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CAUSES AND CHILD HEALTH CONSEQUENCES OF MATERNAL FERTILITY CHOICES IN CAMEROON

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This paper examined correlates of fertility choices and the effect of fertility choices on child health status, while controlling for other correlates. Use is made of the 2004 Cameroon Demographic and Health Survey (DHS) and the control function econometric approach to address these issues. Results showed that women with twins have higher fertility and fertility choices are strongly negatively correlated with child health. There is an indirect effect of fertility on child health captured by the interaction of fertility with its predicted residual. Mother's education at both household and community levels was found to be inversely related with maternal fertility but consistent with the production of better child health. Policy implications suggested that expanding public support for social services reaching poor households, would accordingly reduce expected fertility rates and bring about better child health.

Keywords: Maternal Fertility, Child Health, DHS, Cameroon.
JEL Classification: I12, J13

1. INTRODUCTION

Microeconomic theory suggests that the greater the number of children a household has, the less is the amount of household resources that the household can devote to each child and hence the lower will be the "quality" of each child (Maitra and Pal, 2008). Children with many siblings tend to have poorer human capital outcomes. According to De Tray (1973) and Horton (1986), an additional child increases demand for resources in households facing fixed constraints in terms of both financial resources and the time inputs of parents. Children in larger families are therefore disadvantaged by having to share material resources, as well as the time and attention of caregivers with other siblings (Glick *et al*., 2007).

Children with many siblings typically do less well with respect to long-term nutritional status indicators such as height-for-age z-scores (HAZ) which reflects

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stunting (Wolfe and Behrman, 1982; Lalou and Mbacke 1992; Desai, 1993), have lower academic achievements (Blake, 1981; Lloyd, 1994) and lower school enrolments (Rosenzweig and Schultz, 1987; Alderman *et al*., 2001). Other studies tend to assume that the composition of the population of children classified by health is unrelated to prior fertility decisions (Makepeace and Pal, 2007). Moreover, poor rural households who have access to physical assets may not care about current income and hence might choose to have more children as insurance against anticipated future income short-falls.

Whether or not prior fertility decisions affect the composition of children classified by health, the role of schooling on reducing fertility has been established (Baird et al., 2011; Fafchamps and Shilpi, 2014; Duflo *et al*., 2015). Female schooling typically delays choices related to the timing of employment, marriage and childbearing. In this context, better educated women turn to face a higher opportunity costs in bearing and rearing children than their less educated counterparts (Becker, 1981). Education also mediates the quantity-quality trade-off of children in favour of quality-engendering investments that improve child health and reduce child mortality (Schultz, 2010).

Related to this view is the observation that with more schooling and exposure, women acquire more information about their bodies and are more able to process that information to their advantage (Vavrus and Larson, 2003). The ensuing autonomy also increases the wisdom of later marriages, the use of contraceptives and lower fertility (Mason, 1986). By the same token, communities with higher proportions of more educated women are likely to provide better sanitation, medical services and shared health knowledge (Alderman *et al*., 2003) that have implications for lower fertility and better child health.

In other to verify these views empirically using Cameroon data, a key question arises: what are the proximate direct and indirect effects of fertility choices on child health in Cameroon? The corresponding main objective of this paper is to empirically establish a link between maternal fertility (captured by total number of children ever born by a woman) and child health (captured by weight-for-height z-scores). The specific objectives are: (1) to examine the effect parental education on fertility choices; (2) to evaluate the consequences of fertility choices on child health; and (3) to suggest policy orientations on the basis of the findings.

These objectives are motivated by two hypotheses: holding other things constant, (1) parental education is expected to be inversely related to fertility choices; and (2) higher fertility rates are likely to bring about the production of poor child health both directly and indirectly. The rest of the paper is organized as follows: Section 2 presents some mother and child health indicators in Cameroon. Section 3 reviews the literature. Section 4 dwells on the methodology and data. Section 5 reports the empirical results and the conclusion and policy orientations are summarized in Section 6.

2. BACKGROUND: CHARACTERISTICS OF MOTHER AND CHILD HEALTH IN CAMEROON

The millennium development goals (MDGs) health targets over the 1990-2015 horizon were adopted to improve the health of Cameroonians by reducing malnutrition and infant mortality, enhancing maternal health, controlling HIV/AIDS and other pandemics in combination with the other important objectives. In the 1990s, a series of laws and regulations were enacted with a view to reducing the role of the State in the provision of healthcare services, and to facilitating the development of the private health sector. In 1992 in particular, the Ministry of Public Health published a national declaration aimed at implementing the new health strategy.

By 2000, the authorities adopted a comprehensive and ambitions health strategy based on extended consultations with the main actors. Its main objectives, as expressed in the 2003 poverty reduction strategy paper (PRSP), were: (1) to decentralize health services, encourage partnerships, and improve the effectiveness and efficiency of public resource management; (2) to clarify the roles and responsibilities of all stakeholders in the provision and financing of health services; and (3) to prepare sub-sector strategies for addressing priority public health issues including infant health, and reproductive and maternal health services.

Notwithstanding these efforts, health outcomes are out of synch with the country's potential and lag behind other countries in the region, making Cameroon seriously off-track the health- and nutrition-based MDG targets. The rate of chronic malnutrition for infants aged up to 36 months and under-five mortality rate in Cameroon increased from 23% to 29% and from 32% to 44% between 1991 and 1998, respectively (Government of Cameroon, 2003). Infant mortality per 1,000 stood at 85 in 1990, 88 in the year 2000 and 87 in 2007. These figures are worse than the averages for Africa in the same period, which stood at 51, 51 and 52 per 1,000, respectively (WHO, 2010). Maternal mortality in Cameroon was 669 in 2004 and increased to 1,000 per 100,000 live births in 2007, which is equally worse than the ratio for the African region of 900 per 100,000 live births in the same year (WHO, 2010). These indicate a worsening child and mother health status in Cameroon.

Maternal fertility in Cameroon is relatively high. Each woman has an average of about 6 children at the end of her fertility life. With reference to the desire for more children, only 20% of women aged 15 to 49 in 2004 did not desire more children, while 71% would want to have children again. Among those who wish to have children in the future, 32% would want to space the next birth by at least two years, while 31% would want to have the next child in less than two years.

3. LITERATURE REVIEW

Much of the previous research examining the link between sib size and children's human capital outcomes has been grounded in the dilution theory (Blake, 1981). According to this theory, declines in fertility result in the spreading of family resources among fewer children, thereby increasing the resources available for each child and improving individual child outcomes. With only a few exceptions (Becker and Lewis, 1973; Gomes, 1984), most of the evidence from developing countries suggests that having more siblings is disadvantageous for a child's well-being with respect to both education and health. Lalou and Mbacke (1992) found that having more siblings increased the likelihood that children would experience malnutrition in Mali.

The downside of the dilution theory is that it does not take into consideration the distribution of resources within the household. Even when families have fewer children, the potential for discrimination within households means that all children may not benefit equally (Alderman et al., 2001). Secondly, even if the total fertility rate declines, the number of children in households can remain stable or even increase. This can happen either when fertility declines are concentrated among certain groups (Giroux et al., 2008) or when the prevalence of fosterage increases and extra foster children compete with the existing children in their foster families for limited resources, especially in sub-Saharan Africa.

For Lloyd (1994) and Desai (1993), the relationship between family size and children's outcomes is likely to depend on the context of the family culture, subsidization of child rearing costs, and the stage in the demographic transition, all having an impact on children's outcomes. Shapiro and Tambashe (2001) show that the fertility decline in rural areas lagged far behind the decline in urban centers, whereas Kirk and Pillet (1998) found substantial variations in fertility declines by family socioeconomic status.

Desai (1993) also found that the relationship between sib size and height-for-age is heavily dependent on the extent to which parents bear the cost of child welfare. Thus, even if similar declines in fertility occur across regions, this does not necessarily translate into reductions in stunting in all regions. Instead, the influence of these factors can augment or dampen the dividend as proposed by the dilution theory. Using the 2004 DHS data in the context of the present health policy in Cameroon and a relatively underdeveloped health infrastructure will help us clarify the extent to which fertility declines matter for child health outcomes.

According to Thirlwall (1999), there are a number of reasons why mother's education is expected to lower fertility: (1) education improves work opportunities for mothers, which makes it more costly in time to have children; (2) educated mothers want their own children to be educated, which raises the cost of having children; (3) education and literacy make women more receptive to information about contraception; (4) education and employment delay marriages and the time available to rear children; and (5) education improves the status, bargaining power and independence of women, encouraging and enabling them to make more rational choices.[1]

[1] Thus, from a vicious circle of no education, high fertility, poor health for children and low productivity,

The few empirical studies on child health/nutrition in Cameroon include Fambon (2004), Baye and Fambon (2010) and Baye (2010). Fambon (2004) examines the determinants of malnutrition in Cameroon using the OLS method and the 1998 Cameroon's DHS data. Baye and Fambon (2010) study the link between parental education and child health captured by weight-for-age z-scores (WAZ) and Baye (2010) using the same survey, estimates the contemporaneous response of household economic well-being to child health status using a survey-based Heckman/control function approach.

To contribute to this growing literature on reproductive health in Cameroon, we study the effect of maternal fertility choices on child health status using the Heckit/control function approach that simultaneously purges parameter estimates of potential endogeniety, sample selection bias and unobserved heterogeneity biases of fertility choices. A better understanding of the empirical link between fertility choices and child health and factors that condition the link, can deduce public policies that would encourage households to have fewer children and to desire improvements on the human capital of the children. Since no study has analyzed the effect of fertility decisions on child health in Cameroon, this study intends to fill this gap.

4. THEORETICAL FRAMEWORK, METHODOLOGY AND DATA

4.1. Theoretical Framework

We glimpse at child health/nutrition through the demand behaviour for reproductive health services by the mother by envisaging a framework in which mother's utility function encompasses child health. The underlying theory guiding the framework is the "new household economics" model of the family, which recognises that households also derive utility from goods and services that are produced at home or for which there is no market.

The application of this theoretical framework to children's health status is well known, and is discussed in detail in Behrman and Deolalikar (1988) and Thomas et al. (1991). In a simple version of the framework, the mother is typically seen as maximising a utility function defined over leisure, market-purchased goods and home produced goods such as child health and health related good such as family planning services, and faces three main constraints: a budget constraint, a time constraint and a health production function. The health production function will depend on market-purchased inputs such as food (or nutrients) and health services, the time and characteristics of the mother, environmental features and community characteristics such as access and proximity to public goods, as well as child's and father's endowments. By understanding

the education of women can lead to a virtuous circle of lower fertility, better childcare, more educational opportunities and higher productivity.

the empirical link between fertility choices and child health and factors that condition the link, one can deduce public policies that would encourage an optimal sib size and improvements on the human capital (health and education) of the children.

4.2. Methodology

Fertility choices are assumed to be a significant input in child health production. Since child health (CH) and fertility (F) are jointly and simultaneously determined and each has a ceteris paribus behavioural interpretation, their underlying links can be depicted by the following structural equations (see, Wooldrige, 2002; Baye, 2010).

$$CH = v_1\partial_{ch} + \varphi_1 F + \varepsilon_1, \quad (1)$$

$$F = v_2\partial_f + \varphi_2 CH + \varepsilon_2, \quad (2)$$

where CH is child health – the endogenous explanatory variable in the fertility choice function - surrogated by weight-for-height z-scores; F is fertility – the endogenous explanatory variable in the child health production function – captured by the total number of children ever born by a woman; v_1 is a vector of exogenous variables that determine child health; v_2 is a vector of exogenous variables that determine fertility (F); and ∂, φ, are parameters to be estimated, and ε_1 and ε_2 are the two structural error terms. Given that F is determined simultaneously with CH, it is correlated with ε_1, which leads to bias and inconsistency in OLS estimates. For a similar reason, CH is correlated with ε_1.

Given that the interest here is to estimate Equation 1, if the right-hand side of Equation 1 is plugged in for CH in Equation 2, one gets:

$$F = v_2\partial_f + \varphi_2(v_1\partial_{ch} + \varphi_1 F + \varepsilon_1) + \varepsilon_2. \quad (3)$$

To solve for F, the assumption must be made that $\varphi_2\varphi_1 \neq 1$ to yield to Equations 4 and 5:

$$(1 - \varphi_2\varphi_1)F = \varphi_2 v_1\partial_{ch} + v_2\partial_f + \varphi_2\varepsilon_1 + \varepsilon_2, \quad (4)$$

$$F = v_1 z_{ch} + v_2 z_f + \varepsilon_3, \quad (5)$$

where $z_{ch} = (\varphi_2\partial_{ch})/1 - \varphi_2\varphi_1$; $z_f = (\partial_f)/(1 - \varphi_2\varphi_1)$, and $\varepsilon_3 = (\varphi_2\varepsilon_1)/(1 - \varphi_2\varphi_1)$. Equation 5, which expresses F in terms of the vectors of exogenous variables v_1 and v_2, and the error terms, is the reduced form equation for fertility (F). The vector of parameters z_{ch} and z_f are reduced form parameters – they are nonlinear functions of the structural parameters in Equations 1 and 2. The reduced form error, ε, is a linear function of the structural error terms, ε_1 and ε_2. Since ε_1 and ε_2 are each uncorrelated with v_1 and v_2, ε_3 is also uncorrelated with v_1 and v_2. Thus, the vectors of parameters z_{ch} and z_f can be consistently estimated by the OLS

The attention of this paper is on the effect of fertility on child health. Estimation of the parameters of the child health production function requires knowledge of inputs into the process and, since inputs and outputs are jointly determined, causality is expected to run in the other direction as well (reverse causality). Moreover, many studies have shown that maternal fertility is a key determinant of child health outcomes (Preston, 1975; Case and Paxson, 2001; Thomas and Frankenberg, 2002). A conventional strategy to reduce the problem of endogeneity is to use the instrumental variables (IV) method. In this regard, potential instruments for fertility are needed in order to consistently estimate effects of fertility on child health. The instruments for fertility are those factors that affect fertility choices without directly influencing child health.

In addition, heterogeneity of child health due to non-linear interaction of maternal fertility with unobservable variables could bias the estimated structural coefficients. This may result from mother-specific unobserved differences in health or genetic reproductive endowments of mothers. Again, estimates may not be applicable to all children aged 0 to 36 months because children whose weights or heights were not registered are not captured in Equation 1. Thus failing to consider an approach that reflects the entire sample of children means that parameter estimates may suffer from sample selection bias, except selection of children into the estimation sample is a random process.

We appeal to the control function approach to address these potential issues (see, Garen, 1984; Wooldridge, 1997; Mwabu, 2009; Baye and Fambon, 2010). Thus, to account for potential endogeneity, heterogeneity of responses of unobservables that are complementing with or substituting for maternal fertility and sample selection, Equation 1 is augmented to Equation 6, which is a control function model.

$$CH = \beta_0 + v_1\partial + \varphi_1 F + \beta_1\hat{\varepsilon}_3 + \theta(\hat{\varepsilon}_3 F) + \lambda IMR + u, \qquad (6)$$

where $\hat{\varepsilon}_3$ is residual of fertility (F), derived from the reduced form model of fertility (Equation 5); $(\hat{\varepsilon}_3 F)$ is interaction of fertility with its residual; IMR is the inverse of the Mills ratio derived from the probit for sample selection and u is the error term of the estimating equation; and ∂, φ, β, θ and λ are parameters to be estimated. $\hat{\varepsilon}_3$, $(\hat{\varepsilon}_3 F)$ and IMR are control function variables.

The predicted error term, $\hat{\varepsilon}_3$, serves as a control for unobservable variables that are correlated with F, thus allowing this endogenous input to be treated as if it were an exogenous covariate during estimation. The interaction term, $(\hat{\varepsilon}_3 F)$, controls for the effect of neglected non-linear interaction of unobservable variables with the input into child health. Lastly, IMR, the inverse of the Mills ratio (the pseudo error term) holds constant the effects of sample non-randomness on structural parameters in the usual ceteris paribus fashion (Heckman and Robb 1985; Mwabu, 2009).[2]

4.3. Presentation of Data and Model Identification

Presentation of Cameroon's DHS Data

The data used in this study is extracted from Cameroon's Demographic and Health Survey (DHS) collected by the National Institute of Statistics (INS), in 2004. The Demographic and Health Survey was conducted through representative sampling techniques at the national level and provided detailed information on fertility, family planning, maternal health, nutritional status of children aged up to three years, infant and child mortality and maternal mortality. The survey covered all the ten regions of Cameroon.

The survey was conducted in collaboration with the Ministry of Public Health and the technical support of UNICEF. During the survey conducted between February and August 2004, 10,462 households were interviewed and 11,304 eligible women were identified. Among the eligible women, 10,656 women aged fifteen to forty-nine years were successfully interviewed. About 5,280 men aged fifteen to ninety-five years were successfully interviewed out of the 5,676 eligible men identified. Our unit of measurement is the child, 16,346 children aged up to three years were involved.

Model Identification

According to Schultz (2010), correlation between fertility and child health does not necessarily denote causation if one fails to develop a compelling identification strategy of the "cross effect". As fertility and child health are jointly determined, there is need for exogenous variations in fertility. To properly estimate parameters in our model, it is important that child health effects of the endogenous fertility and of the sample selection indicator be identified. In this case, identification requires at least two exclusion restrictions because there are two equations that need to be solved simultaneously. That is, we need at least an exogenous instrument for the endogenous fertility and another exogenous variable that determines the selection of children into the estimation sample.

[2] Equation 6 has a number of interesting features about model specification, estimation and testing: (1) The standard t and F statistics are applicable to Equation 6; (2) if β_1, θ, and λ are statistically equal to zero, the structural parameters of the child health equation can be consistently estimated by OLS using the selected sample. (3) if θ and λ are statistically non-significant, the only control function variable in the child health equation is the residual of fertility predicted from the reduced form equation. In such a case, the structural parameters can be consistently estimated by the 2SLS on the selected sample. Moreover, when θ and λ are both statistically equal to zero, the IV method is a special case of the control function approach; (4) if only λ is statistically equal to zero, Equation 6 can be estimated omitting the IMR; (5) if λ is statistically different from zero, the estimation of the outcome equation will be through the Heckit to account for sample selection bias; and (6) if β_1, θ, and λ are all statistically significant, the Heckit/control function approach is to be preferred.

In this regard, we use three instruments: multiple births (twins) by the mother, mother's age at first marriage and mother's age at first intercourse all generated using cluster level information to reduce their dependence on individual household choices.[3] However, even with valid instruments, it is difficult in practice to completely separate out the impact of an endogenous input from the effect of unobservables in the structural model. This is probably the main reason why experimental approaches to identification of the structural parameters have become popular in development economics literature (Schultz, 2008).[4]

Twins are more readily interpreted across cultures as an instrument for exogenous variation in fertility, especially in Sub-saharan Africa, because they represent a "treatment" of a woman to an unanticipated "shock" or increase in her biological supply of birth.[5] In a ceteris paribus fashion, the later a woman gets married and /or indulges in sexual intercourse, the less likely she is to end up with many children. Considering these instruments as community-level variables using cluster level information is an elegant way of ensuring that they should have no effect on child outcomes other than through fertility. Diagnostic tests are used to check the relevance, strength and validity of these instrumental variables.

5. EMPIRICAL RESULTS

5.1. Descriptive Statistics

Table 1 provides summary statistics describing the variables of interest. The overall average weight-for-height of the analytic sample is -0.11 z-scores, which is above the weight-for-height poverty line of -2 z-scores. The average mother is about 34 years old and has about 4 years of education and weighs about 61kg. The mean age of mother at first marriage is about 17 years, whereas average age of mother at first intercourse is a little over 15 years. These may explain the relatively high maternal fertility rate of 6.01 children per mother. About 50 percent of children captured in the study are males.

[3] In general, acceptable instruments must be relevant: if their effect on the potentially endogenous explanatory variable is statistically significant, strong: if the size of the effect is large enough; and valid: if uncorrelated with the structural error term, and the exclusion restrictions are correctly excluded from the estimating equation. Valid instruments are typically hard to come by.

[4] Following Murray's (2006) advice, our candidate instruments are subjected to intuitive, theoretical and empirical scrutiny to reduce the risk of using invalid instruments.

[5] But twins have the disadvantage of occurring infrequently, in the sense that they normally affect less than one percent of pregnancies, and therefore a large sample is required to obtain precise estimates from this instrument of the cross effect of fertility (Schultz, 2008). Assuming that the occurrence of twins captured at the cluster level is approximately exogenous in the determination of fertility, there appears to be no conceivable direct channels through which it can influence child health except through fertility itself.

Only about 3 percent of the children are of multiple births and about 7 percent of children slept under treated mosquito nets within the two weeks before the survey, whereas close to 5 percent suffered from diarrhoea. The mean child age captured in the dataset is 9 months. About 79 percent of fathers were at home during the survey and about 51 percent are employed in the agricultural sector. The sample selection indicator shows that only about 26 percent of the children are captured by the estimation sample, thus suggesting the need to check for potential sample selection bias.

5.2. Reduced Form and Sample Selection Estimates

Correlates of Maternal Fertility

Column 1 of Table 2 presents correlates of fertility from the reduced form equation. Multiple births captured at cluster level are significant and positively correlated with fertility. Column 1 also indicates that age at first marriage and age at first intercourse captured at cluster level are significant and negatively associated with the demand for children. These results indicate that our instruments are statistically relevant. The outcome-equation variables such as husband's presence at home and agricultural employment correlate positively and significantly with having more children. The negative coefficient on the interaction of husband's education and mother's own education suggests some synergy in seeking for family planning technologies that would help in keeping fertility low. Moreover, as suggested by Schultz (1997), education may increase women's market wages, thus increasing the opportunity cost of the time women spend rearing children. Mother's age is associated with more children, whereas child age exhibits a U-shape association with maternal fertility.

Sample Selection Estimates

Column 2 of Table 2 presents probit model parameter estimates of the likelihood of including a child in the estimation sample. Whereas age at first marriage reduces the probability of selection into the sample, age at first intercourse enhances the probability of selection into the estimation sample. With regard to variables included in the outcome equation, mothers who were immunized against tetanus tend to reduce the probability of a child being selected into the sample, whereas the probability of selection increases with child age but decreases after some critical age. Column 2 of Table 2 also presents the probit index (the sum of each estimated coefficient multiplied by its respective covariate), the probability density, and the cumulative density of the probit index. It is worth noting that the cumulative probability of the probit index (0.53) is exactly the predicted conditional probability of including a child in the estimation sample.

5.3. Determinants of Child Health (WHZ) Production in Cameroon

Since maternal fertility and child health are jointly determined decisions, OLS estimates of child health as a function of maternal fertility are likely to be bias. For

Table 1. Weighted Descriptive Statistics of Variables Short-listed for Regression Analysis

Variable	Obs.	Mean	Std. Dev.
1. Outcome variables			
Dependent Variables:			
Child health (Weight for height z-score) CH	4,277	-0.11	1.24
Endogenous Explanatory Variables			
Maternal fertility = total children ever born (F)	16,346	6.01	2.82
Exogenous explanatory Variables			
Mother's education (years)	16,346	3.96	3.85
Mother's education (Cluster level mean)	16,346	3.76	2.61
Father's education (years)	16,346	5.15	4.78
Mother's times father's education	16,346	34.05	46.42
Father at home (=1, and 0 otherwise)	16,346	0.79	0.41
Mother's age (years)	16,346	33.79	7.84
Mother's age squared	16,346	1203.03	533.52
Mother's weight in kg	16,346	61.12	12.97
Mother's weight squared	16,346	3903.73	1971.23
Child's age (months)	16,346	8.97	7.09
Child's age squared	16,346	130.71	175.62
Gender of child (Male=1, and 0 otherwise)	16,346	0.50	0.50
Child has diarrhoea (=1, and 0 otherwise)	16,346	0.05	0.22
Child has diarrhoea (cluster level mean)	16,346	0.04	0.03
Child uses bednet (=1, and 0 otherwise)	16,346	0.07	0.25
Father is an agriculturalist (=1, and 0 otherwise)	16,346	0.51	0.50
Mother immunized against tetanus (=1, and 0 otherwise)	16,346	0.16	0.36
Mother immunized against tetanus (cluster level mean)	16,346	0.13	0.05
2. Instruments for maternal fertility and sample selection			
Mother has twin (=1, and 0 otherwise)	16,346	0.03	0.18
Mother has twin (cluster level mean)	16,346	0.17	0.14
Mother's age at first marriage	16,346	16.70	3.66
Mother's age at first marriage (cluster level mean)	16,346	0.52	0.16
Mother's age at first intercourse	16,346	15.49	2.25
Mother's age at first intercourse (cluster level mean)	16,346	0.48	0.13
3. Controls for unobservable variables			
Sample selection indicator	16,346	0.26	0.44
Inverse of Mills Ratio	16,346	0.15	0.21
Predicted maternal fertility residual (F minus its fitted value)	16,346	-2.77	4.87
Maternal fertility times its predicted residual	16,346	-18.45	38.40

Source: Compiled by authors from the 2004 Cameroon DHS data set

Table 2. Reduced-form Estimates of Maternal Fertility and Probit for Sample Selection

Variables	Maternal Fertility (1)	Child health reported =1 and 0 otherwise (2)
Mother's education	-0.017 (-1.33)	-0.016 (-1.39)
Mother's education (Cluster level mean)	0.001 (0.09)	0.006 (0.48)
Father's education	0.006 (0.67)	0.013 (1.57)
Mother's times father's education	-0.004*** (-3.74)	-0.8.5*10-5 (-0.08)
Father at home	0.222*** (4.22)	0.032 (0.66)
Mother's age	0.067** (2.52)	0.049* (1.91)
Mother's age squared	0.002*** (4.49)	-0.4.4x10-4 (-1.1)
Mother's weight	0.012 (1.5)	0.005 (0.64)
Mother's weight squaredx10-3	-0.079 (-1.51)	-0.0375 (-0.75)
Child's age (months)	-0.154*** (-3.08)	0.214*** (5.07)
Child's age squared	0.030** (2.32)	-0.163*** (-18.66)
Gender of child (Male=1)	0.058 (1.38)	0.003 (0.06)
Child has diarrhoea (cluster level mean)	-0.923 (-1.08)	1.312 (1.59)
Child uses bednet	0.163** (2.08)	0.560*** (6.99)
Father is an agriculturalist	0.184*** (4.12)	-0.022 (-0.53)
Mother immunized against tetanus (cluster level mean)	-1.083** (-2.21)	-1.094** (-2.5)
Identification variables for maternal fertility and selection into the sample		
Mother has twin (cluster level mean)	1.186*** (5.75)	0.078 (0.42)
Mother's age at first marriage (cluster level mean)	-4.746*** (-18.87)	-0.456** (-2.09)
Mother's age at first intercourse (cluster level mean)	-2.343*** (-6.97)	0.833*** (2.75)
Constant	4.933*** (8.35)	-0.028 (-0.05)
R-squared/Pseudo R-squared	0.7328	0.7197
F-Stat [df; p-value]/ LR chi2 [df; p-value]	614.53 [19, 4257; 0.000]	13523.57 [19; 0.000]
Partial R-squared (on excluded instruments)	0.1586	
Test of excluded instruments -Test for Ho: coefficients on instruments = 0: F-stat [df; p-value]	267.46 [3, 4257; 0.000]	
Fitted value of probit index [standard deviation]		-18.401 [28.08]
Probability density of probit index [standard deviation]		0.089 [0.13]
Cumulative density of probit index [standard deviation]		0.533 [0.05]
Number of observations	4277	16346

Source: Computed by authors using the 2004 Cameroon DHS data set and STATA 10.1.

Notes: Coefficients and standard errors are adjusted for sampling weights and clustering. (·) implies t-ratios. ***, ** and * indicate 1%, 5% and 10% levels of significance, respectively.

instance, it could be that households with malnourished children are also the ones that are more likely to demand for more children thus overestimating the effect. The direction of the bias is an empirical issue because it could alternatively be that household with information that they are susceptible to malnutrition due to poor family endowments may be more likely to demand for family planning services, thus biasing φ towards zero and underestimating the effect. These possibilities imply that it is important to correctly attribute effects for policy guidance.

Table 3 displays estimates of structural forms of child health production function under different assumptions. In particular, column (1) hosts the OLS estimates of the structural parameters of Equation 1; Column (2) gives the 2SLS estimates of the structural parameters accounting for potential endogeneity; columns (3a) and (3b) are Heckit/control function estimates: column 3a is indeed the 2SLS estimates correcting also for potential sample selection bias and column (3b) the 2SLS estimates correcting also for both potential sample selection bias and unobserved heterogeneity captured by the interaction of fertility with its residual. Estimates in Column 1 indicate that exogenously increasing maternal fertility by 1 child, child nutrition reduces significantly by 0.04 standard scores, controlling for other covariates. This is an indication that child health is strongly negatively associated or correlated with maternal fertility.

A potential problem with the OLS estimates is that of endogeneity of fertility, due to the possibility that households with fewer children are more likely to be those that indulge in health and nutrition seeking behaviours that will reduce malnutrition. Thus, maternal fertility is identified by using as identifying instruments those variables that are expected to directly affect demand for children but not child health, except through fertility (see Table 2). According to the 2SLS estimates (column 2 of Table 3), the coefficient of fertility is negatively signed and statistically significant at the 1% level. Indeed, increasing fertility by a child engenders deterioration in observed nutritional status by 0.159 standard scores. Similar results were found by Schultz (1997) using Kenyan DHS data. This shows that correcting for endogeneity, the effect of fertility on child health significantly deepens by about 4-fold compared to the OLS estimate (column 1), controlling for other correlates. This is indication that the size of the effect of fertility on child health depends on the estimation method. To avoid spurious policy implications, it is therefore, important to use proper estimation method which internalises potential econometric problems.

If the residuals from the WHZ equation (the outcome equation) are correlated with the probability that weight-for-height z-scores of some children were not reported - conditional on the determinants of WHZ, the estimates in column 2 would be adulterated by sample selection bias (Heckman, 1979). Column 3a corrects for potential endogeniety and sample selection biases, while column 3b corrects for biases due to potential endogeneity, sample selection and unobserved heterogeneity of fertility with unobservable variables.

When the control function approach is used without the interaction term, the coefficient of fertility becomes -0.157, which is virtually unchanged (column 3a). The indication is that accounting for both endogeneity and sample selection bias registers the effect of fertility on child health which is 0.99 of the 2SLS effect in the full sample. Additionally accounting for the possibility of non-linear interactions of fertility with unobservables, the coefficient of fertility on child health is -0.153 standard scores and it is still 3.8 times the OLS estimate (columns 1 and 3b). Since the interaction of fertility with its residual is statistically significant at the 5% level, we adopt the control function approach as the appropriate estimation strategy.

The coefficient on reduced form fertility residual (column 3b) is statistically significant at the one per cent level. The corresponding coefficient on the inverse of the Mills ratio is significant at the one percent level, suggesting that correcting for sample selection bias was imperative. The control function approach is interesting because the estimated coefficients of the child nutrition production technology under this specification are an improvement to the IV estimates. Since the interaction term is statistically significant at the 5% level, the indication is that maternal fertility status is endogenous to child nutrition, and there is evidence of unobserved heterogeneity of response of child nutrition to maternal fertility choices. The indirect effect of fertility on child health therefore depends on the estimated coefficient of the interaction of fertility with its residual captured at the mean value of the fertility residual.

Table 3, Column 3b also shows the estimated coefficient of the inverse of the Mills ratio of (-0.744) which is statistically significant at the 1% level. This result justifies our choice of the Heckit/control function modelling strategy because it can be used to simultaneously purge the structural parameters of the three potential econometric problems: endogeneity, sample selection bias and heterogeneity of unobservables with the endogenous variable. The negative coefficient of the IMR suggests that children selected into the estimation sample are likely to be malnourished (health poorer) than children drawn from the general population randomly. Specifically, since the sample mean of the inverse of the Mills ratio is 0.15 (Table 1), children captured in the estimating sample are $0.11(= |-0.744 \times 0.15|)$ standard scores less healthy than their counterparts randomly selected from the general population.

Scrutinising the preferred estimates (column 3) of the structural equation reveal that, there is no evidence that gender of the child matters. Using Kenya's DHS data, Mwabu (2009) found that the birth weight for the male child was higher than for the girl child. The pattern of coefficients of child age in all specifications is U-shaped, indicating that younger children are more likely than older children to be malnourished. Schultz (1997) for Kenya instead found that younger children are likely to be better nourished than older ones. On the contrary, the pattern of coefficients on mother's weight in all structural specifications indicate an inverted U-shape, depicting that obese mothers are less likely to have well-nourished children than non-obese ones. In addition, older mothers are more likely to have well-nourished children than younger ones. In a sample of nine African countries, Stifel *et al.* (1999) also found that older mothers are more likely to have well-nourished children than younger ones.

Table 3. Child Health Production Function Under Different Assumptions - Dependent Variable: Weight for Height *z*-score
(Robust *t*-statistics in Parentheses, Except otherwise Specified)

Variables	Method of estimation			
	OLS	IV 2SLS	Heckman/control function approach	
	(1)	(2)	(3a)	(3b)
Maternal fertility	-0.040***	-0.159***	-0.157***	-0.153***
	(-3.37)	(-5.34)	(-5.04)	(-4.92)
Mother's education	0.044***	0.036***	0.044***	0.043***
	(4.18)	(3.32)	(3.93)	(3.85)
Mother's education (Cluster level mean)	0.032***	0.030***	0.025**	0.024**
	(2.87)	(2.64)	(2.09)	(2.07)
Father's education	0.011	0.011	0.008	0.007
	(1.53)	(1.52)	(1.01)	(0.91)
Mother's times father's education	-0.002**	-0.003***	-0.003***	-0.003***
	(-2.3)	(-2.89)	(-3.03)	(-2.94)
Father at home	0.061	0.089**	0.091*	0.089*
	(1.39)	(1.98)	(1.94)	(1.89)
Mother's age	-0.041**	0.001	0.002	0.002
	(-2.04)	(0.06)	(0.09)	(0.09)
Mother's age squaredx10-3	0.887***	0.778**	0.689**	0.703**
	(2.77)	(2.4)	(2.03)	(2.07)
Mother's weight	0.049***	0.050***	0.048***	0.049***
	(7.57)	(7.65)	(7.14)	(7.23)
Mother's weight squaredx10-3	-0.206***	-0.213***	-0.206***	-0.209***
	(-4.74)	(-4.84)	(-4.52)	(-4.59)
Child's age (months)	-0.303***	-0.315***	-0.418***	-0.417***
	(-7.24)	(-7.44)	(-9.42)	(-9.39)
Child's age squared	0.079***	0.082***	0.148***	0.147***
	(7.38)	(7.53)	(12.00)	(11.96)
Gender of child (Male=1)	0.006	0.013	0.002	0.003
	(0.18)	(0.35)	(0.06)	(0.08)
Child has diarrhoea (cluster level mean)	-3.116***	-3.225***	-3.984***	-3.922***
	(-4.36)	(-4.46)	(-5.25)	(-5.16)
Child uses bednet	0.129**	0.142**	-0.001	-0.001
	(1.97)	(2.15)	(-0.02)	(-0.02)
Father is an agriculturalist	0.124***	0.132***	0.153***	0.153***
	(3.34)	(3.52)	(3.91)	(3.92)
Mother immunized against tetanus (cluster level mean)	1.153***	1.046**	1.369***	1.378***
	(2.81)	(2.52)	(3.16)	(3.18)

Table 3. Child Health Production Function Under Different Assumptions - Dependent Variable: Weight for Height *z*-score (Cont.)
(Robust *t*-statistics in Parentheses, Except otherwise Specified)

Variables	Method of estimation			
	OLS (1)	IV 2SLS (2)	Heckman/control function approach (3a)	(3b)
Control Function Variables				
Fertility residual			0.138*** (4.09)	0.186*** (4.5)
Fertility times its residual				-0.009** (-2.02)
Inverse of the mills ratio			-0.745*** (-11.73)	-0.744*** (-11.74)
Constant	-1.993*** (-5.56)	-2.535*** (-6.62)	-2.280*** (-5.7)	-2.309*** (-5.77)
R-squared/ Log pseudolikelihood	0.1338	0.1127	-9014.972	-9012.942
F-Stat [df; p-val]/ Wald chi2 [df; p-val]	38.68 [17, 4259; 0.000]	38.78 [17, 4259; 0.000]	718.87 [18; 0.000]	723.50 [19; 0.000]
ρ (correlation of child health with sample selection residual) [Std. Err.]			-0.605 [0.04]	-.605 [0.4]
σ (sigma of child health residual) [Std. Err.]			1.231 [0.02]	1.230 [0.02]
LR test of indep. eqns. (rho = 0): Chi2 test for ρ=0 [df; p-value]			37.76 [1; 0.000]	37.64 [1; 0.000]
Underidentification tests (Anderson canon. corr. LR statistic): Chi2 [df; p-value]		738.553 [0.000]		
Weak identification test: Cragg-Donald F-Stat [5% maximal IV relative bias]		267.461 [13.91]		
Sargan statistic (overidentification test of all instruments): Chi-sq [df; p-value]		5.407 [0.0670]		
Durbin–Wu–Hausman Chi2 test for exogeneity of the potential endogenous variables [df; p-value]		19.549 [0.000]		
Number of Observations	16346			
Uncensored observations	4277			
Number of clusters	461			

Source: Computed by author using the 2004 Cameroon DHS data set and STATA 10.1.

Notes: Coefficients and standard errors are adjusted for sampling weights and clustering. (·) implies t-ratios. ***, ** and * indicate 1%, 5% and 10% levels of significance, respectively. As correctly indicated by a reviewer, diarrhoea used as an explanatory variable here, might be one of indications for child health, as well as it could be a cause. As used in this paper, the prevalence of diarrhoea in a community is expected to increase the risk of an individual child registering poor anthropometric indicators.

In all specifications, mother's education appears to be potent in the production of better child health, while father's education is not. Mother's education captured at the community-level is also positive and significantly related to better child health. The negative and significant effect of the interaction between mother's and father's education suggest the absence of synergy between father and mother when seeking for child health technologies. Mothers that received the tetanus toxin and fathers whose main employment was agricultural correlate positively with child health. Incidences of diarrhoea relate negatively with better child health.

6. CONCLUSION

This paper attempted to empirically establish a link between maternal fertility choices and child health (weight-for height z-scores) using the 2004 Cameroon's DHS data collected by the government's statistics office. Specifically, the paper investigated the effect of parental education on maternal fertility and evaluated the response of child health to fertility. The Heckit/control function approach was the preferred econometric strategy as it purged parameter estimates of potential endogeniety, sample selection and unobserved heterogeneity biases simultaneously.

Results showed that women with twins have higher fertility and maternal fertility exhibited a negative and significant effect on child health. Mother's education at both household and community levels was found to be inversely related with maternal fertility, but consistent with the production of better child health. The negative and statistical significance of the interaction of mother's and father's education the estimated fertility demand model suggested some synergy in making fertility choices that are consistent with smaller family sizes, whereas the interaction between mother's and father's education in the estimated child health production model suggested the absence of synergy when seeking child health technologies that improve child health. This implies that in terms of child health, mother's education has a premium over father's education.

Moreover, education would increase the likelihood of mothers working outside their home, increase the productive value of their time, raise the opportunity cost of childbearing, and lead mothers to want to have fewer children. Having fewer children increases the returns from goods and services which are substitutes for children, such as education and health of their children (quality), which tend to reduce fertility by raising the demand for family planning services. The latter reduces fertility and uncertainty regarding the timing of births, and thereby assists them in planning their families, careers, and vocational training. Moreover, women who are relieved of the responsibility of bearing and rearing more unwanted children may be more likely to engage in self-employment activities which add to family resources and increase the opportunity value of women's time to other household activities. Women released from child care responsibilities may also increase their participation in women's groups, including microfinance organizations, and thus acquire productive assets to enhance their business opportunities.

To guide public policy, it is critical to distinguish among the various sources of household economic growth which do not appear to have the same effect on fertility, in particular, between income which flows from the human capital of the mother and father, and income which flows from stocks of physical capital, land and other natural resources. The former source would typically be consistent with lower fertility, whereas the latter source might be consistent with a larger sib size because it can actually raise the expected value of child labour to the parents. Moreover, agricultural employment correlated positively and significantly with fertility choices. Expanding public expenses on social services reaching poor households, such as education for all, preventive child health programmes, and family planning would accordingly reduce expect fertility and engender better child health, which initiates the process of better health and productivity in adulthood.

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