# The Impact of Roads on Poverty Reduction: A Case Study of Cameroon

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# Abstract

Many investments in infrastructure are built on the belief that they will ineluctably lead to poverty reduction and income generation. This has entailed massive aid-financed projects in roads in developing countries. However the lack of robust evaluations and a comprehensive theoretical framework could raise questions about current strategies in Sub-Saharan Africa. Using the second Cameroonian national household survey (Enquête Camerounaise Auprès des Ménages II, 2001) and the Cameroon case study, this paper demonstrates that investing uniformly in tarred roads in Africa is likely to have a much lower impact on poverty than expected. Isolation from a tarred road is found to have no direct impact on consumption expenditures in Cameroon. The only impact is an indirect one in the access to labor activities. This paper reasserts the fact that access to roads is only one factor contributing to poverty reduction (and not necessarily the most important in many cases). Considering that increase in non-farming activities is the main driver for poverty reduction in rural Africa, the results contribute to the idea that emphasis on road investments should be given to locations where non-farming activities could be developed, which does mean that the last mile in rural areas should not be probably a road.



**Keywords:** Roads, Poverty, Labor, Infrastructure, Cameroon.
**JEL:** I32, J22, O12, R40

# 1. Introduction

A very strong impetus has recently been given to infrastructure investments in Sub-Saharan Africa. For the period 2008-2010, the Chinese EXIM bank committed around $20 bn in infrastructure for financing railway rehabilitation in Nigeria, Angola as well as building dams in Ethiopia for instance. The African Development Bank will spend over $5 bn in the next three years, of which over 60% in infrastructure (mainly roads, energy and water). The World Bank committed in 2009 more than $7 bn in Sub-Saharan Africa (with almost $1.5 bn in roads). Aid to Africa is planned to double in the near future of which investments in infrastructure are likely to be the bulk of it.

Among infrastructure, roads are considered of first interest to reduce poverty due to the widely accepted consensus that transport infrastructure has a significant, positive and substantial impact on economic growth and poverty as it enhances the connectivity of isolated and remote areas [1, 2].

In the last decades, there has been a pendulum of the focus in aid agencies between investments in infrastructure and in social sectors. The massive investments in infrastructure of the previous decades did not provide the promised results, especially in Africa. Is it likely to change at the time when a scaling up of investments in roads and in infrastructure in general is expected? Despite a recent impetus in investments in roads, transport prices on the continent remain the highest in the world [3], Africa's share in world's trade has decreased and poverty has not declined in most rural areas in Sub-Saharan Africa. The suggested ineluctability of a poverty reduction impact through roads investments has thus to be questioned and is investigated in this paper using the Cameroon case study.

Literature on the poverty impact of roads is relatively abundant. Poverty is generally modeled as a direct function of isolation without relying on any theoretical framework (while Deaton [4] stresses the importance of correctly defining theoretical mechanisms to test in econometric studies). The impact is usually found to be significant: an easier/improved road access does reduce poverty [5, 6, 7].

However, the majority of these works do not solve the endogeneity bias affecting the poverty-isolation relationship. Road placement is non-arbitrary and people do not randomly settle next to roads once they have been constructed. Moreover such studies make comparisons and generalizations difficult [8]. In particular, van de Walle [9] points out the fact that "`knowledge about [roads] impacts and the heterogeneity in those impacts continues

to be limited"'. Roads projects evaluations performed by Khandker et al. [10] in Bangladesh and Mu and van de Walle [11] in Vietnam provide good examples of a willingness to provide more robust and reliable evaluations of roads' impact that tackle efficiently the endogenous nature of road placement. The former use a difference-in-difference methodology associated with household-level fixed effects. The later combine the difference-in-difference with a propensity score method to yield unbiased estimates under the assumption that a time variant selection bias due to initial observables is at work.

Such methodologies require panel data that are often hard to obtain. Household surveys are generally available but their lack of temporal dimension explains the direct modeling of poverty as a function of road access. Robust estimates on cross-section data require the use of instrumental variables. Gibson and Rozelle [12] provide the only example to our knowledge with their instrument that "measures the year in which the Papua New Guinea (PNG) national highway system penetrated into each of PNG's districts". They assume that any newly created national highway stimulates the feeder roads network, and thus reduces the traveling time to the nearest road. As the national highway building in PNG was from coast to inland, without any wealth considerations, the authors argue that their instrument is uncorrelated with poverty at the household level. However, we consider this direct modeling not completely relevant because that is not the road *per se* that affects poverty but the fact that the road leads to some services or facilities. As Njenga and Davis [13] claim "isolation reduces physical access to vital services such as markets, information sources, social and political networks as well as health and educational services while access to these services is crucial for improving poor people's livelihoods".

The explicit recognition of the indirect impact of road access on poverty, using cross-section data for the year 2001 in Cameroon, constitutes the first contribution of this paper. The literature on poverty and isolation defines three channels through which road access contributes to reduce poverty: access to inputs and output markets, access to education and health services and access to labor opportunities. The focus of the paper is on the third one. We demonstrate that access to roads has a different impact on consumption, depending on the type of activity carried out, since some activities could be considered as a poverty trap.

The second contribution lies in the use of data from the second Cameroonian national household surveys ("Deuxième Enquête Camerounaise Auprès des Ménages", ECAM II) from which the infrastructure side has been poorly (if not) used in the literature. The three national households surveys (the first was in 1996 and the last one in 2007) are also at the core of the

reduction poverty plan for Cameroon, since poverty in Cameroon is of major concern since the 80s[1]. Economic growth began to recover from 1994 but the first national household surveys revealed that 50.5% of the Cameroon population lived under the poverty line in 1996. In 1998/99, private consumption was stagnant thus highlighting the fact that economic growth did not reach population and more importantly the poorest part of it.

Finally, unlike the majority of cross-section analyses of poverty and road access, these results do not call for systematic and widespread investments in roads to fight against poverty. We demonstrate that road access, proxied by the time (in hours) needed to reach the closest tarred road, has no direct impact on consumption expenditures at the household level when the three channels identified by the literature are controlled for. These econometric results contribute to the idea that emphasis on roads investment should be given to locations where non-farming activities could be developed.

This questions the big push in infrastructure in Sub-Saharan Africa, all the more as investments in roads assumes that services will automatically reduce their prices, which is far from reality in most regions in Sub-Saharan Africa, especially in rural areas. Investing uniformly for rural roads in Africa is likely to have a lower impact on poverty than expected. Their efficiency for poverty reduction relies on an appropriate design, taking into account the real needs of road users, depending mainly on their labor opportunities/type of activities.

The paper is structured as follows. Section 2 presents a brief literature review of roads impact studies. Section 3 introduces the data and some descriptive statistics to illustrate the relevance of our study. The Section 4 highlights the econometric methodology and the empirical problems, which were faced. Section 5 provides results of the simultaneous estimations. Section 6 discusses the main policy implications of the results and concludes.

## 2. A Literature Review of Roads Impact: Three Channels

The literature on the poverty impact of roads defines three main channels (described below): the human capital, the market access and the labor activities channel.

1While before 1985 Cameroon exhibited average annual growth rate of 7% thanks to a continuous development of the agricultural production and the exploitation of oil resources, after 1986 and the drop of oil and other exports rates, the economy suffered from a strong degradation (contraction of the economy of 8.2% of GDP and negative growth rate for the year 1986/87). The structural adjustments measures put in place did not suffice to deal with the adverse consequences of the shock. Between 1985/1986 and 1992/1993 consumption per capita fell by 40% and the investment rate was divided by 2 (27% to 13%). Employment and the supply of social services (health, education and other infrastructures services as roads) have also been seriously damaged.

## *The Human Capital Channel*

A first transmission channel of roads' impact is to facilitate provision of basic needs to the poor such as health and education. A common feature of poor people is that they suffer from inadequate access to some human capital facilities that are essential to escape from poverty. Actually Njenga and Davis [13] point out "poverty reduction needs more than economic mechanisms to be effective". Roads appear as complementary input for these provisions of human capital formation facilities to be effective [14]. Roads projects evaluations provide evidence on that topic. Rural roads rehabilitation in Vietnam improved primary school completion rates and enhanced the treatment of broken bones [11]. Road development in Bangladesh led to higher girls' and boys' schooling [10].

## *The Market Access Channel*

The greater availability of inputs and their reduced prices due to lower transport costs increase productivity. Khandker et al. [10] estimate the impact of two roads projects in Bangladesh on seven household outcomes by household fixed-effects method. For the two projects under consideration, road development allowed to significantly reduce the price of fertilizer. Transport costs also decreased significantly. Controlling for soil fertility (and thus for non random placement of roads), Minten and Stifel [15] show that crop yields for the three major staple items in Madagascar (rice, maize, and cassava) are lower in isolated relative to non-isolated areas, with isolation here defined as the travel time to the nearest city.

The improved access to output markets leads to a rise in income thanks to greater opportunities of sales or higher prices. Gibson and Rozelle [12] provide simple correlation between access to roads and prices that farmers receive for their crops: "the rate of price decline is around seven percent for each extra hour to the nearest transport facility". Escobal and Ponce [16] assess the impact of roads projects in Peru by propensity score matching techniques and demonstrate that rehabilitation entails an income increase. Khandker et al. [10] prove that road development entails higher agricultural production, higher wages, and higher output prices. Jacoby and Minten [17] estimate the willingness-to-pay for a reduction in transport costs on cross-sectional data collected in a small region of Madagascar. As this region is relatively homogenous but faces great variations in transport costs to the same market, the problem of non random placement of roads is solved. They found that "A road that essentially eliminated transport costs in the study area would boost the incomes of the

remotest households—those facing transport costs of about $75/ton—by nearly half, mostly by raising nonfarm earnings".

It is also worth noting that Ruijs et al. [18] find out that the direct effect of transport costs reductions on food prices, such as cereals, requires some nuance and tempered expectations in the case of Burkina Faso, notably due to the organization of markets.

### *The Labor Activities Channel*

There is a general consensus, well documented, on the idea that transport infrastructure reduce poverty by creating employment and new job opportunities [19]. First the construction and maintenance of a road are labor-intensive operations and can provide job opportunities to people living around. However these projects are only occasional and cannot represent a long term strategy for reducing poverty. Second the provision of roads entails a greater and/or cheaper availability of labor markets. For example, Mu and van de Walle [11] show that road projects in Vietnam increased employment opportunities by 11% for unskilled labor.

The literature also provides insights on the relationship between road access and the diversification of income sources. The evidence highlights two opposed views. On the one hand, diversification occurs in remote areas as a way to deal with the local demand for multiple goods and services [20, 21]). Facing huge transaction costs, it is more profitable for households living in poorly connected regions to diversify their activities so as to satisfy their own demand. On the contrary, many studies point out that connectivity to markets develops multi-activities since opportunities to diversify are greater. An illustrative example is found in Gibson and Rozelle [12]: in Papua New-Guinea, each extra hour to reach the nearest road induces a 2.6 percent reduction in the number of activities.

Literature on road access and labor also deals with diversification outside the agricultural sector. It is widely considered as an efficient way to escape from poverty. In fact, while the majority of the poor live in rural areas where the main activity is agriculture, there is huge evidence that nonfarm activities are a major source of income and employment for the very poor in developing countries. Smith et al. [22] show that road rehabilitation projects in Uganda extended job opportunities in the service sector. In Tanzania, this kind of project developed job opportunities for non-agricultural employment [23]. Mu and van de Walle [11]

find similar results: households affected by a road project are less likely to rely on agriculture or forestry as their main source of revenues and switch to the service sector.

# 3. Roads and Poverty in Cameroon

## *Overview*

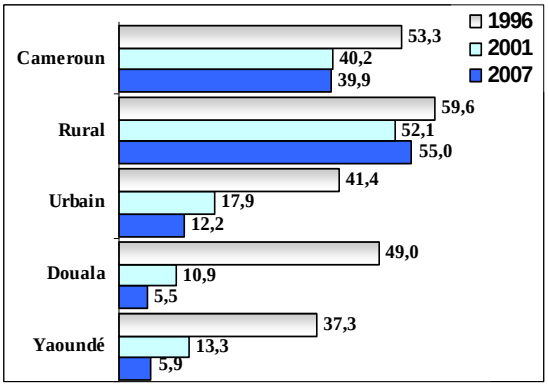
Due a great diversity of climates, terrain and vegetation, Cameroon has several natural advantages that could help to sustain its development. Moreover the 402 km of coast boarding the Guinea Gulf ease trade for Cameroon as well as its closer neighbors. In fact Cameroon is among the ten richest countries in Sub-Saharan Africa. Cameroon's wealth comes from oil and wood resources as well as a diversified agricultural production both in terms of food-producing (maize, cassava, plantain banana, macabo, rice, millet, sorghum, groundnuts, etc…) and cash-crop (cocoa, coffee, cotton, rubber, banana, pineapple, etc…) that makes its agriculture the most prosperous in Central Africa.

The primary sector (agriculture) represented 22% of GDP in 2001; the industry sector was 33% and services 45% of GDP. However employment does not exhibit a similar pattern. In fact in 2001, 60.6% of total employment was in agriculture, 9.1% in industry and 23.1% in services [24].

Figure 1 below presents the evolution of the poverty rate in Cameroon between 1996 and 2007. While poverty at the national level significantly declined between 1996 and 2007 (from 53.3% to 39.9%), this phenomenon encompasses heterogenous situations. Decrease of poverty rate mainly came from the reduction that occurred in urban areas where the proportion of households below the poverty line was 41.4% in 1996, 17.9% in 2001 and 12.2% in 2007. On the contrary, poverty rate in rural areas only lost 4 percentage points over the period.

**Figure 1**

Poverty rate

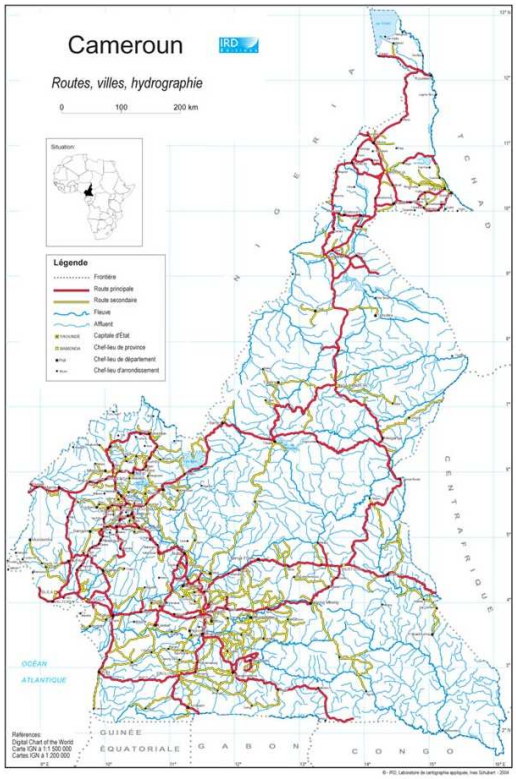



*Sources ECAM I, II and III.*

Figure 2 represents the main road network in red and the secondary network in green, which is the overall tarred network in Cameroon. The provinces of East; Center and Adamaoua, as well as North and Extreme North that are mostly rural suffer from a road network deficit compared to the other regions.

**Figure 2**

Tarred road network




*Source:* http://www.cartographie.ird.fr/publi/ines_rapport/Cameroun_fond.jpg

## *The 2001 Cameroon National Household Survey (ECAM II)*

The aim of ECAM II survey is poverty measurement and analysis. The survey focuses on 16 fields of study covering all the dimensions of poverty: Household's composition and characteristics, Health, Education, Employment and activities income, Fertility, natality and general mortality, Anthropometry and vaccinal coverage, Housing and equipment, Migration, Accessibility to primary infrastructures, Subjective poverty, Familial non farming business, Capital, Agriculture and other rural activities, Retrospective non food expenditures of the households, Daily expenditures of the households, Prices. Both objective and subjective poverty are under consideration. Information has been collected at both the household and the individual level, but there is no data at the community level.

The National Institute of Statistics of Cameroon (NIS) defined 32 strata according to three modalities, urban (12), semi urban (10) and rural (10) which depend on the number of inhabitants per district : more than 50,000 for urban, between 10,000 and 50,000 for semi urban and less than 10,000 for rural. Rural and semi urban strata are considered as equivalent by the NIS. The ECAM II is based on the 1987 census (Recensement Général de la Population et de l'Habitat) which defined 612 counting zones or clusters. In urban strata, the sampling proceeds in two stages or degrees. The clusters are first sampled according to a single random drawing; then in each urban cluster 18 or 12 (for Yaounde and Douala) households are selected according to the same procedure. In rural strata, the sampling selection follows three degrees. First, districts are sampled proportionally to their size in households in 1987. Second in each district, clusters are drawn from a single random drawing, and then 18 households in semi urban strata and 36 or 27 (for the provinces Extrême Nord, Ouest and Nord Ouest) households in rural ones are sampled with the same drawing procedure from the selected clusters. Finally 11,533 households from 612 clusters have been sampled and 10,992 were interviewed.

The survey organization was designed to correctly collect the needed variables to calculate final consumption, the living standards indicator. Daily purchases were collected during respectively 10 or 15 days in rural and urban areas and have been completed with data on retrospective expenditures. The survey ran during three months in order to take into account potential seasonal variations.

The access to roads is measured through two questions. Households are asked how far (in kilometers) they are from the nearest tarred road, and how much time (in minutes) is needed to reach it with their usual means of transport. In the paper, the time needed to reach the nearest tarred road is used because it is the most adequate measurement of isolation. The same questions are asked for primary public schools, health centers and food markets.

## *Descriptive Statistics*

Cameroonian households closely relate the fact of being poor to the ease of accessing a developed and well-maintained tarred roads network. Whatever the poverty status, the first reported root of poverty in Cameroon is the lack of employment. The next causes reported by the households surveyed are decreasing or insufficient revenues and the lack of roads. Indeed the density of tarred roads in Cameroon is less than one meter of tarred road per hectare of arable land. In order to overcome this issue, the Road Fund Cameroon plans to increase the tarred network by 75% during the 15 next years. An initiative also concerns the rural network, which connects the production areas to local markets or commercial centers. The total network under consideration is long of 24,310 kilometers, almost the half of the entire Cameroonian road network. The Road Fund's argument is that thanks to this development strategy "many areas will be open to trade and a great progress will be made in the fight against poverty, insecurity and malnutrition".

The households surveyed share this argument, as showed in Table 1, which presents the three major actions reported by households when they are asked about the first initiative to fight against poverty. Employment is by far the first action against poverty underlined by surveyed people.

**Table 1: Main Perceived Constraints to Reduce Poverty**

| **First action against poverty** | |
|---|---|
| Create employment | 45.51% |
| Roads construction | 11.49% |
| Ease access to education | 6.26% |

*Source: Authors' computations and ECAM II.*

Concerning dissatisfaction about roads, households quote remoteness (53.23%), difficulty of access (18.67%) and roads condition (10.98%) as the first ones, whatever the poverty status[2].

The statistical analysis of our data confirms these subjective views. Among the 10,992 households surveyed 25.15% are poor. As it is in all developing countries, poverty in Cameroon proves to be a rural phenomenon since 34.7% of rural households are poor (against only 13.6% of the urban ones) and 75.6% of the poor live in rural areas. More precisely, poor households primarily live either in the rural Savannah or the High "Plateau" zones. Table 2 presents for each agro-ecological area the corresponding poverty rate, the average time and the average distance to reach the closest tarred road.

**Table 2: Roads' Access, Poverty and Activity across Agro-ecological Zones**

| | | | **Access to the closest tarred road** | |
|---|---|---|---|---|
| **Agro-ecological Zones** | **Poverty Rates** | **Activity Rates** | **Time (min)** | **Distance (km)** |
| Yaounde | 7.9% | 20.7% | 4.16 | 0.57 |
| Douala | 8.6% | 30.3% | 5.39 | 0.67 |
| Other Cities | 17.8% | 29.9% | 8.6 | 1.96 |
| Rural Forest | 29.0% | 35.0% | 77.54 | 38.20 |
| Rural High Plateau | 33.6% | 40.7% | 53.77 | 14.54 |
| Rural Savannah | 40.6% | 38.7% | 68.88 | 29.22 |
| Urban | 13.6% | 29.7% | 6.89 | 1.36 |
| Rural | 34.7% | 38.4% | 65.32 | 25.92 |

*Source: Authors' computations and ECAM II.*

Poverty and bad access to roads appear to be typically rural issues. Poverty rates in the rural areas range from 29% to 40.6% against only 13.6% for cities. The average time to reach the nearest tarred road varies from almost 7 minutes in urban areas to an hour for rural ones. The average distance is 1.36 kilometers in urban zones against 25.92 kilometres in rural areas. We computed mean-comparison on the time and distance variables, among poor/non poor groups and according to the geographical areas. On average, the access to a tarred road is significantly easier for an urban household (than for a rural one) and for a non poor household (than for a poor one). The difference between poor and non poor households remains significant even if the sample between urban and rural areas is divided. However, the

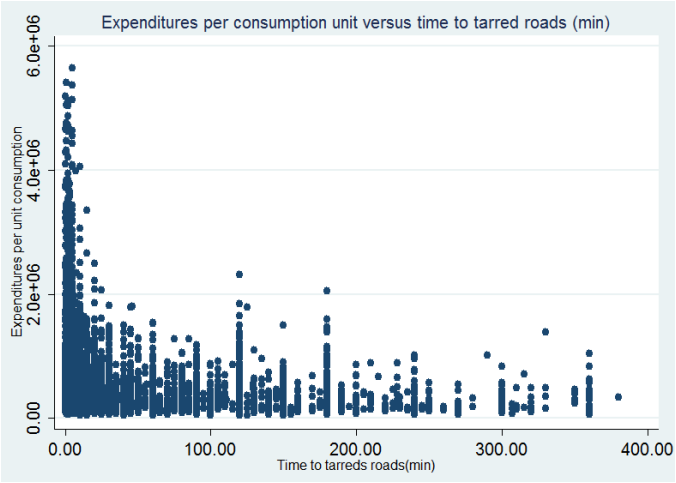
2 A household is considered as poor if its per unit consumption expenditures per year is less than 232 547 CFAF (354 euros).

difference is stronger in the rural areas. Figure 3 provides a first convincing illustration of the fact that is associated with poverty. A negative correlation appears between the consumption expenditures and the ease of accessing a tarred road.

As remoteness from a tarred road increases, households' consumption decreases. In rural areas, even though the activity rate is higher, poverty is dominant. This may be explained by the fact that the main activity is agriculture, which generates low income and productivity.

**Figure 3**

Expenditures per consumption unit versus time to tarred roads




# 4. The Conceptual Framework

## *Poverty, Road Access and Labor*

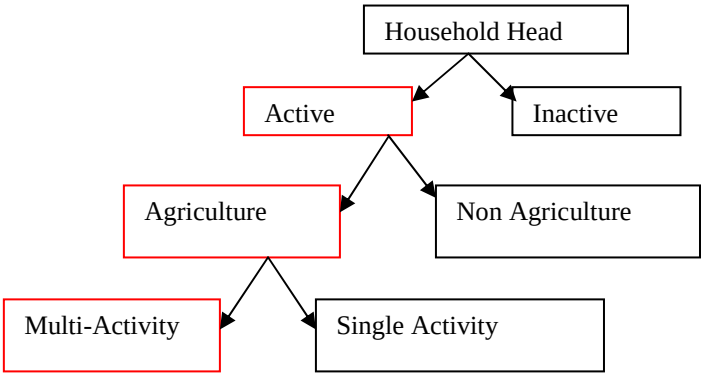
Our poverty variable is built following Gibson and Rozelle [12] who use the "(log) nominal consumption expenditure per adult equivalent", also known as the Welfare Ratio.

Road access is proxied by the time in hours needed to reach the closest tarred road, at the household level. Our choice was restricted by data availability but we control for the education and health channel thanks to two variables: the time to reach the closest primary school and the time to reach the closest health center, both at the household level. The access to markets is also proxied by the time to reach the closest food market at the household level.

Concerning the labor opportunities channel, three types of activities dummies as explanatory variables to control for the household-head labor supply are introduced[3] as described in Figure 4 (Kalugina and Najman [25]).

**Figure 4**

Labor categories




The first binary variable takes the value 1 if the household-head is active; 0 if he is inactive (retired, students, unemployed, disabled, other inactive). Road access is supposed to entail labor opportunities. Therefore, we expect that our isolation indicator will have a negative impact on this variable if the "active" dummy well captures employment opportunities.

The agricultural sector represented 61% of total employment in 2001 [24]. It is worth noting that about 41% of the household-heads in our sample are involved in agriculture; the proportion rises to 66.82 % among poor households and to 78.72% among rural poor households.

Binary variables to assess the impact of road access diversification outside agriculture are constructed. Our first agricultural dummy equals 1 if the household-head declares his main activity to be agriculture (0 if he declares it is not in agriculture). The second variable concerns the household-heads primarily involved in a farming activity and equals 1 for multi-active heads, 0 for the single-active ones. This variable aims at testing if diversification as a

3 Since the labor structure within the household may determine the household-head's choice of activity, we looked at this structure by a simple exercise of descriptive statistics. There is no huge heterogeneity: generally the age-working members of the household are involved in similar activities than the head, particularly if the head is engaged in agriculture.

multiplication of income sources in addition to a main agricultural activity helps to reduce poverty and reduces the isolation impact.

## *Econometric specification*

The hypothesis is that road access *per se* does not have a direct impact on consumption expenditures at the household level. To test this hypothesis, we simultaneously estimate equations of consumption expenditures and labor activities using Three-Stage Least-Squares on the following specification:

$$\text{Welfare Ratio} = \alpha_{wr}.z + \beta_{wr}.z_{wr} + \gamma_{wr}.\text{Roads} + \delta_{wr.}\text{Labor} + u_{wr}$$
$$\text{Labor} = \alpha_{l}.z + \beta_{l}.z_{l} + \gamma_{l}.\text{Roads} + u_{l}$$

where E ($u_{wr}$ | *exog*)=E ($u_l$ | *exog*)=0 and *exog* contains all variables other than *Welfare Ratio, Labor* and *Roads*. We run 3 sets of estimations with the variable *Labor* alternatively being each of our labor categories as defined previously. The coefficient is $\gamma_{wr}$ supposed to be non significant if road access has no a direct impact on consumption.

## *Empirical Issues and solutions*

Inclusion of control variables for the human capital, markets and labor channels deals with the problem of omitted variables; otherwise it would create an upward bias when estimating $\gamma_{wr}$.

The other empirical issue behind the relationship under consideration is endogeneity (van de Walle, 2009). A first cause of endogeneity lies in the measurement error of accessing roads. ECAM II data contains information about time and distance to the closest tarred road. The time variable takes into account the most common means of transport used to access the road. Assuming this fully captures the relevant differences in access to tarred roads among households, we thus select the time variable.

A second cause of endogeneity can be found in a simultaneous determination issue coming from unobservable determinants. The construction of a road is a non-random decision. In fact, this choice is subject to various demands, such as geographic and topographic conditions. To tackle this problem, fixed effects at the district level as well as for the three rural clusters of the sample are introduced.

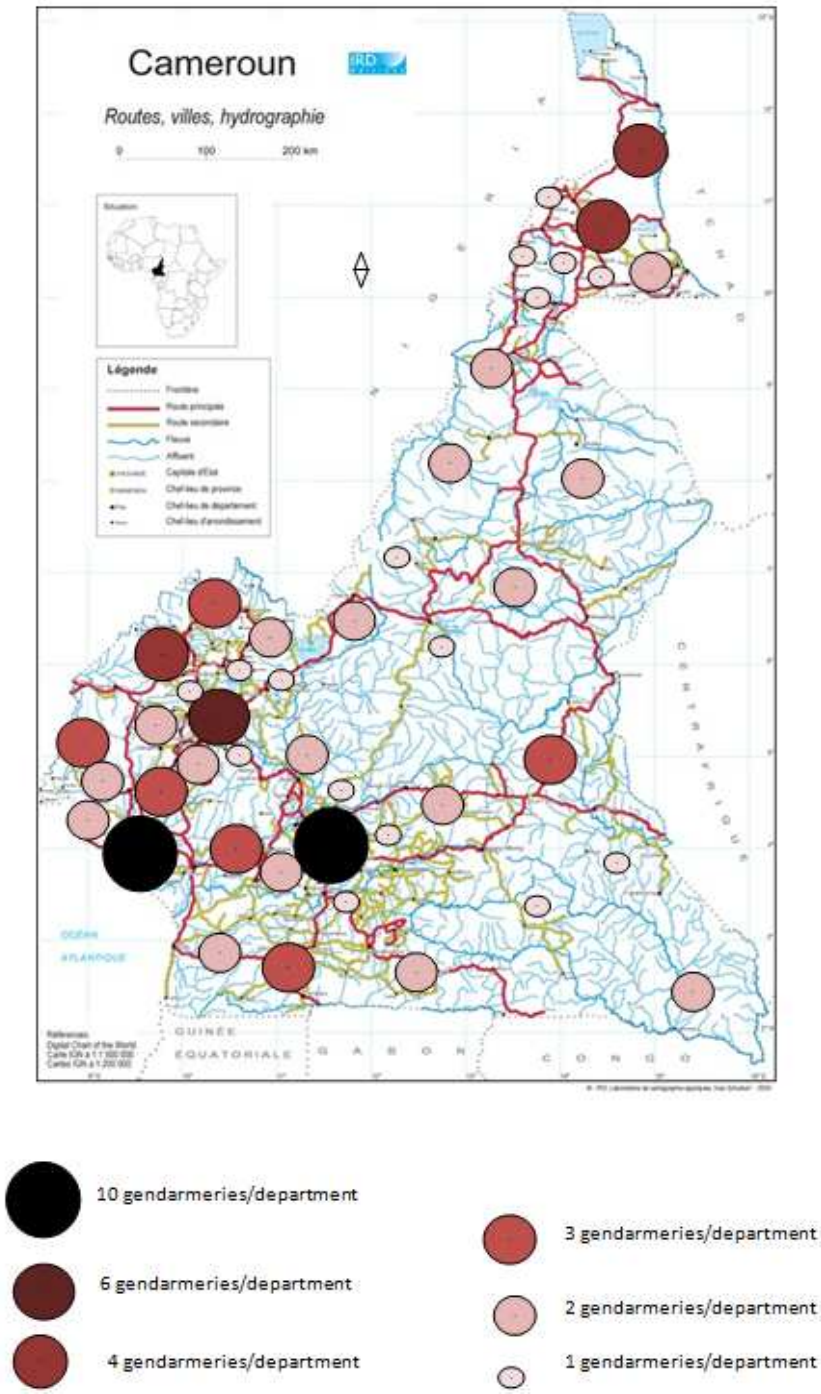
A reverse causality issue between the *Welfare Ratio* or *Labor* variables and the *Roads* variable may also bias the estimates. The localization choices of a household alongside a road and the mean to access roads may be endogenous decisions respective to the poverty status of the household. ECAM II data do not enable to control for localization choices. However, we argue that reverse causality in terms of means to access the road is not the phenomenon that drives endogeneity.

An instrumental variable approach is used to solve the endogeneity of road placement. A road may be constructed in a given region because this is characterized by some economic potential that in turn shapes the poverty situation of households living in that region and/or their labor opportunities. An appropriate instrument has to explain why a given household benefits from a satisfying access to tarred roads but it should not be correlated with the level of consumption expenditures of this household or its labor activities.

The first instrument is the ratio of fixed and mobile "gendarmeries" stations over population density at the department level. Macro literature considers military spending as “the only plainly exogenous major influence on the economy” [26]. Hall [27] used military spending as an instrument since “[it is the only] arguably unresponsive [spending] to the current state of employment and output”. This was transposed to our micro framework, with a twofold argument. First, we assume that the decision to settle a gendarmerie station is exogenous since in only derives from a defense mission linked to the State. Governments have to provide protection to their citizens, whatever their wealth and so on... and the regions they live in. Second, the primary mission of gendarmeries in Cameroon is to ensure security of communication modes. Therefore, households in areas with many "gendarmerie" stations should then have a better access to roads in the sense that the road density in these areas would be higher. Figure 5 below shows that regions with more gendarmeries are also the ones with a higher road density.

**Figure 5**

Roads and Gendarmeries




*Sources: Authors' calculations using the IRD map and the informations on gendarmeries from the French Embassy in Yaoundé*

The second instrument follows Gibson and Rozelle [12], who used “the year in which the Papua New Guinea (PNG) national highway system penetrated into each of PNG's districts (…) those districts that have had a national highway for a longer time are likely to have a larger network of feeder roads, and households in those areas should face shorter travel times”.

Length and the date of commissioning each tarred road at the provincial level data were obtained information from the Ministry of Public Works of Cameroon. Detailed maps at the provincial level were also used. But, it was impossible because of data availability to get the same detailed information than Gibson and Rozelle [12]. To fill the data gap that remained, Cameroonian maps from the “Institut Géographique National” (IGN) for the years 1933, 1949, 1953, 1969 and 1994 were used. An average year for the date of commissioning the tarred/permanent road network was computed. Some departments have no tarred road still today. Therefore, a variable was constructed equal to the number of years between the average year of commissioning of the road network and the year in which the survey occurred (2001). Departments without any tarred road are coded with zero (See Table 7, Appendix B).

This instrument can be interpreted in the same vein as the Gibson and Rozelle’s: households in departments with “older” tarred roads network should have a better access to tarred roads since the secondary/feeder road density should be higher. Indeed, this is confirmed by the different maps.

The last instrument is the tarred road density by province lagged one year (in 2000). The current road access is determined by the previous prevailing network density. A higher density will lead to a reduced time at the household level. Considering that we control for unobserved heterogeneity at the district level thanks to fixed effects, any residual impact on these instruments on our poverty indicator is only through the effect of isolation at the household level.

Another empirical issue lies in the potential reverse causality between the consumption indicator and the *Labor* variable is the “Multi-Active Agriculture” dummy. Incentives to diversify income sources may be due to the vulnerability of specialized poor households. The simultaneous estimates using three-stage least squares solve this issue.

Finally a selection bias arises from the sequential definition of labor categories: the household-head has first to decide whether or not enter the job market and then has to choose the sector of activity. Therefore, we follow Wooldridge [28] to model this issue:

$y_1 = x_1\beta_1 + u_1$

$y_2 = 1\ (x\delta_2 + v_2)$

The assumptions are that (x, y2) are always observed and $y_1$ is observed only when $y_2 = 1$; $(u_1, v_2)$ are independent of x with zero mean; $v_2$ is normally distributed (0, 1); $E\ (u_1|\ v_2) = \gamma_1\ v_2$.

We can thus write that:

$E\ (y_1|\ x, y2) = x_1\beta_1 + E\ (u_1|\ v_2) = x_1\beta_1 + \gamma_1\ v_2$

If $\gamma_1$ is null, there is no selection problem. If $\gamma_1$ is different from zero, using iterated expectations on the previous equation, we have:

$E\ (y_1|\ x, y2) = x_1\beta_1 + \gamma_1 E\ (v_2|x, y2) = x_1\beta_1 + \gamma_1\ h(x, y2)$,

with $h(x, y2) = h(x, 1) = \lambda(x\delta_2)$ the inverse Mills ratio on the selected sample. A consistent estimator of $\delta_2$ is obtained from the probit estimation of the selection equation. This methodology is used to get the two inverse Mills ratios from the probit estimations of the probability the household-head is active on the one hand; and the probability he is primarily involved in agriculture on the other hand. We then introduce these variables as explanatory variables, respectively in the labor equation for the labor category “Agriculture” and in the labor equation for the labor category “Multi-Active Agriculture”.

# 5. Results

The estimates presented in Tables 3 to 5 are made using fixed effects at the district level, but these are not reported due to limited space. Moreover these estimates concern the rural sub-sample as the current debate on investments for roads or infrastructure in general is about providing rural infrastructures or not to these areas where the main activity remains agriculture.

## *“Active” or “Inactive”?*

### *Determinants of consumption expenditures*

The household’s size and composition variables have the expected impacts. Larger households tend to have a lower level of consumption. Compared to a household whose head lives in couple and has children, a couple without children has a higher level of consumption. The single people dummy may be interpreted according to two competing intuitions. As a

single person does not have to share her income with other people, she benefits from a higher level of consumption as illustrated by the positive and significant impact of this dummy. The average level of education in the household has the positive expected effect on consumption expenditures since education leads to higher-paid job opportunities; but the impact is non-significant at the cluster level. However, working-age people affected by malaria in the cluster significantly lowers consumption.

As expected an active-headed household has a higher level of consumption compared to an inactive headed-household. Our hypothesis of a non-direct impact of road access on consumption is also verified.

***Determinants of the probability of being active***

Compared to no education, having received a primary education does not influence the probability of being active. On the contrary this probability is higher for household-heads with a secondary (first and second cycle) or a tertiary education.

The major result concerning this side of the model is the non-significant impact of the road access proxy while a better access to roads is supposed to entail more job opportunities. However, one should note that the labor variable under consideration here may only partly proxy for employment opportunities, since the reference group encompasses both unemployed and other inactive household-heads. In addition, amongst the active household-heads, there can be too much heterogeneity in the labor activities in terms of transport demands. Finally, another potential explanation can be found in the very particular shape of employment in Africa. In Cameroon, the issue of activity and employment lies in a lack of sufficient revenues and underemployment rather than a conventional unemployment status. A large part of the employment is in fact corresponding to informal or agriculture activities with an average little number of worked hours or low productivity activities and therefore produces low revenues.

**Table 3: Simultaneous Estimates; "Active" *versus* "Inactive"**

| Dependant variable: Welfare Ratio | | Dependant variable: "Active" HH-head | |
|---|---|---|---|
| Size | -0.052 | Size | -0.001 |
| | (0.011)** | | (0.001) |
| Number above age 60 | -0.302 | Number above age 60 | 0.023 |
| | (0.134)* | | (0.013) |
| HH-head Couple without children | 0.430 | HH-head Couple without children | -0.015 |
| | (0.121)** | | (0.014) |
| HH-head single parent with children | -0.006 | HH-head single parent with children | -0.004 |
| | (0.104) | | (0.014) |
| HH-head single people | 0.860 | HH-head single people | -0.083 |
| | (0.231)** | | (0.019)** |
| Average level of education | 0.094 | | |
| in the household | (0.024)** | Time to the nearest tarred road | 0.013 |
| "Active" HH-head | 8.269 | in hours | (0.008) |
| | (2.025)** | Male-headed household | -0.008 |
| Time to the nearest tarred road | -0.697 | | (0.008) |
| in hours | (0.648) | Age | 0.000 |
| Time to the nearest primary school | 0.166 | | (0.000) |
| in hours | (0.172) | Primary education | 0.014 |
| Time to the nearest health center | 0.220 | | (0.007) |
| in hours | (0.245) | Secondary (1st cycle) education | 0.018 |
| Time to the nearest food market | 0.210 | | (0.006)** |
| in hours | (0.251) | Secondary (2nd cycle) education | 0.035 |
| Part of people affected by malaria | -0.237 | | (0.011)** |
| in the cluster | (0.289) | Tertiary education | 0.067 |
| Average level of education | -0.271 | | (0.019)** |
| in the cluster | (0.306) | | |
| Semi Urban | 0.849 | Semi Urban | -0.061 |
| | (0.215)** | | (0.015)** |
| Rural Savannah | -0.752 | Rural Savannah | -0.100 |
| | (1.217) | | (0.099) |
| Rural High Plateaux | -0.113 | Rural High Plateaux | -0.065 |
| | (0.974) | | (0.110) |
| Constant | -6.603 | Constant | 1.038 |
| | (2.403)** | | (0.096)** |
| District Fixed Effects | yes | District Fixed Effects | yes |
| Instrumental Variables | yes | Instrumental Variables | yes |
| Observations | 2936 | Observations | 2936 |
| RMSE | 1.834 | RMSE | .207 |
| (robust se); *: p<5%; **: p<1% | | | |

## *“Agriculture” or “Non Agriculture”?*

***Determinants of consumption expenditures***

Household’s characteristics, regional dummies and the control variables for the channels of road’s impact on poverty, generally have comparable impacts on consumption than previously.

Road access is found to have no direct impact on the level of expenditures. The household-head’s involvement in agriculture tends to greatly lower the level of consumption expenditures for his household. The farming sector therefore appears to be a kind of “poverty trap” for Cameroonian households as this activity is unable to provide sufficient revenues to help increase consumption.

***Determinants of the probability the main activity is agriculture***

The structure of the household is not a significant determinant of the decision to enter the farming sector. But the probability of working in agriculture decreases further with the level of education.

The positive coefficient of the road access indicator highlights the indirect effect of road isolation on consumption. Remoteness from markets forces households to insure their food subsistence by their own means since they cannot rely on trade opportunities. They therefore remain stuck in farming subsistence activities providing only low revenues.

Notice that the inverse Mills ration is not significant here; there is no selection bias due to the restriction of the sample to active household-heads.

**Table 4 : Simultaneous Estimates; "Agriculture" *versus* "Non agriculture"**

| Dependant variable: Welfare Ratio | | Dependant variable: "Agriculture" HH-head | |
|---|---|---|---|
| Size | -0.056 | Size | 0.002 |
| | (0.005)** | | (0.003) |
| Number above age 60 | -0.078 | Number above age 60 | 0.020 |
| | (0.049) | | (0.023) |
| HH-head Couple without children | 0.288 | HH-head Couple without children | 0.010 |
| | (0.046)** | | (0.024) |
| HH-head single parent with children | -0.056 | HH-head single parent with children | 0.001 |
| | (0.045) | | (0.029) |
| HH-head single people | 0.193 | HH-head single people | -0.017 |
| | (0.064)** | | (0.035) |
| Average level of education in the household | 0.088 | Time to the nearest tarred road in hours | 0.069 |
| | (0.015)** | | (0.013)** |
| "Agriculture" HH-head | -0.964 | | |
| | (0.159)** | "Multi-Active" HH-head | -0.059 |
| "Multi-Active" HH-head | -0.018 | | (0.015)** |
| | (0.029) | Male-headed household | 0.059 |
| Time to the nearest tarred road in hours | -0.388 | | (0.025)* |
| | (0.256) | Age | 0.002 |
| Time to the nearest primary school in hours | 0.105 | | (0.001)** |
| | (0.065) | Primary education | -0.069 |
| Time to the nearest health center in hours | 0.181 | | (0.019)** |
| | (0.103) | Secondary (1st cycle) education | -0.156 |
| Time to the nearest food market in hours | 0.158 | | (0.024)** |
| | (0.103) | Secondary (2nd cycle) education | -0.287 |
| Part of people affected by malaria in the cluster | -0.368 | | (0.030)** |
| | (0.188) | Tertiary education | -0.370 |
| Average level of education in the cluster | -0.225 | | (0.038)** |
| | (0.138) | Semi Urban | -0.506 |
| Semi Urban | -0.134 | | (0.026)** |
| | (0.095) | Rural Savannah | -0.127 |
| Rural Savannah | -1.548 | | (0.170) |
| | (0.523)** | Rural High Plateaux | 0.294 |
| Rural High Plateaux | -1.039 | | (0.189) |
| | (0.387)** | Constant | 0.708 |
| Constant | 2.573 | | (0.169)** |
| | (0.730)** | Mills | Not sign |
| District Fixed Effects | yes | District Fixed Effects | yes |
| Instrumental Variables | yes | Instrumental Variables | yes |
| Observations | 2783 | Observations | 2783 |
| RMSE | .628 | RMSE | .353 |
| (robust se); *: p<5%; **: p<1% | | | |

### *Multi-Active Agriculture" or "Single Active Agriculture"?*

One can first note that the inverse Mills ratio is here significant, emphasizing the selection issue bias coming from the decision to exclude the non-agricultural sector from the sample of active household-heads.

Again there is no direct impact of road access on consumption. The isolation variable has a positive and significant impact on the probability a farmer household-head diversifies his/her labor activity. This supports the argument of an autarky behavior: isolated households tend to diversify their activity to fit their own demand.

However, the main result is the non-significant impact of the "Agriculture Multi" dummy on the level of consumption expenditures. The diversification[4] status of a household-head primary involved in agriculture thus implies no differences for the consumption expenditures of the household. As a consequence, access to a tarred road as no impact on the consumption level of the households whose heads are primarily involved in agriculture. This is an important finding as it highlights the problematic situation of some farmers in Cameroon for which this sector truly constitutes a poverty trap. This result is in line with the study by Beegle et al. [29] on Tanzania. They show that staying in agriculture is associated with lower growth than exiting the sector. The only way to increase the level of consumption for farming households seems to be a diversification outside agriculture.

4 However one should note that we are unable to identify the nature of the secondary activity. Consequently part of the multi-active household-heads may actually be involved in a secondary farming activity.

**Table 5: Simultaneous Estimates; "Multi Agriculture" *versus* "Single Agriculture"**

| Dependant variable: Welfare Ratio | | Dependant variable: "Agriculture Multi" HH-head | |
|---|---|---|---|
| Size | -0.062 | Size | 0.019 |
| | (0.004)** | | (0.004)** |
| Number above age 60 | -0.015 | Number above age 60 | 0.114 |
| | (0.035) | | (0.035)** |
| HH-head Couple without children | 0.257 | HH-head Couple without children | 0.051 |
| | (0.039)** | | (0.037) |
| HH-head single parent with children | -0.091 | HH-head single parent with children | -0.102 |
| | (0.039)* | | (0.045)* |
| HH-head single people | 0.138 | HH-head single people | -0.091 |
| | (0.055)* | | (0.058) |
| Average level of education | 0.077 | Time to the nearest tarred road | 0.124 |
| in the household | (0.017)** | in hours | (0.022)** |
| "Agriculture Multi" HH-head | 0.166 | | |
| | (0.151) | | |
| Time to the nearest tarred road | -0.021 | Male-headed household | 0.213 |
| in hours | (0.057) | | (0.047)** |
| Time to the nearest primary school | 0.025 | Age | 0.005 |
| in hours | (0.027) | | (0.001)** |
| Time to the nearest health center | 0.008 | Primary education | -0.164 |
| in hours | (0.032) | | (0.031)** |
| Time to the nearest food market | -0.009 | Secondary (1st cycle) education | -0.493 |
| in hours | (0.026) | | (0.056)** |
| Part of people affected by malaria | -0.365 | Secondary (2nd cycle) education | -1.370 |
| in the cluster | (0.185)* | | (0.119)** |
| Average level of education | -0.016 | Tertiary education | -2.153 |
| in the cluster | (0.073) | | (0.200)** |
| Semi Urban | 0.179 | Semi Urban | -2.069 |
| | (0.067)** | | (0.150)** |
| Rural Savannah | -1.446 | Rural Savannah | -0.625 |
| | (0.477)** | | (0.464) |
| Rural High Plateaux | -1.581 | Rural High Plateaux | 0.307 |
| | (0.609)** | | (0.481) |
| Constant | 1.361 | Constant | -1.056 |
| | (0.455)** | | (0.435)* |
| | | Mills | Sign.** |
| District Fixed Effects | yes | District Fixed Effects | yes |
| Instrumental Variables | yes | Instrumental Variables | yes |
| Observations | 1636 | Observations | 1636 |
| RMSE | .423 | RMSE | .410 |
| (robust se); *: p<5%; **: p<1% | | | |

# 6. Main Policy Implications and Conclusions

This paper somehow questions certain beliefs that improved road access automatically leads to poverty reduction. This faith in a certain poverty reduction impact of roads already fueled the previous massive investments in transport infrastructure in Africa but the promised results have not been reached.

Contrary to the plethora of empirical studies that directly model poverty as a function of isolation, we found that road access has no direct impact on the consumption expenditures for Cameroonian households when we control for the various channels identified by the literature. The impact is only indirect: it is not road availability *per se* that helps to reduce poverty, but the opportunities opened by roads, more specifically labor opportunities outside the agricultural sector. Agriculture acts as a poverty trap for Cameroonian households and the lack of a developed and dense road network keeps them captive in that sector.

Rural Africa is usually characterized by semi-subsistence, low-input, low-productivity systems. Lukanu et al. [30] give the example of the southern Niassa province of Mozambique and explains that most smallholders give priority to cultivating food crops for consumption and what is left over is used to cultivate cash crops. Therefore, for most households involved in agriculture, a better access to roads could still leave them in a poor condition because they do not have the necessary endowments (land, skills, labor) to increase production and surplus.

These results are in line with the argument of a beneficial impact of improved road access on the opportunity to diversify outside the farming sector. Although we cannot use similar methodologies as in Lanjouw [23], [22] or [11], our results in the Cameroonian context confirm their own findings for Tanzania, Uganda and Vietnam.

Paper estimates also demonstrate a non-significant effect of the diversification status of farmers' household-heads. Households headed by a multi-active farmer exhibit no significant difference in their consumption level compared to a single-active farmer. On the contrary, isolation has positive impact on the probability that these household-heads diversify their activity, which refers to the autarky argument. Unfortunately, one cannot identify the second sector of activity. We could assume that as long as they remain close to the farming sector, this could explain the result of a non-significant impact on the consumption level.

These results emphasize that investing uniformly for roads in Africa is likely to have a lower impact on poverty than expected. Their efficiency for poverty reduction relies on an appropriate design, taking into account the real needs of road users, depending mainly on their labor opportunities/type of activities. This also implies that construction of roads needs to be

decided and planned according to labor opportunities outside the agriculture sector (or in the commercial farming sector). As Beegle et al. [29] underline "how to deliver poverty reduction if the main engine of growth appears to be elsewhere". It is indeed now increasingly documented that non-farming incomes (rather than farming) have a major impact on poverty reduction [20]. A particular example for Cameroon is the work of Gockowski et al. [31]. They show that horticulture provides a pathway for intensification among smallholders in southern Cameroon driven by growth in urban market demand and high relative prices.

This is especially crucial for aid effectiveness in Africa at the time when the Rural Access Index[5] has become the most important target for the donor community regarding transport in Sub-Saharan Africa. Therefore, this norm should either be changed or its use should done with important flexibility otherwise current investments in rural roads are most likely bound to be unsustainable for most Sub-Saharan Africa countries and a with limited benefit in most cases.

The labor channel needs to be studied carefully when any decision is taken on investments and therefore, the type of investment needs to be tailored to the actual and potential demand. As plot size in Cameroon is limited on average to less than one hectare (Raballand et al. [32]), a farmer's transport requirement is usually minimal and does not necessarily involve massive investments in infrastructure because most farmers cannot fully load a truck (and pay for this service) and, even if productivity would significantly be higher, the production threshold would not be reached by most individual farmers.

Moreover, the idea of scaling up in roads investment assumes that investment in roads will lead to reduced transport prices and neglect market structure of behavior of provider of transport services, which seems to be problematic for aid effectiveness (Arvis et al. [33]). However, infrastructure is only one component of the production function of the service provider and the link between roads condition and transport prices is far from being automatic, at the international corridor level [3] as well at the local level [33, 34].

But the question of roads investments as an efficient poverty reduction tool also requires a discussion on their governance capacities. In many African countries, roads are

5 The rural access index (RAI) is the proportion of rural people who live within two kilometers (typically equivalent to a 20-minute walk) of an all-season road. An all-season road is a (gravel or bitumen paved) road that is passable all year by the prevailing means of rural transport (often a pick-up or a truck which does not have four-wheel-drive). Predictable interruptions of short duration during inclement weather (e.g. heavy rainfall) are acceptable, particularly on low volume roads. Despite major problems of measurement of the RAI, it is required for most donors in SSA to report it on a bi-annual basis and assess the number of people covered at 2 kilometers in the project area.
For a more detailed discussion of the RAI, see Raballand et al. (2010).

built not for economic reasons but rather for political allegiance and the high risks of embezzlement may render ineffective any well-thought road project.

Finally the interrelation between road access and migration has still to be studied in depth. Beegle et al. [29] find that migration to more connected areas is associated with higher consumption growth. Fafchamps and Shilpi [35] show that better access to paved roads in some regions reduces migration. However, the availability of roads and thus access to other areas that may be more connected may induce more internal migration in the form of seasonal or temporary migration.

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# Appendices

## *Appendix A*

### Table 6: Summary Statistics. [A]: Reference Group

| | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Welfare Ratio | 10991 | .4867298 | .7136692 | -2.425216 | 4.621913 |
| **Household's characteristics** | | | | | |
| Size | 10991 | 5.134929 | 3.518971 | 1 | 38 |
| Number above age 60 | 10991 | .2551178 | .5485235 | 0 | 6 |
| Dummy, HH-head in Couple with children[A] | 10991 | .5549995 | .4969885 | 0 | 1 |
| Dummy, HH-head in Couple without children | 10991 | .1140024 | .3178286 | 0 | 1 |
| Dummy, HH-headsingle parent with children | 10991 | .149304 | .3564041 | 0 | 1 |
| Dummy, HH-head single people | 10991 | .1815121 | .3854595 | 0 | 1 |
| Average level of education | 8727 | 2.670905 | 1.317237 | 1 | 7 |
| Time to reach the nearest tarred road | 10319 | .2111728 | .4081593 | 0 | 13.36667 |
| **Household-Head's Characteristics** | | | | | |
| Dummy , Male-headed household | 10991 | 1.243927 | .4294687 | 1 | 2 |
| Age | 10991 | 42.92412 | 15.06109 | 13 | 99 |
| Dummy , No education [A] | 10991 | .2685834 | .4432429 | 0 | 1 |
| Dummy , Primary education | 10991 | .314894 | .4644948 | 0 | 1 |
| Dummy , Secondary (1st cycle) education | 10706 | .1857837 | .3889502 | 0 | 1 |
| Dummy , Secondary (2nd cycle) education | 10803 | .1130242 | .316637 | 0 | 1 |
| Dummy , Tertiary education | 10991 | .0791557 | .2699939 | 0 | 1 |
| **Channels controls** | | | | | |
| Dummy, HH-head active | 10875 | .8650115 | .341727 | 0 | 1 |
| Dummy, HH-head agriculture | 9407 | .4090571 | .491686 | 0 | 1 |
| Dummy, multi-active | 9367 | .2618768 | .4396794 | 0 | 1 |
| Dummy, HH-head agriculture multi-active | 3838 | .338197 | .4731576 | 0 | 1 |
| Time to reach the nearest primary school | 10906 | .3267467 | .4174181 | 0 | 8.683333 |
| Time to reach the nearest health center | 9889 | .4474045 | .6141364 | 0 | 8.366667 |
| Time to reach the nearest food market | 10954 | .4039985 | .6246352 | 0 | 8.333333 |
| **Regional Characteristics** | | | | | |
| Share of people affected by malaria | 10991 | 2.785574 | .9441693 | 1.017241 | 6.555555 |
| Average level of education | 9158 | .1101484 | .0861446 | 0 | .44 |
| Dummy, Urban[A] | 10991 | .4525521 | .4977662 | 0 | 1 |
| Dummy, Rural Forest | 10991 | .1497589 | .3568512 | 0 | 1 |
| Dummy, Rural Savannah | 10991 | .1865162 | .3895404 | 0 | 1 |
| Dummy, Rural High Plateaux | 10991 | .2111728 | .4081593 | 0 | 1 |
| Semi Urban | 10991 | .1944318 | .3957807 | 0 | 1 |
| **Instrumental Variables** | | | | | |
| Tarred Road Density | 10991 | .0136201 | .0075429 | .0007403 | .0293937 |
| "Gendarmerie" Density | 10867 | .1547943 | .4255581 | 0 | 2 |
| « A la Gibson & Rozelle » | 10991 | 29.3718 | 15.08913 | 0 | 68 |

## *Appendix B*

**Table 7: Tarred road network age, by department**

| Departments | Tarred network "age" (in years) |
|---|---|
| Faro-et-Deo, Mayo-Banyo, Haute-Sanaga, Boumba-et-Ngoko, Haut-Nyong, Kadey, Faro, Bui, Donga-Mantung, Menchum, Ndian | 0 |
| Lom-et-Djerem | 8 |
| Vina | 11 |
| Ndé | 14 |
| Mayo-Tsanaga | 17 |
| Mayo-Rey | 22 |
| Djerem, Mbere | 23 |
| Lekie | 24 |
| Mayo-Sava, Sanaga-Maritime | 25 |
| Bamboutos | 26 |
| Bénoué, Nyong-et-Soo | 27 |
| Dja-et-Lobo | 28 |
| Mbam, Logone-et-Chari | 28,5 |
| Mayo-Louti, Mfoundi | 29 |
| Diamare | 30 |
| Mefou | 31 |
| Kaele | 32 |
| Mezam | 37 |
| Nyong-et-Mfoumou | 37,5 |
| Nyong-et-Kelle | 38,5 |
| Wouri, Ocean | 39 |
| Mifi, Mayo-Danay | 40 |
| Fako | 42 |
| Ntem | 43 |
| Haut-Kam | 45 |
| Moungo | 45,5 |
| Nkam | 48 |
| Menoua | 50 |
| Manyu, Meme | 52 |
| Noun | 68 |

*Sources: Author's calculations using maps from the Institut Géographique National and data from the Ministry of Public Works of Cameroun.*