag behind in healthcare (Dakoro and Guidan Roumdji in the Maradi region) or primary schools (Maïné-Soroa and Diffa, in the region of Diffa). Kollo and to some extent Madarounfa seem to benefit from localisation externalities of urban communities within their borders (Niamey and Maradi). In terms of medium-term coverage expansion (Table 2: censored variables), only three departments, i.e. Arlit (Agadez), Boboye (in the south-western region of Dosso), and Tahoua (in the homonymous region), fall in the upper quartile of relatively dynamic developments for both sectors. Conversely, minimal or no improvement in both sectors especially concerns some southern and eastern regions (Fig. 2).

To compute spatially lagged variables and test for unobserved spatial disturbances, the spatial weighting criterion was based on geographical arc-distances d_{ij} (estimated with GeoDa; Anselin, 2003a) between UN-SALB admin 2-level centroids of unprojected spherical maps. The weight matrix (row-standardised to unit-sum) complies with the following conditions: $w_{ij} = 0$ for i=j and $d_{ij}>d_{max}$ (=diffusion cut-off distance), $w_{ij} = (1/d_{ij})^2$ for $d_{ij}<d_{max}$. For a sensitivity analysis on results, two matrices were constructed: one based on a cut-off distance near an average connectivity level (at 2/5 of the range between minimum and maximum feasible distances), and another on the minimum distance threshold, which ensures that each observation has at least one neighbour. Similarly, two

average access thresholds are used to test for possible eligibility effects in regression models (see notes for Tables 4-5). Since national access coverage rates slightly exceed the respective cross-department averages (56 vs. 52.5% for primary education, and 42 vs. 39% for healthcare), an 'upper' censoring threshold appears to be justified, and reflects looser criteria of eligibility by planning authorities. To simplify and better compare results between sectors, the lower threshold for primary schooling and the upper threshold for healthcare are both set to S_{av}=50%.[8]

3.2 Principal components and Tobit regressions with spatial and eligibility effects

Principal components are used to describe a set of variables in terms of a number of orthogonal linear combinations of lower dimensionality. Of two alternative sets (crop yields are unavailable in three departments of the Agadez region, with virtually no agricultural activities apart from livestock), the first three components explain nearly 65% of the information (Table 3; variables are listed in ascending order of the first component/application), and are used here as regressors for Probit equations in Tobit models with eligibility effects.[9] The first component (*pc1(f)*) suggests a trade-off between public service access, ratios of gross-to-net primary school enrolment, and dominance of nomadic livestock activities on the one hand, and population and household size, gender gaps in school enrolment (consistently with Iimi's hypothesis: Appendix A), and infant mortality on the other. In the second component, nomadic livestock and female access shortfalls have opposite loadings relative to public service access in both sectors. Relative to the sub-sample (excluding the departments of the Agadez region), the first component (*pc1(s)*) associates cropland size per producer with population and household size, along with female participation in agriculture, and opposite to shares of agricultural land under female ownership and crop yields. The latter might be explained by increased soil conservation and input intensity to compensate for smaller planted areas in some districts, and prevalence of large, scarcely productive cropland in populated zones facing severe soil degradation. Reverse parameter signs for two gender/rural disparity indicators (*femal* vs. *femaar*, also in *pc2(s)*) suggest that upgrading women's status may entail asset redistribution in some districts, and increased labour participation in others.

In Tables 4 and 5, the first two columns report Tobit model results on zero-censored medium-term changes in access to public service provision with exogenous eligibility, while the remaining columns refer to Tobit specifications with spatial and/or endogenous eligibility effects. Slightly better simulation fits are mainly obtained for healthcare than primary education, according to mean absolute errors (while mean absolute percent errors are not computable with censored dependent variables, MAE results are approximately comparable due to near-equivalent means, ranges and standard deviations; see Table 2: *hcacens*, *schcens*). Additionally, the Doornik-Hansen test (based on a small sample correction to the Jarque-Bera test; Hendry and Doornik 2001: p. 261) rejects the Gaussian distribution hypothesis for generalised residuals from primary education regressions. A semi-parametric approach, based on maximum score in selectivity equations and log-logistic ML in outcome equations, yields similar results as parametric regressions, apart from stronger spatial effects (models D4 and H5).

---

8 Similarly, Mukherjee and Singer (2010) apply a sensitivity analysis on IMF Facility programmes as a proxy for the incidence of these programmes (modelled in a selectivity equation), and account for spatial clustering in an outcome equation to explain capital account liberalisation across countries.

9 In a similar logic, in the presence of a relatively large number of predetermined variables in a multi-equation system, principal components of these variables can used instead of the latter as *ad hoc* instrumental variables in 2SLS estimation (Kloek and Mennes 1960).

For both sectors, agricultural sector characteristics turn out to have a minor influence on allocation of funds for improved public access rates. *Ceteris paribus*, more densely populated departments tend to benefit from improvements in access to primary education more than sparsely inhabited ones, but, at given population sizes, Sahelian and, to lesser extent, Sahelo-Sudanian departments lag behind northern regions (Table 4). This is consistent with the hypothesis that weaker social networks and unequal land tenure in southern regions may slow down the diffusion of education opportunities, thus partly offsetting advantages in first nature geography. Relative to healthcare, the relevance of average household size may be explained by location preferences by large-sized households concerned with distances from emergency health centres (Table 5). The influence of demographic factors appears to be stronger if spatial and endogenous eligibility effects are not modelled, and spatial lag parameters are in turn biased upward if the eligibility dummy is omitted. Neither public utilities reap significant location externalities in areas surrounded by populous departments (T.4-5: *lnpop(sp)*). With stricter (*r(l)*) eligibility criteria, cross-department spillovers (modelled by spatial lag service access) are more relevant for healthcare than primary schools. Within sectors, spatial diffusion parameter estimates are also sensitive to sample, principal components (T.5: H1, H3 and H4), spatial weights, and eligibility (for primary schools –T.4–, the strength of this process dampens when passing from a minimum cut-off distance to near-average connectivity level, and from upper to lower eligibility thresholds).

A path consistent with budget-constrained average access maximisation is weakly supported for primary education. Based on full sample estimation, $\delta>0$ for all the different specifications, but the parameter is statistically significant (at 5% level) only if spatial effects are omitted (Table 4: A1/2, B1/2). Relative to other specifications, the zero null on δ is rejected only in model C4, with an 'autonomous' gain based on a looser selection criterion (u=60%, which includes departments slightly above the national access average). As for healthcare, unlike expectations of marginal benefit theory with underdeveloped infrastructure, $\delta>0$ and statistically significant (except for H5; similar results are obtained if 2002-03 is chosen as an initial baseline: parameter estimates in italics in Table 5). In both sectors, if eligibility is modelled endogenously, neither the inverse Mill's ratio λ parameter estimated by Heckman's two-step approach, nor ML estimates of ρ and σ_ε (see previous section; Greene 1998: pp. 712-17) are statistically different from zero. This suggests a lack of selectivity bias with eligibility modelled exogenously (ETE $\cong$ ATE). The only exception is based on a selectivity equation with the second set of principal components (H4; similar results for primary schools). Beyond good predictive power of the Probit model, this exception has limited interpretability, since component parameters are statistically insignificant (unlike statistically significant, expectedly negative parameters –given eigenvector scores of the access status variable *lnhca*– associated with the first two components of the first set; see Tables 3 and 5). Hence, for both sectors, no additional gains accrue to poorer administrative departments, relative to targeted departments randomly chosen.

4. Conclusion

In Niger, poverty alleviation should be targeted at strengthening human and physical capital in remote, largely rural communities, by improving access to education and healthcare facilities, and fostering new irrigation and rural infrastructure projects, non-farm rural income-generating activities, and outreach programmes for poor urban areas. As undertaken elsewhere (e.g., Senegal, Cameroon, Honduras, Panama, Jamaica), since the mid-2000s Niger's government has embarked on plans for fostering decentralisation of social services and redressing territorial imbalances (HCCT, 2009).

Relative to health services, national user fees (which had been introduced between 1994 and 1997) were abolished in 2006 for primary healthcare for children under five and pregnant women, with costs of this exemption policy partly covered by French development aid: however, given funding and institutional constraints, a few districts have meanwhile reinstated user fees (Ridde *et al.* 2011). While an overall assessment of public service reforms is premature (also due to slow implementation), no consensus is found on the effects of decentralisation of social service provision. On the one hand, it may facilitate targeting a social optimum, with improved service access, efficiency and information flows for residents. On the other hand, in the presence of local elites, weak institutions and numerous administrative tiers, it may contribute to further aggravate an inefficient and unequal provision of services, induce regressive fiscal effects, and possibly even increase an aggregate bribe burden (Fan *et al.* 2009). In this respect, Botswana illustrates a successful case, while Sierra Leone is regarded as an example of mismanagement at local government level (Gallego 2010). With predominant subsistence agriculture, the outcome will also largely depend on parental decisions concerning the engagement of children in agricultural activities in poor and isolated communities.

Marginal benefit theory envisages that public utilities which do not require substantial infrastructure investment (such as primary schools) will more easily expand in a pro-poor direction even in the absence of pro-poor policies, while the opposite is likely to affect public services with severe gaps in access coverage and costly infrastructure requirements. Spatial diffusion effects will also vary, depending on relevance of localisation economies across sectors and districts. Regarding primary education versus healthcare, the econometric results of this study provide mixed evidence for Niger. Healthcare lags behind primary education in service delivery, in terms of average access and geographical disparity. Under strict eligibility criteria in Tobit regressions with endogenous or exogenous ‘treatments’, local spatial spillovers (of being adjacent to, or conversely, distant from areas with relatively favourable conditions) are more relevant for healthcare, in accordance with expectations. For primary schools, these effects are overshadowed by spatial clusters of systematic ‘underperformance’, especially in Sahelian regions. Evidence in support of an autonomous gain for worse off districts is stronger for healthcare than primary schools: this is likely to reflect different government priorities and parental choices in the two sectors, which are partly inconsistent with marginal incidence theory. On a negative side, for both sectors no indication emerges as to additional gains for worse off administrative departments relative to targeted departments chosen at random. For future extensions of this analysis, spatial weights could be adjusted for directional effects and more disaggregate data could be useful when they become available. On a theoretical and applied level, the analysis could also gain new insights from examining geographical allocation decisions of public services within individual sectors (for instance, assessing to what extent the expansion of secondary education may be receiving more attention than the goal of universal primary education, particularly when general economic conditions worsen; Fredriksen 2009).

Table 1 – Disparities in access to education and healthcare: selected country studies

Main objective	Method	Country (sample years)	Disadvantaged areas/population	Policy recommendations	Source
female education access (school enrolment rates); nutritional and health status	descriptive statistics and regression analysis	Eritrea (1991-98)	regions other than the capital	fostering female teacher participation and female formal employment opportunities	Brixiová *et al.* (2001)
healthcare infrastructure and health status (new hospital buildings and costs; child/infant mortality)	descriptive statistics and regression analysis	Turkey (1990-95)	rural areas; Eastern and South Eastern Anatolia	improving access to healthcare and adequate immunisation in worse-off provinces	Mainardi (2003)
basic needs, living conditions and access to education/healthcare (school enrolment rates; malnutrition; distance from school and healthcare utilities)	descriptive statistics	Haiti (1999-2003)	rural areas, urban areas other than metropolitan region, and some communes near the capital; gender-related inequality	guidelines for improving poverty-alleviation targeting and resource allocation	MPCE (2004)
basic needs and living conditions (composite indicators include years of schooling and school absenteeism)	spatial data analysis	Colombia (1985, 1993)	spatial clustering and diffusion (poverty relocation or expansion contagion among administrative departments/ communes)	guidelines for improving poverty-alleviation targeting and resource allocation	Pérez (2005)
education attainments and health status (illiteracy; infant mortality)	descriptive statistics	China (1964, 1981, 1990, 1995)	rural areas; gender-related inequality	fiscal reforms and strengthening governance at village level	Zhang and Kanbur (2005)
quality of governance (female school enrolment rates; access to safe drinking water)	spatial data/ spatial regression analysis	Cambodia (2002-04)	densely populated rural areas	reducing domestic violence, land conflicts and crime	Bennini *et al.* (2008)
school quality and costs (mathematics test scores; per-pupil expenditures)	descriptive statistics and regression analysis	Chile (2005)	rural areas	consolidation (towards schools exploiting economies of scale, within one-hour a day of travel)	Gallego *et al.* (2008)
education access and performance (school enrolment rates; final examination pass rates)	descriptive statistics and correlation analysis	Ghana (2005)	Northern regions	upgrading one secondary school in each district of the regions concerned	Higgins (2008)

Table 2 - List of variables and descriptive statistics

Variable	Definition	Mean	Minimum	Maximum	Standard deviation	Skewness	Kurtosis
Dependent (censored) variables							
hcacens	marginal benefit in access to healthcare (logarithm of the ratio of healthcare access: 2007 vs. 2000-01; 0 if ≤ 0)	0.15	0	0.68	0.19	1.06	3.18
schcens	marginal benefit in access to primary education (log-ratio of gross enrolment rates: 2006-07 vs. 2004-05; 0 if ≤ 0)	0.12	0	0.7	0.19	1.98	6.19
Demographic indicators (2004-05)							
hsize	average number of persons per household	6.72	4.75	9.72	1.23	0.47	2.43
lnpop	population (thousands, natural logarithm)	5.52	2.94	7.03	0.9	-1.36	4.47
popagr	% population living on agriculture (1=100%)	0.77	0.29	1	0.16	-0.77	4.09
Agriculture (2004-05)							
lnarpp	average cultivated area per agricultural producer (ha/person with collective or individual management, log.)	1.26	0.47	2.02	0.42	-0.14	1.95
nsedlstock	% nomadic and transhumant husbandry in total livestock (including sedentary livestock; 1=100%)	0.32	0.06	0.85	0.23	0.95	2.98
femaar	ratio of female- to male-owned average cultivated area	0.43	0.07	1.16	0.25	0.55	3.07
femal	ratio of female to male number of agricultural producers	0.23	0.02	0.64	0.16	0.76	2.97
lnyd	average yield of staple crops (millet, sorghum and cowpea, tonne/ha weighted by respective national averages, log.)	5.68	4.87	6.03	0.27	-0.96	3.7
Healthcare							
lnhca	% population residing within 5 km from a healthcare centre (log.; 2002-03)	-1.07	-1.83	-0.24	0.39	-0.12	2.26
lnimr	infant mortality in region* (per thousand, log.; 2006)	5.25	4.71	5.59	0.29	-0.88	2.36
lnmedr	medical doctors in region* (log.; 2006)	2.86	2.3	4.19	0.36	0.77	6.12
lnvispc	annual medical visits per resident (log.; 2005-06)	3.13	2.48	3.8	0.3	0.44	2.76
Primary education (2004-05)							
lnnetgap	log-ratio of gross to net primary school enrolment rates	0.16	0.09	0.38	0.05	2.92	14.4
lngpscenr	gross primary school enrolment rate (1=100%, log.)	-0.68	-1.36	0.17	0.28	0.62	4.16
lnfemgap	log-ratio of total av. to female gross primary school enrolment rates	0.23	0.03	0.52	0.14	0.48	2.24
Dummies							
isohsahel	Sahelian isohyetal zones (between northern limit of cropping and 350 mm rainfall p.a.)						
isohsudan	Sahelo-Sudanian and Sudanian isohyetal zones (between 350 and 800 mm rainfall p.a.)						
livestock	predominant livestock activities (households with main occupation in livestock [with/without agricultural work] exceeding 90% or rural households; 2005)						

*Average population-weighted figure for Department of Kollo (region of Tillaberi + Niamey city). Sources: INS (2006, 2008a); MDA/MRA (2008): vol. 3 (T. M5r), vol. 6 (T. 11, T. 13); MSP/LCE (2005: T. 52); Abdoulaye and Sanders (2006); Niger-Info (www.ins.ne).

Table 3 – Principal component analysis (first three components, full sample and subsample)

Components	pc1(*f*)	pc2(*f*)	pc3(*f*)	pc1(*s*)	pc2(*s*)	pc3(*s*)
Eigenvalue decomposition of the correlation matrix						
Eigenvalues	3.52	1.56	1.16	3.45	1.86	1.23
(% variation)	(35.2)	(15.6)	(11.6)	(34.5)	(18.6)	(12.3)
Eigenvectors						
femaar				0.41	-0.24	-0.02
lnyd				0.39	0.01	-0.14
nsedlstock	0.33	-0.37	0.17	0.25	0.02	0.55
lnhca	0.26	0.45	0.28	0.12	0.51	-0.51
lnnetgap	0.21	0.22	0.32			
lngpscenr	0.13	0.55	0.13	-0.11	0.53	-0.13
popagr	-0.02	0.34	-0.62	-0.004	0.35	0.32
lnfemgap	-0.27	-0.29	0.15			
hsize	-0.31	0.21	-0.34	-0.43	0.03	-0.06
lnmedr	-0.39	0.26	0.45			
lnpop	-0.468	0.01	0.23	-0.28	-0.36	-0.43
lnimr	-0.472	0.02	0.02			
femal				-0.37	0.28	0.3
lnarpp				-0.44	-0.24	0.14

Full sample (*f*): 37 administrative departments. Subsample (*s*): 34 departments (excluding those of the Agadez region, i.e. Bilma, Arlit and Tchirozérine)

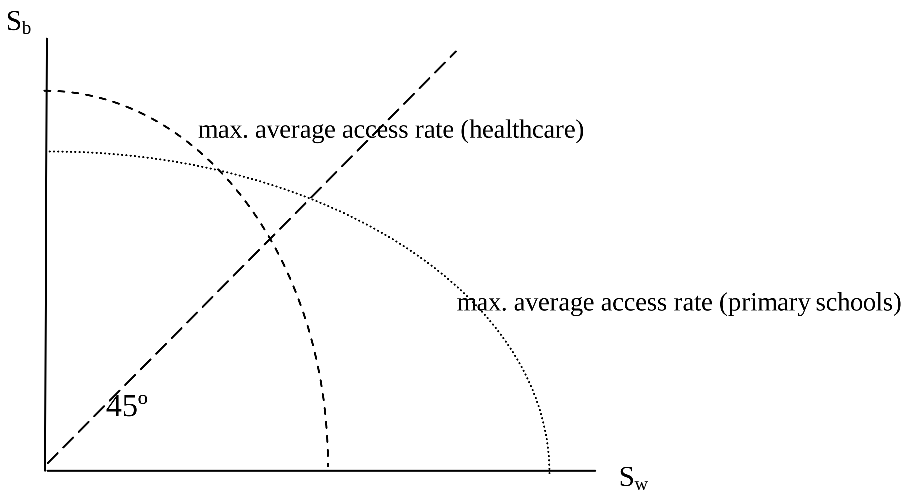
Notes for Tables 4-5 (list of variables in Table 2). Dependent variable: *schcens* (Table 4); *hcacens* (Table 5); *r* (T. 4-5, in selectivity equations; average access thresholds: *l* 50%, *u* 60% in T. 4; *l* 40%, *u* 50% in T. 5). Cut-off distance for spatial lag variables (*sp*): *a* 420.4 km (= 2/5 connectivity level between minimum and maximum feasible distances), *b* 239.1 km (= minimum distance, with each observation having at least one neighbour). Principal components: *f* full sample, *sf* (/*s*) subsample excluding Agadez region, based on first (/second) set of components (Table 3). T-statistics in parentheses (statistical significance: *p≤0.01, ‘p≤0.05, “p≤0.10). In italics: parameter estimate in model *(i)* augmented (*popagr* in C1/D1; *lnpop* in G1), *(ii)* with upper (instead of lower) eligibility threshold (*isosahel* in D3, in brackets), *(iii)* with marginal changes in healthcare access 2007 vs. 2002-03 (instead of 2007 vs. 2000-01: *r(l,u)* in F1/2, G1/2, H1/2). Norm.χ^2: Doornik-Hansen residual normality test. MAE: mean absolute error (·100). PREDR: correct prediction rate of binary choices (selectivity equations).

Table 4 – Access to primary education: Tobit estimates

model	*standard Tobit*		*Tobit with eligibility*		*spatial Tobit*				*spatial Tobit with eligibility*			
method	[A1] ML	[A2] ML	[B1] Heckman	[B2] ML	[C1] ML	[C2] ML	[C3] ML	[C4] ML	[D1] ML	[D2] Heckman	[D3] Heckman	[D4] max. score + (ML) log-logistic
constant	-1.29	-1.04	-0.49	-0.47	0.19	2.18	-3.24	1.04	0.07	2.16	2.04	0.85
	(-2.25)’	(-2.32)’	(-1.9)”	(-1.77)”	(0.18)	(1.18)	(-1.99)’	(0.63)	(0.6)	(1.62)”	(1.53)	(-0.4)
lnpop	0.22	0.21	0.12	0.1	0.18	0.17	0.16	0.14	0.1	0.09	0.07	0.13
	(2.82)*	(2.76)*	(2.97)*	(1.73)”	(2.4)’	(2.43)’	(2.14)’	(2.14)’	(1.4)	(2.35)’	(1.89)”	(1.67)”
hsize	0.02											
	(0.6)											
popagr	0.29	0.24	0.19	0.24	*0.26*				*0.27*			
	(1.01)	(0.9)	(0.99)	(1.16)	*(0.9)*				*(0.87)*			
nsedlstock	0.17											
	(0.61)											
lngpscenr*(sp)*					1.32 (*a*)	4.06 (*b*)	6.45 (*b*)	2.39 (*b*)	0.45 (*a*)	1.9 (*b*)	3.19 (*b*)	6.71 (*b*)
(*a*, *b*)					(0.98)	(1.58)	(2.5)’	(1.05)	(0.3)	(1.67)”	(1.72)”	(2.08)’
lnpop*(sp)*							0.14 (*b*)			-0.19 (*a*)		0.6 (*a*)
(*a*, *b*)							(0.95)			(-1.13)		(1.11)
isohsahel	-0.47	-0.51	-0.36	-0.42	-0.4	-0.37	-0.37	-0.42	-0.32	-0.34	-0.12 *[-0.18]*	-0.39
	(-2.12)’	(-3.02)*	(-3.64)*	(-4.37)*	(-2.66)*	(-2.6)*	(-2.65)*	(-3.19)*	(-3.04)*	(-4.17)*	(-1.1) *[-1.67]”*	(-3.73)*
isohsudan	-0.41	-0.41	-0.31	-0.3	-0.33	-0.27	-0.28	-0.26	-0.29	-0.22	-0.06	-0.27
	(-1.88)”	(-2.45)’	(-3.03)*	(-3.17)*	(-2.07)’	(-1.69)”	(-1.76)”	(-1.79)”	(-2.21)’	(-2.42)’	(-0.54)	(-2.1)’
livestock	-0.06											
	(-0.57)											
r (*l*, *u*)	0.2 (*l*)	0.19 (*l*)	0.15 (*l*)	0.25 (*u*)	0.14 (*l*)	0.09 (*l*)		0.28 (*u*)	0.09 (*l*)	0.12 (*u*)	-0.02 (*l*)	0.16 (*u*)
	(2.11)’	(2.08)’	(1.95)’	(2.22)’	(1.53)	(0.93)		(2.6)*	(1.06)	(1.24)	(-0.22)	(1.5)
σ_ε	0.21	0.21		0.13	0.21	0.2	0.19	0.18	0.15			0.09
	(6.23)*	(6.26)*		(7.1)*	(6.26)*	(6.17)*	(6.2)*	(6.29)*	(5.93)*			(5.52)*
λ(r=1)			-0.05							0.06	0.02	0.19
			(-0.82)							(0.85)	(0.45)	(1.06)
ρ				0.02					0.08			
				(0.02)					(0.1)			
norm. χ^2(2)	20.1*	16.1*	14.5*	6.3’	16.8*	16.9*	15.3*	12.3*	16.6*	9.4*	17.8*	
MAE	9.65	9.74	10.8	9.43	9.76	9.46	9.57	8.89	10.02	9.93	8.92	
constant			0.62 (*f*)	1.1 (*f*)					0.63 (*f*)	1.11 (*f*)	0.63 (*sf*)	0.68 (*f*)
			(1.63)”	(1.53)					(0.8)	(2.67)*	(1.63)”	(2.92)*
pc1 (*f*, *s*)			0.02 (*f*)	-0.11 (*f*)					0.01 (*f*)	-0.11 (*f*)	0.03 (*sf*)	-0.001 (*f*)
			(0.08)	(-0.23)					(0.02)	(-0.62)	(0.14)	(-0.01)
pc2 (*f*, *s*)			-1.57 (*f*)	-1.21 (*f*)					-1.56 (*f*)	-1.22 (*f*)	-1.56 (*sf*)	-0.73 (*f*)
			(-3.09)*	(-1.93)’					(-1.94)’	(-2.61)*	(-3.04)*	(-4.15)*
pc3 (*f*, *s*)			-0.04 (*f*)	0.13(*f*)					-0.01 (*f*)	0.13 (*f*)	-0.03 (*sf*)	0.03 (*f*)
			(-0.13)	(0.22)					(-0.02)	(0.4)	(-0.1)	(0.09)
PREDR			0.84	0.81					0.84	0.81	0.79	0.89

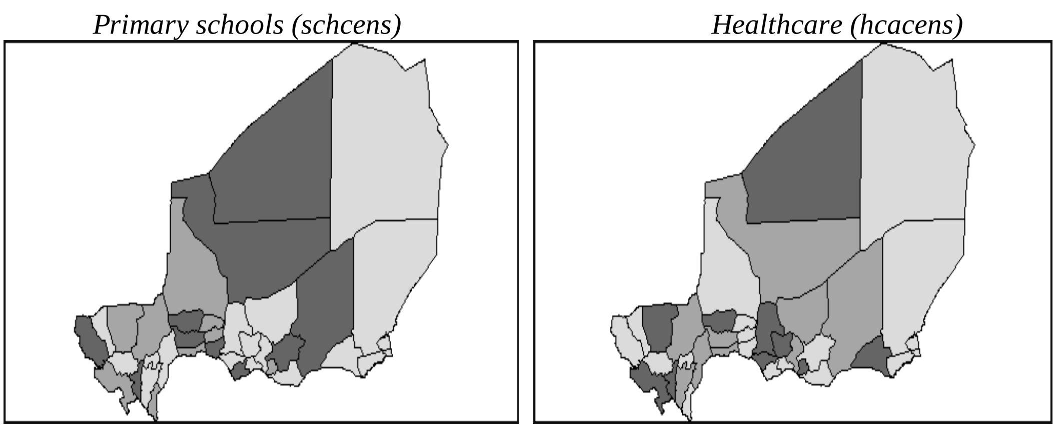
Table 5 – Access to healthcare: Tobit estimates

model	*standard Tobit*		*Tobit with eligibility*		*spatial Tobit*			*spatial Tobit with eligibility*				
method	[E1] ML	[E2] ML	[F1] Heckman	[F2] Heckman	[G1] ML	[G2] ML	[G3] ML	[H1] Heckman	[H2] Heckman	[H3] Heckman	[H4] Heckman	[H5] max. score + (ML) log-logistic
constant	-0.63	-0.56	-0.01	-0.04	0.27	1.33	1.95	0.65	1.21	0.37	-1.32	4.8
	(-1.28)	(-1.43)	(-0.08)	(-0.21)	(0.56)	(0.67)	(0.91)	(2.17)’	(1.04)	(0.61)	(-1.33)	(1.59)
lnpop	0.01	0.02			*0.02*		0.11					
	(0.06)	(0.2)			*(0.34)*		(1.23)					
hsize	0.08	0.06	0.04	0.05	0.05	0.09	0.07	0.03	0.07	0.03	0.04	0.13
	(2.2)’	(1.86)”	(1.99)’	(2.06)’	(1.71)”	(2.09)’	(1.45)	(1.66)”	(2.38)’	(1.73)”	(2.03)’	(1.77)”
popagr	-0.16		-0.19	-0.29								
	(-0.56)		(-1.29)	(-1.64)”								
nsedlstock	0.33											
	(1.22)											
lnhca*(sp)*					0.68 (*a*)	1.8 (*b*)	1.45 (*a*)	0.75 (*a*)	1.45 (*b*)	-0.17 (*a*)	-0.95 (*a*)	5.47 (*b*)
(*a*, *b*)					(1.68)”	(0.93)	(2.64)*	(2.9)*	(1.28)	(-0.22)	(-1.11)	(1.72)”
lnpop*(sp)*							-0.26 (*a*)	*-0.12 (b)*				
(*a*, *b*)							(-0.61)	*(-0.95)*				
isohsahel	0.02	-0.18	-0.06	-0.1	-0.04	-0.15	0.1	-0.01	-0.13	0.07	0.08	-0.1
	(0.09)	(-1.24)	(-0.84)	(-1.08)	(-0.32)	(-1.25)	(0.53)	(-0.07)	(-1.36)	(0.87)	(1.001)	(-0.44)
isohsudan	-0.14	-0.26	-0.13	-0.15	-0.11	-0.22	0.16	-0.05	-0.15	0.02	0.07	-0.09
	(-0.64)	(-1.68)”	(-1.83)”	(-1.7)”	(-0.79)	(-1.72)”	(0.07)	(-0.67)	(-1.62)”	(0.22)	(0.08)	(-0.39)
livestock	-0.12											
	(-1.03)											
r (*l*, *u*)	0.47 (*l*)	0.46 (*l*)	0.21 (*l*)	0.22 (*u*)	0.4 (*l*)	0.44 (*l*)		0.23 (*l*)	0.23 (*u*)	0.22 (*l*)	0.19 (*l*)	0.44 (*u*)
	(4.12)*	(4.68)*	(3.06)*	(2.29)’	(4.39)*	(4.35)*		(3.75)*	(2.28)’	(3.82)*	(4.27)*	(1.48)
			0.15’	*0.18’*	*0.48**	*0.53**		*0.17**	*0.2’*			
σ_ε	0.18	0.19			0.17	0.19	0.24					0.14
	(5.99)*	(5.99)*			(5.97)*	(6.04)*	(5.7)*					(4.47)*
λ(r=1)			0.01	-0.11				-0.03	-0.09	-0.01	0.16	-0.55
			(0.14)	(-1.45)				(-0.67)	(-1.19)	(-0.21)	(3.22)*	(-0.43)
norm. $\chi^2(2)$	7.6’	4.01	3.28	0.95	2.24	2.79	6.89’	1.23	8.35’	1.7	4.4	
MAE	8.19	9.01	9.14	12.7	8.14	8.94	11.2	8.45	12.11	8.41	7.76	
constant			0.07 (*f*)	2.29 (*f*)				0.07 (*f*)	2.29 (*f*)	0.08 (*sf*)	-1.14 (*s*)	0.39 (*f*)
			(0.25)	(2.61)*				(0.25)	(2.61)*	(0.23)	(-0.48)	(1.08)
pc1 (*f*, *s*)			-0.63 (*f*)	-0.75 (*f*)				-0.63 (*f*)	-0.75 (*f*)	-0.67 (*sf*)	-6.15 (*s*)	-0.32 (*f*)
			(2.59)*	(-1.76)”				(2.59)*	(-1.76)”	(-2.25)’	(-1.3)	(-1.66)”
pc2 (*f*, *s*)			-0.89 (*f*)	-1.77 (*f*)				-0.89 (*f*)	-1.77 (*f*)	-1.03 (*sf*)	5.87 (*s*)	-0.38 (*f*)
			(-2.72)*	(-1.97)’				(-2.72)*	(-1.97)’	(-2.06)*	(1.23)	(-2.1)’
pc3 (*f*, *s*)			0.02 (*f*)	-0.38 (*f*)				0.02 (*f*)	-0.38 (*f*)	0.12 (*sf*)	2.02 (*s*)	-0.78 (*f*)
			(0.08)	(-0.7)				(0.08)	(-0.7)	(0.37)	(1.13)	(-1.25)
PREDR			0.81	0.95				0.81	0.95	0.88	0.97	0.95



PPF for primary education (dotted line) vs. PPF for healthcare and basic infrastructure services (dashed line)

Figure 1 – Public service production possibility frontiers



Quartiles (number of administrative areas or *départements*; lighter shading for minor or no improvement): 1st + 2nd (18; light grey); 3rd (9; grey); 4th (10; dark grey).

Figure 2 – Quartile maps of marginal improvements in public service delivery

References

Abdoulaye, T, J Sanders (2006): "New Technologies, Marketing Strategies and Public Policy for Traditional Food Crops: Millet in Niger", *Agricultural Systems*, 90(1-3): 272-92.

Ajwad, M, Q Wodon (2007): "Do Local Governments Maximize Access Rates to Public Services across Areas? A Test Based on Marginal Benefit Incidence Analysis", *Quarterly Review of Economics and Finance*, 47(2): 242-60.

Ajwad, M, Q Wodon (2002): "Who Benefits from Increased Access to Public Services at the Local Level? A Marginal Benefit Incidence Analysis for Education and Basic Infrastructure", *World Bank Economists' Forum*, No. 2, pp. 155-75. (mpra.ub.uni-muenchen.de/12309)

Alabi, R (2008): "Income Distribution and Accessibility to Primary and Secondary Schools in Nigeria", *IWIM Discussion Paper Series*, No. 114, University of Bremen. (www.iwim.uni-bremen.de)

Amemiya, T (1984): "Tobit Models: A Survey", *Journal of Applied Econometrics*, 24(1-2): 3-61.

Anselin, L (2003a): *GeoDa 0.9 User's Guide*, Urbana-Champaign: CSISS, University of Illinois.

Anselin, L (2003b): "Spatial Externalities, Spatial Multipliers, and Spatial Econometrics", *International Regional Science Review*, 26(2): 153-66.

Anselin, L (2002): "Under the Hood. Issues in the Specification and Interpretation of Spatial Regression Models", *Agricultural Economics*, 27(3): 247-67.

Bennini, A, T Owen, and H Rue (2008): "A Semi-Parametric Spatial Regression Approach to Post-War Human Security: Cambodia, 2002-2004", *Asian Journal of Criminology*, 3(2): 139-158.

Bosker, M, H Garretsen (2009): "Economic Development and the Geography of Institutions", *Journal of Economic Geography*, 9(3): 295-328.

Boubacar, Y (2000): "Évolution des régimes de propriété et d'utilisation des ressources naturelles dans la région de Maradi", *Drylands Research Working Papers*, No. 29, Somerset. (www.drylandsresearch.org.uk)

Brent, R (1990): *Project Appraisal for Developing Countries*, Hemel Hempstead: Harvester-Wheatsheaf.

Brixiová, Z, A Bulíř, and J Comenetz (2001): "The Gender Gap in Education in Eritrea in 1991-98: A Missed Opportunity?", *IMF Working Papers*, WP/01/94. (papers.ssrn.com)

Brueckner, J (2003): "Strategic Interaction among Governments: An Overview of Empirical Studies", *International Regional Science Review*, 26(2): 175-88.

CEPAL (2002): *El impacto socioeconómico y ambiental de la sequía de 2001 en Centroamérica*, Santiago: UN-ECLA.

Chay, K, J Powell (2001): "Semiparametric Censored Regression Models", *Journal of Economic Perspectives*, 15(4): 29-42.

Davis, B (2003): *Choosing a Method for Poverty Mapping*, Rome: FAO. (www.povertymap.net/publications)

Davoodi, H, E Tiongson, and S Asawanuchit (2003): "How Useful are Benefit Incidence Analyses of Public Education and Health Spending?", *IMF Working Papers*, WP/03/227. (papers.ssrn.com)

Deichmann, U (1999): *Geographic Aspects of Inequality and Poverty*, Washington DC: World Bank. (www.worldbank.org/poverty/inequal)

Fan, CS, C Lin, and D Treisman (2009): "Political Decentralization and Corruption: Evidence from around the World", *Journal of Public Economics*, 93(1-2): 14-34.

Flores-Lagunes A, K Schnier (2010): "Estimation of Sample Selection Models with Spatial Dependence", *Journal of Applied Econometrics*, DOI: 10.1002/jae.1189.

Fredriksen, B (2009): "Rationale, Issues, and Conditions for Sustaining the Abolition of School Fees", in World Bank-UNICEF, *Abolishing School Fees in Africa. Lessons from Ethiopia, Ghana, Kenya, Malawi, and Mozambique*, World Bank, Washington DC, pp. 1-41.

Gallego, F (2010): "Historical Origins of Schooling: The Role of Democracy and Political Decentralization", *Review of Economics and Statistics*, 92(2): 228-43.

Gallego, F, C Rodríguez, and E Sauma (2008): *Public School Outcomes in Rural Areas under Management of Local Governments and Soft Budget Constraints: Evidence from Chile*, Santiago: Pontificia Universidad Católica. (www.economia.puc.cl)

Gilliard, P (2005): *L'extrême pauvreté au Niger*, Paris: Karthala.

Greene, WH (2003): *Econometric Analysis*, Upper Saddle River-NJ: Pearson.

Greene, WH (1998): *LIMDEP Version 7.0. User's Manual*. New York: Econometric Software Inc.

Greene, WH (1981): "Sample Selection Bias as a Specification Error: Comment", *Econometrica*, 49(3): 795-98.

Haut Conseil des Collectivités Territoriales (HCCT) (2009): *Rapport national de l'évaluation de la mise en œuvre de la décentralisation au Niger*, Niamey.

Heckman, J (1979): "Sample Selection Bias as a Specification Error", *Econometrica*, 47(1): 153-61.

Heckman, J, J Tobias, and E Vytlacil (2000): "Sample Estimators for Treatment Parameters in a Latent Variable Framework with an Application to Estimating the Returns to Schooling", *NBER Working Papers*, NBER, Cambridge-Mass. (www.nber.org/papers)

Heckman, J, L Lochner, and C Taber (1998): "General-Equilibrium Treatment Effects: A Study of Tuition Policy", *American Economic Review*, 88(2), 381-86.

Hendry, D, J Doornik (2001): *Empirical Econometric Modelling Using PcGive 10*, vol. I., London: Timberlake.

Henninger, N, M Snel (2002): *Where Are the Poor? Experiences with the Development and Use of Poverty Maps*, Washington DC: WRI. (population.wri.org)

Higgins, K (2008): “Regional Inequality and Secondary Education in Ghana”, *Policy Brief (prepared for the World Development Report 2009)*, Overseas Development Institute. (www.odi.org.uk/resources)

Iimi, A (2004): “Decentralization and Economic Growth Revisited: An Empirical Note”, *JBICI Working Papers*, No. 17, JBIC Institute, Tokyo. (www.jbic.go.jp)

Institut National de la Statistique (INS) (2009): *Rapport sur les indicateurs sociaux (Enquête Nationale sur le budget et la consommation des ménages 2007-08)*, Niamey.

INS (2008a): *Annuaire statistique 2003-07*, Niamey.

INS (2008b): *Tendances, profil et déterminants de la pauvreté au Niger: 2005-08*, Niamey.

INS (2006): *Niger. Répertoire National des Communes (RENACOM)*, Niamey.

INS-Programme des Nations Unies pour le Développement (PNUD) (2008a): *La sécurité alimentaire dans un pays sahélien*, Niamey.

INS-PNUD (2008b): *Rapport sur l’état de la pauvreté*, Niamey.

Kanbur, R, T Venables (2003): “Spatial Dimensions of Development and Inequality in Africa”, *Introduction to a Symposium in the Journal of African Economies*, Centre for the Studies of African Economies, University of Oxford. (www.arts.cornell.edu/poverty)

Khan, S, J Powell (2001): “Two-step Estimation of Semiparametric Censored Regression Models”, *Journal of Econometrics*, 103(1-2): 73-110.

Kloek, T, L Mennes (1960): “Simultaneous Equations Estimation Based on Principal Components of Predetermined Variables”, *Econometrica*, 28(1): 45-61.

Kutengule, M, A Nucifora, and H Zaman (2006): “Malawi: Agricultural Development and Marketing Corporation Reform”, in A Coudouel, A Dani, S Paternostro (eds.), *Poverty and Social Impact Analysis of Reforms. Lessons and Examples from Implementation*, Washington DC: World Bank, pp. 415-51.

Lattin, J, J Carroll, and P Green (2003): *Analyzing Multivariate Data*, London: Thomson.

Lessmann, C (2009): “Fiscal Decentralization and Regional Disparity: Evidence from Cross-section and Panel Data”, *Environment and Planning A*, 41(10): 2455-73.

Mainardi, S (2003): “Social Welfare Objectives and Distribution Weights in Public Health Planning in Turkey”, *Journal for Studies in Economics and Econometrics*, 27(3): 29-47.

Mertler, C, R Vannatta (2001): *Advanced Multivariate Statistical Methods*, Los Angeles: Pyrczak.

Ministère de la Planification et de la Coopération Externe (MPCE) (2004): *Carte de pauvreté d’Haïti*, République d’Haïti, Port-au-Prince.

Ministère de la Santé Publique et de la Lutte contre les Endémies (MSP/LCE) (2005): *Plan de Développement Sanitaire 2005-2009*, Niamey.

Ministère du Développement Agricole/ Ministère des Ressources Animales (MDA/MRA) (2008): *Recensement General de l'Agriculture et du Cheptel (RGAC 2004/08)*, Niamey.

Mukherjee, B, D Singer (2010): "International Institutions and Domestic Compensation: The IMF and the Politics of Capital Account Liberalization", *American Journal of Political Science*, 54(1): 45-60.

Nachega, J-C, T Fontaine (2006): "Economic Growth and Total Factor Productivity in Niger", *IMF Working Papers*, WP/06/208. (papers.ssrn.com)

Naudé, W (2007): "Geography and Development in Africa", *UNU-WIDER Discussion Papers*, 2007/03, Helsinki. (www.wider.unu.edu)

Orr, L. (1976): "Income Transfers as a Public Good: An Application to AFDC", *American Economic Review*, 66(3): 359-371.

Pérez, GJ (2005): "Dimensión especial de la pobreza en Colombia", *Documentos de Trabajo sobre la Economía Regional*, No. 54, CEER-Banco de la República, Cartagena de Indias. (www.banrep.gov.co)

Powell, J (2008): "Semiparametric Estimation", in S. Durlauf and L. Blum (eds.), *The New Palgrave Dictionary of Economics*, Palgrave: Macmillan. (www.dictionaryofeconomics.com)

Ridde, V, A Diarra, and M Moha (2011): "User Fees Abolition Policy in Niger: Comparing the Under Five Years Exemption Implementation in Two Districts", *Health Policy*, 99(3), 219-225.

Sanhueza, C (2009): "Tamaño de familia y orden de nacimiento en Chile: usando gemelos como experimento natural", *Revista de análisis económico*, 24(2): 133-152.

Sikirou, S (2008): "Pauvreté et accessibilité des ménages urbains aux biens et services publics à Ouagadougou et Bobo-Dioulasso", in B. Kouassi (ed.), *Pauvreté des ménages et accès aux soins de santé en Afrique de l'Ouest*, Paris: Karthala, pp. 51-112.

Stifel, D, B Minten, and P Dorosh (2003): "Transaction Costs and Agricultural Productivity: Implications of Isolation for Rural Poverty in Madagascar", *MSSD Discussion Papers*, No. 56, IFPRI. (www.ifpri.org)

Tandon, A (2006): "Improving Primary Enrollment Rates among the Poor", *ERD Policy Briefs*, No. 46, Asian Development Bank, Manila. (www.adb.org/documents)

Thobani, M (1984): "Charging User Fees for Social Services: Education in Malawi", *Comparative Education Review*, 28(3), 402-423.

Venables, A (2006): "Shifts in Economic Geography and their Causes", *Economic Review*, Federal Reserve Bank of Kansas City, QIV, 61-85. (www.kansascityfed.org)

Verbeek, M (2004): *A Guide to Modern Econometrics*, Chichester-UK: J. Wiley & Sons.

Walker, I, P Serrano, and J Halpern (2000): Pricing, Subsidies and the Poor: Demand for Improved Water Services in Central America, *Policy Research Working Paper Series*, No. 2468, World Bank. (www-wds.worldbank.org)

Wooldridge, J (2002): *Econometric Analysis of Cross Section and Panel Data*, Cambridge-Mass.: MIT Press.

World Bank (2008a): *Niger: Food Security and Safety Nets*, Washington DC.

World Bank (2008b): *Niger: Modernizing Trade during a Mining Boom*, Washington DC.

Zhang, X, R Kanbur (2005): "Spatial Inequality in Education and Health Care in China", *China Economic Review*, 16(1): 189-204.

Ziervogel, G, A Cartwright, A Tas, J Adejuwon, F Zermeglio, M Sgale, and B Smith (2008): *Climate Change and Adaptation in African Agriculture*, Stockholm Environment Institute. (www.wikiadapt.org)

Appendix − Public services and geography

A − Evidence from other developing countries

In cross-region (/country) studies, location and distance are increasingly regarded as relevant factors, with distinctions between absolute (or *first nature*) and relative (or *second nature*) geography. The former refers to features unrelated, or loosely related, to human activity (climate, disease burden, soil quality, topography, etc.); the latter to economic and institutional interdependencies due to interactions between agents (e.g., individuals or regions). Additionally, *third nature* geography is explained in terms of prior human intervention, such as adoption of new technologies, thus largely overlapping with the second concept. In Africa, absolute and relative geography have often hindered the development of positive externalities of localisation and urbanisation economies, with implications for costs, quality and coverage of public services. These constraints include long travel times, suboptimal economic agglomeration in sparsely populated regions, overgrown metropolitan areas, and negative feedbacks between neighbouring countries with weak institutions (Venables, 2006; Naudé, 2007; Bosker and Garretsen, 2009).

Developing economies' basic services have mainly been focused on relative to Asia and Latin America, while sub-Saharan Africa has remained less investigated. Selected country case studies are listed in Table 1. Economic geography concepts are not easily distinguishable in practice. Keeping other conditions constant, lower transport costs and travel time provide urban areas with relatively higher rates of school enrolment and attendance, and easier access to healthcare (Kanbur and Venables, 2003). Public service utilisation in rural areas is highly sensitive to travel time: in Chile, more than half of municipal school choices by children of rural households are based on vicinity of the establishment (Deichmann, 1999; Gallego *et al.*, 2008). As for *relative* geography, an egalitarian income distribution can foster knowledge diffusion and productivity through geographically balanced, more pro-poor service provision, whereas with high ethno-linguistic diversity, collective action for public investment can be more difficult and costly to enforce and coordinate. As for interactions with *absolute* geography, road and healthcare infrastructure backlogs can aggravate the impact of droughts in remote areas, with high risk of contamination from water tanks, epidemics, infant dehydratation, and undernourishment (CEPAL, 2002: p. 44).

In terms of demand composition, maternal (/adult female) education can foster school enrolment of females, also indirectly by increasing the proportion of female teachers. Along with medical (antenatal and delivery) maternity care, mothers' education levels also impact on children's health status, with substantial gaps in infant mortality between better off and poorer communities (Mainardi 2003). Low parental literacy is regarded to be often associated with teachers' absenteeism and less concern for inter-generational transmission of education as a goal. This hampers the quality of basic education, with lower education attainments especially for later-born children in large-sized households (Tandon, 2006; Sanhueza, 2009). Increasing out-of-pocket expenses and inefficient small municipal administrations can even widen a spatial divide in public service delivery and quality (Zhang and Kanbur, 2005; Gallego *et al.*, 2008). Diversification away from traditional agricultural activities, gender equality in school access, and easier access to other public services, enhance the scope for human capital accumulation by different age cohorts (which can be reflected by larger spreads between gross and net school enrolments; Iimi, 2004).

B – Evidence and hypotheses on Niger

Half of Niger's population resides more than five kilometres from a healthcare centre, and for 15% this distance exceeds 15 km (MSP/LCE, 2005: p. 48). In rural areas in particular, nearly 60% of residents lack access to healthcare facilities. Hospital and medical clinic infrastructures are concentrated in few urban centres, but even there at least half of the sick cannot afford medical consultations (Gilliard, 2005: p. 202; Sikirou, 2008: p. 83). As far as schooling is concerned, in 2007 literacy (among individuals with or above fifteen years of age) was 29% and highly imbalanced against females (17% vs. 43% for males; INS, 2009: p. 61). A wide gender-gap also concerns gross school enrolments (47% female vs. 64% male; INS-PNUD, 2008a: 90; INS, 2008b and 2009). In terms of place of residence, literacy rates vary from 65% in urban communities, to 49% in smaller urban centres, down to nearly 22% in rural areas (INS, 2009: p. 61). Several mainly rural administrative departments (such as Gouré in the region of Zinder) suffer from severe backlogs in public school services.

Health status and education tend to be inversely related to incidence of poverty, food insecurity, and urban-rural disparities (INS-PNUD, 2008a/b). For instance, measures of prevention of food insecurity can be expected to be more easily and effectively adopted by agricultural producers with relatively higher levels of technical training. As such, cross-department disparities in access to schools and healthcare should be seen in a broad framework, relative to poverty, food insecurity, and provision of other services. Poverty affects large shares of the population, especially in Maradi, Tillaberi and Dosso (the regions of Agadez and Diffa appear to be less affected: INS, 2008b). More than 80% of the labour force is employed in agriculture (which accounts for 40% of GDP), and 90% of the population resides in rural areas. Droughts induce a nearly 10% real income loss in growth per capita, relative to the growth potential achievable in normal years (Nachega and Fontaine, 2006). With more than three fifths of rural households living in poverty (vs. 36% of urban households), almost 94% of the poor in Niger are rural, and highly depend on rain-fed crops and livestock for subsistence (INS-PNUD, 2008a).

Based on 2007-08 budget surveys, a household in Niger is defined as poor if its annual consumption per capita is below 150000 CFA Francs in urban areas, or below 100000 CFAF in rural areas (≅ 229 and 152 EUR). Over the last fifteen years, almost two thirds of the population have lived below the poverty line. More than one fifth suffers from chronic extreme food insecurity, with caloric consumption of less than 1800 kcal/day per capita (World Bank, 2008a). Households' responses to shocks to income and food access are limited to extra borrowings, livestock sales, and migration. Relative to other public services, starting from a very low base, some improvements have been registered. Between 2002 and 2007, access to safe drinking water increased from 43% to 66%, and gross school enrolment rates from 42% to 57% (INS, 2008b). However, statistical sources are not always consistent (based on World Bank estimates, access to improved water sources remained around 40% throughout the 1990s and 2000s; ddp-ext.worldbank.org), nor do achievements necessarily imply reductions of socioeconomic disparities across and within regions.

Poverty relates to specific household and regional characteristics, but survey evidence is again partly contradictory. Some surveys suggest strong associations with female-headed households, but not with household size, while others yield opposite indications (Gilliard, 2005: pp. 150-51). Among households headed by an individual involved in agriculture, poverty is found to be more widespread than among the unemployed (64% vs. 48%; INS-PNUD, 2008b). Especially since the market liberalisation of the 1990s, sparsely populated regions with very limited agricultural potential (close to the Sahelo-Saharan northern limit of cropping) have suffered from reduced subsidies and access to credit. In some of these regions, besides market distance and road quality, domestic service costs are further aggravated by insecurity problems. A semi-nomadic livestock sector (Table 3: *nsedlstock*, *livestock*) may also explain lower access to public services. While this mainly concerns the north of Niger, weak social networks and unequal land tenure systems are serious constraints in populated southern areas. The latter have experienced progressive erosion of traditional social insurance, and increasing land scarcity and inequality (Boubacar, 2000; population size and area are inversely related across departments, with a correlation coefficient $\rho = -0.38$ in 2004). Unequal and poorly defined land tenure and limited education opportunities, particularly for households headed by women living on marginal land, can hamper the propensity to invest by farmers and make them more vulnerable to droughts (Ziervogel *et al*., 2008; Table 3: *lnfemgap*, *femal*, *femaar*, *lnarpp*, *lnyd*).

In regression models of improved access to education and healthcare services across districts, explanatory and control variables (including geographical spillover effects proxied by spatial lag variables of demographic scale and service access coverage) can partly account for the features discussed above. A general functional form can be expressed as follows:

ΔS = f(population size, household characteristics, predominance and type of agricultural activities, agro-climatic zones, *lnpop(sp)*, *S(sp)*, *r*)

Regressors enter the model both directly (eq. (1) and (2): vector X), and, along with other covariates, indirectly through a latent eligibility threshold r^* (eq. (3); Z vector data are concentrated in three principal components in this analysis). Expected parameter signs vary according to sector characteristics, infrastructure requirements, and government objectives (this is further discussed in the second section).