The Interaction Between Health & Fertility: Evidence from the Ivory Coast.

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Abstract

This paper looks at the interaction between parental investment in child health and fertility. There is evidence that health investment, in the form of vaccinations, has a negative association with fertility and lower fertility in turn encourages more investments in children. Unlike most of literature on the interaction between the quantity of children and parental investment, this paper looked at health investment (measured by vaccinations) as a measure of child "quality" rather than educational attainment.

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The ***Journal of Health and Population in Developing Countries (ISSN 1095-8940)***
is a publication of the Department of Health Policy and Administration, School of Public Health
University of North Carolina at Chapel Hill.

UNC
SCHOOL OF PUBLIC HEALTH
DEPARTMENT OF
HEALTH POLICY
AND ADMINISTRATION

Introduction

The latest *State of the World Report* by the United Nations Population Fund[1] calculates that developing countries can increase their annual economic growth rates by reducing population growth rates through lower fertility. The report asserts that in many East-Asian countries, lower fertility rate led to a lower dependency ratio, and this fostered savings and investments needed for economic growth. The key factors behind this "demographic dividend" are investments in health, education and gender equality. According to the report, as fertility declines, the working-age adult population increases relative to the young and the old. With a lower dependency ratio and investments in health and education, families were able to use this window to move out of poverty, and this led to faster economic growth. This population effect accounted for third of the economic growth of East-Asian countries, says the report.

According to the report, even though countries have only one chance to take advantage of this effect during their demographic transitions, many developing countries, especially in sub-Saharan Africa, have yet to reach that stage. If this assertion by the UNFPA report is correct, then investments in health and education in developing countries now take on more importance since their effect on economic growth may be larger than previously thought.

For countries to take advantage of this "population effect" on economic development, a better understanding of the effects of these investments and their ramifications on economic growth is needed. What kinds of health and educational investment are most effective? How do these investments affect incentives in the typical household in a developing country?

Countless studies have established the inverse relationship between the education and health of parents and their fertility[2]. Almost all have reached the conclusion that higher education leads to lower fertility by improving the social status of women, increasing awareness of reproductive health services and opening labor market opportunities. However, very few studies have looked at the interactive effects between the child "quality" and quantity and its effect on fertility decline in developing countries[3]. This model of fertility, originally developed by Becker and Lewis, differs from previous ones because it emphasizes the endogenous relationship between the quantity of children and their human capital (Becker and Lewis, 1973). Increased education for women does not always leads to greater participation in the labor market (thereby reducing fertility) but can lead to greater productivity at home through higher human capital investment in their children in the form of more schooling and better health. This higher investment (quality) increases the cost of having an additional child and may leads to a fall in the demand for children (quantity).

A few recent studies have investigated the effect of the interaction between quantity and quality on fertility decline. Most of this literature uses child schooling as proxy for child quality – ignoring investments in health. Using 1984 data from the Brazilian Statistical Bureau, Lam and Duryea (1999) found that as the level of education of women in Brazil rose, their wage rate increased. However, the increase in the wage rate was not accompanied by higher labor force participation rates. They explained this seeming contradiction by arguing that as the educational level of Brazilian women went up, not only did their market wages increase, but so did their reservation wages. The rising reservation wages diminished women's likelihood to enter the labor force. Therefore, they concluded that the decline in fertility could not have been caused by a higher labor force participation rate, since no such effect was observed.

This particular study highlighted the importance of quality-quantity interaction. If increases in their labor market wages did not lead to higher labor force participation of women, there must have been another effect in play. The increase in human capital from more education must have also led to higher productivity at home to cause a rise in reservation wages. The authors found that an increase in the

[1] UNFPA, *State of the World Population: People, Poverty and Possibilities*, December 2002
[2] See Ainsworth (1988), McCabe (1974), Shultz (1993), Vijverberg (1993) and Weinberger (1987)
[3] The model of quality and quantity interaction was formalized by Becker and Lewis (1973).

education of both parents is associated with decreased infant mortality and higher schooling for children and lower fertility. They concluded that instead of substituting her labor from the household into the labor market, the average woman actually used her higher productivity by investing in her children. In other words, higher education and wages of the parents must have led to changes in preferences towards higher "quality" children. Since higher quality children are very costly, this resulted in increasing the price of having an additional child, hence lower fertility.

Working with World Bank household data on Ivory Coast and Ghana, Kouame, Montgomery and Oliver (1995) estimated the quantity-quality interaction effect on fertility by using child schooling as a proxy for child quality. They found that higher schooling is associated with high fertility in Ivory Coast - the opposite of what is predicted by theory. A trade-off was only evident when they looked at the urban residents in that country. Despite controlling for the endogeneity of child schooling and fertility, this paper did not consider the parental investments in child health.

Ribero (2000) investigated quality-quantity interaction in Colombia. This paper also used child schooling as a proxy for child quality. As expected, there is a significant inverse relationship between the quantity of children and average child schooling. The author took into account the endogenous relationship between quality and quantity using instrumental variables. As in other studies that have looked at quality-quantity interaction, parental investment in child health was not taken into account in this study.

Using an input (schooling) as a proxy for an unobservable output (child quality) is most appropriate if there is a fixed input-output relationship across the relevant population (Behram, 1987). However, because of the disparity in access to schooling within many developing countries, the cost of child schooling (even for households within the same income bracket) is bound to differ. Therefore, the ubiquitous use of schooling as a proxy for child quality (and the neglect of health investments in children) may lead to significant understatement of the effect of quality-quantity interaction.

In this paper, I use child vaccinations as a measure of health investment from the Demographic and Health Survey to explore the effect of the interaction between quantity of children and quality in Ivory Coast. Immunizations against various infectious diseases provided by vaccinations are an important health investment. The benefits of these vaccinations go far beyond the immediate health benefits since they result not only in the prevention of thousands of deaths, but also free up valuable and limited resources usually devoted to caring for the sick.

Theory

Becker and Lewis[4] developed the first theoretical framework that explicitly models the interaction between quantity and quality and their effect on the demand for children. In this model, parents care not only about the number of children but the quality of those children as well. The household maximizes the following utility function

$$U = U(n, q, Z) \qquad (1)$$

where n is the quantity of children, q represent quality and Z represents a vector of other goods. The quality of each child in a household is assumed to be equal and is provided by the family with market and own resources. In other words, there is home production technology for quality and its inputs are time and market-purchased goods and services. Each family would face the following budget constraint[5]

[4] See Becker (1960, 1961, 1981), Becker and Lewis (1973), Willis (1973), Becker and Tomes (1976), and Tomes (1978)

[5] This budget constraint can be written as: Shadow Income, $M \equiv I + p_c nq = (p_c n)q + (p_c q)n + \pi_z Z = \pi_q q + \pi_n n + \pi_z Z$

$$I = p_c qn + \pi_z Z \qquad (2)$$

where I is income, π_z is the price of other goods Z, p_c represents the constant cost of a unit of child quality and q is the total quality of each child. Therefore $p_c qn$ represents the total amount of quality spent on all the children "produced" in the household. This budget constraint is nonlinear because the relationship between quantity (n) and quality (q) that enter the utility function is multiplicative, not additive. When the utility function (1) is maximized subject to the budget constraint (2), we get the following equilibrium conditions:

$$\left.\begin{aligned} \partial U/\partial n &= MU_n = \lambda p_c q = \lambda \pi_n \\ \partial U/\partial q &= MU_q = \lambda p_c n = \lambda \pi_q \\ \partial U/\partial z &= MU_z = \lambda \pi_z \end{aligned}\right\} \qquad (3)$$

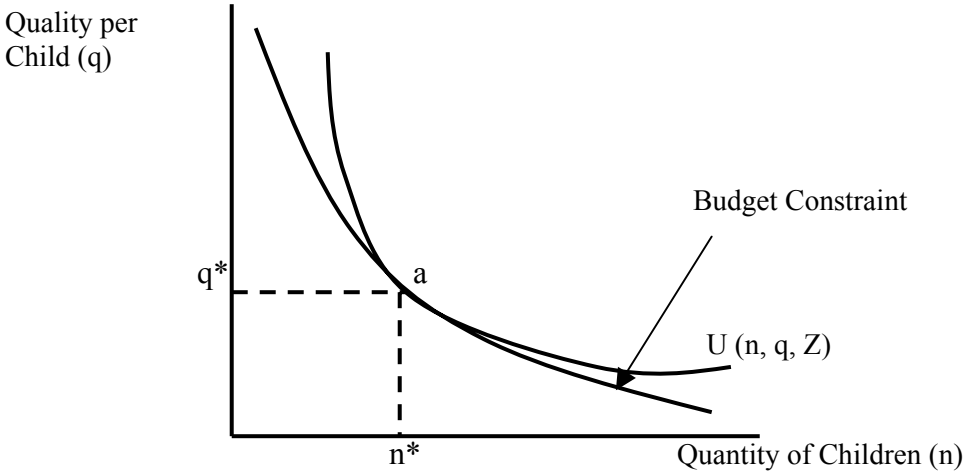
where λ is the marginal utility of income, $\pi_q = p_c n$ is the shadow price of quality and $p_c q = \pi_n$ is the shadow price of quantity. The shadow price of quality ($p_c n$) is the cost of increasing quality and the shadow price of quantity ($p_c q$) is the cost of increasing quantity. When quantity is increased, the price of quality rises and when quality is increased, the cost of quantity rises. With high quality children, it is very expensive to increase their quantity because it would require more time and income. So quantity and quality are simultaneously determined. From equation (3), we can write implicit demand functions for quantity of children (n) and quality (q):

$$n = d_n (\pi_n, \pi_q, \pi_z, M) \qquad (4)$$
$$q = d_q (\pi_n, \pi_q, \pi_z, M) \qquad (5)$$

where π_n, π_q and π_z are the shadow prices and M is the shadow income. An increase in quality of children (q) raises the shadow price of children and decreases the quantity (n) demanded and likewise, a decrease in quality reduces the shadow price of children and this leads to an increase in the quantity of children.

Parents with higher education will tend to have easier access to resources for their children. Therefore increased parental education has the effect of reducing the price of quality (p_c), which will lead to a higher demand for quality. The increased demand for quality will increase the cost of an additional child and thus, the quantity demanded for children falls.

Figure 1: Quality, Quantity and Preferences



An internal equilibrium similar to position "a" is only possible if *n* and *q* are not close substitute. If *n* and *q* were close substitutes, the curvature of the utility curve would approach that of budget constraint and this would result in corner solutions.

Empirical Model

The Becker and Lewis (1973) theory suggests quantity and quality are determined simultaneously, which can be modeled using the following simultaneous equations:

$$\boldsymbol{n}_i = \delta_0 + \delta_1 Age_i + \delta_2 Age_i^2 + \delta_3 Educ_i + \delta_4 Income_i + \delta_5 BirthControl_i + \delta_6 Girl\text{-}boy_i + \delta_7 Rural_i + \delta_8 Married_i + \delta_9 \boldsymbol{q}_i + \varepsilon_i \quad (6)$$

$$\boldsymbol{q}_i = \beta_0 + \beta_1 Age_i + \beta_2 Age_i^2 + \beta_3 Educ_i \ \beta_4 Income_i + \beta_5 BirthControl + \beta_6 \boldsymbol{n}_i + \beta_7 Rural_i + \beta_8 Married_i + \beta_9 Visithealthfac_i + \beta_{10} Childweight_i + \beta_{11} Childheight_i + \theta_i \quad (7)$$

where $\boldsymbol{n}_i$ is the total number of children ever born (quantity) to the *i*th woman and $\boldsymbol{q}_i$ is a measure of quality using the number of vaccinations received by the last child of the respondent. Age_i and $Educ_i$ denote the age of the respondent in years and the number of years of school attended respectively. $Income_i$ is a dummy variable indicating if the respondent earns labor wage, $Girl\text{-}boy_i$ is the number of girls as a percentage of total number of children of the respondent and $Rural_i$ indicates if the respondent lives in a rural area. $BirthControl_i$ represents the use of family planning methods or contraceptives, $Visithealthfac_i$ is the number of visits to a health center within the past 12 months, $Childweight_i$ is the weight of the respondent's last child and $Childheight_i$ is the height of last child. The expected values of both ε_i and θ_i are zero.

Since fertility decisions are usually made by women within the child-bearing age range of 15-49, one should expect the number of children born to increase with age but at a decreasing rate. The use of birth control can reduce unplanned children born and this should reduce fertility because a smaller number of children will be delivered through the reduction of unplanned births. The ideal variable to use in place of *BirthControl* would be the availability of family planning facilities or programs in the area. Unfortunately these data are not available in this sample. However, the use of contraceptives, especially in developing countries, is highly dependent on the family planning programs. While the use of contraceptive is endogenous, the presence of a facility is not and therefore *BirthControl* should be a good proxy.

Children can help on the farm and this will reduce their cost and increase their quantity demanded. Therefore families in rural areas should have higher fertility since farming is the main economic activity. Earning higher wages raises the opportunity cost of children and this should reduce fertility. However, if we assume that a child is a "normal good", higher income should increase fertility. Consequently, the effect of income on fertility is ambiguous.

Higher ratio of girls (*Girl-boy*) should increase fertility. A lot of evidence indicates that poor families in developing countries desire boys more than girls. This is explained by the fact that boys generally stay within the family and become a source of financial and other kinds of assistance, as the parents grow old. Other traditional (non-material) reasons may be behind this phenomenon and could be equally important. Assuming a household makes a fertility decision conditional on a certain proportion of boys and girls, there will be a higher demand for children if a disproportionate quantity of children delivered turned out to be girls. This variable (*Girl-boy*) does not appear in equation (7). Once children

are born to parents, increased investment in their well-being is highly unlikely to be altered because of an unexpected gender distribution[6].

The challenge is to estimate δ_9 and β_6 consistently, given the simultaneity of the two equations. A 2-stage Poisson estimation is used to achieve this task. Equations (6) and (7) are identified since both contain at least one variable that does not appear in the other. If there is a trade-off between quality and quantity, one should expect δ_9 in equation (6) to be negative.

The variables *Visithealthfac, Childweight$_i$, and Childheight$_i$* do not appear in equation (6). For a child to have access to vaccinations, the proximity of a health center or a visit to one is a necessity. The justification for excluding *Visithealthfac* from equation (6) centers on fact that most births in developing countries take place outside of a health facility. While the health of a baby will be positively influenced by delivery in a health facility, the total number of children born should not be.

The Poisson model is estimated using the maximum likelihood:

$$\text{Ln } L = \Sigma [-\mu_i + n_i * x_i\beta - \ln(n_i)!]$$

where

$$\mu_i = \exp(\delta_0 + \delta_1 Age_i + \delta_2 Age_i^2 + \delta_3 Educ_i + \delta_4 Income_i + \delta_5 BirthControl_i + \delta_6 Girl\text{-}boy_i + \delta_7 Rural_i + \delta_8 Married_i + \delta_9 \boldsymbol{q}_i + \varepsilon_i).$$

Data

All the data used in the paper come from the Demographic and Health Survey (DHS) funded by the United State Agency for International Development (USAID) through Macro International, Inc. The DHS program started in 1984 and collects data from select countries in Africa, Asia, Latin America, Caribbean, and the Near East. The data contains detail information on age, education, health, fertility, and household characteristics.

This particular data set comes from the 1998/99 survey of 3040 women between the ages of 15-49 in Ivory Coast. Within the sample, there are 973 women from rural areas and 2067 from urban areas. Only 1013 of these women have children born within the last three years and from this subgroup, 424 live in the rural areas and 589 in urban areas. Table 2 gives summary statistics of the key variables.

Because of some limitations within the data collected, several variables suggested by the model are not available. The incomes of both parents are not available but the variable *currently working* is used as a proxy for labor income. Not many household characteristics are available and consequently, it is not possible to estimate the effect of non-labor income. Similarly, the number of vaccinations given to the last child of the respondent serves as the proxy for child 'quality'. The data did not indicate if the vaccinations received were subsidized or paid in full by the parents. However, that does not diminish the importance of this variable as an appropriate proxy for 'quality'. The time and resources used by parents to obtain such services have an opportunity cost. In other words, the parents could have performed other valuable services with their time instead of spending hours to get to the nearest health center. Therefore, since every parent wants a healthy and a living child, this variable becomes a very important input to child quality.

[6] If the dependent variable in equation (7) were the amount of schooling received by child, then the gender of child would be an important variable in this equation. Parents may discriminate between boys and girls in terms who receives education but the lack of essential vaccination is a matter of life and death.

Table 1: Descriptions of Key Variables

VARIABLE	DEFINITION
Fertility	Total number of children ever born by respondent
Age	The age of the respondent in years.
Education	The number of years of education
Visited Health Facility	Dummy variable = 1 if the respondent visited a health center within the past 12 months.
Birth Control Use	Dummy variable =1 if the respondent used any contraceptive method within the last three years.
Girl-Boy	The percentage of children of the respondent who are female.
Currently Working	Dummy variable = 1 if the respondent has worked within the past 12 months. This variable is a proxy for income.
Vaccinations Received by Child (proxy for child quality)	Of the four vaccinations recorded (polio, measles, Tuberculosis, DPT[7]), the number given to respondent's last child.
Married	Dummy variable = 1 if the respondent is married.
Polygamous	The number of co-wives if the respondent is in a polygamous marriage.

Results

Table 3 presents the regression results from equation (6). The table is divided into two columns: one controlling for endogeneity with a two-stage Poisson estimation and the other estimated separately. Most of the parameter estimates have the expected signs. The number of children born is positively correlated with age but at a decreasing rate. At the average age of 27.08, an additional increase in age leads to 0.23 increase in fertility. This effect of age on fertility is virtually the same irrespective of the location of the woman. Fertility rises with age until 47 when it begins to fall. An additional year of education reduces fertility by 0.98.

Women in polygamous marriages tend to have higher fertility. The presence of a co-wife increases fertility by one child. This could be explained by many factors. First of all, a man who chooses to marry more than one wife is less likely to worry about size of his household. If this plays a key factor in this sample, then this variable will be endogenous to a household fertility decision. This would also mean that the woman has little or no control over her own fertility. It could also be the case that the presence of co-wives induces competition among wives. Having more children could lead to a cementing of the wife's relationship with the husband and make divorce or estrangement less likely. Which of these effects is more dominant is beyond the scope of this paper but nevertheless; policies that increase the cost of polygamy should have a negative effect on fertility. Birth control use is significant and but has a positive effect on fertility. Instead of being a good proxy for the availability of family planning programs, this result is most likely indicating the endogeneity of contraceptive use in a woman's fertility decision.
The results from this model show no support for the claim that families discriminate against young girls in Ivory Coast. The variable *Girl-Boy,* while showing a negative effect on fertility, is insignificant. In other words, controlling for other variables, women do not seek more children to increase the likelihood of having more boys. This does not mean that parents would not favor boys over girls because there is no argument here against the possible claim of parental favoritism towards boys over girls among children already born.

[7] DPT stands for Diphtheria, Pertussis (whooping cough), and Tetanus. It is a single vaccination shot that protects against all these three diseases.

Table 2: Data Summary – averages with standard deviations in parenthesis.

	Total	Level of Education		Location	
	Sample	WITH ABOVE PRIMARY EDUCATION	WITH PRIMARY OR LESS EDUCATION	RURAL	URBAN
Age	27.08	25.26	27.55	28.36	26.48
	(9.2)	(8.10)	(9.42)	(9.63)	(8.94)
Education	3.57	10.24	1.79	1.81	4.40
	(4.24)	(2.48)	(2.50)	(2.89)	(4.52)
W/ above	0.21	--	--	0.06	0.28
Primary educ.	(0.41)			(0.23)	(0.45)
Household Size	9.91	9.17	10.11	10.96	9.42
	(6.68)	(5.38)	(6.97)	(7.36)	(6.28)
Fertility	2.49	1.29	2.81	3.25	2.14
	(2.75)	(1.97)	(2.84)	(2.94)	(2.59)
Married	0.65	0.42	0.71	0.77	0.59
	(0.48)	(0.49)	(0.45)	(0.42)	(0.49)
Polygamous	0.43	0.15	0.47	0.58	0.34
	(0.79)	(0.44)	(0.82)	(0.95)	(0.66)
Girl-Boy	0.51	0.50	0.51	0.51	0.51
	(0.35)	(0.39)	(0.35)	(0.34)	(0.36)
Currently	0.69	0.46	0.75	0.89	0.60
Working	(0.46)	(0.49)	(0.43)	(0.32)	(0.49)
Rural Dummy	0.32	0.09	0.38	--	--
	(0.47)	(0.29)	(0.49)		
Birth Control	0.51	0.79	0.44	0.37	0.58
Use	(0.49)	(0.41)	(0.49)	(0.48)	(0.49)
Visited Health	0.56	0.65	0.53	0.48	0.59
Facility	(0.49)	(0.47)	(0.49)	(0.49)	(0.49)
Vaccinations	3.12	3.75	3.02	2.75	3.36
Recd. For Child	(1.40)	(0.56)	(1.46)	(1.50)	(1.27)
Sample Size	3040	638	2402	973	2067

The measure of quality in this estimation is the number of vaccinations received by the respondent's last child born within the last three years. The coefficient has the expected negative sign and is highly significant, indicating that an increase in vaccinations (quality) leads to less fertility (quantity). This shows a trade-off between quality and quantity.

The theory states the quantity of children and quality are chosen simultaneously. The coefficients of quality (vaccinations) changes from -0.0326 when endogeneity of quantity and quality is not taken into consideration to -0.1783 when a 2-stage Poisson estimation is used to account for this endogeneity. In addition, the incremental effects of other variables change as well. This difference in the coefficients gives clear evidence that there is indeed a trade-off between quantity and quality. Furthermore, it supports the hypothesis in this paper that investment in child health is an important input in child quality.

Limitations with the data prevented the direct estimation of the effect of parental income on quality-quantity interaction. The proxy for income is a dummy variable of parents who are currently earning income through work. This variable is statistically insignificant. However, the most likely reason why income in this model is insignificant is that the identification of working parents (with no indication on variation in income) may not be a good proxy for labor income.

Table 3: Results (standard errors are in parenthesis) with Equation (6). The dependent variable is fertility, n (number of children ever born)[8].

	COEFFICIENTS	
	2-Stage Poisson Estimation[9]	Poisson Estimation (no endogeneity between n and q taken into account)
Age	0.2068***	0.2060***
	(0.0177)	(0.0173)
Age^2	-0.0022***	-0.0022***
	(0.0003)	(0.0003)
Education	-0.01659**	-0.0238***
	(0.0058)	(0.0056)
Birth Control Use	0.0855**	0.0114
	(0.0391)	(0.0367)
Polygamous	0.0328**	0.0402**
	(0.0165)	(0.0164)
Currently Working	0.0476	0.02409
	(0.0431)	(0.0421)
Rural	0.0451	0.01298
	(0.0369)	(0.0347)
Girl-Boy Ratio	-0.0599	-0.0592
	(0.0539)	(0.0526)
Vaccinations (q)	-0.1783***	-0.0326***
	(0.0299)	(0.0116)
Constant	-2.5855***	-2.6566***
	(0.2936)	(0.2801)
R^2	0.2326	0.2260
N	1013	1049
Log Likelihood	-1788.8553	-1864.076

***significant at the 1%; * *significant at 5%; * significant at 10%

Table 4 breaks down the results into the locations and the educational level of the woman. The effect of education is significantly different between rural and urban women. While education is insignificant for rural women in this sample, an additional year of schooling reduces the fertility of urban women by almost 1 child. This finding is not surprising and is consistent with other fertility studies done on Ivory Coast (Ainsworth, 1988). The insignificance of schooling on fertility among rural women could be explained by their low level of schooling. Polygamy has a strong effect for women with little or no education. This particular result shows one of many avenues where increased education can indirectly reduce fertility.

The magnitude of the trade-off between quantity and quality changes a little when the sample is categorized but still stays significant. This trade-off is stronger among urban women than rural women by 7%. Categorizing the sample into education level also shows some interesting results.

[8] The *Married* variable is dropped from this regression because of perfect collinearity with *Polygamous* variable. Every women in a polygamous relationship is married.
[9] Predicted values of the variable *Vaccinatioins(q)* were obtained from equation (7).

Conclusion

This paper has presented an empirical model to estimate the effect of the quality and quantity interaction on the demand for children in Ivory Coast. Most of the results support traditional determinants of fertility. The importance of parents' education on fertility cannot be overemphasized. An additional year of schooling reduces the number of children by almost one. On the other hand, polygamy and rural residency have positive effects on fertility.

The results show evidence for the quantity-quality interaction determinant of fertility. Higher investment in child health (in the form of vaccinations) has a negative effect on quantity of children born. Using 2-stage Poisson estimation and contrasting it with a model with no control for endogeneity between quality and quantity shows further evidence on the hypothesis of this paper. This trade-off remains significant and constant irrespective of the women's level of education or whether they live in rural or urban areas.

A significant contribution of this paper is that investment in child health by parents is a key input of child quality. This has been demonstrated by the significance of the negative effect of vaccinations on fertility. For developing countries with poor health facilities, vaccination is a very cost effective strategy for combating infectious diseases. According to UNICEF statistics, there has been a general increase in the rate of child vaccination in developing countries but this trend has started to level off, particularly in Africa. Several countries in Africa have actually experienced a decline in the amount of immunization given to infants. For example, DPT (diphtheria, pertussis, and tetanus) immunization in Africa rose from 16% in 1980 to 56% in 1990 but fell to 46% by 1999 (in Ivory Coast in 1998, only 70% of children received DPT)[10]. With vaccinations, thousands of lives can be saved annually and limiting resources devoted to treating the sick. Studies that fail to incorporate this aspect of child quality leave out one of the significant means through which higher productivity of parents (in terms of health investments) leads to lower fertility. An appreciation of this relationship should also help prepare developing countries in exploiting the "population effect" of economic development.

[10] UNICEF (2002)

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