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Modeling the Gender Gap in Children's Educational Expenditure in Egypt: An Econometric Hurdle Model Approach

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Abstract This study investigated gender gaps in household educational expenditure among children aged 4-18 years in Egypt. The study used nationally representative survey data from the 2019-2020 Household Income, Expenditure, and Consumption Survey (HIECS), conducted biennially in Egypt by the Central Agency for Public Mobilization and Statistics (CAPMAS). The sample consisted of 14,892 children from 6,721 Egyptian households. Descriptive statistics were used to summarize the demographic, social, and economic characteristics associated with household educational expenditure. A hurdle model was employed to analyze gender differences in educational spending, distinguishing between two stages: (1) the likelihood of incurring any educational expenditure, and (2) the level of educational expenditure on children among households with positive spending. In the first stage, all gender-age interactions were significant ($p < 0.001$). Compared to males, females aged 4-8 (OR = 0.51) and 14-18 (OR = 0.66) were less likely to receive educational expenditure while those aged 9-13 were more likely (OR = 6.32). In the second stage, only females aged 4-8 exhibit a statistically significant gender disparity in expenditure, as their educational expenditure declines by 0.2264 units relative to males ($p < 0.001$); the other age groups were not significant. Household income and parental education were positively associated with educational investment, while rural residence and larger household size were negatively associated with expenditure. The findings highlight the importance of targeted policies that address both gender and age to promote equity in children's educational expenditure in Egypt.

Keywords Children, Egypt, Educational Expenditure, Gender Gap, Hurdle Model

AMS 2010 subject classifications 62P20, 62J12, 91B82

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1. Introduction

Achieving gender equality is a central objective of the 2030 Sustainable Development Agenda. The fourth Sustainable Development Goal (SDG 4) emphasizes ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all, while the fifth goal (SDG 5) focuses on achieving gender equality and empowering all women and girls. Gender equality is recognized as both a fundamental human right and a prerequisite for sustainable development [28].

Addressing inequalities in educational investment between males and females is critical for these global objectives, as unequal investment in education between male and female children reflects underlying inequities in intra-household resource allocation and limits opportunities for human capital development [29, 12].

Globally, gender gaps in household educational investment persist in many developing countries. These disparities often manifest as unequal educational expenditure within households, with resources frequently favoring male children over female children [14, 18, 26]. Such inequalities can have long-term consequences for human capital accumulation, intergenerational mobility, and broader socioeconomic development. A substantial

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body of empirical research documents persistent gender-based differences in intra-household resource allocation [5, 6, 7, 15, 20, 21].

Egypt provides a particularly relevant context for examining these issues. According to the Global Gender Gap Report 2023, Egypt ranks 134th out of 146 countries in overall gender equality, with significant gaps in educational outcomes [30]. National data from the Central Agency for Public Mobilization and Statistics (CAPMAS) indicate that education constitutes a substantial portion of household expenditure, with households enrolling children in school spending an average of 4,450.6 EGP annually on educational expenses [10]. These patterns highlight the potential for gender-based differences in household educational investment across childhood stages.

Although gender disparities in household educational expenditure have been widely studied in other developing countries, empirical evidence for Egypt is still limited, particularly regarding age-specific differences. This gap is crucial given the role of educational investment in shaping children's future labor market outcomes and long-term economic development [12, 14, 18, 26].

Accordingly, this study examines gender disparities in household educational expenditure among children aged 4-18 years in Egypt. It focuses on both the probability of receiving investment and the amount spent, highlighting differences between males and females across age groups. Additionally, the study explores the economic, demographic, and social determinants of these disparities and identifies the age cohorts most affected. While previous studies in the MENA region have examined the determinants of educational expenditure using Tobit or OLS models [23, 24], and some have assessed the impact of cash transfer programs on total consumption [3], these studies have not explicitly separated the participation decision from the intensity of expenditure, nor have they focused on age-specific gender differences. Our study contributes to the literature by using more recent data (HIECS 2019-2020), employing a two-part Hurdle model, and explicitly linking the findings to the Takaful and Karama program particularly its effects on the 9-13 age group. The findings aim to provide policy-relevant evidence to support interventions that reduce gender gaps and promote more equitable household investment in children's education.

In addition to the econometric approach employed in this study, our methodological framework draws upon recent advances in statistical distribution theory to model the stochastic properties of educational expenditure data. Specifically, the construction of household expenditure indices can be informed by flexible parametric distributions that capture tail behavior, zero-inflation, and structural breaks in spending patterns [32, 40]. The characterization results based on generalized order statistics [33, 35, 36, 37, 38] provide theoretical foundations for understanding persistence, heterogeneity, and nonlinearity in household-level panel data. Moreover, transmuted and fractional distribution families [32, 34, 40, 39] offer alternative specifications for error terms and residual analysis, which is particularly relevant when dealing with the high proportion of zero expenditures typical of educational outlays. These theoretical tools complement the two-part hurdle framework, especially in evaluating the robustness of our estimates of gender-based disparities under alternative distributional assumptions for the positive expenditure component.

2. Literature Review

The economic and social literature consistently highlights that household decisions regarding educational expenditure are not gender neutral, with many households allocating a larger share of resources to male children, particularly during school-age years [2, 12, 14, 18, 26]. A substantial body of empirical research has examined gender disparities in household educational expenditure among children aged 4-18 years using individual and household-level data and a variety of analytical approaches, including Ordinary Least Squares (OLS) regression, Probit models, and Hurdle models [8, 11, 15, 16, 17, 20, 25].

Empirical evidence consistently documents the existence of gender gaps in household educational expenditure across different stages of childhood, often favoring male children, particularly during middle and secondary education, while such gaps tend to be narrower during early and primary education. Household and child-specific characteristics including the child's age and gender, birth order, household size, parental education, household income, type of schooling, and place of residence play a significant role in shaping educational expenditure patterns

for children aged 4-18 years. Studies indicate that urban households and those with higher parental education and income are more likely to invest in children's education, whereas larger household size and poverty are associated with lower educational expenditure, especially for female children [8, 11, 15, 16, 20, 27].

Despite the extensive literature on gender disparities in household educational expenditure, several gaps remain. Most existing studies do not explicitly examine age-specific gender differences across the full school-age range (4-18 years). Moreover, while economic factors are frequently emphasized, the combined influence of demographic and social characteristics is often insufficiently explored. In addition, the presence of zero educational expenditure values particularly among poorer households poses methodological challenges for accurate estimation. Consequently, recent methodological studies recommend the use of Two-Part or Hurdle models to appropriately address zero expenditure outcomes and obtain consistent estimates of household educational expenditure behavior [2, 8, 11, 18].

Building on these insights, the current study focuses on measuring gender disparities in household educational expenditure among children aged 4-18 years in Egypt. The study examines the role of demographic, social, and economic factors in shaping both the likelihood of incurring educational expenditure and the level of expenditure, employing a Hurdle model to address zero expenditure values. By explicitly accounting for age-specific differences and the presence of zero expenditure, this study provides a more comprehensive and policy-relevant understanding of gender-based resource allocation in household investment in children's education.

3. Objectives of the Study

The study aims to identify gender gaps in household educational expenditure among children aged 4-18 years in Egypt by:

1. Measuring the relationship between household expenditure on children's education and the demographic, social, and economic characteristics of children and their households.
2. Evaluating gender disparities in household expenditure on children's education and identifying the age groups most affected by these disparities.
3. Determining and analyzing the demographic, social, and economic determinants influencing household expenditure on children's education.

4. Study Hypotheses

Based on previous studies, this study proposes a conceptual framework to describe and illustrate how children's and household background characteristics (demographic, social, and economic variables) affect gender disparities in household expenditure on children's education. Figure (1) presents the framework guiding this study.

Accordingly, as illustrated in Figure 1, the study tested the following research hypotheses:

H1: The child's gender across different age groups influences household expenditure on children's education.
H2: The child's educational level influences household expenditure on children's education.
H3: The type of school influences household expenditure on children's education.
H4: Place of residence influences household expenditure on children's education.
H5: Household size influences household expenditure on children's education.
H6: Education of the household head influences household expenditure on children's education.
H7: Household income influences household expenditure on children's education.

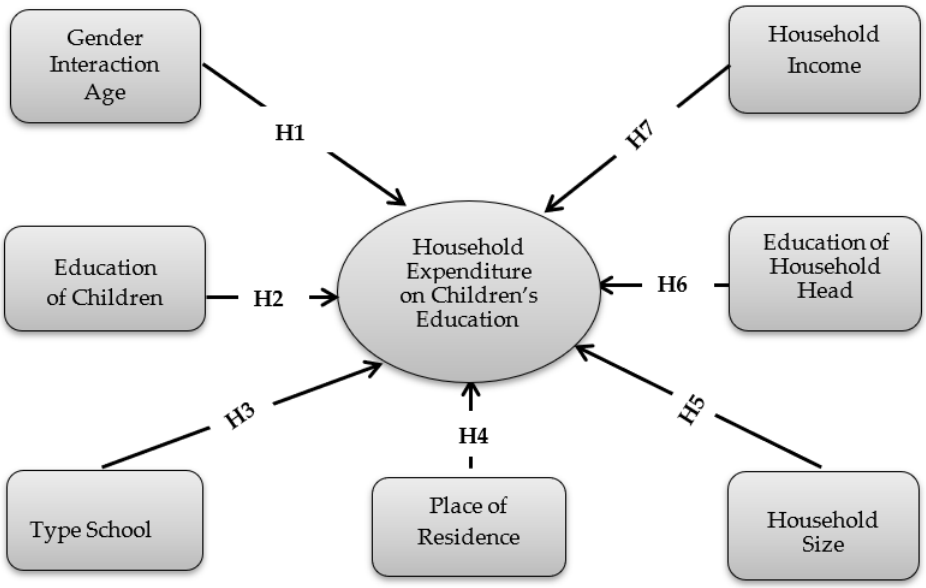

Figure 1. Research Hypotheses Conceptual Framework

Note: This conceptual framework was designed and prepared by the researchers, based on previous studies.

5. Data Sources

This study utilized data from the nationally representative 2019-2020 Household Income, Expenditure, and Consumption Survey (HIECS), conducted biennially in Egypt by the Central Agency for Public Mobilization and Statistics (CAPMAS). The HIECS provided detailed information on the demographic, social, economic, and educational characteristics of Egyptian households, as well as comprehensive data on household consumption patterns and educational expenditures patterns over the twelve months preceding the survey. The dataset is publicly available for research purposes and contains no personally identifiable information. The author did not participate in data collection or survey implementation. CAPMAS was responsible for all ethical and legal approvals related to the survey; therefore, the use of this secondary data complied with established ethical standards for scientific research, and no additional ethical approval was required.

The study sample included 14,892 children aged 4-18 years from 6,721 households. The initial unweighted sample contained 14,913 children; however, after applying survey sampling weights to ensure national representativeness, the final analytical sample was adjusted to 14,892 children. The large sample size supported robust statistical analysis. The HIECS dataset includes several modules on household and individual expenditure, including educational expenditure for children, and provides detailed information on household characteristics and child-specific attributes relevant to the study objectives.

6. Methodology

The study employed a combination of descriptive and advanced analytical approaches to examine household education expenditure among children aged 4-18 years in Egypt.

6.1. Dependent Variable

Educational expenditure is operationalized as the total household outlay on the education of its members over the six-month period preceding the survey. In accordance with the survey instrument, this aggregate measure comprises tuition fees and school charges, private tutoring costs, group supplementary tutoring expenses, expenditures on literacy programs, and other education-related outlays. Educational expenditure is measured in Egyptian Pounds (EGP) as a continuous positive variable for the second stage of the Hurdle model (Gamma GLM), where it directly models the conditional mean of the untransformed positive expenditure.

6.2. Descriptive Analysis: Chi-Square Test

Initially, the chi-square test was used to assess associations between the categorical study variables and the occurrence of household education expenditure [1]. The chi-square statistic is given by:

$$\chi^2 = \sum_i \sum_j \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \tag{1}$$

where O_{ij} denotes the observed frequency in the cell corresponding to row i and column j and E_{ij} denotes the expected frequency in the cell corresponding to row i and column j.

To examine the decision to incur household education expenditure, the continuous expenditure variable was converted into a binary indicator ($0 =$ no expenditure, $1 =$ positive expenditure).

6.3. Econometric Modeling: The Hurdle Model

To further analyze the determinants of household education expenditure, a hurdle model was applied. The model was appropriate because the dependent variable was continuous and characterized by a high proportion of zero values, a common feature in household income and expenditure surveys, particularly for education and among low-income households [13, 31].

The hurdle model treats zero and positive expenditure values separately by assuming that the decision to incur any expenditure and the amount of expenditure are governed by two distinct stochastic processes. By modeling the zero-generation process independently from positive values, the model improves estimation accuracy in datasets containing a large number of zeros [4, 13, 31].

Compared with the Tobit model, which assumes a single process generating both zero and positive outcomes and may suffer from heteroskedasticity and biased parameter estimates, the hurdle model provides more flexible and efficient estimation [22]. To empirically validate the choice of the Hurdle model over the Tobit alternative, we estimated both specifications and compared their fit using Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The Hurdle model consistently yielded lower values for both criteria, confirming its superior suitability for our two-part decision process.

Let Y_i denote the expenditure for the ith observation, $i = 1, 2, \ldots, n$, n is the total number of observations, the general structure for the two-part hurdle model is given by:

$$f\left(y_i \mid x_i, z_i\right) = \begin{cases} 1 - \pi_i & y_i = 0 \\ \pi_i \frac{1}{\phi^{1/\phi}\Gamma(1/\phi)} y_i^{1/\phi - 1} e^{-y_i/(\phi\mu_i)} & y_i > 0 \end{cases} \tag{2}$$

Where:

$$\pi_i = \frac{\exp(x_i\beta)}{1 + \exp(x_i\beta)} \tag{3}$$

$$\mu_i = \exp(z_i'\gamma) \tag{4}$$

y_i be the observed outcome for observation i, x_i be covariates for the binary hurdle part (logit), z_i be covariates for the positive outcome part (Gamma GLM), β be coefficients for logit part, γ be coefficients for Gamma part, $\phi > 0$ be the dispersion parameter for Gamma distribution.

6.3.1. First Part: Selection Model (Binary Logistic Regression) The participation decision for household education expenditure is modeled using π_i through a binary logistic regression as follows:

$$\pi_i = pr(Y_i > 0|x_i) = 1 - pr(Y_i = 0|x_i) = \frac{\exp(x_i\beta)}{1 + \exp(x_i\beta)} \tag{5}$$

This probability represents the probability of crossing the hurdle (i.e: $Y_i > 0$), where Y_i represents household education expenditure, x_i is the vector of covariates and β denotes the logistic regression coefficients.

Using logit link:

$$\log\left(\frac{\pi_i}{1-\pi_i}\right) = x_i'\beta \tag{6}$$

where β are coefficients and x_i are the covariates.

This part is applied to data indicating whether the event has occurred or not (a binary dependent variable). It estimates the probability of selection based on a set of explanatory variables. A logit model is employed to identify the factors affecting the likelihood of the presence or absence of the hurdle (zero outcome), and hence whether the event occurs. The first part answers the following question: Does the observation cross the hurdle (i.e., have any positive count at all)?

6.3.2. Second Part: Generalized Linear Model (GLM) with Gamma Distribution and Log Link The intensity of positive expenditure, conditional on participation, is modeled using a Generalized Linear Model (GLM) with a Gamma distribution and a log link function. This accounts for the skewed nature of health/education spending and ensures positive predicted values [19].

Given $y_i > 0$:

$$y_i \mid (y_i > 0, z_i) \sim \text{Gamma}(\mu_i, \phi) \tag{7}$$

with mean μ_i and dispersion ϕ (or shape $= 1/\phi$, scale $= \mu_i\phi$).

Using log link:

$$\log(\mu_i) = z_i'\gamma \tag{8}$$

where γ are coefficients and z_i are the covariates.

The Second part answers the following question: Given the count is positive, what is the distribution of the actual count values?

By combining the two parts, we obtain the full likelihood function for the two-part Hurdle Model:

$$L = \prod_{i:y_i=0} (1-\pi_i) \prod_{i:y_i>0} \pi_i f_{Gamma}(y_i, \mu_i, \phi) \tag{9}$$

6.4. Estimation and Diagnostic Checks

To ensure that our estimates are nationally representative, we accounted for the complex survey design of the 2019-2020 Egypt HIECS in all stages of our econometric analysis. Following standard practice, the analysis incorporated the provided survey sampling weights (Normaliz), which adjust for differential selection probabilities, non-response, and post-stratification. For the first-stage participation decision, we employed a weighted logistic regression using the glm() function in R (version 4.3) with the weights argument. For the second-stage intensity decision, we estimated a weighted Gamma Generalized Linear Model (GLM) with a log link, using the same sampling weights (Normaliz) to account for the positively skewed distribution of educational expenditure among households reporting positive spending. The Gamma distribution with a log link was selected because it directly models the conditional mean of the untransformed positive expenditure, effectively accommodating the inherent heteroskedasticity and positive skewness in the distribution of educational spending among households reporting positive amounts. To correct for potential correlation of errors within households (clusters) and to obtain robust

standard errors, we estimated cluster-robust standard errors at the household level (Serial) using the vcovCL function from the sandwich package, in conjunction with the coeftest function from the lmtest package. This clustered covariance matrix accounts for the hierarchical structure of the data, thereby ensuring that the reported standard errors are consistent even in the presence of within-household dependence, a common feature in household survey data.

To facilitate economic interpretation, we computed Average Marginal Effects (AME) for both model components, expressing the conditional amount effects in Egyptian pounds (EGP) and the participation effects in probability changes.

With respect to the selection of variables for the final model, it is worth noting that although several variables including birth order, household poverty status, and the employment status of the household head exhibited statistically significant associations with the outcome in the descriptive analysis, they were not retained in the final hurdle specification. For birth order, preliminary model diagnostics indicated that its inclusion led to a marked attenuation of the regression coefficients and diminished the statistical significance of the other key covariates, implying considerable shared variance among these predictors. Similarly, household poverty status was excluded due to its strong collinearity with household income; we retained income as a continuous measure to capture finer variations in purchasing power. Regarding the employment status of the household head, it was excluded because its coefficient was not statistically significant in the preliminary regression models, and its inclusion adversely affected the significance levels of other predictors likely reflecting shared variance with other household-level characteristics such as income and the head's education level. To circumvent model over-specification, and to secure stable, parsimonious, and interpretable estimates for the primary variables of interest, these variables were excluded from the final model.

Additionally, we assessed multicollinearity among the independent variables using the Generalized Variance Inflation Factor (GVIF); all adjusted GVIF values were below the conventional threshold of 5, indicating no serious multicollinearity concerns.

7. Results

7.1. Descriptive Analysis

Table (1) presents the demographic, social, and economic characteristics of children aged 4 to 18 years and the household heads in the study sample. The table summarizes children's demographic composition, educational characteristics, and the socioeconomic conditions of their households, providing an overview of the study sample and the distribution of household educational expenditure.

Regarding educational expenditure among children aged 4-18 years, 70.9% of children in the study sample had educational expenditure, whereas 29.1% had none. Male children constituted 51.3% of the sample, compared to 48.7% female. The age distribution indicated that 37.6% of children were aged 4–8 years, while 33.6% were aged 9-13 years and 28.8% were aged 14-18 years.

In terms of educational characteristics, 62.7% of the children had an educational level below the primary stage, whereas 19.2% were enrolled in primary education, and 18.1% reached preparatory or secondary education. In addition, 93.5% of the children were enrolled in public schools, while only 6.5% attended private schools. With respect to birth order, 29.8% of children were first-born, 34.9% were second born, and 35.3% were third birth order or higher, indicating variation in family size and child positioning within households.

Regarding household characteristics, 59.2% of children resided in rural areas, whereas 40.8% lived in urban areas. Furthermore, 36.4% of the children belonged to poor households, while 63.6% were from non-poor households. In terms of the socioeconomic characteristics of household heads, a substantial proportion had attained secondary or intermediate education, and 89.9% of household heads were employed at the time of the survey, reflecting relatively high labor market participation among household heads in the sample.

Table 1. Demographic and Socioeconomic Characteristics of Children and Household Heads in the Sample (Descriptive Distribution)

Characteristic	Frequency N	Percentage %
Expenditure on education		
Expenditure	10562	70.9
No expenditure	4330	29.1
Child's gender		
Male	7640	51.3
Female	7251	48.7
Age group		
4 to 8	5598	37.6
9 to 13	5007	33.6
14 to 18	4287	28.8
Education of children		
Less than elementary school	9342	62.7
Primary	2862	19.2
Preparatory and Secondary	2688	18.1
Type school		
Public	9973	93.5
Private	687	6.5
Birth order		
First child	4433	29.8
Second child	5197	34.9
Third or more	5261	35.3
Place of residence		
Urban	6075	40.8
Rural	8817	59.2
Household poverty		
Non-poor	9473	63.6
Poor	5419	36.4
Household size		
2-4	3492	23.4
5-6	10340	69.4
7+	1060	7.1
Household income		
5000 - 50000	4188	28.1
50001-100000	8583	57.6
100001-150000	1542	10.4
150001-200000	348	2.3
200001+	231	1.6
Education of household head		
Less than primary	4376	29.4
Primary & preparatory	2296	15.4
Secondary & above intermediate	5841	39.2
University & higher	2378	16.0
Employment status of household head		
Working	13387	89.9
Not working	1504	10.1
Total	14892	100.0

Note: The variables education expenditure, income, child's age, and household size are continuous in the original data but were categorized for descriptive analysis; some were also used in the hurdle model analysis.

7.2. Trends in School Enrollment by Gender and Age

When examining educational participation, it is essential to understand gender-specific patterns across age groups. Figure 2 illustrates school enrollment rates for children aged 4-8, 9-13, and 14-18. Enrollment is highest among children aged 9-13, with minimal differences between males and females. Enrollment is lower for the youngest group (4-8) and for adolescents (14-18), with females showing a sharper decline as age increases, highlighting persistent gender-specific barriers to continued schooling.

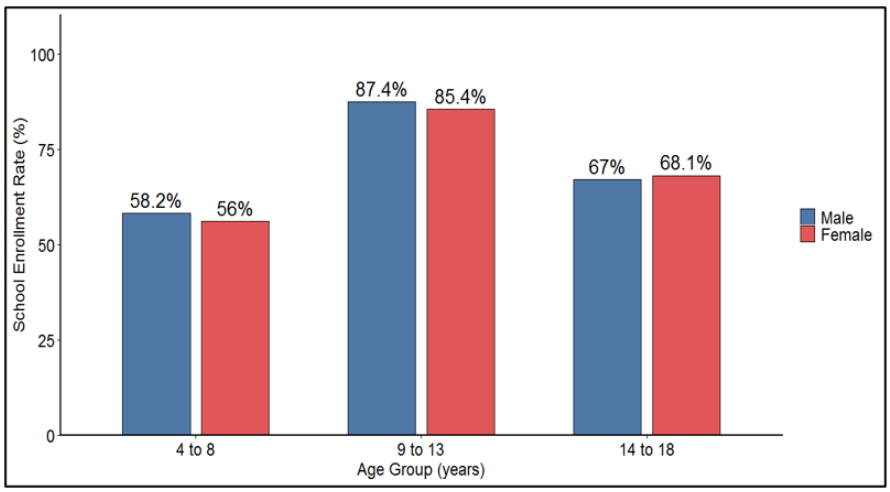

Figure 2. School enrollment by gender and age

Note: This Figure was prepared by researchers based on data from the CAPMAS, HIEC Survey, 2019-2020 in Egypt.

Figure (2) illustrates gender-specific school enrollment patterns across age groups. Enrollment is high for both males and females in early childhood, with minimal differences between genders. Enrollment rates are highest among children aged 9-13, while children aged 4-8 and 14-18 show lower enrollment. In particular, females experience a sharper decline in enrollment as age increases, highlighting persistent gender-specific barriers to continued schooling at older ages.

7.3. Gender Differences across Age Groups in Household Educational Investment

Figure (3) illustrates the distribution of educational expenditure between male and female children across different age groups. This figure provides a detailed comparison of gender-based expenditure patterns within each stage of childhood and adolescence, allowing for a clearer assessment of age-specific disparities in household allocation behavior.

The Figure highlights gender differences in household educational expenditure across age groups at the individual level. It shows that males generally receive more investment, though the gap narrows with age. To achieve the first objective of the study, descriptive analysis using chi-square tests is employed to examine the relationship between household expenditure on children's education and the demographic, social, and economic characteristics of children aged 4-18 years and their households.

7.4. Separating the Participation (Probability) and Intensity (Amount) Effects in the Hurdle Model by Age and Gender

Figure (4) highlights gender differences in household educational expenditure across age groups at the individual level. It shows that males generally receive more investment, though the gap narrows with age. Specifically, this figure presents the predicted probabilities of incurring any educational expenditure (bars, left Y-axis) and

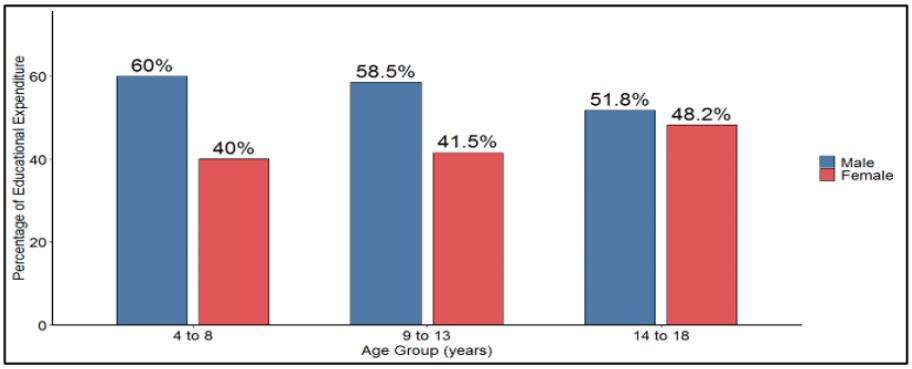

Figure 3. Educational Expenditure by Gender Within Each Age Group (Expenders Only)

Note: This Figure was prepared by researchers based on data from the CAPMAS, HIEC Survey, 2019-2020 in Egypt.

the predicted conditional expenditure in Egyptian pounds (EGP) (points, right Y-axis) across age groups and by gender, based on the two-part Hurdle model (Logit + Gamma GLM). The solid bars represent the probability of spending (participation decision), while the points (circles for males, triangles for females) represent the conditional amount spent, conditional on positive expenditure. Estimates are derived from the 2019–2020 Egypt HIECS data, incorporating survey sampling weights (Normaliz) and household-level clustered robust standard errors. All covariates are held at their means. The figure visually separates the "probability effect" from the "amount effect," illustrating that gender disparities are age-dependent and operate through different stages of the Hurdle model.

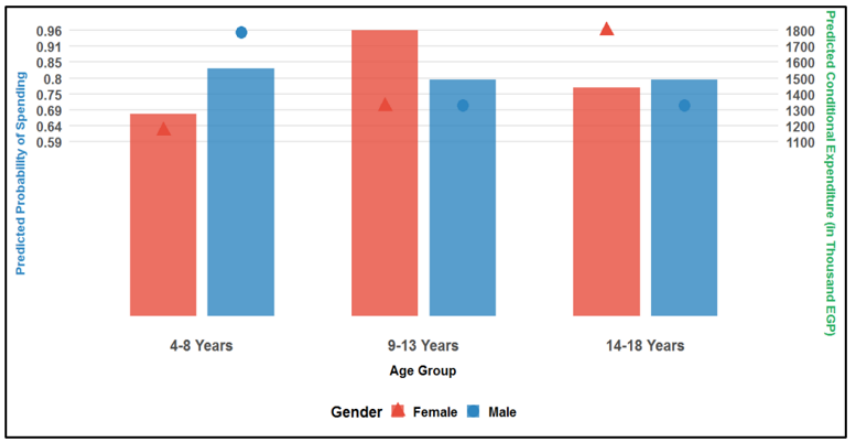

Figure 4. Hurdle Model Estimates: Participation vs Intensity by Age and Gender

Source: HIECS 2019-2020, Egypt. Estimates based on Hurdle Model (Logit + Gamma GLM). All other covariates held at their means.

7.5. Descriptive and Inferential Analysis

Table 2 presents the number and percentage of children aged 4–18 years by annual educational expenditure status (expenditure versus no expenditure), disaggregated by selected demographic, social, and economic characteristics of children and their households. The table also reports Chi-square (χ^2) statistics to assess the statistical significance of associations between these characteristics and educational expenditure.

Table 2. Children Receiving or Not Receiving Educational Expenditure by Child and Household Characteristics

Variable	Expenditure on education		χ^2
	Expenditure N (%)	No Expenditure N (%)	
Child's gender			
Male	5498 (72.0)	2142 (28.0)	8.145**
Female	5064 (69.8)	2187 (30.2)	
Age group			
4-8	3169 (56.6)	2429 (43.4)	1314.81***
9-13	4432 (88.5)	575 (11.5)	
14-18	2962 (69.1)	1325 (30.9)	
Birth order			
First child	2971 (67.0)	1463 (33.0)	80.39***
Second child	3639 (70.0)	1558 (30.0)	
Third or more	3953 (75.1)	1308 (24.9)	
Education of children			
Less than elementary school	6203 (66.4)	3139 (33.6)	317.617***
Primary	2388 (83.4)	474 (16.6)	
Preparatory and Secondary	1971 (73.3)	717 (26.7)	
Place of residence			
Urban	4563 (75.1)	1512 (24.9)	87.151***
Rural	6000 (68.0)	2818 (32.0)	
Household poverty			
Non-poor	7250 (76.5)	2223 (23.5)	396.31***
Poor	3313 (61.1)	2106 (38.9)	
Household size			
2-4	2354 (67.4)	1137 (32.6)	142.38***
5-6	7596 (73.5)	2744 (26.5)	
7+	612 (57.7)	448 (42.3)	
Household income			
5000 - 50000	2505 (59.8)	1683 (40.2)	465.83***
50001-100000	6270 (73.1)	2313 (26.9)	
100001-150000	1269 (82.3)	273 (17.7)	
150001-200000	306 (87.9)	42 (12.1)	
200001+	213 (92.2)	18 (7.8)	
Education of household head			
Less than primary	2674 (61.1)	1702 (38.9)	417.61***
Primary & preparatory	1604 (69.9)	692 (30.1)	
Secondary & above intermediate	4288 (73.4)	1553 (26.6)	
University & higher	1996 (83.9)	383 (16.1)	
Employment status of household head			
Working	9617 (71.8)	3770 (28.2)	53.70***
Not working	943 (62.8)	559 (37.2)	
Total	10562 (70.9)	4330 (29.1)	

Note: This table was prepared by researchers based on data from the CAPMAS, HIEC Survey, 2019-2020 in Egypt; For the variable "educational status," children in secondary education were combined with those in preparatory education due to the small number of students in the secondary stage, as this does not affect the analysis of the preparatory stage; $***p < .001$, $**p < .01$.

The proportion of children aged 4-18 who had annual educational expenditure varies across demographic, social, and economic characteristics of both children and their households. Expenditure differed by gender, with higher

expenditure observed among male children than female children. Educational expenditure also varied across age groups, with children in the middle age range receiving higher expenditure than younger children, while older children received relatively lower expenditure. Birth order showed an increasing pattern, as later-born children were more likely to receive educational expenditure compared to first-born children. Education expenditure was highest among children in primary school, lower among those in preparatory and secondary education, and lowest for children below the elementary level, indicating that expenditure increases at the primary stage and then slightly declines in later educational stages. Regarding place of residence, higher levels of educational expenditure were observed in urban areas compared to rural areas. In addition, clear disparities were found between poor and non-poor households, with non-poor households reporting higher levels of expenditure on children's education. Furthermore, the results reveal substantial variation in educational expenditure by household income, with higher income levels associated with higher rates of education expenditure. Similarly, children living in households headed by more educated household heads exhibited higher levels of educational expenditure compared to those in households with lower educational attainment. Finally, the findings indicate differences in educational expenditure by household size, with lower expenditure rates observed among larger households compared to smaller households. Chi-square test results confirm the existence of statistically significant associations between annual educational expenditure among children aged 4-18 and child gender, age, place of residence, birth order, household poverty status, household income, household head education, household size, and employment status of the household head.

7.6. Generalized Variance Inflation Factor (GVIF) Test

To assess multicollinearity among the explanatory variables, variance inflation factors (VIF), including generalized VIF (GVIF) for categorical variables, were computed. As shown in Table (3), all adjusted GVIF values were below 5, ranging from 1.0037 to 1.4436, indicating no severe multicollinearity in the estimated models.

Table 3. GVIF Test Results

Variable	**GVIF**	**Df**	**Adjusted GVIF**
Household income	1.3200	1	1.1489
Child's gender	1.0075	1	1.0037
Age group	4.3426	2	1.4436
School type	1.1676	1	1.0806
Child's education level	4.3152	2	1.4413
Education of household head	1.2072	3	1.0319
Household size	1.0814	2	1.0198
Place of residence	1.0934	1	1.0456

Note: All VIF/GVIF-adjusted values were below the commonly accepted threshold of 5, indicating that multicollinearity was not a concern.

7.7. Determinants of Educational Expenditure: Hurdle Model Results

To achieve the second and third objectives of the study, a Hurdle model is employed to analyze both the household's decision to spend on children's education and the level of conditional educational expenditure among children aged 4-18 years. The results reveal pronounced gender disparities in both the participation decision and the intensity of educational expenditure, with substantial variation across age groups. As reported in Table 4, gender and age variables are incorporated to capture how gender gaps in educational expenditure evolve across different developmental stages, with male children serving as the reference category. The hurdle model estimates reported in Table (4) indicated that both the household decision to incur educational expenditure for children aged 4-18 years and the conditional level of expenditure were associated with several demographic, socioeconomic, and household

characteristics. The odds ratios (ORs) were obtained by exponentiation of the estimated logit coefficients from the participation equation (OR = $\exp(\beta)$).

Table 4. Determinants of Household Educational Expenditure for Children (4-18 Years): Hurdle Model Estimates

Variable	Hurdle Model Estimates	
	Any Expenditure	**Conditional Expenditure**
Household income (log)	0.6560***	0.8030***
	(0.0881)	(0.0537)
Gender interaction age (ref: Male)		
F4 to 8	-0.6801***	-0.2264***
	(0.0756)	(0.0371)
F9 to 13	1.8440***	-0.0050
	(0.1387)	(0.0272)
F14 to 18	-0.4126***	-0.0112
	(0.1040)	(0.0398)
School type (ref: Public)		
Private	0.1338	1.0678***
	(0.1636)	(0.0518)
Child's education level (ref: Less than elementary)		
Primary	1.1253***	0.3543***
	(0.0982)	(0.0256)
Preparatory and Secondary	0.4762***	0.7650***
	(0.1015)	(0.0401)
Place of residence (ref: Urban)		
Rural	-0.1493*	-0.2399***
	(0.0671)	(0.0287)
Household Size (ref: 2–4 individuals)		
5:6 individuals	-0.5952***	-0.2716***
	(0.0847)	(0.0298)
7+ individuals	-1.5725***	-0.8955***
	(0.1383)	(0.0824)
Household Head education (ref: Less than elementary)		
Primary and preparatory	0.2434*	0.1364**
	(0.0965)	(0.0434)
Secondary and above intermediate	0.5008***	0.2439***
	(0.0776)	(0.0353)
University and above	0.9978***	0.3488***
	(0.1149)	(0.0504)
Observations	14892	10562

Note: Authors' calculations based on HIECS 2019-2020. (ref) = reference category. Clustered standard errors in parentheses. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

7.7.1. First Stage: Participation Decision (Probability of Any Educational Expenditure) The first stage of the hurdle model employed a binary logistic regression to estimate the likelihood of incurring any educational expenditure for a child aged 4–18 years. The results in Table 4 indicate that several demographic and socioeconomic factors were significantly associated with this probability.

Regarding gender differences by age group, female children aged 4-8 years ($\beta = -0.680$, OR = 0.507, $p < 0.001$) were significantly less likely to receive any educational expenditure than males. In contrast, female children aged 9-13 years ($\beta = 1.844$, OR = 6.321, $p < 0.001$) were significantly more likely to receive any educational expenditure compared to males. For female children aged 14–18 years ($\beta = -0.413$, OR = 0.662, $p < 0.001$), they were significantly less likely to receive any educational expenditure than males.

For other variables, the probability of any educational expenditure was significantly higher for children with higher household income ($\beta = 0.656$, OR = 1.927, $p < 0.001$). Regarding the child's educational level, children in primary education ($\beta = 1.125$, OR = 3.080, $p < 0.001$) and those in preparatory or secondary education ($\beta = 0.476$, OR = 1.610, $p < 0.001$) were significantly more likely to receive educational expenditure compared to less than elementary school level.

Regarding household head education, compared to heads with less than elementary school, children in households where the head had primary and preparatory education ($\beta = 0.243$, OR = 1.276, $p < 0.05$), secondary and above intermediate education ($\beta = 0.501$, OR = 1.650, $p < 0.001$), and university and above ($\beta = 0.998$, OR = 2.713, $p < 0.001$) were significantly more likely to receive any educational expenditure. In contrast, children living in rural areas ($\beta = -0.149$, OR = 0.861, $p < 0.05$) and those living in larger households (5-6 members: $\beta = -0.595$, OR = 0.551, $p < 0.001$; 7+ members: $\beta = -1.573$, OR = 0.208, $p < 0.001$) were significantly less likely to receive any educational expenditure. The type of school (private vs. public) was not statistically significant ($\beta = 0.134$, OR = 1.143, $p > 0.05$).

7.7.2. Second Stage: Conditional Expenditure (Level of Positive Educational Expenditure) The second stage of the hurdle model employed a Gamma GLM with a log link function to estimate the level of educational expenditure, conditional on positive spending. Because the link function is a log link, the coefficients (β) do not directly represent the percentage change; rather, they are transformed into the percentage change in expected educational expenditure using the following equation:

$$\text{Percentage change} = (e^{\beta} - 1) \times 100 \tag{10}$$

Gender disparities by age group in the conditional stage showed a distinct pattern. Female children aged 4-8 years showed 20.2% lower expected expenditure than males ($\beta = -0.226$, $p < 0.001$). For female children aged 9-13 years ($\beta = -0.005$, $p > 0.05$) and aged 14-18 years ($\beta = -0.011$, $p > 0.05$), the coefficients were not statistically significant, indicating no significant gender gap in the amount spent during middle childhood and adolescence.

For other variables, children attending private schools showed 190.9% higher expected expenditure than those in public schools ($\beta = 1.068$, $p < 0.001$). A one-unit increase in log household income was associated with a 123.2% increase in expected expenditure ($\beta = 0.803$, $p < 0.001$). Rural residence was associated with 21.3% lower expected expenditure ($\beta = -0.240$, $p < 0.001$).

Regarding the child's educational level, children in primary education showed 42.5% higher expected expenditure ($\beta = 0.354$, $p < 0.001$), and those in preparatory or secondary education showed 114.9% higher expected expenditure ($\beta = 0.765$, $p < 0.001$) compared to children below elementary level.

Regarding household head education, compared to heads with less than primary education, primary and preparatory education was associated with 14.6% higher expected expenditure ($\beta = 0.137$, $p < 0.01$), secondary and above intermediate education with 27.6% higher expected expenditure ($\beta = 0.244$, $p < 0.001$), and university and above with 41.8% higher expected expenditure ($\beta = 0.349$, $p < 0.001$).

Larger household size significantly reduced expenditure: households with 5-6 members by 23.8% ($\beta = -0.272$, $p < 0.001$) and households with 7 or more members by 59.2% ($\beta = -0.896$, $p < 0.001$).

7.8. Average Marginal Effects (AME) from the Hurdle Model

Table (5) presents the Average Marginal Effects (AME) from the Hurdle Model for the socioeconomic variables. This framework separates education spending into two stages: whether a household spends anything at all, and how much it spends, given that it has positive expenditure.

Table 5. Average Marginal Effects (AME) from the Hurdle Model for Educational Expenditure, Children 4–18 Years

Variable	Any Expenditure		Conditional Expenditure	
	AME	Std.Error	AME	Std.Error
Household income (log)	0.0885***	0.0097	2261.95***	86.91
Gender interaction age (ref: Male)				
F4 to 8	-0.0918***	0.0090	-637.73***	93.50
F9 to 13	0.2489***	0.0170	-14.12	75.52
F14 to 18	-0.0557***	0.0121	-31.47	93.37
School type (ref: Public)				
Private	0.0181	0.0190	3007.58***	142.00
Child's education level (ref: Less than elementary)				
Primary	0.1519***	0.0123	998.23***	75.59
Preparatory and Secondary	0.0643***	0.0117	2154.87***	100.14
Place of residence (ref: Urban)				
Rural	-0.0202**	0.0076	-675.92***	60.49
Household Size (ref: 2-4 individuals)				
5:6 individuals	-0.0804***	0.0096	-765.00***	69.43
7+ individuals	-0.2123***	0.0154	-2522.42***	154.14
Household Head education (ref: Less than elementary)				
Primary and preparatory	0.0329**	0.0108	384.35***	93.34
Secondary and above intermediate	0.0676***	0.0086	686.98***	74.41
University and above	0.1347***	0.0128	982.55***	92.92

Note: This table was prepared by the authors using data from the 2019-2020 Household Income, Expenditure, and Consumption Survey (HIECS) conducted by the Central Agency for Public Mobilization and Statistics (CAPMAS) in Egypt. (ref) = reference category. Clustered robust standard errors, clustered at the household level. Statistical significance levels: *** $p < 0.001$, ** $p < 0.01$.

Household income and the household head's education emerge as the strongest determinants, significantly and substantially raising both the probability and the actual amount of spending, underscoring the income elasticity of educational outlays. The head's education level exhibits a pronounced cumulative effect; households headed by university graduates show an approximately 13.5% higher probability of spending and increase the conditional expenditure by roughly EGP 983 compared to those with less than elementary education.

The results show a clear age-gender interaction. For children aged 4-8, the likelihood of spending is higher for girls than for boys. This pattern reverses among those aged 9-18, where girls become less likely to receive spending. The disparity is most pronounced in the 14-18 age group, with conditional spending on girls falling short by roughly EGP 638. This statistically significant gap points toward a reallocation of household resources in favor of boys as children progress through school.

School type matters mainly for the amount spent, not for the decision itself. Attending a private school raises conditional expenditure by roughly EGP 3,008, which captures the higher fees these institutions charge. As for the child's grade level, the costs rise steeply later on. Students in preparatory or secondary school generate conditional spending that is more than twice that of those in primary education, suggesting a marked jump in educational outlays as children grow older.

Rural residence significantly reduces both the likelihood and the amount of expenditure. An interesting paradox emerges concerning household size: larger families (7+ members) are less likely to spend on education; however, should they opt to spend, they disburse a significantly larger amount (an increase of EGP 2,522) compared to smaller families. This may reflect the higher aggregate financial requirement needed to cover the education of more children when the decision to invest is made.

In summary, the marginal effects derived from the model indicate that educational expenditure is primarily governed by the household's financial capacity (income) and human capital (head's education), alongside a notable gender bias against older girls. Furthermore, clear spatial disparities exist between urban and rural areas; while

rural and larger households are generally less inclined to spend; however, when they do spend, the amount is considerably larger, probably because they have more children in school.

7.9. Tobit Model Estimates for Educational Expenditure on Children (Ages 4-18)

Table (6) presents the Tobit coefficients for household education spending. Since a sizable share of households report zero expenditure, the Tobit framework is appropriate here; it treats the outcome as a latent continuous variable, which gives us a single estimate for how each predictor shifts the expected level of spending across the full distribution, including the zeros.

Table 6. Tobit Model Estimates for Household Educational Expenditure, Children 4-18 Years

Variable	Estimate	Std.Error
Household income (log)	5149.22***	663.52
Gender interaction age (ref: Male)		
F4 to 8	-1399.88***	196.39
F9 to 13	997.38***	157.50
F14 to 18	-75.14	281.40
School type (ref: Public)		
Private	7151.53***	597.65
Child's education level (ref: Less than elementary)		
Primary	1027.81***	162.36
Preparatory and Secondary	1623.56***	269.41
Place of residence (ref: Urban)		
Rural	-395.53***	118.00
Household Size (ref: 2–4 individuals)		
5:6 individuals	-1668.10***	245.17
7+ individuals	-4570.92***	467.30
Household Head education (ref: Less than elementary)		
Primary and preparatory	186.95	137.07
Secondary and above intermediate	395.96**	130.06
University and above	1317.23***	185.81

Note: This table was prepared by the authors using data from the 2019-2020 Household Income, Expenditure, and Consumption Survey (HIECS) conducted by the Central Agency for Public Mobilization and Statistics (CAPMAS) in Egypt. (ref) = reference category. Clustered robust standard errors, clustered at the household level. Statistical significance levels: *** $p < 0.001$, ** $p < 0.01$.

Income is a strong positive predictor. A one-unit increase in log income raises expected expenditure by roughly EGP 5,149, supporting the view that education outlays are highly responsive to household resources. The effects of the household head's education are graded: relative to heads with less than elementary schooling, those with a university degree spend about EGP 1,317 more. The secondary-level coefficient is smaller (EGP 396, $p < 0.01$).

The gender-age interactions show a somewhat uneven pattern. Girls aged 4-8 attract substantially lower spending (by about EGP 1,400) compared to boys in the same age group. This reverses for girls aged 9–13, whose spending is roughly EGP 997 higher. For the 14-18 group, the coefficient is negative but small and statistically weak. This suggests that the gender gap is not monotonic; rather, it shifts direction across age cohorts in a way that warrants closer inspection.

Private schooling stands out: attendance at a private institution adds about EGP 7,152 to expected expenditure, consistent with the large fee differential between private and public provision. Child grade level also matters; preparatory and secondary students generate about EGP 1,624 more spending than those below elementary level, while primary enrollment adds about EGP 1,028.

Rural residence reduces spending by roughly EGP 396. Household size has a clear dampening effect: compared to smaller households (2-4 members), those with 5-6 members spend about EGP 1,668 less, and the gap widens to

nearly EGP 4,571 for households with seven or more members. This could reflect budget constraints per child as family size expands.

All standard errors are clustered at the household level, and the data come from the 2019–2020 HIECS survey. Most coefficients are significant at the 0.001 level, with the exception of the primary-and-preparatory education category for the household head.

7.10. Summary of Key Findings from the Hurdle Model

The two-part hurdle model revealed that gender disparities in educational expenditure are age-specific and operate through two distinct mechanisms. Female children aged 4-8 years face significant barriers to accessing any educational expenditure, and conditional on access, they also receive significantly lower expenditure levels than their male counterparts. Notably, female children aged 9-13 years show a reversed pattern in the access stage, being significantly more likely to receive educational expenditure; however, they do not face significant spending gaps conditional on access. Adolescent girls (14-18 years) face significant barriers to accessing any educational expenditure; yet, those who overcome access barriers do not face further spending gaps. Socioeconomic factors, particularly household income, place of residence (rural), household size, and child's education level, significantly influence both stages. Household head education affects both the decision to spend and the level of expenditure, with a graded dose-response relationship across all education levels.

7.11. Comparison with the Tobit Model

To assess the robustness of the hurdle model findings and justify its selection, a Tobit model was estimated as a single-equation censored regression benchmark. The dependent variable in the Tobit model is total educational expenditure measured in Egyptian pounds (EGP); therefore, all coefficients represent absolute changes in expected educational expenditure, in contrast to the hurdle model's second stage which estimates percentage changes.

7.11.1. Overall Consistency Between Models The Tobit model results, presented in Table (6), largely align with the hurdle model in terms of direction and significance of effects. These findings mirror the hurdle model's conditional stage results, confirming the overall robustness of the findings.

7.11.2. Similarities in Significant Determinants The Tobit model confirmed the age-specific gender disparities observed in the hurdle model. For female children aged 4-8 years, all model specifications consistently showed significantly lower educational expenditure compared to males. For female children aged 9-13 years, both models agreed on a positive pattern. For adolescent girls aged 14-18 years, both models agreed on no significant gender differences in the level of expenditure. Beyond gender, both models consistently identified private school attendance, higher household income, higher child education levels, and higher household head education as positive determinants, while rural residence and larger household size were associated with lower expenditure.

7.11.3. Differences Between Model Specifications Several notable differences emerged between the models. First, private school attendance was strongly significant in the Tobit model and the hurdle conditional stage, but not in the hurdle participation stage, indicating that private schooling primarily affects the level of expenditure rather than the decision to spend. Second, household head primary and preparatory education was significant in both hurdle stages but not in the Tobit model, suggesting that the single-equation Tobit may mask the nuanced effect of lower education levels on the spending decision. Third, regarding age-specific gender patterns, for the 9-13 age group, the Tobit model showed significantly higher expenditure for females, contrasting with the non-significant conditional stage finding of the hurdle model, despite both models agreeing on the positive role of this group in the participation stage.

7.12. Model Fit and Diagnostic Statistics

7.12.1. AIC and BIC Comparison To justify the use of the hurdle model over the Tobit model, both models were compared using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). As

shown in Appendix Table A1, the two-part hurdle model (Logit + Gamma GLM) yielded substantially lower AIC (152,219.5) and BIC (152,426.7) values compared to the Tobit model (AIC = 176,161.9; BIC = 176,270.7). The large differences in both criteria (AIC = 23,942.4; BIC = 23,844.0) confirm that the two-part hurdle specification provides a statistically superior fit for this dataset, which is characterized by a substantial proportion of zero educational expenditures (29.1% of the sample, with 4,330 children having zero expenditure out of 14,892 observations).

7.12.2. Additional Diagnostic Checks All models were estimated with robust standard errors clustered at the household level to account for intra-household correlation among children. As previously reported in Section 7.2 and Table (3), multicollinearity was not a concern in any of the estimated models, with all adjusted GVIF values ranging from 1.0037 to 1.4436, well below the commonly accepted threshold of 5.

7.13. Conclusion of the Comparison

The two-part hurdle model was retained as the primary model for this study for three reasons. First, its superior fit (lower AIC and BIC) makes it more appropriate for data with a high proportion of zero expenditures (29.1%). Second, by separating the decision to spend from the level of spending, it provides more nuanced insights into the mechanisms underlying gender disparities and other socioeconomic determinants. Third, the hurdle model offers more flexible and efficient estimation compared to the Tobit model, which assumes a single process generating both zero and positive outcomes. Therefore, the discussion that follows focuses primarily on the hurdle model results, with reference to the Tobit model where relevant for comparison.

8. Discussion

This study examined correlates of household educational expenditure on children in Egypt, utilizing data from the Household Income, Expenditure, and Consumption Survey (HIECS) 2019-2020 conducted by the Central Agency for Public Mobilization and Statistics. To provide a nuanced understanding of household behavior regarding educational investment, the study employed a hurdle modeling approach, distinguishing between the decision to incur educational expenditure and the level of expenditure conditional on positive expenditure. This methodology allowed for a comprehensive analysis of how families allocate resources to children's education across various demographic and socioeconomic contexts.

This study used descriptive statistics to identify the demographic, social, and economic factors that are associated with the prevalence of household educational expenditure on children in Egypt. The study found that patterns of household expenditure on children's education are related not only to financial capacity but also to social norms, cultural expectations, and family dynamics. Analytical statistics were then employed to measure the factors associated with household educational expenditure using a hurdle modeling approach, which distinguishes between the probability of incurring educational expenditure on children and the level of expenditure conditional on positive expenditure.

The findings reveal that gender is associated with household educational expenditure in a markedly age-dependent manner. In the participation stage, females aged 4-8 and 14-18 exhibited a significantly lower probability of receiving educational spending relative to males, which is consistent with the persistent pro-male bias documented in other developing contexts [8, 11]. In striking contrast, females aged 9-13 displayed a significantly higher probability of being allocated educational funds a pattern broadly consistent with [15], though their evidence pertains to the conditional amount stage among Ghanaian junior-secondary children rather than the participation decision. In the conditional amount stage, the gender gap narrowed considerably: only females aged 4–8 received significantly lower amounts than their male counterparts once the spending decision was made. This finding is consistent with the documented pro-male bias in primary-level expenditures [15]. Notably, no significant gender differences in actual spending were observed for the 9-13 and 14-18 age groups at this stage. Taken together, these patterns suggest that households may adopt strategic investment behaviors at critical educational transitions favoring girls at the middle-school ages while simultaneously revealing persistent age-specific disadvantages at

early-primary and secondary levels. This points to the importance of designing targeted, age-sensitive policy interventions to effectively address gender-based educational inequities.

This pro-female pattern at ages 9-13 requires careful theoretical and contextual interpretation. The magnitude of this positive association warrants additional consideration; several demographic and educational dynamics may account for this notable effect size. First, this age bracket coincides with the transition from primary to preparatory education in Egypt, a critical juncture where households may concentrate financial resources to prevent dropout, particularly for girls. Second, the onset of puberty and associated shifts in parental expectations regarding marriage trajectories may amplify the perceived returns to maintaining girls' educational status [3]. While standard household bargaining models often posit a pro-male bias rooted in son preference [8, 11], our findings are consistent with the possibility that, at this specific age threshold, household investment behavior may align with strategic marriage-market considerations. Third, the clustering of this effect on the participation margin suggests that households may prioritize allocating scarce funds to girls at this specific stage before diverting resources elsewhere. Alternatively, while this pattern may partially reflect the influence of targeted government programs such as the Takaful and Karama cash transfer initiative which explicitly incentivizes school enrollment and attendance with particular emphasis on girls, we exercise considerable caution in attributing this finding directly to the program. Although the HIECS survey captures household participation in the program, our model does not include this variable, as our study was not designed to evaluate the program's causal impact. Consequently, the observed association could be confounded by unobserved household characteristics, geographic targeting, or broader socioeconomic dynamics coinciding with program implementation. Thus, rather than an isolated statistical artifact, this result likely reflects a complex interplay of demographic transitions, strategic educational transitions, economic incentives, and socio-cultural norms associated with intra-household allocation decisions.

The child's educational stage emerged as a key factor associated with household educational expenditure. Households generally allocate greater resources to children as they progress to higher educational stages, which corresponds with the increasing costs associated with schooling, including tuition, school materials, and supplementary academic support. Children enrolled in private schools were found to receive higher household educational expenditure compared to those in public schools, highlighting the financial implications of school type on family investment decisions. These findings align with prior research, which suggests that families strategically adjust educational expenditure based on both the child's stage of schooling and the associated costs [8, 11].

Household socioeconomic factors also appear to be related to educational expenditure. Higher household income was positively associated with both the likelihood of incurring educational expenditure and the level of conditional expenditure, suggesting that wealthier families tend to be more capable of investing in children's education [16]. In contrast, larger household size was linked to reduced per-child expenditure, consistent with the "resource dilution effect" observed in previous studies [8, 16], although some research suggests that total expenditure may increase in larger households with multiple economically active members [15, 11].

The study also identified the significance of parental education, showing that higher levels of parental education corresponded to increased likelihood and higher levels of household educational expenditure. This finding is consistent with the well-documented role of parental education in promoting children's education, as more educated parents tend to be more aware of the long-term benefits of schooling and more committed to investing in their children's human capital [11, 15, 16].

Place of residence was also related to educational expenditure, with urban households generally allocating more resources to children's education than rural households. This disparity may be related to differences in access to educational institutions, higher household income levels, and greater awareness of the importance of education in urban areas, aligning with findings from previous research [8, 15, 16].

Overall, the findings of this study indicate that household educational expenditure in Egypt is associated with a complex interplay of demographic and socioeconomic factors. Gender, age, educational stage, type of school, household income, household size, parental education, and place of residence are collectively related to both the probability of incurring educational expenditure and the level of expenditure. These results point to the importance of designing targeted policies and interventions aimed at reducing gender disparities, supporting large and low-income households, and enhancing educational opportunities in under-resourced areas. Moreover, raising parental awareness about the long-term benefits of education and promoting equitable investment strategies are essential

steps toward reducing inequalities in educational outcomes and fostering inclusive human capital development across Egypt.

The AME results reveal a significant gender gap only for the 4-8 age group, where girls receive approximately EGP 638 less than boys in conditional educational spending. This pronounced disadvantage in early childhood is consistent with son preference in household resource allocation, where boys are prioritized for educational investment at the onset of formal schooling. This pattern aligns with broader evidence of pro-male biases in primary education and suggests that gender-based discrimination in educational spending is most acute when children first enter the school system. The absence of significant gaps in older age groups may indicate that households treat boys and girls more equally in terms of spending intensity once the decision to invest in schooling is made, or that other factors such as the equalizing effects of social protection programs offset potential biases at later stages. These findings underscore the importance of early intervention policies to address gender disparities at the foundational stage of education.

However, these findings should be interpreted in light of two key methodological limitations. First, this study relies on cross-sectional data (HIECS 2019-2020), which precludes tracking cohort effects or temporal changes in household spending behavior. Consequently, the reported findings represent conditional associations rather than definitive causal relationships. Second, the survey period coincided with the onset of the COVID-19 pandemic in early 2020, which was accompanied by severe economic shocks (lockdowns, job losses, inflation) that may have affected educational spending patterns in atypical ways. It is plausible that the impacts of this shock were heterogeneous across genders; financial pressures may have diverted resources toward boys' education in some households (reinforcing traditional male bias), or conversely, social protection programs such as Takaful and Karama may have enhanced households' ability to retain girls in school during the crisis, thereby mitigating inequalities. Given that the study design does not allow for disentangling the pandemic's effects from other factors, we recommend future longitudinal studies to assess the impact of economic shocks on gender equity in educational expenditure.

9. Strengths and Limitations of the Study

One of the main strengths of this study is the use of nationally representative data from the 2019-2020 Household Income, Expenditure, and Consumption Survey (HIECS), conducted biennially in Egypt by the Central Agency for Public Mobilization and Statistics (CAPMAS). The survey provides detailed and reliable information on household consumption patterns, including children's educational expenditures. The large sample size supports robust statistical analysis and allows stratification by age group, gender, and socioeconomic characteristics, enabling a comprehensive assessment of disparities in household educational expenditure. By relying on child-level data within households, the study allows comparisons between males and females within each age group and within the same household, thereby reducing bias arising from inter-household variation and providing a more precise understanding of intra-household gender disparities.

This study contributes to the literature by examining gender-related disparities in educational expenditure among children aged 4-18 years. Whereas many previous studies focused on educational expenditure without considering age-specific differences, the refined age classifications used here provide a clearer picture of how expenditures are distributed across stages of childhood and adolescence. In addition, by analyzing both the occurrence and the level of expenditure using a hurdle model, the study addresses the high prevalence of zero expenditure by distinguishing between the household's decision to incur any educational expenditure and the level of expenditure conditional on positive expenditure, thereby improving the precision and interpretability of the estimated effects.

In the Egyptian context, no previous study has analyzed household educational expenditure for children aged 4-18 years using the 2019-2020 HIECS data, with a detailed comparison between male and female children within the same age groups. This study provides the first evidence of its kind for Egypt, effectively addressing a critical gap in the national literature.

Despite these strengths, several limitations should be acknowledged. First, the analysis is based on cross-sectional data, which limits the ability to establish causal relationships or to examine changes in household

educational expenditure behavior over time. Second, HIECS captures only monetary educational expenditures and does not account for non-monetary investments in children's education, such as parental time, informal tutoring, or learning support provided within the household. As a result, the full extent of intra-household inequalities in educational investment may be underestimated. In addition, although the analysis is conducted at the individual-child level within households, the data does not allow for full control of unobserved individual characteristics, such as innate ability or motivation, beyond the variables available in the survey. Future research could address these limitations by using longitudinal data or incorporating broader measures of household investment in children's education.

10. Conclusion and Recommendations

This study provides a comprehensive analysis of the determinants of household educational expenditure on children in Egypt, highlighting the influence of demographic, socioeconomic, and social factors. The findings indicate that household investment in children's education is shaped by gender, age, educational stage, type of school, household income, household size, parental education, and place of residence. Female children tend to receive lower educational expenditure than male children in early childhood and adolescence, while households with higher income and more educated parents invest more in their children's education. Urban households also allocate more resources compared to rural households.

10.1. Recommendations

- **Gender Equity:** Policies should address gender disparities in educational investment by promoting awareness campaigns about the importance of equal education for boys and girls and by supporting programs that encourage families to invest equitably in female children's education.
- **Socioeconomic Support:** Targeted interventions are needed to support low-income and large households, including financial assistance, scholarships, and educational subsidies, to ensure that all children have access to quality education regardless of household resources.
- **Parental Engagement:** Programs to enhance parental awareness about the long-term benefits of education are essential. Educated parents are more likely to invest in their children, so community education programs and workshops should be encouraged.
- **Rural Education Development:** Investments in rural educational infrastructure and access are critical. Policies should focus on improving school facilities, transportation, and teacher availability in rural areas to reduce urban-rural disparities.
- **School Type Considerations:** Families investing in private schools indicate both financial capacity and social aspirations. Policymakers should ensure the quality of public schools to reduce inequality and provide equitable educational opportunities.
- **Future Research:** Further studies should examine additional factors affecting educational expenditure, including parental attitudes, social norms, and children's academic performance, to develop more targeted policy interventions.

By implementing these recommendations, Egypt can enhance equitable access to education, reduce disparities in household educational investment, and foster human capital development nationwide.

Appendix

Table 7. Model Comparison Statistics (AIC and BIC) for Hurdle and Tobit Models

Model	AIC	BIC
Two-Part Hurdle model (Logit + Gamma GLM)	152219.5	152426.7
Tobit model	176161.9	176270.7

Note: The Hurdle model shows better fit than the Tobit model according to both AIC and BIC criteria.

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