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Infrastructure Access and Household Welfare in Rural Ghana

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***Abstract*:** Empirical evidence in the literature on the extent to which access to different infrastructure services contribute to enhancing household economic welfare remains limited. Our paper contributes to fill in the gap by assessing the influence of access to public infrastructure on welfare in rural areas of a developing country such as Ghana, taking into account the heterogeneity in household endowment. Based on pseudo panel modelling and using three waves of nation-wide household living standard surveys between 1991 and 2006, the empirical findings suggest that access to public transport, electricity and water infrastructure has important but differential impacts on household welfare.

1. Introduction

Access to infrastructure services, such as electricity, water and sewerage, markets, transport network, telecommunication, education and health care, is often identified in the literature as a key factor for sustained and rapid development. Several papers have shown, for various regions of the world, that improved infrastructure increases economic development and growth (Démurger, 2001; Brenneman and Kerf, 2002; Fan and Zhang, 2004; Fedderke *et al*., 2006; Agénor, 2010; Vijil *et al*., 2011). Jowitt (2009) stresses that achieving the Millennium Development Goals will be possible with the delivery of basic infrastructure services. In the case of Africa, in particular, several reports also emphasize the need for improving infrastructure access (African Development Bank, 1999; Commission for Africa, 2005; AFD/World Bank, 2010). Some studies have focused on the role of access to infrastructure such as water, sanitation, electricity and transport, on health (Esrey *et al*., 1991; Brenneman and Kerf, 2002; Fay *et al*., 2005), while others considered the influence of infrastructure on poverty reduction and welfare improvement (Rioja, 1999; Fan *et al*., 2000; Hanjra *et al*., 2009; Dillon *et al*., 2011; Skoufias and Olivieri, 2013).

Some authors document considerable biases in the distribution of basic public infrastructure services and of investment in these services in favour of the urban sector (for instance, Masika and Baden, 1997; Bates, 1981; Torero and Chowdhury, 2005; Bezemer and Headey, 2008; Aryeetey *et al*., 2009). Masika and Baden (1997) further observe that recent shifts in African economic policies towards market liberalization have implied that African rural communities will continue to benefit less from infrastructure service provision than their urban counterparts, as the size of demand for these services in the urban areas will continue to overwhelm the overall demand in rural communities. Among rural communities, the allocation of infrastructure may favour specific groups, in particular the resource-rich constituents. Thus, without proper targeting, the provision of quality infrastructure facilities, rather than reducing poverty and bridging any pre-existing income gap, may instead exacerbate the situation.

Our paper contributes to the literature by assessing the influence of access to public infrastructure on welfare in rural areas of a developing country, namely Ghana. In addition, we take into account the heterogeneity in household endowment and overall capability to use and therefore to withdraw the benefits of public infrastructure. More precisely, our objective is to investigate how different infrastructure services impact on the welfare of the rural population in Ghana. The underlying question is whether the ownership of private assets enhances the role of public infrastructure on welfare. As mentioned above, several studies have focused on how public infrastructure may increase households' welfare. For example, Skoufias and Olivieri (2013) explained that road access indirectly influences welfare through increased employment opportunities. Few studies have investigated the role of

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private assets' ownership on poverty. For example Hackey (2005) in Ghana has shown that private assets decreased the likelihood of households' poverty in urban as well as rural areas. But no study has considered the joint role of public and private assets. We use rural household data from three living standard surveys between 1991 and 2006, and estimate a panel data model based on aggregated individual observations into household cohorts using General Method of Moment (GMM) estimators.

This paper is structured as follows. Section 2 provides information on the background, namely the conceptual framework and Ghana. Section 3 explains the data and methodology used, while Section 4 describes the empirical results. Section 5 concludes.

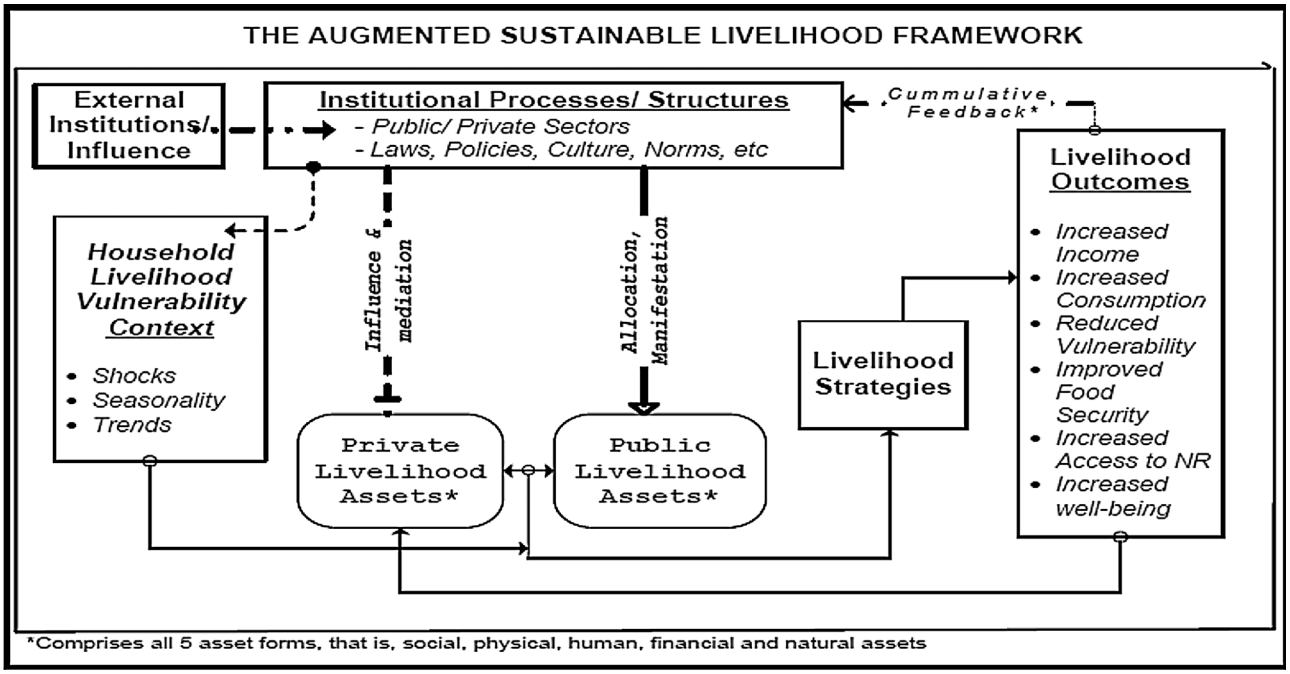
2. Background

2.1 Conceptual Framework

The conceptual framework behind our analysis is the Augmented Sustainable Livelihood Framework (ASLF) by Mensah (2012), which is a reconstruction of the Sustainable Livelihood Framework (SLF) provided in the Department of International Development (1999) and used in several studies investigating households' poverty and livelihood changes (e.g. Weldegiorgis and Jayamohan, 2011; Radeny *et al*., 2012; Bhandari, 2013). The SLF conceptualizes the relationship between assets and well-being. The ASLF is illustrated in Figure 1. The key distinctive feature of the ASLF from the SLF is the definition of livelihood assets in terms of tenure rights, that is to say either private or public, in addition to the form in which such assets may exist, that is to say physical, financial, social, natural or human. Livelihood assets are thus introduced in the framework in two types: (1) those assets that households are able to hold and control, whose levels and user rights are directly determined by the decisions and behaviour of households themselves (in Figure 1 this is the box 'Private Livelihood Assets'); (2) those assets that occur mainly as outcomes of policy decisions, whose levels and access are exogenous to the decisions and behaviour of households and to which no private user rights or control can be exercised by households (in Figure 1 this is the box 'Public Livelihood Assets').

Consequently, the ASLF postulates that household welfare is a function of (1) private capital held by households; (2) a vector of public capital that transpires to households through the manifestation of the prevailing institutional structure and public policy decisions; (3) households' own characteristics; and (4) factors that define the vulnerability context of their livelihoods.

Figure 1: The Augmented Sustainable Livelihood Framework (ASLF)



Source: Mensah (2012).

2.2 Rural Ghana

Ghana, located in the west of sub-Saharan African, is a dominantly agrarian, low income developing economy. The proportion of the country's land under agricultural use has grown consistently from 53 per cent in the early 1980s to over 65 per cent since 2003 (World Bank, 2011). The country has maintained an average annual gross domestic product (GDP) growth rate of about 6 per cent since 2005 (Bank of Ghana, 2011). In terms of the structure of the economy, agriculture still dominates. The sector employs over 60 per cent of the country's labour force, and until 2000, the share of the sector's value added in the country's GDP was well over 40 per cent. This has declined consistently to a level of about 30 per cent in 2009.

Rural households in Ghana form the backbone of the country's food security and natural resource conservation efforts. Beyond the economy, rural Ghana is pivotal to the country's social and political transformation. As the principal basis for most traditional authorities, rural Ghana remains the locus of the country's cultural heritage; the embodiment of the culture and tradition of the majority of indigenous Ghanaian societies. It therefore represents the environment within which the history, music, food, social norms and lifestyle of elemental Ghanaian societies are preserved.

However, the state of Ghana's rural economy could simply be described as underdeveloped and unstructured, with poverty being a crucial issue. Ghana Statistical Service (GSS, 2000, 2007), in its review of poverty trends in the country since the early 1990s, argues that poverty in Ghana is predominantly a rural phenomenon. In the Ghana Poverty Reduction Papers (GPRS I and II) — the country's medium- to long-term development programme from 2001 to 2009 — the Ghanaian National Development Planning Commission identified improvement in public infrastructure as a strategic support investment for accelerated poverty reduction (NDPC, 2003 and 2005). This is important as the country's rural sector lags behind in terms of access to public infrastructure services. Across all three agro ecological zones in the country (coastal zone, forest zone and savannah zone) and during the period 1991/1992 and 2005/2006, water from natural sources accounted for the largest share of water sources for rural households in the country. The proportion of households that receive water through public sector infrastructure such as pipe-networks for in-house plumbing, public stand pipes and even protected wells (boreholes) remains very low. Similarly, the national average of the proportion of households that have access to improved toilet facilities differ significantly from the proportion in rural areas. Focusing specifically on public toilet provisions (which is mainly via the Kumasi Ventilated Improved Pit (KVIP) system), rural households continue to show extensive dependence on unimproved systems such as the pit latrine and pan. In addition, rural households have limited access to electricity. This bias in distribution is more strongly manifested in the rural savannah, where households' connection to electricity has grown from less than 5 per cent in 1991/1992 to just 15 per cent in 2005/2006.

3. Data and Methodology

3.1 Data Source

The data used here are extracted from the latest three rounds of the Ghana Living Standard Survey (GLSS). The GLSS is a nationally representative household and community survey conducted by the Ghana Statistical Service (GSS). The structure of this survey follows from the World Bank's Living Standard Measurement Survey (LSMS), which was first conducted in 1987. The latest three waves of the GLSS that are considered here are the GLSS 3 (years 1991/1992), the GLSS 4 (years 1998/1999) and the GLSS 5 (years 2005/2006). The GLSS is organized into four main components (Coulombe and McKay, 2008): (1) the household survey instruments; (2) the non-farm household survey instruments; (3) the rural community survey instruments; and (4) the prices of food and non-food items survey instruments. The first two sets of instruments are collected at the level of individuals, with households constituting the sampling unit. The number of households sampled is respectively 4,523 in the GLSS 3, 5,998 in the GLSS 4 and 8,688 in the GLSS 5. The fractions of the rural sub-sample in the total household sample for the three GLSS are 65.1 per cent, 63.3 per cent and 58.4 per cent, respectively. Among the key information obtainable from the household survey instruments are the households' structure, income and expenditure patterns, health, education as well as assets, savings and access to key infrastructure services. Information on migration, remittance, employment and household production activities (including agriculture) are also reported in this component of the overall survey instrument, while all non-farm income-generating activities are reported in the non-farm household instrument. The latter two instruments are collected as community-level information. The rural community survey instrument presents information on community facilities and infrastructure, as well as socio-economic and political organization of the sampled communities.

Table 1: Poverty in Ghana in the 1991–2005 GLSS

		GLSS 3		GLSS 4		GLSS 5	
		Rural households	All households	Rural households	All households	Rural households	All households
Share of poor households in terms of:							
When the higher poverty line is considered	HPI	63.6	51.7	49.5	39.5	39.3	28.6
	PGI	24.0	18.5	18.2	13.9	15.5	9.6
When the lower poverty line is considered	HPI	47.1	36.5	34.4	26.9	25.6	18.1
	PGI	14.8	11.1	11.2	8.3	8.1	5.7

Notes: HPI: headcount poverty index; indicates the share of households which are poor; PGI: poverty gap index; represents the average gap to the poverty line; Poverty line: level of welfare under which a household is considered poor.
Source: Authors' calculations based on GLSS.

The three independent waves of the GLSS data are pooled together here, bringing a total sample size of 19,209 households. The analysis focuses here on rural Ghana, and therefore households residing in urban Ghana were dropped. In addition, households with economically inactive heads were not considered. The final pooled sample therefore contains 11,519 rural households. Table 1 provides a brief description of the rural sample in terms of poverty, as compared to the full GLSS sample. The headcount poverty index (HPI) with the higher poverty line identifies more than half of the households (namely 51.7 per cent) as poor in 1991/1992 (GLSS 3), but the share reduces to less than one-third (namely 28.6 per cent) in 2005/2006 (GLSS 5). It can be noted that, whatever the measure of poverty, rural households are in general poorer than the whole population, confirming the claim made in Section 2.2.

3.2 Econometric Specification

Following the works of Deaton (1985), Collado (1997) and Inoue (2008) we use a dynamic pseudo panel model to estimate the impacts of infrastructure access on household's welfare using 11,519 rural households in Ghana.

The Basic Model

The welfare (w) of a household i ($i = 1,\ldots,N$) at a given time t ($t = 1,\ldots,T$) is basically modelled as:

$$w_{it} = f\left(x_{it}^{h}, x_{it}^{e}, x_{it}^{p}, x_{it}^{c}\right) \tag{1}$$

where, x_{it}^{h} refers to a vector of variables defining household-level characteristics; x_{it}^{e} refers to household's private asset endowment; x_{it}^{p} refers to a vector of indicators of household's access to public capital (focusing here on public physical infrastructure); and, x_{it}^{c} refers to a vector of variables defining the livelihood vulnerability context of the household.

Access to public infrastructure x_{it}^{p} is used to imply the existence, within reasonable proximity, of the opportunity to make regular use of functional, public physical infrastructure. As argued by Gassner (1998), this may not imply an actual use of the service but a prevailing condition that, when desired, a household can actually use the resource as would be expected. Thus, at any given time, all households could be described as either having access to a public physical infrastructure or not.

The household private asset endowment x_{it}^{e} is built using the Principal Component Analysis (PCA) procedure. It is based on the eigen decomposition of the correlation matrix of several indicator variables. The latter are obtained from information provided by households on whether they own a given asset. This procedure tends to reflect better the long-term rather than the short-term view of the household's asset endowment (Filmer and Pritchett, 2001). Therefore, assets considered here reflect households' long-term capital holdings and include the following durable goods: furniture, sewing machine, stove (kerosene, gas and electric), refrigerator, air conditioner and fan. Assets also include radio and radio cassette player, television, car, tractor, plough, carts, spraying machine and land. McKenzie (2005) and Vyas and Kumaranayake (2008) have argued that a key principle for achieving a good index in PCA is to limit the selection of assets to those that are relatively more correlated and whose distribution varies

significantly across the sample population. On this basis, regular agricultural inputs such as cutlass and other basic tools are left out of the analysis. The factor score of the first principal component is predicted and used as the measure of household private asset endowment.

The Empirical Model

Several explanatory variables are considered, based on the existing literature investigating the determinants of well-being or poverty (e.g. Anyanwu, 2005; Epo and Baye, 2012; Skoufias and Olivieri, 2013). The model to estimate is specified as follows.

$$\begin{aligned} lnwelfare = {} & \beta_0 + \beta_1 age + \beta_2 age^2 + \beta_3 male + \beta_4 size + \beta_5 asset + \beta_6 power \\ & + \beta_7 water + \beta_8 pubtrans + \beta_9 asset * power + \beta_{10} asset * water \\ & + \beta_{11} asset * pubtrans + \beta_{12} educ + \beta_{13} educ^2 + \beta_{14} sector + \beta_{15} migrant \\ & + \beta_{16} lnwelfare_{t-1} + \beta_{17} cohort + + \beta_{18} period + \varepsilon \end{aligned} \tag{2}$$

where all variables are estimated as the cohort averages for the respective cross-section such that ***lnwelfare*** stands for $\boldsymbol{lnwelfare_{ct}}$, which is the cohort average of the logarithmic transformation of the welfare index of a given cohort, ***c*** at time ***t***. The $\boldsymbol{\beta}$s are the coefficients of the explanatory variables, representing the partial effects of the explanatory terms.

- ***welfare*** is household's total consumption per equivalent adult per year (in constant 1999 Accra prices). It is used as the measure of welfare (GSS, 2000). In other words, welfare is measured as the total expenditures on goods and services per equivalent adult in a household, over the survey period. Welfare is modelled dynamically to reflect the argument that shocks to past levels of welfare (including bumper harvest or declines in earnings) do not terminate instantaneously but are attenuated through time as households smooth their consumption ($\boldsymbol{welfare_{t-1}}$). Higher levels of welfare in the past are therefore hypothesized to impact on current welfare outcomes positively. Following Collado (1997), the lag of the sample cohort means is used as the estimate.
- ***age*** is age of the head of household, in years. To identify possible non-linearities in the effect of age on household welfare, the square of the age variable is also introduced and estimated in the model as $\boldsymbol{age^2}$. Below a certain threshold, age is expected to have negative effect on household welfare as younger households are expected to maintain relatively low asset levels and income generation potential. Beyond this threshold, age is expected to impact positively on household welfare based on increased potential for higher income generation, better risk management and enhanced livelihood strategies skills through life experiences, and so forth.
- ***male*** is the gender of the head of household, which is constructed as a dummy variable, assigned a value 1 if the head is male, 0 otherwise. Male-headed households are expected to maintain higher levels of welfare than female-headed households, especially based on the generally labour-intensive and manual nature of income generation activities in rural Ghana. Social and cultural norms that may limit females from engaging in some high-risk but relatively high-return economic activities could also hamper the capacity of female-headed households to maintain welfare levels comparable with male-headed households (Ellis, 2000). Further, female-headed households could be systematically more vulnerable than their male counterparts in Ghana's patriarchal societies.
- ***size*** is the adult size of the household, to proxy the labour resources available to the household. It is measured as the proportion of members aged over 18 years in the household. This variable has a positive *a priori* expectation.
- ***educ*** is the number of years of education and skill training attained by the head of the household. It is a proxy variable that captures the potential effect of education and skill level of the household on welfare. Education is likely to show an increasing effect on the quality of household decision and livelihood formation. A non-linear effect could be expected such that at lower levels of education, the returns on welfare will be negative. Beyond a given threshold, education could then be expected to show a positive and significant impact on welfare, all things being equal. A quadratic term of this variable is therefore introduced ($\boldsymbol{edu^2}$) in the model.
- ***asset*** is the index of household's endowment in private capital obtained with PCA as explained above. Assets are hypothesized in the model to have a positive impact on welfare.
- ***power***, ***water*** and ***pubtrans*** are indicator variables for access to public infrastructure. They reflect the degree of access to physical infrastructure by households within a given cohort. Three different physical infrastructures are investigated. These

are public transport (***pubtrans***), water (***water)*** and electricity (***power***). At the level of individual households, these variables are measured as dummies, assuming a value 1 if a household has access from own home, in the community or within a distance of 1 km or less from the residence), and 0 otherwise. These variables are postulated to have direct relationship with welfare. In addition, they are introduced in the model as their interaction with household asset endowment index (***assets*** × ***power***, ***assets*** × ***water*** and ***assets*** × ***pubtrans***) to evaluate the degree of complementarities between infrastructure access and household's capital endowment. All three interacted terms are also hypothesized to have a positive effect on welfare.

- several dummy variables representing the dominant sector of employment of the household head. The seven sectors are food crop production, cash crop production, the public, formal private and informal private sectors, self-employment and non-working (that is, unemployed or retired). Non-working households are generally considered to be economically inactive and therefore dropped. We follow this approach here and proceed with the remaining six, which are identified with dummy variables, with 1 implying the relevant sector and 0 otherwise.
- ***migrant*** represents the status of the household head as a migrant or indigene of the community of residence, assuming a value 1 if the head is a migrant, 0 otherwise. Like the choice of economic sector, migration is identified in the literature as an important livelihood strategy (Ellis, 2000). Migration is interpreted as a rational economic decision exercised by the household in optimizing welfare outcomes. It is therefore argued to impact positively on welfare directly.
- $\boldsymbol{cohort_c}$ is defined as the cohort-fixed effects.
- ***period*** is a dummy variable used to proxy time effects, assuming 1 for a given cross-section, 0 otherwise.
- ε is the stochastic error term of the model.

Table 2 summarizes the variables used and their expected impact on household's welfare.

Description of the Data Used and Estimation Method

We follow the argument of Deaton (1985) that since households in our dataset differ from one survey to another, standard panel estimation techniques are not appropriate. As Deaton (1985) suggests, errors-in-variables techniques can be used such that a taxonomic grouping of the population sample could be constructed and tracked in the various survey years. Once such groups (or cohorts) are well-defined on the basis of some time-invariant attributes of the population; they would be fixed in membership and identifiable anytime they show up in a population sample. Thus, an aggregation of the individual observations to cohort averages makes possible the tracking of the latter in different cross-sections. These cohort observations, including any presumed

Table 2: Synthesis of the variables used in the econometric analysis

Livelihood outcome	Conceptual arguments	Livelihood explanatory factors	Empirical measures	*A priori* expectation
	Household attributes	Household socio-economic features	Age	− (+)*
			Male	+
			Migrant	+
Measure of household welfare:			Sector	**
- Consumption	Household livelihood assets	Household private asset endowment	Size	+
- Expenditure			Education	− (+)*
			Private assets	+
		Public capital assets	Power	+
			Water	+
			Public transport	+
	Household livelihood vulnerability context	Shocks, trends, seasonality	Lag welfare	+
			Time effect	**

Notes: (+) *refers to the expected sign of the quadratic term; **implies indeterminate expectation.

(unobserved) cohort fixed effect, could thus be handled just like panel data without facing attrition bias. This gives rise to pseudo-panel modelling.

In this paper, the existence of waves of independent countrywide household survey datasets in Ghana allows for the use of pseudo-panel modelling based on group averages for the cohorts in estimating the relationship of interest. Cohorts of generation of households are constructed in two stages. First, following Gyimah-Brempong and Asiedu (2014), the year of birth of household heads was used as the first level of aggregation of households. Cohorts thus comprise household heads born before 1932, those born between 1932 and 1938, and in similar order of a 7-year gap until the last and youngest generation of household heads born after 1969. Second, these cohorts are further disaggregated by location of residence in respect of the three agro-ecological zones in Ghana. This disaggregation is useful in enhancing the homogeneity of household observations within each cohort as natural resources remain an important factor in rural household livelihood formation. There are 24 cohorts in total. Table A1 in the Appendix provides the distribution of the sample observations for these rural household cohorts. Descriptive statistics for all variables used to estimate Equation (2) are reported in Table A2.

While Deaton (1985) suggested either a least squares estimator or a fixed effects as appropriate estimators for the estimation of model (2) based on cohorts of households, other authors consider that these estimators may be inconsistent due to possible endogeneity bias. Indeed, in our case, it could be argued that access to infrastructure services may be endogenous to households' wealth. For this reason, the GMM is used here, where lagged variables are used as instruments (see Moffitt, 1993; Collado, 1997; Verbeek, 2008; McKenzie, 2004, for discussion).

4. Results

Table 3 presents the results of the estimation of model (2) using the GMM estimation.

Focusing first on the key variables of interest, the results suggest that public infrastructure in terms of electricity and public transportation has a positive influence on rural Ghanaian households' welfare, as expected. This effect is reinforced by the ownership of private assets, as the interaction terms of electricity (*power*) on the one hand, and public transportation (*pubtrans*) on the other hand, with the private assets index have significant positive coefficients. By contrast, in the absence of private capital, access to water has negative and significant effect on welfare. However, the effect is positive when interacted with private assets.

These results are consistent with the *a priori* expectations and provide some important empirical evidence of the degree of complementarities between key public capital investments and household private assets in rural Ghana. They suggest that the impact of access to water on household's economic welfare is largely dependent on the level of the household's private capital endowment, whereas access to public transport and electricity has a positive and significant effect for all households, irrespective of endowment in private assets.

In respect of the other explanatory terms, the estimated model reveals that past levels of welfare and the size of the household both have a direct and significant effect on household welfare. This is consistent with the expectations. The effects of age and education on household livelihood are also observed to show increasing returns such that at low levels of age and years of formal training, these variables have adverse effect on welfare. These effects reverse and turn positive in their impact on household welfare from the age threshold of about 26 years and equivalent formal education of at least lower primary, respectively.

Again, consistent with the hypothesis, the difference in welfare between male- and female-headed households is noted to be positive and significant. A similar observation is identified for the migrant status of the head of household. Thus, migration in rural Ghana is found here to provide important avenue for enhancing household welfare outcomes. Indeed, as the model already instruments differences in natural resource endowments and also accounts for differences in access to public infrastructure, this result provides a quantitative estimate of the contribution of realized migration to livelihood outcomes for reasons relating especially to employment, education, marriage and family (GSS, 2000).

Finally, household livelihood outcomes are also found to show significant differences among the different sectors of employment of the household head. The results reveal that relative to households with self-employed heads, those households with heads employed in formal or in informal private sectors experience lower welfare outcomes. On the other hand, households with heads in agricultural employment (both cash and non-cash) as well as in public employment experience livelihood outcomes that are positive and significantly higher than the reference category of self-employment. For households in cash (or export) agricultural sub-sector, this difference is found to be very large, reflecting the high returns identified with export-oriented agro-production.

Table 3: Results of the estimation with GMM

Dependent variable: *lnwelfare*	Coefficient and significance	Robust standard error
$lnwelfare_{t-1}$	0.482***	0.079
power	0.515**	0.241
water	−0.396*	0.212
pubtrans	2.117***	0.1901
assets	−4.251***	0.409
power∗assets	0.557***	0.039
pubtrans∗assets	0.788***	0.084
water∗assets	4.052***	0.401
size	0.451***	0.139
age	−0.050**	0.019
age^2	0.001***	0.0001
educ	−0.209***	0.029
$educ^2$	0.038***	0.003
male	0.381**	0.144
migrant	1.397***	0.192
Dummy for public sector	1.082***	0.273
Dummy for private formal sector	−9.998***	0.719
Dummy for private informal sector	−7.175***	0.756
Dummy for cash crop sector	5.324***	0.316
Dummy for food crop sector	1.591***	0.129
period	0.479***	0.092
Number of observations	24	
Number of groups	24	
F(21, 24)	1191.90***	

Notes: *indicates 10 per cent significance level; **indicates 5 per cent significance level; ***indicates 1 per cent significance level.

5. Conclusion

We have investigated here how access to public infrastructure influenced household's welfare in rural Ghana, using a pseudo-panel model with cohorts constructed from household's data in three waves of the Ghana Living Standard Survey between 1991 and 2006. Our results indicate that, as expected, access to electricity and transport infrastructure enhances household's welfare. By contrast, access to water was found to reduce household's welfare. We considered the possibility of private assets to enhance the effect of public assets on household's welfare. When interacted with private assets, all categories of public assets, namely electricity, transport and water, increase household's welfare. This shows that the ownership of private assets is crucial in the role of water access.

A possible interpretation of the negative effect of water access (when not interacted with private assets) compared to the positive effect of electricity and transport infrastructure, is that the opportunity cost of the distance travelled to access water in rural Ghana increases significantly with the level of the household's private capital investments. The economic impact of electricity and transport would therefore be direct, whereas that of the latter would be indirect through opportunity cost. Thus, where the opportunity cost of time is low (in the case of households with low endowment in private capital investments, for example), the savings in travel time to access water from public water facilities may not sufficiently offset the user cost. By contrast, private assets such as a car can facilitate access to water and, for example, enable agricultural households to use substantial volumes of water for irrigation.

Our analysis suggests that, in Ghana, the past infrastructure development policies focusing on developing access to water, may not have been effective in improving household's welfare. It may have increased welfare for households with substantial private assets. The paper highlights that public investment in infrastructures is identified to be an important tool for poverty reduction in rural Ghana. Policy makers should thus try to prioritize this in their development policy in order to enhance rural communities'

welfare. Aid for Trade (AfT) which is considered as a promising development tool to help developing countries to expand their trade could contribute to this project. Indeed the largest share of AfT flows is distributed through programmes and projects contributing to economic infrastructures. Policy makers should also ensure that households could exploit the strong complementarities between such investments and private capital assets. This may imply that expenditures in public investment could be accompanied by specific policy instruments aiming at facilitating the purchase of private assets.

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Appendix

Table A1: Sample distribution of rural households by agro-ecological zone and generation cohort

Number of observations per cohort	GLSS 3	GLSS 4	GLSS 5	Total
Coastal, <=1931	184	106	54	**344**
Coastal, 1932–1938	61	114	46	**221**
Coastal, 1939–1945	95	86	68	**249**
Coastal, 1946–1951	79	121	70	**270**
Coastal, 1952–1957	99	101	119	**319**
Coastal, 1958–1963	99	147	103	**349**
Coastal, 1964–1969	62	104	114	**280**
Coastal, >=1970	19	81	241	**341**
Forest, <=1931	268	209	103	**580**
Forest, 1932–1938	105	176	134	**415**
Forest, 1939–1945	148	190	205	**543**
Forest, 1946–1951	187	221	199	**607**
Forest, 1952–1957	192	246	257	**695**
Forest, 1958–1963	217	345	271	**833**
Forest, 1964–1969	187	264	299	**750**
Forest, >=1970	31	253	629	**913**
Savannah, <=1931	182	102	105	**389**
Savannah, 1932–1938	83	92	143	**318**
Savannah, 1939–1945	110	100	197	**407**
Savannah, 1946–1951	146	130	181	**457**
Savannah, 1952–1957	120	144	244	**508**
Savannah, 1958–1963	108	170	280	**558**
Savannah, 1964–1969	82	121	305	**508**
Savannah, >=1970	14	84	567	**665**
Total	**2,878**	**3,707**	**4,934**	**11,519**

Table A2: Descriptive statistics of key variables

	Pooled data					Cohorts				
Variable	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
$lnwelfare_{t-1}$	11519	13.859	0.723	10.742	17.092	72	13.853	0.315	13.307	14.418
power	11519	0.297	0.457	0	1	72	0.285	0.187	0	0.755
water	11519	0.877	0.329	0	1	72	0.854	0.106	0.474	0.971
pubtrans	11519	0.623	0.485	0	1	72	0.611	0.189	0.148	0.909
assets	11519	0.016	1.725	−1.116	15.445	72	−0.049	0.457	−0.753	1.358
size	11519	0.565	0.264	0.1	1	72	0.579	0.091	0.421	0.796
age	11519	45.82	15.36	16	99	72	47.367	16.38	20.07	81.6
educ	11519	3.55	5.326	0	24	72	3.411	2	0.336	7.645
male	11519	0.731	0.444	0	1	72	0.7119	0.12	0.37	0.929
migrant	11519	0.414	0.493	0	1	72	0.392	0.117	0.143	0.611
Dummies for sectors:										
Dummy for public sector	11519	0.054	0.227	0	1	72	0.053	0.044	0	0.188
Dummy for private formal sector	11519	0.028	0.166	0	1	72	0.027	0.027	0	0.112
Dummy for private informal sector	11519	0.033	0.179	0	1	72	0.031	0.031	0	0.141
Dummy for cash crop sector	11519	0.096	0.294	0	1	72	0.078	0.103	0	0.408
Dummy for food crop sector	11519	0.194	0.491	0	1	72	0.603	0.155	0.296	0.867
Dummy for self-employed sector	11519	0.194	0.395	0	1	72	0.208	0.093	0.069	0.457

Notes: Obs.: number of observations. Std. Dev: standard deviation. Min: minimum. Max: maximum.