Chapter

Discrete Choice Model: An Application to the Educational Decision of Ivorian Households

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Abstract

Faced with unlimited needs, the scarcity of resources forces economic agents to make choices. The analysis using discrete choice models aims to identify the bases of these decisions. The aim here is to highlight the explanatory factors of the demand for education by Ivorian households for their children. To do this, the simple logit model is applied to explain the decision of schooling children. Then the multinomial logit model is used to explain the continuation of education. Household living standard survey data of 1998 and 2008 are used. It shows that age, household composition, and the provision of primary and secondary education services have a positive influence on the education of children. Income influences only high school education. The effects of sociodemographic factors vary by region. Security and accessibility of administrative services encourage the education of children.

Keywords: logit, multinomial logit, education, human capital, decision

1. Introduction

Through education, the individual acquires a set of general or specific knowledge or know-how that is determinant in the production process. The knowledge accumulation is an important source of economic growth [1, 2]. It slows the rate of change to the steady state by mitigating the effects of diminishing returns on physical capital accumulation. This leads to a positive long-term growth rate since the accumulation of knowledge is proportional to the stock of existing knowledge. In addition, the stock of knowledge affects a country's ability to innovate (see [3]). Education determines the employee's ability to perform tasks and allows them to integrate technology and/or the environment of technological innovation.

Côte d'Ivoire has made training one of its priorities as soon as it attains independence with an education-training sector budget of about 40% of the general state budget [4]. The aim was to generalize primary education and ensure the growth and development of secondary and higher education. But, the successive crises of the 1980s will slow down this momentum. At the end of the structural adjustment program (SAP), the state undertook to reinvigorate education policy by adopting a new legal framework that makes education the means by which all individuals integrate socially, culturally, and professionally and exercise their citizenship (Art. 1, Law No. 95-696 of 7/09/1995).

The private sector participates in the provision of education in all three levels of formal education. For the years 2010–2011 and 2011–2012, it trained, respectively, 14.17 and 12.26% of primary students, 32.06 and 43.27% of lower secondary general education, 32.23 and 44.74% of upper secondary general education, and 60.41% of learners in technical and vocational education. However, this public-private collaboration did not achieve the goal of Education for All in 2015 [5].

Therefore, it seems of interest to seek to understand the fundamentals of the education decision of the Ivorian households. We are looking for ways to ensure that all children are able to attend school and complete the educational process by studying the basis of the demand for education in order to highlight the determinants of household choice, considering three main categories of actors: the household, the child, and the public authorities.

For individuals, investing in education provides economic and social returns. It increases both employment rates and labor income. But, education requires the learner's full involvement in the training process, hence the importance of time in the cost of training [6]. However, the possibilities of accumulation of knowledge depend on the physical and intellectual capacities of the individual, supposed to decrease with the age of the individual.

It has been proven that the sources of motivation for studies must be sought in the financial benefits of education and competition in the labor market [7] so that the duration of studies is positively correlated with the level of remuneration of work. This makes it possible to cover the costs of the years of study. Also, the more or less strong mobility of the productive factors which characterizes the generalized liberalization of the markets makes that the labor market becomes more and more competitive. The labor market is also a market where very often the sectors or branches of activity (segments) require specific knowledge. As a result, mobility between industries requires additional investment in education. Moreover, the personalization of the training constitutes a natural protection against the risks of appropriation by others. The effectiveness of this protection increases the incentive to invest in oneself [6]. But this customization limits external funding opportunities for investment in education.

Investment in education also serves social purposes [8]. Some works on the determinants of differences in levels of life in various long-term economies have reignited the debate about endogenous growth theory, empirical growth analysis, and convergence (i.e., [2, 9–11]). Education plays a key role in countries' ability to innovate [4]. And investment in education follows logic of maximization of utility [12].

Moreover, integrations of the intergenerational transfers required in the explanation of the education decision show that the lack of a market to finance educational investment makes young people captive to parental funding [13]. This in turn forces them to pay back to their parents the highest possible share of their activity income.

From a macroeconomic point of view, public intervention is important to maintain their labor force as unemployed, given the costs associated with this maintenance [14]. But such a selective and discriminatory policy may discourage the individual interview of their skills by all the unemployed. One advocated a generalized credit system that allows young people to study and reimburse fees when they are active (i.e., [15]). Otherwise, the level of education will be zero. Therefore, the public supply of education aims to correct this failure of the financing system and encourage the expression of a latent demand for education [16].

In sum, the demand for education is motivated by factors related to individual and collective social well-being. It is in this sense that the state sometimes substitutes itself to the market to generating the expression of a latent demand thanks

to the public policy of education. The rest of this paper is structured as follows. Section 2 gives an overview of discrete choice models, and then the method of analysis and the data that will be used for the empirical analysis of the determinants of education are presented in Section 3. Section 4 presents the results and discusses them. Section 5 summarizes the main findings of the study.

2. The discrete choice models

In a decision-making process, it is a question of finding the best solution among the possible alternatives to satisfy the objectives. The decision can be continuous choice or discrete choice. In the first case, it amounts to choosing a combination of the quantity of possible alternatives where the quantities for each alternative can vary continuously. With the second option, it is a question of choosing only one alternative among several alternatives. We present in this section first the theoretical foundations of discrete choice models and then the mathematical formulas of the multinomial logit model.

2.1 Theoretical basis of discrete choice models

Suppose the consumer can compare all possible alternatives. There is a utility function U that expresses consumer preferences. Let C_n be the set of alternatives available to the n decision-makers during the decision process, where U_i is the utility of the decision-maker associated with the alternative i; the utility function can be defined in terms of attributes as follows:

$$U_i = U(Z_i) \tag{1}$$

where Z_i is the vector of the attributes for the alternative i. Thus, for the decision-maker n, the alternative i is chosen if and only if

$$U_i \succ U_j \quad j \neq i, \quad i, j \in C_n \tag{2}$$

In fact, when repeating the same choice test, or with the same set of choices, the same attributes, and the same socioeconomic characteristics, different individuals will choose different alternatives. The theory of probabilistic choice explains this inconsistency of the preferences of individuals. It is assumed that human behavior is intrinsically probabilistic or that more specific information about the individual decision-making process is lacking. The probabilistic mechanism can capture the effects of unobservable variations among decision-makers and the unobservable attributes of alternatives. It also considers the stochastic behavior and the error caused by the method of data collection.

Thus, the probabilistic characteristics of the choice decision make it possible to highlight the alternative that a decision-maker will choose in the decision-making process by calculating the probability that a decision-maker will choose the alternative. The hypothesis of the agent's rationality always assumes that individuals select alternatives with the highest utility. The probability that a decision-maker selects the alternative i will be that the utility of this alternative i is greater than that of the other alternatives:

$$P_i = P_i\left(U_i \succ U_j, \forall j \neq i\right) \tag{3}$$

Since the utilities are not known for certain, they must be treated as random variables by decomposing the random utility function of a two-part alternative:

$$U_i = V_i + \varepsilon_i \tag{4}$$

Since each agent has a set of choices designated by C_n, with $j \prec J$ as the number of choices (alternatives), the probability that the alternative i in C_n is chosen can be rewritten as

$$\begin{aligned} P(i) &= P\left(V_i + \varepsilon_i \geq V_j + \varepsilon_j, \forall j \in C_n, j \neq i\right) \\ &= P\left(\varepsilon_j \leq V_i - V_j + \varepsilon_i, \forall j \in C_n, j \neq i\right) \end{aligned} \tag{5}$$

where V_i denotes the systematic component of utility and ε_i refers to the random component of utility.

The determination of the model specification depends on the choice of the form of the utility function. This specification concerns the systematic component which is supposed to be a linear function on the parameters (acronym for "linear in parameters"). Let β, the vector of k unknown parameters, be the linear function on the parameters written as

$$V_i = \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_k X_{ik} \tag{6}$$

In the equation above, the parameters β_1, β_2, and β_k are assumed to be the same for all. But in reality, the socioeconomic characteristics are not identical for all agents. The parameters must not be fixed and must instead be variable according to the different characteristics of the individuals. This problem can be solved by treating the parameter β as a random variable that follows a probabilistic distribution.

Moreover, assuming that the chosen alternative i is the first alternative in Cn and $f\left(\varepsilon_i, \varepsilon_2, \ldots, \varepsilon_j\right)$ that the joint density function of the error terms is designated, the probability can be written in the form

$$P(1) = \int_{\varepsilon_{1=-\infty}}^{\infty} d\varepsilon_{1n} \int_{\varepsilon_{2=-\infty}}^{V_1 - V_2 + \varepsilon_1} d\varepsilon_2 \ldots \int_{\varepsilon_{j=-\infty}}^{V_1 - V_j + \varepsilon_1} f\left(\varepsilon_1, \ldots \varepsilon_j\right) d\varepsilon_j \tag{7}$$

The density function of the error terms ε_j depends on the correlation between these error terms. Correlations internal to the observations are the correlations between the residues relative to the different alternatives for the same individual. In this case, for every individual, we have $E\varepsilon_j \varepsilon_j^{'} = \sum_n$, and $\sum_n$ is no longer a diagonal matrix. By making assumptions about the joint probabilistic distribution of the error terms ε_j, any multinomial choice model can be deduced. In the following, only the multinomial logit model and the logit model with random parameters will be processed.

2.2 Logit multinomial model

If one assumes that they are independently and identically distributed (IID), hypothesis equivalent to the hypothesis independence of irrelevant alternatives (IIA), and that what follows them is a distribution of Gumbel, one obtains the multinomial logit model (MNL model):

$$P(i) = \frac{\exp\left(V_j\right)}{\sum_{j \in C_n} \exp\left(V_j\right)} \tag{8}$$

If the utility function is linear on the parameters, the model is written as

$$P(i) = \frac{\exp\left(\beta' X_i\right)}{\sum_{j \in C_n} \exp\left(\beta' X_j\right)} \tag{9}$$

where X_i is explanatory variables representing the socioeconomic and demographic characteristics of individuals, their environment, or contextual characteristics and β is the parameters to estimate.

2.3 Logit model with random parameters

In the logit model, β_k is constant (set for all individuals) and therefore cannot capture the effects of individual characteristics. To remove this constraint, we assume that β_k is a random variable of specific or normal distribution. In this case, the probability of choice can be written in the following form:

$$P(i) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \ldots \int_{-\infty}^{\infty} P'(i) f(\beta_k, \ldots, \beta_1) d\beta_k \ldots d\beta_1 \tag{10}$$

where $f(\beta_1, \ldots, \beta_k)$ is the density function of the parameters of the individual utility function

$$with\ P'(i) = \frac{\exp\left(\beta' X_i\right)}{\sum_{j \in C} \exp\left(\beta' X_j\right)} \tag{11}$$

For example, if C is the cost of education, T is the duration of education, and X is the other explanatory variables, the linear utility function is written as

$$U_i = \beta_c C_i + \beta_T T_i + \alpha' X_i + \varepsilon_i \tag{12}$$

Assuming, moreover, that the coefficient of the duration of education β_T takes a random value [17], of the normal type, the function of the probabilistic density β_T is written as

$$f(\beta_T) = \frac{1}{\sigma \beta_T \sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\beta_T - \omega}{\sigma}\right)^2\right] \text{ with } \beta_T \succ 0 \tag{13}$$

In this case, the probability of choice can be written as follows:

$$P(i) = \frac{1}{\sigma\sqrt{2\pi}} \int_0^{\infty} \frac{\exp\left(\beta_c C_i + \beta_T T_i + \alpha X_i\right)}{\sum_{j=1}^{J} \exp\left(\beta_c C_j + \beta_T T_j + \alpha X_j\right)} * \frac{1}{\beta_T}\left[-\frac{1}{2}\left(\frac{\beta_T - \omega}{\sigma}\right)^2\right] d\beta_T \tag{14}$$

Although this model is also based on the hypothesis IIA, the fact that the coefficients of the attributes can vary among the individuals improves the specification of

the logit model. In the next section, the multinomial logit model will be applied to Ivorian data to explain the choice of Ivorian households in education.

3. The household education decision

This section presents the theoretical framework and method of analysis as well as the data sources for empirical applications.

3.1 Theoretical framework of the analysis model

The economic agent who invests in training expects a return higher than the cost of his investment in terms of labor compensation. Thus, a methodology is developed from gain functions (see [18–21]). Starting from Becker's models of education (see [22–24]), the demand for education can be modeled from the utility function of the household. Let us consider a model of choice of inter-temporal education where the representative household has only one child and lives two periods (i.e., [25]). The household derives its utility from the consumption of goods and services (C) and the cognitive skills of its child (A). In period 1, the child may be in school, work, or both. In the latter case, the child goes to school first and works after school [26]. The utility function of the household can then be written as

$$U = C_1 + \delta C_2 + \sigma A \tag{15}$$

where δ is the discount factor of future consumption and σ represents parents' preferences for child-rearing. Children's education can increase parental consumption. It also directly affects the usefulness of parents. The acquisition of cognitive skills can be expressed using a production function as follows:

$$A = \alpha f(Q)g(S) \tag{16}$$

where α is the child's learning efficiency that encompasses a number of factors, such as the child's learning abilities and motivation and the parents' ability to support their child in school work, Q is the quality of the school, and S is the grade. The parents' consumption in each period is expressed as follows:

$$C_1 = Y_1 - pS + (1 - S)kY_c \tag{17}$$

$$C_2 = Y_2 + kY_c \tag{18}$$

where p is the price of education and Y_1 and Y_2 are the income of parents at periods 1 and 2. Y_c is the child's income when working and the share of that income paid to parents. 1-S is the time the child devotes to work. Income is completely exhausted at the end of each period. The household does not go into debt either. Children's income can be modeled on cognitive skills:

$$Y_c = \pi A \tag{19}$$

where π is the productivity of cognitive skills in the labor market.

Substituting Eq. (16) in Eq. (19), Eq. (19) in Eqs. (17) and (18), and Eqs. (16)–(18) in Eq. (15), the utility function of parents is written as a function of years of schooling and the quality of the school:

$$U = Y_1 - p_0 S + \delta Y_2 + [(1 - S + \delta)k\pi + \sigma]\alpha f(Q)g(S) \tag{20}$$

If the quality of the school is considered exogenous, then the variable that determines the choice is the time of education (S). The optimal duration of education is obtained by maximizing the utility function of the household. But, parents have the opportunity to also choose the quality of the school they want for their child. Thus, the price of education will depend on the quality of the school:

$$p = p_0 Q \tag{21}$$

where p_0 is the basic price of education. By replacing p by $p_0 Q$ in Eq. (6), we obtain the expression of the utility function to be maximized according to the quality variables (Q) and the study time (S):

$$U = Y_1 - p_0 QS + \delta Y_2 + [(1 - S + \delta)k\pi + \sigma]\alpha f(Q)g(S) \tag{22}$$

To simplify derivation calculations, one postulates that the quality function of the school and the duration of education have the following functional forms (see [27]): $f(Q) = Q^{\beta}$ and $g(S) = S^{\gamma}$ with $\beta > 0; \gamma > 0$. One can then write the functional form of the utility function of the parents as being equal to

$$U = Y_1 - p_0 QS + \delta Y_2 + [(1 - S + \delta)k\pi + \sigma]\alpha Q^{\beta} S^{\gamma} \tag{23}$$

Maximizing the utility function of parents following S and Q determines the optimal values of the length of education and the quality of the school:

$$S^* = \frac{(\gamma - \beta)\left(1 + \delta + \frac{\sigma}{k\pi}\right)}{(1 + \gamma - \beta)} \tag{24}$$

S^* is positive if and only if $(\gamma - \beta) \geq 0$. The sensitivity of cognitive skills to learning times must be greater than the sensitivity of cognitive skills to the quality of the school. Eq. (24) suggests that parents' preferences for education and future consumption have a positive influence on the length of their child's education. But when the share of his income that the child has to give back to his parents increases less he makes long studies. Also, a high productivity of cognitive skills in the labor market will encourage the child to opt for work earlier than education:

$$Q^* = \left(\frac{\alpha\beta k\pi}{p_0}\right)^{\gamma - 1} \left[\frac{\left(1 + \delta + \frac{\sigma}{k\pi}\right)}{1 + \gamma - \beta}\right]^{\gamma} \tag{25}$$

From Eq. (25), we conclude that the child's learning abilities, preferences for future consumption, and parents' level of education are positively related to the quality of children's education. On the other hand, the basic price of education negatively influences the quality of education that parents are willing to choose for their child.

The level of knowledge acquisition is determined by integrating Eqs. (24) and (25) into the cognitive skill acquisition equation. The production of cognitive skills can be expressed in a linear form for the sake of simplification [25]. The functional form of this production function is

$$A = \mu_0 + \mu_1 S + \mu_2 \alpha + \mu_3 Q + \varepsilon \tag{26}$$

The parameter μ is the vector of the coefficients to be estimated and ε the error term which captures the measurement errors of the variables Q, S and α. The quality of the school differs according to the type of school. Also, learning efficiency is

also a multidimensional notion and can be influenced by several factors. The equation of acquisition of cognitive skills can then be rewritten in the form

$$A = \mu_0 + \mu_1 S + \rho_1 \alpha_1 + \rho_2 \alpha_2 + ... + \rho_n \alpha_n + \tau_1 Q_1 + \tau_2 Q_2 + ... + \tau_n Q_n + \varepsilon \quad (27)$$

The level of knowledge can be validly equated with the level of education. As a result, the level of education is explained by a set of variables relating to the school, its quality and its environment, the child, the parents, and the socioeconomic context.

3.2 Econometric analysis model

The empirical application of the educational demand model will be done using a multinomial qualitative variable model as in the study for the analysis of the demand for education in rural areas of Benin (see [28]). We first estimate the probability of being schooled using a logit model in which the variable of interest is a binary variable that takes the value 1 when the child is enrolled and 0 if not:

$$\text{logit}[Enrol = 1] = \Phi(X_I \beta) \quad (28)$$

where X_i is a vector capturing the individual, family, and community characteristics that can influence the probability of a child going to school, β is the vector of unknown parameters to estimate, and Φ (.) is the normal cumulative distribution function. It is therefore necessary to estimate the probability of being educated conditionally to the explanatory variables transformed by the distribution function;

$$P(Y = 1 \mathrm{I} X) = \beta_0 + \beta_i X_i + \beta_m X_m + \beta_r X_r + \varepsilon \quad (29)$$

where
$$\begin{cases} X_i = \text{the individual characteristics of the child} \\ X_m = \text{socio-economic and demographic characteristics of the household} \\ X_r = \text{the characteristics of the place of residence of the household and the child} \\ \varepsilon = \text{term of error} \end{cases}$$

In a second step, we estimate a multinomial model to capture the explanatory factors of the continuation of school life once children are enrolled:

$$\text{mlogit}[School = k] = \Phi(X_I \beta) \quad (30)$$

with k = 1, 2, and 3 corresponding, respectively, to primary, first, and second cycles of secondary school. It is a question of estimating the function $U_{ik} = X_i \beta_k + \varepsilon_{ik}$ where ε_{ik} is an independent random variable and the individual characteristics of the child, those of the household, and the place of residence. The probability of choosing a category k is given by

$$P(Y_i = k) = \frac{\exp(X_i \beta_k)}{\sum_{k'=1}^{K} \exp\left(X_i \beta_{k'}\right)} \quad (31)$$

Household living standard survey data (ENV98 and ENV2008) will be used for applications. They provide information on the characteristics of households, their members, and their living environment. Each individual is attached to a household whose demographic structure and socioeconomic context are well-known.

4. Empirical evaluations

We analyze the probability of being schooled using a binary logit model. Then we apply the multinomial logit to grasp the explanatory factors of the continuation of studies in the secondary cycle. The estimation technique is the maximum likelihood.

4.1 Factors explaining the school decision

The analysis of the determinants of schooling will be conducted according to individual characteristics, family determinants, and contextual elements (**Table 1**). We also calculate odds ratios (**Table 2**) and marginal effects (**Table 3**).

4.1.1 Individual determinants

The age of the child, his sex, and the relationship to the head of the household are the characteristics considered. Their influence on schooling has evolved over time. The age of the children acts positively in favor of schooling with an inverted U-shaped evolution as the age increases. The age thus has an inverted U-shaped effect on the education decision, thus joining the education decision in Benin [28].

Young boys are more likely to be in school. This confirms findings of other study taking account West African counties [29]. Girls are discriminated for schooling in some West African countries, including Côte d'Ivoire. It should be noted, however, that in 2008, the individual characteristics of the child were less important in his schooling than in 1998. His health status was of greater concern to his parents when it came to sending him to school.

4.1.2 Family determinants

Sociodemographic determinants such as household size and number of adults in the household have significant effects on children's schooling. In 1998, there was a positive correlation between the number of adults in a family and the schooling of children in that family. In 2008, the number of children under 5 is positively correlated with the school decision. But, the number of adults in the household discourages schooling. In addition, the number of educated adults in the household encourages the education of children. Children in a single-parent household are less likely than those in a couple to be in school.

The responsibility for educational expenses is not a barrier to schooling for children. However, parents with a primary level are not very favorable to schooling their children, while those who have not been to school are motivated to send their children to school. The socio-professional category of parent influences the education decision with greater for public employees compared to private sector employees and farmers.

4.1.3 The contextual elements

Membership in a social organization and the supply of education encourage the schooling of children. Membership in the association therefore has positive externalities on the probability of raising children. Also, bringing education supply to households encourages parents to send their children to school. In 2008, this influence of educational provision was reinforced by the availability of secondary education institutions in the region or department. When the nearest security office

ENV1998			ENV2008		
Enroll	**Coef.**	**z**	**Enroll**	**Coef.**	**z**
Individual determinants					
Age	0.4497**	2.23	Age	−0.0255	−0.46
age2	−0.0435***	−5.41	age2	−0.0048	−1.67
child_hh	−0.1733	−0.80	ChilGen	−0.7186***	−6.98
ChilGen	0.7404***	4.79	lchild11hh	−0.0173	−0.41
			lchil12.15hh	−0.3506**	−7.24
			lchil16.18hh	−0.1219**	−2.43
			SickDur	0.2689***	2.85
Family determinants x					
Size_h	−0.5694***	−5.62	Size_h	0.1203	1.31
Sexhh	0.21101	0.84	Sexhh	−0.9466***	−5.75
SPC	−0.0138	−0.42	SPC	−0.0942**	−2.17
non_ed_parh	0.3623***	3.56	matStahh	0.9453***	6.70
Paredh	−0.3267***	−3.45	Edupar	−0.0354	−0.44
child_5h	0.2926***	2.87	child_5	0.3388**	2.30
Mal19_59h	0.3285***	3.40	fem19_59	−0.3755***	−3.31
fem19_59h	0.3611***	4.06	male19_59	−0.3406***	−3.29
adult60h	0.3148**	2.08	adult60	−0.3118*	−1.69
An_rev_hh	2.96e-09	0.72	Revenu	3.44e-08	1.61
Respedh	0.7403***	10.27	Scolm	0.21892*	1.78
Scolh	0.2018***	4.65	Child	0.5492***	3.34
Migrant	−0.8082	−1.33	Migrant	0.0108	1.20
Resid	0.2481	1.23			
Contextual determinants					
Associat	0.3741**	2.00	Associat	−0.0628	−0.47
Region	−0.0212	−0.27	coges_ape	1.5506***	8.71
GdRegion	0.0381	1.22	Pu_sch	1.3742***	14.55
Infracom	0.0878	0.46	Pr_sch	1.2302***	13.17
Transp	0.0945	0.57	Ip_sch	−0.0557	−0.24
PPSh	0.7569***	9.61	Is_sch	0.0847	0.33
Gen_sch_hh	0.1892*	1.79	Admin	0.0284	0.20
_cons	2.1982	1.61	Securit	−0.0152	−0.06
			Infracom	−5.33e-08	−0.50
			D_infocom1	−0.0920	−0.67
			D_infocom	0.2719***	3.85
			D_adm0	−0.1731***	−3.17
			D_adm1	−0.2103***	−4.99
			D_adm	0.0324*	1.84
			D_securit1	0.0181	0.11

ENV1998			ENV2008		
Enroll	**Coef.**	**z**	**Enroll**	**Coef.**	**z**
			D_securit	−0.2295*	−1.94
			D_prim	−1.3031***	−9.24
			D_second1	−0.3276	−0.99
			D_second	−0.6560***	−3.43
			_cons	1.7753***	3.53
Number of observations = 3321			Number of observations = 3892		
LR chi2(25) = 1701.91			LR chi2(39) = 1444.97		
Prob > chi2 = 0.0000			Prob > chi2 = 0.0000		
Pseudo R2 = 0.5727			Pseudo R2 = 0.4142		
Log likelihood = −634.85088			Log likelihood = −1021.9515		

**Significance at the threshold of 10%*

***Significance at the threshold of 5%.*

****Significance at the threshold of 1%.*

Source: Author using data from ENV98 and ENV2008.

Table 1.
Results of the binary regression of the probability of schooling.

is located more than 5 km from the residence, parents are less motivated to enroll their children in school [30]. The presence of the administration acts positively on the schooling.

4.1.4 Odds ratios

The odds ratios allow appreciating the influence of the independent variables on the dependent variable in terms of percentage but are not elasticities. The difference between the displayed value and the unit gives the weight of this influence and its meaning (see **Table 2**).

In 1998, age acted positively on the school decision in more than 56% of cases. Gender is the determining factor in the child's own characteristics with a comparative advantage for young boys. The main determinant of schooling in 2008 is the state of health of the child. The marital status of the head of household and the presence of administrative services strongly contributed to the schooling of children in 2008. The number of children under 5 is crucial for more than 40% of cases. The presence of adults frees children and increases their chance of attending school by more than 50% in 1998. On the other hand, the influence of the number of educated adults in the household is smaller than that of the number of adults even if it is positive. But 2008, the number of educated people in the household is an essential lever for schooling.

The supply of education and the responsibility for school expenses determine the decision to go to school in more than 80% of cases. The endowment of communication infrastructures greatly increases the probability of being in school.

4.1.5 Marginal effects

The marginal effects let us to assess the impact of the independent variables on the dependent variable (see **Table 3**). For example, in 1998, when the size of the household increased by 10%, the motivation to enroll children dropped by 2%. The probability of going to school increases by 2% from a girl to a boy. Also, the parents' membership of an association increases by 1.5% the chance of the children to be educated. In addition, the 10% increase in the supply of primary education increases

ENV1998			ENV2008		
Enroll	**Odds ratios**	**z**	**Enroll**	**Odds ratios**	**z**
Individual determinants					
Age	1.5678**	2.23	Age	0.9748	−0.50
age2	0.9575***	−5.41	age2	0.9952*	−1.80
child_hh	0.8409	−0.80	ChilGen	0.4874***	−9.46
ChilGen	2.0967***	4.79	lchild11hh	0.9828	−0.54
			lchil12.15hh	0.7042***	−9.52
			lchil16.18hh	0.8852***	−3.31
			SickDur	1.3086***	2.92
Family determinants					
Size_h	0.5659***	−5.62	Size_h	1.1279*	1.91
Sexhh	1.2349	0.84	Sexhh	0.3881***	−6.58
SPC	0.9863	−0.42	SPC	0.9101**	−2.30
non_ed_parh	1.4366***	3.56	matStahh	2.5736***	6.57
Paredh	0.7213***	−3.45	Edupar	0.9652	−0.39
child_5h	1.3399***	2.87	child_5	1.4033***	2.88
Mal19_59h	1.3889***	3.40	fem19_59	0.6869***	−3.91
fem19_59h	1.4349***	4.06	male19_59	0.7114***	−3.96
adult60h	1.3700**	2.08	adult60	0.7322*	−1.83
An_rev_hh	1.0000	0.72	Revenu	1.0000	1.53
Respedh	2.0966***	10.27	Scolm	1.2447	1.35
Scolh	1.2236***	4.65	Child	1.7318***	3.64
Migrant	0.4457	−1.33	Migrant	1.0101	1.07
Resid	1.2816	1.23			
Contextual determinants					
Associat	1.4537**	2.00	Associat	0.9391	−0.47
Region	0.9790	−0.27	coges_ape	4.7142***	10.45
GdRegion	1.0389	1.22	Pu_sch	3.9519***	18.04
Infracom	1.0918	0.46	Pr_sch	3.4219***	13.85
Transp	1.0992	0.57	Ip_sch	0.9458	−0.21
PPSh	2.1316***	9.61	Is_sch	1.0883	0.34
Gen_sch_hh	1.2083*	1.79	Admin	1.0288	0.20
_cons	9.0084	1.61	Securit	0.9849	−0.06
			Infracom	0.9999	−0.73
			D_infocom1	0.9121	−0.75
			D_infocom	1.3124***	3.91
			D_adm0	0.8411***	−3.33
			D_adm1	0.8104***	−4.63
			D_adm	1.0329	1.59
			D_securit1	1.0183	0.12

ENV1998			ENV2008		
Enroll	**Odds ratios**	**z**	**Enroll**	**Odds ratios**	**z**
			D_securit	0.7950**	−2.25
			D_prim	0.2717***	−9.06
			D_second1	0.7206	−1.01
			D_second	0.5189***	−3.77
			_cons	5.9018***	3.38
Number of observations = 3321			Number of observations = 3892		
LR chi2(25) = 1701.91			LR chi2(39) = 1444.97		
Prob > chi2 = 0.0000			Prob > chi2 = 0.0000		
Pseudo R2 = 0.5727			Pseudo R2 = 0.4142		
Log likelihood = −634.85088			Log likelihood = −1021.9515		

**Significance at the threshold of 10%*

***Significance at the threshold of 5%.*

****Significance at the threshold of 1%.*

Source: Author using data from ENV98 and ENV2008.

Table 2.
The odds ratios.

enrollment by almost 3%, compared with 7% points for supply of secondary education. The presence of a secondary school in the locality increases by 0,21% the probability of being educated against 0,09% for the administration. Being a direct descendant of the household head increases the chance of being in school.

In 2008, a 10% increase in the number of children in the household led to a 3% increase in the probability of being in school. Similarly, the increase in the number of children under 5 by 10% increases the chances of attending school by 1.9%. This influence is 5.3% when moving from a single-parent household to a couple. A 10% increase, respectively, in public and private education offers increases the probability of attending school by 7.7 and 6.9%. The existence of a COGES improves this probability by 7.48%. In contrast, an additional adult in the household reduces the probability of attending school by 2.11 or 1.92% depending on whether a woman or a man is between 19 and 59 years old.

An extension of 1 km of distance to the nearest administration causes a decrease of 1.18% in the probability of being in school compared to 1.29% for the security services and 10.67% for the primary school against not more than 3.7% for the secondary establishment.

4.2 Determinants of the continuation of educational life in the secondary cycle

The analysis of the determinants of the pursuit of education follows the same logic as that of the explanatory factors of schooling (**Table 4**).

4.2.1 Individual determinants

In 1998, the age of the child is the only significant individual variable for continuing high school education. Younger children are much more likely to go to high school. This is in line with the findings of the case study on Benin [28] that the likelihood of continuing education declines as the child approaches the end of childhood.

In 2008, it is rather the relationship with the head of household that becomes determinant for secondary school. Also, a significant number of children of primary

1998: y = Pr(enroll) (predict) = 0.9606			2008: y = Pr(enroll) (predict) = 0.9400		
Variables	**dy/dx**	**z**	**Variables**	**dy/dx**	**z**
Individual					
Age	0.0170**	1.98	Age	−0.0014	−0.50
age2	−0.0016***	−4.10	age2	−0.0003*	−1.77
child_hh	−0.0066	−0.83	ChilGen	−0.0405***	−9.14
ChilGen*	0.0297***	4.41	lchild11hh	−0.0010	−0.54
			lchil12.15hh	−0.0198***	−8.69
			lchil16.18hh	−0.0069***	−3.24
			SickDur	0.0152***	2.92
Family					
Size_h	−0.0215***	−4.68	Size_h	0.0067842*	1.90
Sexhh	0.0080	0.87	Sexhh	−0.0534***	−6.63
SPC	−0.0005	−0.44	SPC	−0.0053**	−2.28
non_ed_parh	0.0137***	3.24	matStahh	0.0533***	6.17
Paredh	−0.0123****	−3.27	Edupar	−0.0020	−0.39
child_5h	0.0111**	2.59	child_5	0.0191***	2.87
Mal19_59h	0.0124***	3.36	fem19_59	−0.0212***	−3.90
fem19_59h	0.0137***	3.93	male19_59	−0.0192***	−3.92
adult60h	0.0119**	2.15	adult60	−0.0176*	−1.83
An_rev_hh	1.12e-10	0.88	Revenu	1.94e-09	1.54
Respedh	0.0280***	8.76	Scolm	0.0123	1.35
Scolh	0.0076***	4.24	Child*	0.0317***	3.53
Migrant*	−0.0434	−0.84	Migrant	0.0006	1.08
resid	0.0094	1.21			
Contextual					
associat*	0.0157*	1.71	associat*	−0.0036	−0.47
region	−0.0008	−0.27	coges_ape*	0.0748***	10.20
GdRegion	0.0014	1.25	Pu_Sch	0.07748***	15.46
infracom*	0.0032	0.47	Pr_Sch	0.0694***	12.20
transp*	0.0036	0.57	Ip_Sch*	−0.0032	−0.21
PPSh	0.0286***	8.18	Is_Sch*	0.0046	0.35
Gen_sch_hh	0.0072*	1.70	admin*	0.0016	0.20
			securit*	−0.0009	−0.06
			info_com	−3.00e-09	−0.73
			D_infocom1	−0.0052	−0.75
			D_infocom	0.0153***	3.88
			D_adm0	−0.0098***	−3.30
			D_adm1	−0.0118***	−4.53
			D_adm	0.0018	1.59
			D_securit1	0.0010	0.12

1998: y = Pr(enroll) (predict) = 0.9606			2008: y = Pr(enroll) (predict) = 0.9400		
Variables	**dy/dx**	**z**	**Variables**	**dy/dx**	**z**
			D_securitt	−0.0129**	−2.24
			D_prim*	−0.1062***	−6.48
			D_second1*	−0.0210	−0.90
			D_second	−0.0370***	−3.79

**Significance at the threshold of 10%. dy/dx is for dummy variable changes from 0 to 1 for discrete variables.*

***Significance at the threshold of 5%.*

****Significance at the threshold of 1%.*

Source: Author using data from ENV98 and ENV2008.

Table 3.
The marginal effects of exogenous variables on the probability of schooling.

school and primary school age have a negative effect on entry to secondary school. On the other hand, a large number of children of upper secondary age who are directly related to the head of household increases the chances of attending secondary school. The first may serve as a guide or framer to the latter. This increases their "learning efficiency" (see [25]) and reduces the cost of education related to repetition. Good health is also important for high school.

4.2.2 Family characteristics

The number of adults in the household is inversely related to the continuation of secondary education. In addition, children of couples are more likely to have a full secondary education compared to single-parent families.

In 1998, residency status had a positive effect on secondary education, and migrant status had a negative influence. On the other hand, in 2008, migrations were positively correlated with secondary education. In our database, the main reasons declared to justify the migration of populations are related to education, professional reasons, and the crisis. Most of the displaced pupils have returned to school in their new places of residence thanks to certain facilities (relay school), hence the strong correlation between internal displacement and secondary education in 2008.

In addition, the increase in household size negatively influences children's chances of attending secondary school. On the other hand, the increase in household income has a very positive impact on the continuation of secondary education.

4.2.3 The contextual elements

Populations in the western forest region and in the central and northern savannah regions are those whose offspring are less likely to be in high school compared to families in the Abidjan region. The high labor demand for field work in these cash crop production areas may explain the fact that children over 12 years of age are removed from school to assist in plantations. Also, migration flows from central and northern populations to forest areas reduce the available labor force in the departure areas. Thus, the greatest children are regularly asked for the cultivation of the fields.

The fact that parents belong to an association or a union increases children's chance for secondary education in 1998. On the other hand, in 2008, associative activism (union, COGES, etc.) discourages further education in secondary education. In fact, the often high level of contributions in these associations is in competition with educational expenditure. This reduces the shares of income devoted to

ENV1998			ENV2008		
School	**Coef.**	**z**	**School**	**Coef.**	**z**
Non-educated					
Individual determinants					
Age	−0.5810***	−2.96	Age	−0.0174	−0.40
age2	0.0496***	6.22	age2	0.0016	0.69
child_hh	0.0495	0.25	ChilGen	0.0416	0.66
ChilGen	−0.7483***	−5.15	lchild11hh	0.0095	0.34
			lchil12.15hh	0.1867***	5.61
			lchil16.18hh	0.5134***	14.43
			SickDur	0.4265***	5.75
Family determinants					
Size_h	0.6085***	5.65	Size_h	0.0061	0.10
Sexhh	−0.2162	−0.95	Sexhh	0.2879**	2.23
SPC	0.0032	0.10	SPC	0.0338	0.95
non_ed_parh	−0.3864***	−3.69	matStahh	−0.7316***	−4.50
Paredh	0.2948***	3.14	Edupar	0.0704	0.92
child_5h	−0.3904***	−3.62	child_5	0.1221	1.26
Mal19_59h	−0.3511***	−4.06	fem19_59	−0.3342***	−3.76
fem19_59h	−0.4244***	−5.00	male19_59	0.0262	0.32
adult60h	−0.3922***	−2.76	adult60	0.31547**	2.12
An_rev_hh	−9.69e-11	−0.03	Revenu	3.17e-08**	2.17
Respedh	−0.7886***	−11.99	Scolm	−0.5934***	−3.58
Scolh	−0.1817***	−4.42	Child	−0.5354***	−4.15
Migrant	0.6688	1.05	Migrant	0.0385***	4.73
Resid	−0.2304	−1.21			
Contextual determinants					
Associat	−0.3258*	−1.74	associat	−0.5917***	−4.88
Regions			coges_ape	0.3105***	2.72
Other cities	−0.0931	−0.41	Pu_Sch	−1.089***	−16.86
Forest East	−0.1325	−0.46	Pr_Sch	−0.5735***	−7.93
Forest west.t	−0.0074	−0.03	Ip_Sch	−0.1013	−0.46
Savannah	−0.0730	−0.21	Is_Sch	0.0280	0.13
GdRegion	−0.0226	−0.69	admin	0.0857	0.71
infracom	0.0322	0.19	securit	0.2033	0.86
Transp	−0.0599	−0.38	infracom	−1.11e-08	−0.15
PPSh	−0.7175***	−10.54	D_infocom1	−0.0748	−0.75
Gen_sch_hh	−0.3734***	−3.13	D_infocom	−0.1631***	−3.51
_cons	−1.1867	−0.92	D_adm0	0.1401***	3.07
			D_adm1	0.1295***	3.53
			D_adm	0.0820***	4.72

ENV1998			ENV2008		
School	**Coef.**	**z**	**School**	**Coef.**	**z**
			D_securit1	0.2020	1.60
			D_securit	0.1211	1.54
			D_prim	1.2777***	10.33
			D_second1	−0.6889***	−3.09
			D_second	−0.2969**	−2.06
			_cons	−0.1052	−0.21
Prim_School	Basis line				
Second_School					
Individual determinants					
Age	1.6447***	2.70	Age	−0.071788	−1.49
age2	−0.0222	−1.06	age2	0.005174**	2.09
child_hh	−0.1549	−0.83	ChilGen	−0.1177127*	−1.81
gendchil	0.1433	0.99	lchild11hh	−0.1111***	−4.01
			lchil12.15hh	0.0496	1.58
			lchil16.18hh	0.4325***	12.78
			SickDur	0.0910	1.09
Family determinants					
Size_h	0.0064	0.07	Size_h	−0.1583***	−3.04
Sexhh	0.0898	0.40	Sexhh	0.4011***	2.94
SPC	−0.0284	−0.74	SPC	−0.0137	−0.38
non_ed_parh	0.1008	1.07	matStahh	−0.2796	−1.54
Paredh	0.1421	1.56	Edupar	0.1152	1.63
child_5h	0.0131	0.14	child_5	−0.0066	−0.07
Mal19_59h	−0.3441***	−4.02	fem19_59	−0.0019	−0.02
fem19_59h	−0.1421*	−1.69	male19_59	0.1347*	1.83
adult60h	−0.1203	−0.83	adult60	0.8167***	5.83
An_rev_hh	5.82e-09*	1.83	Revenu	−6.29e-08***	−4.36
Respedh	0.0204	0.61	Scolm	0.0435	0.29
Scolh	−1.3133*	−1.89	Child	0.5782***	4.12
Migrant	0.3394	1.64	Migrant	0.0654***	7.80
Resid	−0.8711***	−10.52			
Contextual determinants					
Associat	0.16534	1.03	associat	−0.2192*	−1.69
Regions:			coges_ape	−0.5885***	−4.59
autres villes	−0.3615	−1.57	Pu_Sch	0.2840***	5.24
Forêt Est	−0.7284**	−2.23	Pv_Sch	0.37748***	5.93
Forêt Ouest	−0.7140**	−2.34	Ip_Sch	0.0013	0.01
Savane	−0.8853**	−2.11	Is_Sch	−0.0202	−0.09
GdRegion	−0.0381	−1.07	admin	0.0370	0.28

ENV1998			ENV2008		
School	**Coef.**	**z**	**School**	**Coef.**	**z**
infracom	0.2844	1.40	securit	0.5716**	2.39
Transp	−0.2222	−1.40	infracom	1.81e-07***	2.71
EPPm	0.2190***	3.18	D_infocom1	−0.4196***	−2.82
Ets_gén_pcm	0.6429***	7.52	D_infocom	0.1293***	3.12
_cons	−19.6011***	−4.41	D_adm0	0.0525	1.09
			D_adm1	0.1611***	3.61
			D_adm	0.0913***	5.19
			D_securit1	−0.1474	−0.92
			D_securit	−0.1244	−1.45
			D_prim	1.1673***	7.97
			D_second1	−0.2504	−1.21
			D_second	−1.4441***	−9.24
			_cons	−1.9054***	−3.55
Number of observations = 4055			Number of observations = 3964		
Wald chi2(56) = 1179.88			LR chi2(78) = 2605.07		
Prob > chi2 = 0.0000			Prob > chi2 = 0.0000		
Pseudo R2 = 0.5862			Pseudo R2 = 0.3473		
Pseudo log likelihood = −1408.2873			Pseudo log likelihood = −2447.6977		

**Significance at the threshold of 10%*

***Significance at the threshold of 5%.*

****Significance at the threshold of 1%.*

Source: Author using data from ENV98 and ENV2008.

Table 4.
Results of multinomial regressions.

education hence the inverse relationship between belonging to an association and the chances of going to secondary school in 2008.

Also, the presence of secondary schools is beneficial for the continuity of studies. This positive relationship between the supply of education and the probability of attending secondary school is reinforced by the presence of communication infrastructures and the reduction of distances to the first educational, security, and administrative infrastructure (see [30]).

5. Conclusion

This study aims to elucidate the factors that underlie the decision of households to invest in the education of their children from the Ivorian case. It is an application of the multinomial logit model using data from the living standards surveys of 1998 and 2008.

The findings show that in Côte d'Ivoire the age of the children, composition of the household, as well as education supply (the probability of being able to go to secondary school combined with the proximity of primary schools) are the factors that motivate parents to enroll their children in primary school. For the continuation of studies at the secondary level, the level of income is very decisive. Sociodemographic factors also play a very important role, such as the size and

composition of the household as well as the sex of the head of the household and the type of household. Also, children entering high school are more likely to continue their studies. However, from one region to another, disparities can be observed according to the sex of the child and the socio-professional category of the head of the household.

Bridging the security services encourages education mostly secondary despite the distance to the nearest school. The presence of the administration or its bringing together of citizens and the development of communication and transport infrastructures reinforce the attractiveness of the school in Côte d'Ivoire. However, some school management structures, such as COGES, tend to reduce school life, especially at the secondary level.

In addition, considering the endogenous quality of education provision will make the results of the study more robust. To do this, it is necessary to gather information on the characteristics of the educational offer, particularly the number of pupils per teaching, the actual execution of the school curriculum, the provision of teaching materials for training structures, etc. Also, considering the decision-making mechanism within households makes it possible to better identify the sociodemographic factors that influence the decision to educate households. The availability of information on the above variables is an extension of this study.

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