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A Semi-parametric Recursive Trivariate Probit Modeling of the Contemporaneous Dynamics of Literacy, Labor Market Participation and Poverty in Burkina Faso: What role does Formal Education Play?

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Abstract

This research contributes to the overall debate on education for sustainable development (ESD) by shedding lights on the contributing role of formal education to the contemporaneous dynamics of literacy, labor market participation and poverty reduction in Africa, with a focus on Burkina Faso. The study uses a semi-parametric recursive trivariate probit modeling approach, and data from the 2014 National Survey on Household Living Conditions in Burkina Faso.

The results show that the embraced systemic approach in this analysis is statistically significant as shown by the 95% confidence intervals on the three correlation coefficients in the model. Furthermore, education does improve literacy skills, however improved literacy skills in itself does not guaranty active labor market participation in Burkina Faso. Active labor market participation seem to be affected by labor market rates of return, and individual reservation wage (or income). When labor market rate of return is short of high literacy skilled individuals' reservation wage, then the natural response is a choice of inactivity in the labor market, by the later group. Simultaneously however, it is found that active labor market participation leads to poverty reduction; therefore, in addition to new industrial policies for structural transformation of the economy, policy makers in Burkina Faso should consider education and minimum wage reforms to give highly literate household members the incentive to be active in the labor market.

Keywords: Formal Education, Labor Market Participation, Literacy, Poverty, Sustainable Development, Semipametric Trivariate Probit

JEL: C12, C14, C51, J08, I25, I32

1. Introduction

From large infrastructure development projects launched with the support of bilateral and multilateral institutions to local indigenous innovations, the new millennium has brought substantial social and economic progress in many African countries (United Nations, 2008; Samans et al., 2017). In the African context, innovation defined as "the embodiment, combination or synthesis of knowledge in relevant and original valued new products, processes or services" has involved reorganizing the way business is done, production organized, supply chain structured, financial resources distributed, and key services provided (Reij and Waters-Bayer, 2014).

Despite notable progress, Africa still lags behind in its pace of innovation, and most countries remain relatively slow to adopt innovations (Organization and Publications, 2016) . The constraints on technological innovation and diffusion include the high rate of out-migration of educated Africans, the lack of resources allocated to research and development, and the small size of most local markets. At the local level, the low levels of literacy and numeracy of prospective technology adopters, many of whom are poor, also contributes to hinder adoption and diffusion (Coleman, 2011). In such context, the build-up of a critical mass of African innovators and innovating capacity in the sciences remains essential for the structural transformation of African economies, in favor of high productivity activities, key to sustained growth, employment creation and poverty reduction (Samans et al., 2015).

Experience from the BRICS countries shows that education could play an essential role in this process (Cassiolato and Vitorino, 2010; Carnoy et al., 2013; Loyalka et al., 2014). In the past, education was about teaching people something, and educators could expect that what they taught would last a lifetime of their students (Pinheiro et al., 2015). Now education is more about helping students develop a reliable compass and the navigation skills to find their own way through an increasingly uncertain, volatile and ambiguous world (Thomas, 2009). Educators need to prepare students for more rapid economic and social changes than ever before, for jobs yet to be created, to use technologies yet to be invented, and solve problems yet to arise (Hesselbarth and Schaltegger, 2014).

Education for sustainable development (ESD) (RATHOD, 2013) is designed to support the development of a range of skills including, digital literacy skills, problem solving skills, critical thinking for internet services and electronic media consumption, and the ability to evaluate and assess the impact of ones choices on the environment, the economy and society at large (Meijers and Kopnina, 2014). These skills are important especially within the ever evolving realm of corporate social responsibility (Cadbury, 2006; Tai and Chuang, 2014), as more and more employers are now looking for skills related to social and environmental responsibility (Suliman et al., 2016).

Unlike most education movements however, ESD was initiated and developed by actors outside of the education community, such as international organizations (United Nations, World Bank). Therefore, this research aims to bring an education community's perspective to the ESD discussion,

by shedding lights on the contributing role of formal education to the contemporaneous dynamics of literacy, labor market participation and poverty reduction in Africa, with a focus on Burkina Faso.

As a West African Sahelian country, Burkina Faso covers 274,200 square kilometers in the loop of the Niger river. With a high demographic growth of 3.1 percent, mainly due to high fertility and declining mortality, its population was estimated at over 17.9 million in January 2015 (World Bank, 2016). The country's rate of progress towards the eradication of extreme poverty and the reduction of inequalities over recent years has been sub-optimal (World Bank Group, 2017). Poverty projections show that, with the current trends, the country might not reach one of the twin goals, which is eradicating poverty by the year 2030 (World Bank, 2016). This is partly due to its strong population growth, and productivity challenges, which are all influenced by education. In fact, Education improves human capital and has a positive impact on income and on poverty reduction. It also affects many other phenomena, including the use of contraceptives, fertility and under-nutrition.

Although the latest world bank Systematic Country Diagnostic (SCD) report (World Bank Group, 2017) provides the most up to date picture of the link between education poverty reduction and shared prosperity in Burkina Faso, it still does not account for the contemporaneous dynamics between education, literacy, labor market participation and poverty reduction. Therefore, the current study as a follow up to Niankara (2016b,a) attemps to fill in this gap by addressing the following general question: *How does formal education affect the contemporaneous dynamics of literacy status, labor market status and poverty status in Burkina Faso ?*
To the best of our knowledge, no prior study has taken a systemic approach to addressing this question in the literature before, as such we aim to specifically know:

- **Q01**: *How formal education affects literacy status in Burkina Faso ?*
- **Q02**:*How literacy status affects employment status in Burkina Faso ?*
- **Q03**: *How employment status affects poverty status in Burkina Faso ?*

Based on studies grounded on human capital theory (Olaniyan and Okemakinde, 2008), we can formulate the following hypotheses in regards to each of the above three specific questions

- **H01**: *Education impacts positively literacy status, by raising literacy skills*
- **H02**: *Literacy status affects positively labor market participation, by raising productivity and the opportunity cost of inactivity*
- **H03**: *Labor market participation affects negatively poverty status, by improving household income and purchasing power*

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In our attempt to test the above hypotheses, we organize the rest of the paper as follows: Section 2 discusses a brief literature on education for sustainable development. Section 3 presents the Random Utility Model of literacy, labor market status and poverty. Section 4 describes the econometric framework in the form of a recursive trivariate probit model of literacy, labor market participation and poverty. Section 5 presents the data and variables used in the analysis. Section 6 presents the results, while section 7 gives a brief discussion and concludes the analysis.

2. Literature review on Education for Sustainable Development (ESD)

Generally thought to have three intertwined components: the environment, society, and the economy; sustainable development (SD) is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 2015). From the time SD was first endorsed at the United Nations (UN) General Assembly in 1987, the parallel concept of education to support sustainable development has also been explored (UN General Assembly, 1987). At the 2015 world education forum, this commitment was reiterated through the education 2030 Agenda, "to providing inclusive and equitable quality education and promote lifelong learning opportunities for all"(Incheon Declaration, 2015). As an important policy framework, Education for Sustainable Development (ESD) presents opportunities for innovation and development through its effect on literacy (Banga Chhokar, 2010; Correia et al., 2010; Lozano et al., 2013).

Broadly defined as "understanding, evaluating, using and engaging with written text to participate in society, to achieve one's goals and to develop one's knowledge and potential", literacy has been shown to greatly affect economic outcomes(Sum et al., 2004) and poverty (Mchombu and Cadbury, 2006; Murray and Shillington, 2011; Niankara, 2016b). Literacy could be a key component in achieving the UNs SD goals (Suso, 2006), since each of the 17 goals including goal 9 related to industry, innovation and infrastructure, will be limited by the inability of illiterate citizens to be sufficiently informed on key issues, and less empowered to take action (United Nations, 2015). Therefore education can provide the best means for overcoming poverty caused by illiteracy (Cree et al., 2012).

Several studies have looked at this link between education, poverty reduction and sustainability (Harber, 2002; Craig and Porter, 2003; Rwehera, 2004; Dercon et al., 2012; Nsabimana et al., 2013). For example, a study by (May and Woolard, 2007) in south Africa suggests that each year of additional primary schooling leads to an increase in consumption spending by 11%. Balma et al. (2011) also found a strong correlation between education and poverty reduction. In rural Vietnam, Baulch and Dat (2011) found that households led by heads with secondary education, have 31% higher chances of coming out of poverty compared to those headed by someone with no formal schooling. McCulloch et al. (2007) had similar findings in Indonesia, where each year of schooling translated into a 6% growth in income for the 7 years spanning the study. It is believed

that education by allowing for greater productivity and innovation, improves quality of life, and provides a way out of poverty(World, 2016).

3. The Random Utility Model

The economic model describing our problem is based on the Random Utility framework following Marshak (1959); Manski and McFadden (1981); Train (2009). It is assumed that each household acts as a decision making unit, faced with three choice situations i (with $i = 0$ if literacy choice, $i = 1$ if labor market participation choice, and $i = 2$ if per-capita spending choice (or poverty status)), where the household must choose between two alternatives indexed respectively with zero (0) and one (1), according to which one provides the greatest utility/well-being. In the first situation the choice is between 1-"Acquiring literacy skills", and 0-"Not acquiring literacy skills". In the second situation, the choice is between 1-"Being active in the labor market", and 0 -"Not being active in the labor market". Finally in the third situation the choice is between 1-"Spending a per-capita amount above the poverty line" , and 0-"Spending a per-capita amount below the poverty line". In each choice situation the household chooses the alternative with the highest utility/well-being. Therefore in the first choice situation, the discrete outcome variable (LitStat) takes the value 1 if alternative 1 has the greater utility of the two, otherwise LitStat =0. Similarly in the second choice situation, the discrete outcome variable (LMStat) takes the value 1 if alternative 1 has the greater utility of the two, otherwise LMStat =0. Finally, and same as the first two choice situations, the discrete outcome variable (PovStat) takes the value 1 if alternative 1 has the greater utility of the two, otherwise PovStat =0. Additive random utility modeling (ARUM) specifies the utilities of alternatives 0 and 1 in each choice situation i for $i = 0, 1, 2$ as:

$$\begin{aligned} U_{i0} &= V_{i0} + \epsilon_{i0}, \\ U_{i1} &= V_{i1} + \epsilon_{i1}, \end{aligned} \tag{1}$$

where V_{i0} and V_{i1} are deterministic components of utility with ϵ_{i0} and ϵ_{i1} being the random components of utility. We observe $y_i = 1$, if $U_{i1} > U_{i0}$, that is if alternative 1 has the highest utility of the two. Because of the presence of the random components of utility this is a random event with

$$\begin{aligned} Pr[y_i = 1] &= Pr[U_{i1} > U_{i0}] \\ &= Pr[V_{i1} + \epsilon_{i1} > V_{i0} + \epsilon_{i0}] \\ &= Pr[\epsilon_{i0} - \epsilon_{i1} < -(V_{i0} - V_{i1})] \\ &= F(V_{i0} - V_{i1}), \end{aligned} \tag{2}$$

where $F(.)$ is the cumulative distribution function of the error differences $(\epsilon_{i0} - \epsilon_{i1})$. giving

$$Pr[y_i = 1] = F(X^{'}\beta_i) \; if \; V_{i0} - V_{i1} = X^{'}\beta_i \tag{3}$$

The ARUM requires a scale normalization since, if $U_{i1} > U_{i0}$ then $aU_{i1} > aU_{i0}$. This is usually done by specifying the variance of $(\epsilon_{i0} - \epsilon_{i1})$. Different parametric specifications for the distributions of the error terms (ϵ_{i0}) and (ϵ_{i1}) give different $F(.)$ and hence different discrete choice models. The Logit model or logistic regression is obtained when $F(X^{'}\beta_i) = \Lambda(X^{'}\beta_i)$, that is the type 1 extreme value cumulative distribution function. On the other hand, the Probit model is obtained when $F(X^{'}\beta_i)$ is assumed to be the standard normal cumulative distribution function. Since we have three interrelated choice situations, the overall problem becomes a tri-variate modeling situation with a system of 3 equations to be estimated jointly using appropriate multivariate methods as described next.

4. Trivariate model of literacy status, labor market status and poverty status

Our econometric specification defines (LitStat) as the binary variable characterizing the head of household literacy status, a binary labor market status variable (LMStat) defining whether or not the head of household is currently active on the labor market, and a binary poverty status variable (PovStat) capturing whether or not the head of household is living in a household with per-capita annual spending above the poverty line. More specifically, if $LitStat^{\star}$ is the latent utility characterizing the head of household propensity to be literate, $LMStat^{\star}$ is the latent utility characterizing the propensity to be active in the labor market, while $PovStat^{\star}$ is the latent utility characterizing the household average propensity the spend above the poverty line, then the econometric model is a system of three equations with the literacy status indicator:

$$LitStat = \begin{cases} 1 & \text{if } LitStat^{\star} > 0 \\ 0 & \text{if } LitStat^{\star} \leq 0 \end{cases} \tag{4}$$

The labor market status indicator:

$$LMStat = \begin{cases} 1 & \text{if } LMStat^{\star} > 0 \\ 0 & \text{if } LMStat^{\star} \leq 0 \end{cases} \tag{5}$$

and the poverty status indicator:

$$PovStat = \begin{cases} 1 & \text{if } PovStat^{\star} > 0 \\ 0 & \text{if } PovStat^{\star} \leq 0 \end{cases} \tag{6}$$

The recursive tri-variate system of additive random utilities can be written as,

$$\begin{cases} LitStat^{\star} & = \beta_{01} educ + x_0^{*}\beta_1 + \epsilon_1 \\ LMStat^{\star} & = \beta_{02} LitStat + x_1^{*}\beta_2 + \epsilon_2 \\ PovStat^{\star} & = \beta_{03} LMStat + x_2^{*}\beta_3 + \epsilon_3 \end{cases} \tag{7}$$

The unobserved characteristics $\epsilon_i,\ for\ i = 1, 2, 3$ are assumed to be distributed with mean μ_i and variance σ_i, and a variance-covariance matrix Σ expressed as:

$$\Sigma = \begin{bmatrix} \sigma_1 & \theta_{12} & \theta_{13} \\ & \sigma_2 & \theta_{23} \\ & & \sigma_3 \end{bmatrix} \tag{8}$$

Estimation of this trivariate model with maximum likelihood is straightforward if we make the further assumption that :

$$\begin{pmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_3 \end{pmatrix} \sim F_3 \left[\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \theta_{12} & \theta_{13} \\ & 1 & \theta_{23} \\ & & 1 \end{pmatrix} \right] \tag{9}$$

When F_3 is the normal distribution, then we have a fully-parametric tri-variate probit model. However, when F_3 is the logistic distribution, then we have the fully-parametric tri-variate logit model. In the current analysis, we relax the linearity assumption through semi-parametric modeling, by specifying a general function for the parametrically entering numerical variables (hage, hhsize) in the system of equations. This yields the following representation for equation 7 :

$$\begin{cases} LitStat^{\star} & = \beta_{01} educ + X_{11}^{'}\beta_{11} + g(X_{21}^{'}\beta_{21}, \epsilon_1) \\ LMStat^{\star} & = \beta_{02} LitStat + X_{12}^{'}\beta_{12} + g(X_{22}^{'}\beta_{22}, \epsilon_2) \\ PovStat^{\star} & = \beta_{03} LMStat + X_{13}^{'}\beta_{13} + g(X_{23}^{'}\beta_{23}, \epsilon_3) \end{cases} \tag{10}$$

In this formulation, β_{11} , β_{12} and β_{13} represent the vectors of marginal effects for the nominal co-variates of the literacy status equation, the labor market status equation and the poverty status equation respectively. While β_{21}, β_{22} and β_{23} represent the vectors of marginal effects for the numerical co-variates (age and household size) of the literacy status equation, the labor market status equation and the poverty status equation respectively. With the function $g(.)$ unknown, the distribution of $(\epsilon_1, \epsilon_2, \epsilon_3)$ is left unspecified, and the model is called partially linear. Both fully-parametric, and semi-parametric trivariate (Probit , Logit) estimations are implemented using tools from the library Wojtys et al. (2016) in the R Statistical Software (R Core Team, 2015).

5. Data and variables descriptions

The empirical analysis is based upon data from the 2014 National Survey on Household Living Conditions administered by the National Institute for Statistics and demography (INSD) in Burkina faso. The broad objective of the survey is to provide information on households living conditions in Burkina Faso. It uses a two-level stratified random sampling with weights that produce nationally representative estimates for a wide range of demographic and socioeconomic

characteristics for the civilian, non institutionalized population in Burkina Faso. Primary sampling units are selected with probability proportional to their size, and the secondary sampling units or Households selected with equal probability within those primary sampling units. The 2014 Survey was collected during a period of twelve months. Our analysis includes 10411 households after accounting for variables selection and missing data constraints. The following presents the variables used in our analysis

5.1. Dependent variables

In our current analysis, we have the three interacting dependent variables presented below:

- Literacy status - LitStat: This outcome measure presents the literacy status of a head of household in Burkina Faso. As a binary variable, it has two modalities: 1-"Literate", 0-"Illiterate".
- Labor Market Status - LMStat: This outcome measure presents the labor market status of a head of household in Burkina Faso. As a binary variable, it also has two modalities: 1-"Active in the labor market", 0-"Inactive in the labor market".
- Poverty Status - PovStat: This is a binary measure constructed using the combined household per-capita spending on food and non-food consumption, and the overall poverty line of 153530 CFA Franc in 2014. It assumes that households as rational optimizers are looking to maximize their utility from the consumption of goods and services they purchase annually. In this quest to satisfy their needs, households choose to spend yearly on consumption, an amount either greater than the poverty line (in which case the household is considered "non-poor") or less than the poverty line (in which case the household is considered "poor")[1]. This suggest that households per-capita annual spending is an indicator of household poverty status and in this way, the binary poverty status variable is therefore given by :

$$PoverStatus = \begin{cases} Nonpoor = 1 \ \ \forall \ \ CapSpendg > Poverty\ line, \\ Poor = 0 \ \ \forall \ \ CapSpendg \leq Poverty\ line \end{cases} \tag{11}$$

5.2. Independent variables

Like any scientific study using evidence from observational data, our interests here centers on the postulated causal influence of the attributes and environment of individuals' to their responses.

[1]This definition of Poverty status, is given by the National Institute for Statistics and demography (INSD) in Burkina faso which is the agency in charge of the 2014 EICVM surveys. This poverty line was 153,530 CFA Franc for 2014

Keeping in mind that the primary goal of this empirical analysis is to quantify the contributing role of formal education to the contemporaneous dynamics of literacy status, labor market status and poverty status in Burkina Faso, in choosing the variables to be included in the model, the question that needs to be addressed is: In addition to educational attainment, what other factors affect this recursive system in Burkina Faso?

In order to achieve our study goal we need to also account for the effects of the other covariates affecting this relationship such as socio-demographic characteristics (Marital status, sex, and Age of Head of Households). Table (1) provides definitions and summary statistics for all the relevant variables in the analysis.

6. Results

We first tested the association between variables using cross-tabulation and chi-square tests. The test is unilaterally one sided, and is used to check the link between the three binary dependent variables and the nominal explanatory variables. With our primary interest in the effect of formal education on the contemporaneous dynamics of literacy, labor market status, and poverty status, the null hypothesis is that all three dependent variables are independent of the level of formal education, versus the alternative that they are dependent. The same test is repeated with the other nominal explanatory variables in the model. The tables (2), (3) and (4), summarize the results of these chi-square tests for literacy status, labor market status, and poverty status respectively. The third and fourth columns of tables (2), (3) and (4) also present descriptive results in terms of conditional relative frequency per modality of each dependent variable (literacy status, labor market status, and poverty status) respectively as presented next.

6.1. Descriptive results for literacy status

These results for literacy status are shown in table(2).

- With respect to education level, the chi-square test statistic of 5654 and corresponding p-value <2.2e-16 suggest its dependency with literacy status at a 95% confidence level. Furthermore, among households where the head has no education 85.6% are illiterates, against 14.4% literates. Among the household with primary educated heads, 89.9% are literates against 10.1% illiterates. In regards to households with secondary educated heads nearly all of them, or 99.7%, are found to have sufficient literacy skills, against 0.3% still considered illiterates. Finally, among the households with higher educated heads, all of them, or 100%, are found to be literate. These descriptive results suggest that as the level of achieved formal education increases, the relative frequency of household illiteracy decreases in the population. Also higher education allows for complete eradication of illiteracy in the population.

- With respect to the head of household sex, the chi-square test statistic of 147.38 with corresponding p-value <2.2e-16 also suggest its dependency with literacy status at a 95% confidence level. Moreover, we note that among the households headed by females 63% are illiterates against 37% literates. On the other hand for the households headed by males 79.7% are illiterates against 20.3% literates. These results suggest that the relative frequency of illiteracy is greater among male headed households, compared to female headed households in Burkina Faso.

- with respect to marital status, the chi-square test statistic of 386.6% with corresponding p-value <2.2e-16 also suggest its dependency with literacy status at a 95% confidence level. Furthermore, we note that among the households headed by singles, 63.5% are literates against 36.5% illiterates. Among the households with married heads, 65.1% are illiterates against 34.9% literates. Finally among the households headed by widows, 87.2% are illiterates against 12.8% literates. These results suggest that illiteracy is the lowest among singles and the highest among widows in Burkina Faso.

- With respect to residency status the chi-square test statistic of 985.72 and corresponding p-value <2.2e-16 also suggest its dependency with literacy status at a 95% confidence level. Moreover, we note that among households living in rural areas 76.8% are illiterates against 23.2% literates. On the other hand for the households living in urban areas 53.3% are literates against 46.7% illiterates. These results suggest that the relative frequency of illiteracy falls as we move from rural Burkina Faso, to urban Burkina Faso.

6.2. Descriptive results for labor market status

These results for labor market status are shown in table(3).

- With respect to education level, the chi-square test statistic of 108.06 and corresponding p-value <2.2e-16 suggest its dependency with labor market status at a 95% confidence level. Furthermore, among households where the head has no education 90.6% are active in the labor market, against 9.4% inactive or unemployed. Among the household with primary educated heads, 90.3% are active in the labor market against 9.7% inactive. In regards to households with secondary educated heads 82.4% are active in the labor market, against 17.6% unemployed. Finally, among the households with higher educated heads 77.7% are active in the labor market, against 22.3% inactive or unemployed. These descriptive results suggest that as the level of achieved formal education increases, the relative frequency of unemployment (or inactivity) increases in the population.

- With respect to the head of household sex, the chi-square test statistic of 39.586 with corresponding p-value =3.14e-10 also suggest its dependency with labor market status at a 95%

confidence level. Moreover, we note that among the households headed by females 90.1% are active in the labor market against 9.9% inactive or unemployed. Similarly, for the households headed by males 84.5% are active in the labor market against 15.5% inactive. These results suggest that the relative frequency of unemployment (or inactivity) is greater among male headed households, compared to female headed households in Burkina Faso.

- with respect to marital status, the chi-square test statistic of 299.71% with corresponding p-value <2.2e-16 also suggest its dependency with labor market status at a 95% confidence level. Furthermore, we note that among the households headed by singles, 80.7% are active in the labor market against 19.3% inactive or unemployed. Among the households with married heads, 90.6% are active in the labor market against 9.4% inactive. Finally among the households headed by widows, 81.8% are active in the labor market against 18.2% unemployed. These results suggest that inactivity (or unemployment) is the lowest among married and the highest among singles in Burkina Faso.

- With respect to residency status the chi-square test statistic of 79.207 and corresponding p-value <2.2e-16 also suggest its dependency with labor market status at a 95% confidence level. Moreover, we note that among households living in rural areas 91.5% are active in the labor market against 8.5% inactive. On the other hand for the households living in urban areas 86% are active in the labor market against 14% unemployed. These results suggest that the relative frequency of inactivity (or unemployment) rises as we move from rural Burkina Faso, to urban Burkina Faso.

6.3. Descriptive results for poverty status

These results for poverty status are shown in Table(4).

- With respect to education level, the chi-square test statistic of 901.84 and corresponding p-value <2.2e-16 suggest its dependency with poverty status at a 95% confidence level. Furthermore, among households where the head has no education 47.1% are found poor, against 52.9% non-poor. Among the households with primary educated heads, 25.1% are poor against 74.9% non-poor. In regards to households with secondary educated heads 8.6%, are found to be poor, against 91.4% non-poor. Finally, among the households with higher educated heads, nearly all of them, or 99.3%, are found non-poor, and only 0.7% are poor. These descriptive results suggest that as the level of achieved formal education increases, the relative frequency (or incidence) of household poverty decreases in the population.

- With respect to the head of household sex, the chi-square test statistic of 19.594 with corresponding p-value =9.579e-06 also suggest its dependency with poverty status at a 95% confidence level. Moreover, we note that among the households headed by females 40%

are poor against 60% non-poor. On the other hand for the households headed by males 33.8% are poor against 66.2% non-poor. These results suggest that the relative frequency of poverty although fairly equal is slightly greater for male headed households, compared to female headed households in Burkina Faso.

- with respect to marital status, the chi-square test statistic of 182.99% with corresponding p-value <2.2e-16 also suggest its dependency with poverty status at a 95% confidence level. Furthermore, we note that among the households headed by singles, 13% are poor against 87% non-poor. Among the households with married heads, 41% are poor against 59% non-poor. Finally among the households headed by widows, 37.6% are poor against 62.4% non-poor. These results suggest that the incidence of poverty is the highest among singles and the lowest among married headed households in Burkina Faso.

- With respect to residency status the chi-square test statistic of 951.87 and corresponding p-value <2.2e-16 also suggest its dependency with poverty status at a 95% confidence level. Moreover, we note that among households living in rural areas 50.9% are poor against 49.1% non-poor. On the other hand for the households living in urban areas 20.5% are poor against 79.5% non-poor. These results suggest that the relative frequency (or incidence) of poverty falls as we move from rural Burkina Faso, to urban Burkina Faso.

In our quest to test our three hypothesis formulated in the introduction, we've specified and estimated four models: (i) a fully parametric recursive trivariate probit model with results shown in the second column of table (5), (ii) a fully parametric recursive trivariate logit model with results shown in the third column of table (5), (iii) a semi-parametric recursive trivariate probit model with results shown in the second column of table (6), and finally (iiii) a semi-parametric recursive trivariate logit model with results shown in the third column of table (6). In the first two fully parametric specifications (Probit and Logit) the implicit assumption is that all the explanatory variables enter the system of equations in a linear fashion. This assumption is relaxed in the next two semi-parametric specifications (Probit and Logit) so as to allow the numerical explanatory variables such as "age" and "household size" to enter the system in a non-linear fashion using copula functions. The convergence diagnostic checks for the trust region iteration algorithm (see (Wojtys et al., 2016)) used to identify the parameters of all four models, show satisfactory convergence as the largest absolute gradient values are close to zero, and the observed information matrices positive definite in all cases.

6.4. Econometric results

Comparing the model selection criteria measures, Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) for all specified four models we note that the best performing specification with the lowest values of AIC =24162.78 and BIC =24536.56 is the semi-parametric

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recursive trivariate probit model. Therefore this model represents our chosen specification to describe the contributing role of formal education to the contemporaneous correlations between literacy status, labor market status, and poverty status in Burkina Faso. Hence we use its results to test our three formulated hypothesis in the Introduction.

Prior to testing the three hypothesis however, it's important to first check the statistical significance of the system of equations which stipulates that the processes leading to illiteracy, unemployment, and poverty in a given year are related in burkina faso. Indeed, looking at the the positive and significant coefficient values $\theta_{12} = 0.362$ between literacy status and labor market status, $\theta_{13} = 0.158$ between literacy status and poverty status, and $\theta_{23} = 0.702$ between labor market status and poverty status, we can safely say that the unobserved factors affecting these three processes are positively related, as such we have a statistically significant system of equations describing the contemporaneous dynamics of illiteracy, unemployment, and poverty in Burkina Faso.

6.4.1. The literacy status equation results

The coefficient estimates for formal education (Primary, Secondary and Higher) in the literacy status equation allow us to test the first hypothesis H01: under which education impacts positively literacy status in Burkina Faso.

Since all the relative effects of the levels of formal education are positives and significant for primary (2.233) and secondary (3.877), we fail to reject this first hypothesis and conclude that the evidence is enough to suggest that compared to households headed by someone with no formal education, those headed by someone with primary and secondary educations are respectively 2.233 and 3.877 more likely to acquire enough literacy skills and therefore to have a literate status in Burkina Faso. Although the relative effect of higher education is positive but not statistically significant (probably due to the small relative frequency of household members falling in this category), those of primary and secondary educations do confirm the first hypothesis H01.

6.4.2. The labor market status equation results

The coefficients estimates for the literacy status variable in the labor market equation allow us to test the second formulated hypothesis H02: under which literacy status affects positively labor market status. Because this coefficient -0.682 is statistically significant, we can confidently say the evidence is enough to reject the second hypothesis, and conclude that being literate reduces instead the chances of active participation in the labor market in Burkina Faso.

This result seems a bit paradoxical, according to human capital theory we should expect increased labor market participation when literacy skills improve since it raises not only labor productivity, but also the opportunity cost of inactivity. Our result could potentially be explained by low labor market rates of return, and the structure of Burkina Faso's economy which is predominantly informal, and dominated by agriculture and commerce. In fact, to be active in the primary or

informal sector requires very little formal skills in burkina faso, especially for subsistence activities. Furthermore, improved literacy status allows household members to revise their "reservation wage (or income)" upward such that, at current low labor market rate of returns, an inactive status is preferred to that of being active. Because household members with low literacy skills tend to have relatively lower reservation wage (or income), they can still find current labor market returns attractive enough for participation.

6.4.3. The poverty status equation results

The coefficient estimate for the labor market status variable in the poverty status equation allows us to test the third hypothesis H03: under which being active in the labor market affects negatively poverty status in Burkina Faso.

Because the coefficient value -1.384 is statistically significant, we can say the evidence is not enough to reject the third hypothesis, and we conclude that being active in the labor market does reduce the likelihood of spending below the poverty line and thus of being characterized as poor in Burkina Faso.

7. Discussions and Conclusions

This article has concerned itself with analyzing the effects of formal education on the contemporaneous dynamics of literacy, labor market participation and poverty reduction in Burkina Faso, so as to shed some lights on the importance of education for sustainable development (ESD) within the African context. In order to achieve the study goal, we used data from the 2014 survey on household living conditions in Burkina Faso, along with an analytical framework made up of four competing model specifications: two fully parametric (probit and logit) models, and two semi-parametric (probit and logit) models. Using the AIC and BIC measures, the semi-parametric recursive trivariate probit model was found to best fit the data, and thus was chosen as the preferred model.

The analysis has produced several interesting results with significant implications. Overall, the correlation coefficients supported the significance of the contemporaneous system of equations constituted by literacy status, labor market status, and poverty status in Burkina Faso. In fact they suggest that the unobserved factors explaining illiteracy, unemployment and poverty among households in Burkina Faso are positively related. This implies that a systemic approach to resolving these three socio-economic issues will be more successful than isolated policies targeting each one individually.

The results from the three hypothesis tests showed that education does improve literacy skills, however improved literacy skills in itself, does not guaranty active labor market participation, although active labor force participation does reduce the likelihood of poverty in Burkina Faso.

The above results are not specific to the chosen semi-parametric trivariate recursive model, but generalize to all four specifications, suggesting their robustness to potential model mispecification.

The labor market participation result comes as a strike contrast however with the evidence in developed economies. In Canada for example Murray and Shillington (2011) found that literacy not only affects the probability that individuals participate in the labor market, but also influences the amount of work they are able to find. Individuals with low levels of literacy skills in developed economies are much less likely to be employed at some point in the course of a year, and work fewer weeks on average than their more skilled peers. This somewhat paradoxical result could potentially be explained by both demand and supply side factors in Burkina Faso's labor market.

From a labor supply side point of view, the fact that higher literacy skills reduces the chances of labor market participation could be a reflection of structural issues linked to the weight of the informal sector in the Burkina Faso's economy; and also the heavy reliance on the primary sector for employment, coupled with a weak manufacturing and industrial sector. Because rates of return in the primary sector are typically low, household members with high literacy skills could naturally develop reservation wages (or income) greater than the typical market rate of return such that a state of inactivity is preferred to that of being active in the low paying primary sector. In this case, a structural transformation of the economy through effective industrial policies could create high paying manufacturing jobs, essential to sustained growth, employment creation and poverty reduction. In addition, minimum wage reforms in the country could also help make the primary sector more attractive to high literacy skilled household members with relatively high reservation wages.

From a labor demand side point of view, this paradoxical result could be a reflection of labor demanders (companies) finding the acquired literacy skills by workers not suitable to their production needs or goals in relation to corporate social responsibility. As previously stated in the introduction because of global competitive and sustainability pressures, employers are more and more looking for skills related to social and environmental responsibility. If the acquired literacy skills are not in phase with the increasingly uncertain, volatile and ambiguous business world, then they might not be in demand because of skills mismatch. In this case the quality and direction of formal education would have to be reviewed through education reforms to fit the demands of today's business world turned toward, high quality and sustainability.

The descriptive findings also support the econometric results since the relative frequency of households members with higher education degrees is only 2.6%, with the greatest share of the population 74.7 % having no education. At the same time, the relative frequency of illiteracy is seen to decrease with increasing levels of formal education, to be non-existent among higher educated individuals which account for only 2.6% of the population. This observation implies that increasing access to higher education through proper education reforms will eradicate illiteracy and help Burkina Faso not only build up its critical mass of educated innovators, but also raise the level of literacy and numeracy of prospective technology adopters, essential for the industrial

development and structural transformation of the country.

In terms of future directions, it would be interesting to find out which of supply side or demand side factors are most determining this paradoxical result of household labor force participation in Burkina Faso. This will allow government and policy makers alike to plan develop and implement targeted policies to improve labor market outcomes, and thereby reduce poverty in a sustainable fashion.

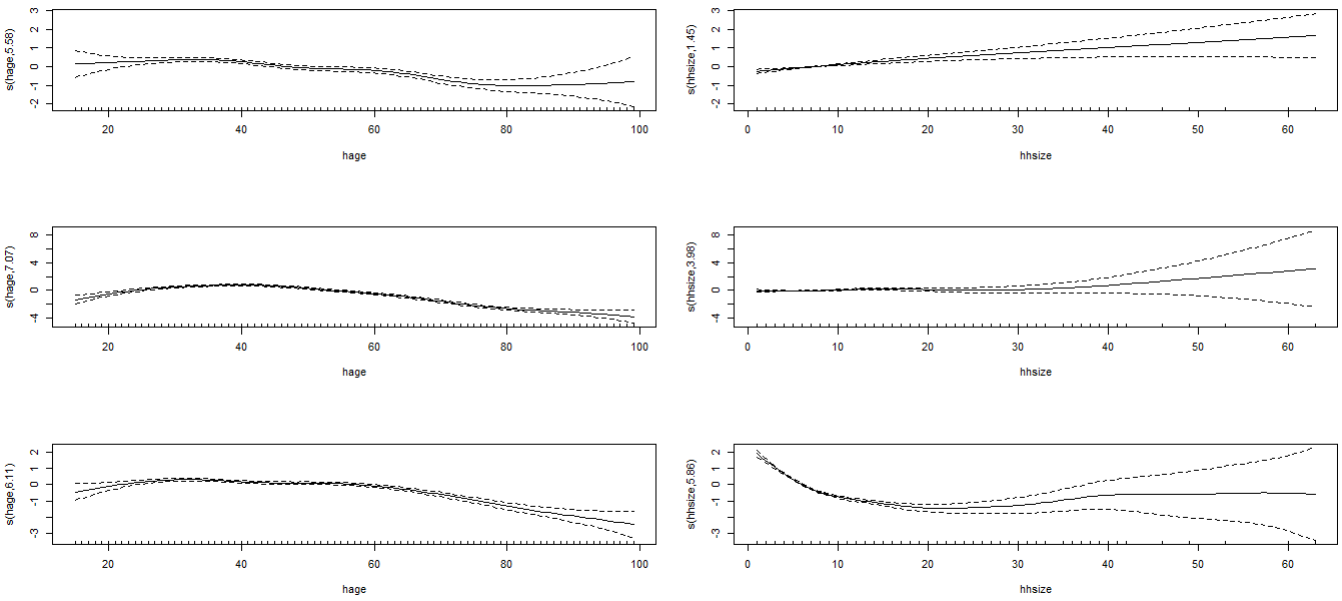

figure: Smooth function estimates and 95% confidence bands for the numerical variables in the semi-parametric model

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Table 1: Summary Description of the Variables used in the Econometric Modeling

Sample Size	n_{2014}	10,411	
Overall Poverty line	in CFA francs	153,530	
		Mean	**sd**
Age	age in years of the head of household	46.570	15.520
HHsize	number of people in the household	7.480	4.970
CapSpendg	Annual household per-capita spending in CFA Franc	273000	309366.8
		Abs. Freq.	**Rel. Freq.**
Literacy Status			
Literate	= 1 if household head is "Literate"	3621	34.8
Illiterate	= 1 if household head is "Illiterate"	6790	65.2
Labor Market Status			
Active	= 1 if household head is "active on the labor market"	9307	89.4
Inactive	= 1 if household head is "not active on the labor market"	1104	10.6
Poverty Status			
Non-Poor	= 1 if household experiences monetary security	6330	60.8
Poor	= 1 if household experiences monetary poverty	4081	39.2
Education Level			
None	= 1 if head has no education	7782	74.7
Primary	= 1 if head has only a primary education	1273	12.2
Secondary	= 1 if head has only a secondary education	1087	10.4
Higher	= 1 if head has some higher education	269	2.6
Sex			
Female	= 1 if head of household is Female	1389	13.3
Male	= 1 if head of household is Male	9022	86.7
Marital Status			
Single	= 1 if head of household is single	586	5.6
Married	= 1 if head of household is married	9011	86.6
Widow	= 1 if head of household is a widow	814	7.8
Residency Status			
Rural	= 1 if Household lives in Rural area	6408	61.6
Urban	= 1 if Household lives in Urban area	4003	38.4

Source: The National Survey on Household Living Conditions(EICVM, 2014)

Table 2: Chi-Squared test and conditional relative frequency for Literacy Status

		Literacy Status	
	Chi^2 stat., df ; p-value	**Literate**	**Illiterate**
Education Level	5654 3 ; <2.2e-16		
None		14.4	85.6
Primary		89.9	10.1
Secondary		99.7	0.3
Higher		100.0	0.0
Sex	147.38 1 ; <2.2e-16		
Female		37.0	63.0
Male		20.3	79.7
Marital Status	386.6 2 ; <2.2e-16		
Single		63.5	36.5
Married		34.9	65.1
Widow		12.8	87.2
Residency Status	985.72 1 ; <2.2e-16		
Rural		23.2	76.8
Urban		53.3	46.7

Table 3: Chi-Squared test and conditional relative frequency for Labor Market Status

	Labor Market Status		
	Chi^2 stat., df ; p-value	**Active**	**Inactive**
Education Level	108.06 3 ; <2.2e-16		
None		90.6	9.4
Primary		90.3	9.7
Secondary		82.4	17.6
Higher		77.7	22.3
Sex	39.586 1 ; 3.14e-10		
Female		90.1	9.9
Male		84.5	15.5
Marital Status	299.71 2 ; <2.2e-16		
Single		80.7	19.3
Married		90.6	9.4
Widow		81.8	18.2
Residency Status	79.207 1 ; <2.2e-16		
Rural		91.5	8.5
Urban		86.0	14.0

Table 4: Chi-Squared test and conditional relative frequency for Poverty Status

		Poverty Status	
	Chi^2 stat., df ; p-value	**Poor**	**Non-poor**
Education Level	901.84 3 ; <2.2e-16		
None		47.1	52.9
Primary		25.1	74.9
Secondary		8.6	91.4
Higher		0.7	99.3
Sex	19.594 1 ; 9.579e-06		
Female		40.0	60.0
Male		33.8	66.2
Marital Status	182.99 2 ; <2.2e-16		
Single		13.0	87.0
Married		41.0	59.0
Widow		37.6	62.4
Residency Status	951.87 1 ; <2.2e-16		
Rural		50.9	49.1
Urban		20.5	79.5

Table 5: Parametric Recursive Trivariate (Probit and Logit) Results

	Trivariate LitStat	**Probit** LMStat	**Model** PovStat	**Trivariate** LitStat	**Logit** LMStat	**Model** PovStat
(Intercept)	-0.682***	2.301***	3.266***	-0.122***	4.218***	5.676***
	(0.108)†	(0.083)	(0.072)	(0.206)	(0.159)	(0.149)
female	-0.578***	-0.273***	-0.171***	-1.093***	-0.484***	-0.306***
	(0.079)	(0.058)	(0.039)	(0.155)	(0.110)	(0.065)
rural	-0.238***	0.092*	-0.581***	-0.414***	0.226**	-0.992***
	(0.037)	(0.037)	(0.030)	(0.067)	(0.069)	(0.052)
age	-0.013***	-0.029***	-0.014***	-0.023***	-0.056***	-0.023***
	(0.001)	(0.001)	(0.001)	(0.023)	(0.002)	(0.002)
hhsize	0.020***	0.016***	-0.074***	0.035***	0.023**	-0.140***
	(0.003)	(0.004)	(0.003)	(0.061)	(0.007)	(0.006)
married	0.294**	0.525***	—	0.568	1.001***	—
	(0.100)	(0.063)	—	(0.076)	(0.117)	—
widow	0.102	0.600***	—	0.225	1.112***	—
	(0.138)	(0.087)	—	(0.267)	(0.158)	—
primary	2.224***	—	—	3.814***	—	—
	(0.053)	—	—	(0.103)	—	—
secondary	3.853***	—	—	7.626***	—	—
	(0.197)	—	—	(0.565)	—	—
higher	7.331	—	—	31.98	—	—
	(3.844)	—	—	(6.363)	—	—
LitStat	—	- 0.720***	—	—	-1.370***	—
	—	(0.045)	—	—	(0.083)	—
LMStat	—	—	-1.522***	—	—	-2.664***
	—	—	(0.060)	—	—	(0.136)
$\hat{\theta_{12}}$		0.4			0.401	
		(0.323,0.458)††			(0.348, 0.461)	
$\hat{\theta_{13}}$		0.149			0.151	
		(0.102, 0.185)			(0.113, 0.194)	
$\hat{\theta_{23}}$		0.796			0.776	
		(0.719, 0.851)			(0.696, 0.84)	
AIC		24822.53			24790.66	
BIC		25018.3			24986.43	

*** Is the 0.01% significance level, ** Is the 1% significance level, *Is the 5% significance level.

† standard deviation of the parameters in parentheses.

†† The 95% confidence intervals on tau and theta

Table 6: Semi-parametric Recursive Trivariate (Probit and Logit) Results

	Trivariate LitStat	**Probit** LMStat	**Model** PovStat	**Trivariate** LitStat	**Logit** LMStat	**Model** PovStat
(Intercept)	-1.046***	1.407***	2.002***	-1.801***	2.494***	3.588***
	(0.102)†	(0.080)	(0.080)	(0.195)†	(0.146)	(0.150)
female	-0.588***	-0.682***	-0.344***	-1.112***	-0.582***	-0.590***
	(0.080)	(0.050)	(0.041)	(0.156)	(0.113)	(0.070)
rural	-0.233***	0.178***	-0.614***	-0.405***	0.367*	-1.021***
	(0.037)	(0.039)	(0.034)	(0.067)	(0.073)	(0.056)
age	edf = 5.673	edf = 7.546	edf = 6.209	edf = 5.579	edf = 7.073	edf = 6.107
	p< $(2e-16)$	p< $(2e-16)$	p< $(2e-16)$	p< $(2e-16)$	p< $(2e-16)$	p< $(2e-16)$
hhsize	edf = 1.456	edf = 3.978	edf = 5.690	edf = 1.447	edf = 3.976	edf = 5.864
	p= $(1.85e-07)$	p = 0.065	p< $(2e-16)$	p= $(2.63e-07)$	p = 0.111	p< $(2e-16)$
married	0.213*	0.137*	—	0.412*	0.266*	—
	(0.103)	(0.076)	—	(0.196)	(0.137)	—
widow	0.033	0.276**	—	0.097	0.524**	—
	(0.141)	(0.098)	—	(0.270)	(0.177)	—
primary	2.233***	—	—	3.834***	—	—
	(0.053)	—	—	(0.103)	—	—
secondary	3.877***	—	—	7.625***	—	—
	(0.202)	—	—	(0.570)	—	—
higher	17.419	—	—	64.581	—	—
	(6.094)	—	—	(31.623)	—	—
LitStat	—	- 0.682***	—	—	- 1.346***	—
	—	(0.050)	—	—	(0.092)	—
LMStat	—	—	-1.384***	—	—	-2.568***
	—	—	(0.100)	—	—	(0.181)
$\hat{\theta_{12}}$		0.362			0.37	
		(0.295, 0.418)††			(0.295, 0.432)	
$\hat{\theta_{13}}$		0.158			0.157	
		(0.12, 0.192)			(0.115, 0.193)	
$\hat{\theta_{23}}$		0.702			0.732	
		(0.572, 0.775)			(0.636, 0.814)	
AIC		24162.78			24167.27	
BIC		24536.56			24537.39	

*** Is the 0.01% significance level, ** Is the 1% significance level, *Is the 5% significance level.

† standard deviation of the parameters in parentheses; †† The 95% confidence intervals on tau and theta.

p : Is the p-value testing the significance of the numerical variable; **edf** : empirical distribution function.

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