Evidence for a Non-Linear Effect of Child Mortality on Fertility Behaviors: Micro Data from a Senegalese Rural Community

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Abstract

The present paper examines the relationship between child mortality and fertility at the micro level. Empirical analysis of both gross and net effects of child mortality on fertility is carried out. We use individual data collected quarterly within the Demographic Surveillance System of the rural community of Niakhar (Fatick, Senegal). Complete birth histories of 2884 women born between 1931 and 1962 are analyzed. The determinants of fertility are investigated using a standard Poisson Regression Model. Among other specifications, fractional polynomial transformations of the child mortality variable are used in order to capture the potential non-linear nature of the relationship. The global impact of child mortality on total and net fertility is found to be positive. To our knowledge, this is the first paper providing evidence for the *child survival hypothesis* - an effect of child mortality on net fertility - at the micro-level. We further show that the response is non linear in the level and in the rate of child mortality. More specifically, an inverted-U shaped relationship between child mortality rates and total and net fertility is exhibited. The main policy implication is that, along with health outcomes and child survival improvements, health policies aiming at reducing child mortality have additional desirable effects on fertility behaviors.

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1. Introduction

Sub-Saharan Africa (SSA) has long been trapped in a Malthusian crisis characterized by a high mortality and high fertility. However, mortality rates have fallen steadily in a significant number of SSA countries from the 1950's, and life expectancy is projected to increase. Concurrently, fertility rates are remaining markedly high. 39 out of the 55 African countries are exhibiting high current fertility levels (United Nations, 2011). Nonetheless, studies reveal that even though some component of fertility arise from an unmet need for family planning, its largest share is actually desired by households (Bongaarts, 2011).

This phenomenon results in a rapid population growth and a high demographic pressure. With regard to demographic transition theories, everything happens as if most countries in SSA was were still at the early stage of the transition (Bongaarts and Casterline, 2013). As matters stand, it seems that the relationship between child mortality and fertility is not as straight-forward as usually stated in traditional demographic theories. The attempt of this paper is to conduct an in-depth quantitative analysis of this relationship in order to provide a better understanding of the actual state of affairs.

The explanation brought by our results is that for child mortality to robustly impact fertility behaviors, the decline should be steeper than the one experienced in SSA so far.

Although infant and child mortality rates are declining continuously since the 1950's, progress have been slower in the past two decades (United Nations, 2012).[1] In line with this statistical evidence, we show that the highest individual-level fertility rates are essentially associated with relatively low values of child mortality.

Hence, alongside traditional family policies which only reduce the undesired component of fertility, it appears than more effort should be made in order to pursue and accelerate the decline in infant and child mortality rates.

2. Background and existing studies

The Demographic Transition literature can be broadly divided into two parts - following the classification provided by Bleakley and Lange (2009).

On the one hand, the *innovation approach* postulate that variations in fertility rates are only correlated to changes in the access to family planning and moral attitudes toward contraception. On the other hand, the *adjustment* approach consider

[1] Contrastingly, the decline of infant and child mortality that have preceded the demographic transition in Europe and the rest of the industrialized world has been faster and sharper on average (Corsini and Viazzo, 1997).

fertility as a choice variable rather than an implicitly-imposed constraint. Households are expected to change their fertility behavior according to the socio-economic context faced in daily life which can change incentives for child-bearing. We argue throughout this paper that the *adjustment* approach is the one that prevails in explaining current fertility trends in SSA.

The availability of family planning services is crucial for the fertility transition to occur. Increased use of modern contraception is obviously strongly associated with fertility decline. In developing countries, knowledge about the availability of methods to delay or avoid a pregnancy is now quite widespread. However, better levels of knowledge are far from being associated with higher use. Cleland et al. (2011) report that progress towards adoption of contraception has been dramatically slow. Access to contraceptives, though improving, is still relatively limited, and attitudinal resistance remains a severe barrier.

But if fertility is volitional, to what extent do the households adjust their behavior in a context of low child survival probability ?

Concerning the relationship between child mortality and fertility, the demographic literature usually points out two strategies which are supposedly incompatible.

The *replacement hypothesis* posits that households have additional children to replace the ones that they lose, involving a targeted number of children chosen by parents. Thus, they react to a child's death by replacing that child, and as a result, mortality directly affects fertility rates.[2]

The *child survival hypothesis* (also known as the *hoarding motive*) suppose an effect of child mortality on net fertility rates (the number of survivors). Indeed, households would generate a precautionary demand for children in order to ensure a sufficiently large family size. This theory predicts that an environment where child mortality is high will lead to disproportionately high fertility and population growth rates.

There is a lack of micro-level empirical studies to test quantitatively these two hypothesis. This is due to the lack of data availability. The demographic and epidemiological monitoring of the population of Niakhar allows us to investigate empirically this decisive research question.

3. Data: Niakhar Demographic Surveillance System

The rural community of Niakhar is located in the Fatick region of Senegal, 135 km east from Dakar. A Demographic Surveillance System has been set up in 8 villages

[2]One can argue that replacement strategy could not be perfect because of physiological limits such as birth spacing, breastfeeding period or limited fecundity.

since 1962, and has been extended to 22 more villages in 1983.[3] Since 1983, the geographical boundaries of the study zone comprehends a total area of 230 km^2 and encompasses 30 villages.

Niakhar is Africa's oldest and still operational statistical observatory, and world's second-oldest (after Matlab, Bangladesh). This is a fairly representative rural West African setting, and the study population is relatively homogeneous in terms of socio-economic characteristics.

The Serer ethnic group comprises 96.5% of the population. Islam and Christianity are the main religions, representing respectively 76% and 21% of the population. The major cause of migration in seasonal migration to Dakar, the closest major urban center, for economic motives. Agriculture is the main activity, and formal education is very low. Villages are subdivided into hamlets, which are themselves subdivided into compounds. Compounds are constituted of one or more "kitchens" (households) which bring together members of the extended patrilineal family. The average household size is approximately 10 persons.[4] There are large variations between households regarding both fertility and child mortality rates. Hence, it is a convenient setting to analyze the relationship between both variables.

At the onset of the DSS, major life events such as birth histories were collected retrospectively, as a baseline, among the inhabitants of the area. The DSS consists in quarterly exhaustive surveys within the study zone. Data on all demographic events are systematically recorded. These events include pregnancies, deaths, marriages, migrations (inside or outside the study area), as well as changes in social characteristics. And it is worth noticing that such events are also being retrospectively and then systematically collected among the immigrants as they enter the study zone. Accounting of pregnancies is practically comprehensive as a result of the quarterly follow-up, and data on mortality events and causes of death via verbal autopsy (following World Health Organization standards) are thoroughly reliable. Altogether, this results in an exhaustive and systematic monitoring of the study population.

Alongside the systematic collection of data, several cross-sectional surveys were conducted for specific purposes. This study uses a cross-sectional survey conducted in 2003 to derive economic characteristics of households which remained supposedly path-dependent until the mid 2000s. In this survey, non-monetary data on living and economic conditions were collected in an exhaustive manner, which allows us to estimate measures of multidimensional poverty. More specifically, we estimate an index of deprivation in living standards. The dimensions taken into consideration are access to electricity, type of sanitation facilities, source of drinking water, type of cooking fuel, possession of certain assets, and flooring material of housing. This index has been calculated following the methodology outlined in Alkire and Santos (2010), which is one of the international standards for the measurement of multidi-

[3]Niakhar DSS has originally been set up and is still maintained by the *Institut de recherche pour le développement* (IRD).

[4]See Delaunay et al. (2002) for more information about the study zone.

mensional poverty with non-monetary data.

Sample screening : The extensive data collection time period (from 1962 to 2010 given our last database extraction) allows us to conduct an individual analysis on complete fertility. We analyze the complete birth histories of 2884 women born between 1931 and 1962. The sample is left censored because of data requirement, and is right censored as the fecund period is usually assumed to last from 15 to 49 years old.[5] The analysis does not include women who died before ending their fertile period. Furthermore, the study is zero-truncated, as it excludes *nulligravidas* - women who have never been pregnant, but not necessarily *nulliparas* - women who never gave birth.[6]

For the sake of simplicity, we will denominate total fertility rate (TFR) the number of times a woman has been pregnant (her obstetrical history, i.e., *gravidity*) and net fertility rate (NFR) the number of her children who survived to age 5. These will be the two dependent variables used in the different model specifications. Descriptive statistics of the variables used in the different model specifications are presented in Table 1. We present in the next section the methodology used in the study to explore the link between child mortality and fertility.

4. Model specifications

Obstetric and birth histories are typical count data. Consequently, we need a model that allows us to capture the discrete and non-negative nature of the two dependent variables (TFR and NFR). The use of an inappropriate model to estimate fertility outcomes can lead to serious drawbacks (Winkelmann, 2008). However, suitable models feature in a scarce number of empirical applications.

Winkelmann and Zimmermann (1994) indicate that the mean-variance equality of the standard Poisson Regression Model often have to be rejected due to the recurrent presence of under-dispersion among fertility data. But this is particularly true for data from developed countries, and this is not the case for our study.[7]

We thus estimate a standard Poisson Regression Model for the determinants of fertility. Let the count outcome y_i - alternatively the TFR and NFR of a woman i, be a Poisson random variable. Hence :

[5]Following United Nations standards.

[6]The drivers of fertility are obviously not the same as the factors determining infertility. Moreover, infertility is uncommon in the study area (Ronsmans et al., 2001).

[7]Negative Binomial Regression Model and Generalized Poisson Regression Model have also been tested

Table 1: Descriptive Statistics

	Mean	Standard deviation
Complete Fertility (Total)	5.59	2.80
Complete Fertility (Net)	4.90	2.43
Child Mortality Level (0-5 years) (per woman)	.70	1.06
Child Mortality Rate (0-5 years) (per 1,000 live birth)	112	155
Mother's age at first birth	22.85	5.44
	Percentage	
Religion		
Islam	76.01	
Christianity	20.98	
Atheism and traditional religions	3.02	
Marital status in the household		
Wife of the household head	56.73	
Other link	43.27	
Living Standards		
Extremely deprived	3.09	
Less deprived	96.91	
Activity		
Housewife	88.18	
Maid	0.97	
Active	10.85	
Household head education		
None	86.93	
Primary and religious school	11.34	
Higher	1.73	
N	2884	

$$Pr(y_i|\mu_i) = \frac{e^{-\mu_i}\mu_i^{y_i}}{y_i!} \quad \text{for } y = 0, 1, 2...^8$$

$$\text{where } \mu_i = E(y_i|X_i) = e^{X_i\beta} \text{ and } Var(y_i) = \mu_i$$

X_i is the vector of covariates of woman i.

A first series of model specifications features the TFR as dependent variable, and a second one the NFR. The explanatory variables include all individual-level determinants of fertility identified in the demographic and economic literature.

We include measures of educational attainment and women's employment in the same regressions as their coefficient of correlation is surprisingly very low. We thus except both variables to have a specific impact on fertility rates.

In order to emphasize the heterogeneous effects that might have child mortality on both TFR and NFR, different model specifications are estimated.

Model 1 aims to capture the *global effect* of child mortality on the two dependent variables. For that purpose, child mortality is introduced as a binary variable for having experienced a child death.

The *level effect* of child mortality is analyzed in Model 2 and Model 3. The former features four categories of women given the level of child mortality at the end of their fecund period (0, 1, 2 and 3 or more). The latter introduces child mortality level as continuous using fractional polynomial transformations of the variable. This allows us to capture the potential non-linear nature of the relationship between the level of child mortality and fertility.[9]

Finally, Model 4 and Model 5 investigate the *rate effect* of child mortality, measured at the individual level (number of child losses divided by the dependent variable). The variable is categorical in Model 4, with four classes : women with a child mortality rate equals to 0, between 0 and 0.2, 0.2 and 0.3, and higher than 0.3. Fractional polynomial transformations of child mortality rate are used in Model 5.

All the other explanatory variables remain unmodified across all specifications.

5. Results

Regression results are presented in Table 2. Coefficients have to be interpreted as incidence rate ratios (IRR).

Figure 1 shows that both TFR and NFR are well estimated, as observed and predicted probabilities are close, their differences lying in a relatively small interval (-0.5 ; 0.5).

[8] Recall that $y = 0$ is only possible for NFR.

[9] Transformations are specified in the Annex.

Table 2: Exponentiated coefficients from Poisson Regression Models of Total and Net Fertility

	Total Fertility					Net Fertility				
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 1	Model 2	Model 3	Model 4	Model 5
main										
Child Mortality										
Global effect										
Child Mortality dummy	1.470***					1.116***				
	26.03					6.79				
Level effect										
Child Mortality (level) categories (ref. = 0)										
1		1.357***					1.142***			
		17.93					7.15			
2		1.549***					1.133***			
		23.43					5.60			
>= 3		1.702***					1.011			
		27.02					0.39			
Continuous: Fractional polynomial transformations of Child Mortality (level)[1]										
CML1			0.538***					3.989***		
			-21.73					8.45		
CML2			1.001**					0.643***		
			2.61					-8.06		
Rate effect										
Child Mortality (rate) categories (ref. = 0)										
<= 0.2				1.510***					1.290***	
				25.30					15.08	
<= 0.3				1.517***					1.119***	
				20.43					5.53	
> 0.3				1.345***					0.761***	
				12.60					-10.11	
Continuous: Fractional polynomial transformations of Child Mortality (rate)[1]										
CMR1					0.000***					0.269***
					-10.19					-9.33
CMR2					0.000***					0.510***
					-10.27					-9.74
CMR3					0.096***					0.922***
					-10.36					-10.00
CMR4					0.000***					0.012***
					-10.06					-16.19
Religion (ref. = atheism and traditional religions)										
Islam	1.078+	1.094*	1.090*	1.074+	1.073+	1.101*	1.098*	1.101*	1.074+	1.077+
	1.92	2.33	2.23	1.84	1.85	2.14	2.08	2.16	1.68	1.78
Christianity	1.070	1.089*	1.087*	1.062	1.070+	1.103*	1.098*	1.099*	1.062	1.074+
	1.64	2.10	2.05	1.46	1.67	2.08	1.99	2.01	1.34	1.65
Marital status in the household										
Wife of the household head	1.224***	1.214***	1.215***	1.222***	1.216***	1.241***	1.244***	1.243***	1.240***	1.227***
	12.77	12.36	12.44	12.74	12.68	12.29	12.44	12.40	12.93	12.77
Living Standards										
Less deprived	0.930+	0.943	0.945	0.926*	0.929+	0.950	0.946	0.944	0.927+	0.935
	-1.83	-1.54	-1.52	-1.96	-1.84	-1.16	-1.25	-1.31	-1.86	-1.63
Activity (ref. = maid)										
Housewife	1.312**	1.265**	1.267**	1.306**	1.267**	1.293*	1.303**	1.305**	1.277**	1.242*
	2.97	2.65	2.66	2.98	2.81	2.54	2.60	2.62	2.70	2.51
Active	1.282**	1.244*	1.246*	1.272**	1.237*	1.274*	1.281*	1.283*	1.247*	1.216*
	2.66	2.40	2.42	2.63	2.46	2.35	2.38	2.40	2.37	2.20
Household head education (ref. = none)										
Primary and religious school	1.087***	1.094***	1.095***	1.083***	1.075***	1.110***	1.106***	1.105***	1.089***	1.076**
	3.84	4.15	4.20	3.67	3.36	4.39	4.25	4.21	3.71	3.26
Higher	1.167**	1.199***	1.195***	1.161**	1.101+	1.225***	1.218***	1.220***	1.183**	1.111*
	3.12	3.62	3.54	3.03	1.95	3.76	3.68	3.74	3.29	2.07
Maternal age										
Mother's age at first birth	0.956***	0.956***	0.956***	0.957***	0.958***	0.952***	0.952***	0.952***	0.956***	0.958***
	-30.12	-30.14	-30.17	-29.26	-28.57	-29.48	-29.67	-29.83	-28.31	-27.79
Constant	8.432***	8.458***	15.675***	8.353***	0.000***	8.801***	8.835***	3.445***	8.638***	103.880***
	19.24	19.87	25.66	19.45	10.41	17.66	17.62	7.20	19.19	16.48
statistics										
Chi2 (df_m)	2775.798 (10)	3137.949 (12)	3094.705 (11)	2886.694 (12)	2067.48 (13)	1567.753 (10)	1601.742 (12)	1621.567 (11)	2188.712 (12)	3928.164 (13)
Pseudo R2	0.138	0.143	0.144	0.140	0.145	0.090	0.091	0.092	0.109	0.122
Log likelihood	-6157.942	-6121.921	-6120.748	-6147.852	-6113.243	-6050.566	-6043.731	-6039.678	-5925.714	-5842.137
AIC	12337.884	12269.842	12265.495	12321.703	12250.486	12123.132	12113.462	12103.355	11877.429	11712.275
BIC	12403.521	12347.412	12337.099	12399.273	12322.090	12188.768	12191.032	12174.959	11954.999	11795.812
N	2884	2884	2884	2884	2884	2884	2884	2884	2884	2884
deviance										
Residual df	2873	2871	2872	2871	2870	2873	2871	2872	2871	2870
Deviance goodness-of-fit	2409.223	2337.180	2334.834	2389.042	2319.825	2555.283	2541.613	2533.507	2305.580	2138.426
(1/df) Deviance	.8386	.8141	.8130	.8321	.8080	.8894	.8853	.8821	.8031	.7451
Pearson goodness-of-fit	2320.109	2255.824	2252.961	2306.306	2236.969	2436.612	2422.589	2416.121	2213.661	2060.850
(1/df) Pearson	.8076	.7857	.7845	.8033	.7792	.8481	.8438	.8413	.7710	.7181

t statistics in brackets

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[1] Transformations are specified in the Annex

Figure 1: Observed and Predicted Probabilities from Model 5 for each value of the two dependent variables

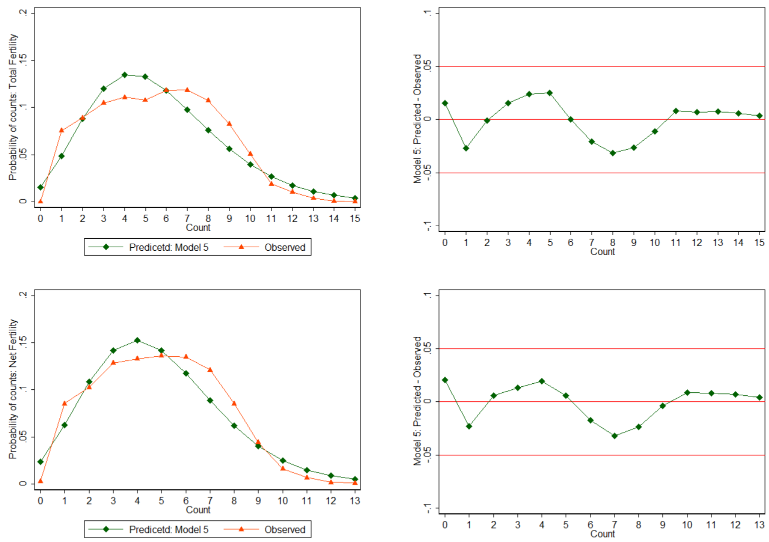
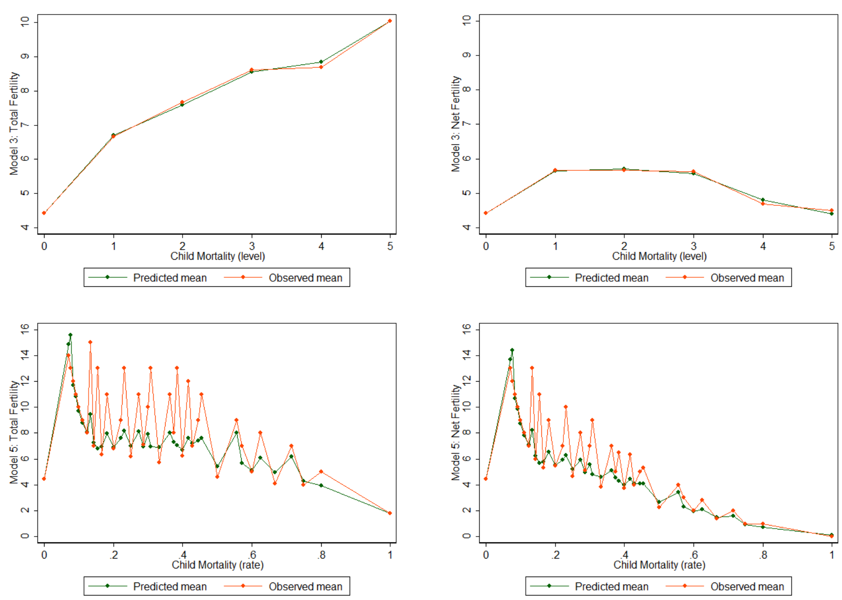


Figure 2 focus on the relationship between child mortality and fertility and shows that average predicted counts given all values of child mortality are accurately estimated.

Figure 2: Average predicted values vs Average observations given all values of Child Mortality from Model 3 and Model 5



Before interpreting coefficients attached to child mortality in the different model specifications, we present the results regarding the other covariates, as their magnitude and significance hardly change across specifications.

As reported in most studies on the determinants of fertility, religion is found to have an impact on fertility, as Muslim and Christian women exhibit higher fertility rates than women having a traditional religion or being atheist.

Marital status within the (extended) family is an important determinant of fertility. Indeed, we found that women married to the household head have a fertility rate that is roughly 1.2 times higher than that of women who are not.

Women belonging to less deprived households have lower fertility rates in comparison with extremely deprived ones (i.e., deprived in each and every dimension of the calculated index).

Not surprisingly, women's activity play an important role in determining their fertility. The reference group being women who were maids, we find that housewives have higher fertility rate. However, there is no significant difference in fertility rates between housewives and other active women.

Household's head educational attainment appears to be negatively associated with fertility rates. And mother's age at first birth is also negatively associated with fertility rates.

Let's now analyze the results regarding the effect of child mortality.

Model 1 reports a positive global impact of child mortality on total and net fertility, in line with other empirical studies. More precisely, we find that women who have experienced at least one child death have a total fertility that is 1.47 times higher than women who have not. Such an increase is proved to be larger than the one needed to replace lost lives, as net fertility is also 1.12 times higher.

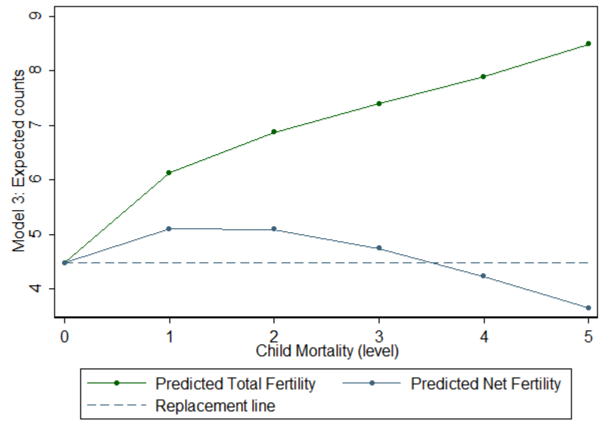
Furthermore, Model 2 seems to indicate that the relationship between child mortality level and fertility may have a non-linear nature. Indeed, women that have experienced 3 or more child deaths have a TFR 1.7 times higher than women who have not lost any child, but their NFR are not significantly different.

In order to confirm this result, we analyze the estimates of Model 3 (featuring fractional polynomial transformations of child mortality levels). As we cannot interpret the coefficients directly from the regression table, the analyze shall be made graphically. Figure 3 gives predicted values of Model 3 for TFR and NFR given all levels of child mortality.

We clearly see that, although the TFR is continuously increasing with the level of child mortality, this increase is insufficient to compensate for lost lives when child mortality levels keep increasing. Women exhibiting the highest NFR are the ones who have experienced relatively low levels of child mortality (i.e., one child loss).

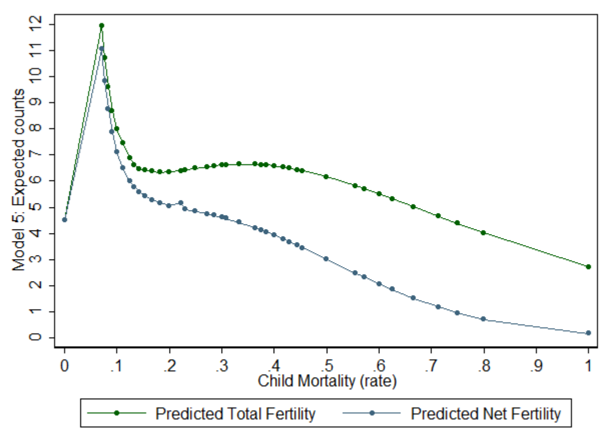
Model 4 and Model 5 are similar to the previous ones in all respects except that they feature child mortality as individual-level rates. This allow us to capture the net effect of child mortality on fertility, as an offset may artificially inflate the coef-

Figure 3: Predicted values from Model 3 for Total and Net Fertility given all levels of Child Mortality



ficients when child mortality is introduced in level. The results remain unchanged, as showed in Figure 4.

Figure 4: Predicted values from Model 5 for Total and Net Fertility given all rates of Child Mortality



6. Discussion

Before focusing on the relationship between child mortality and fertility, let's analyze the results for all other covariates. Recall that are included as controls all the determinants of fertility as identified in the demographic and economic literature.

In all regressions, coefficient estimates for the variable capturing households' economic characteristics seem to lead to an apparently counterintuitive conclusion, as women belonging to less deprived households tend to have higher fertility. The link between economic development and fertility is at the heart of demographic transition theories, and a very rich empirical literature provides evidence of a negative cross-country relationship between fertility and growth, for instance in Ahituv and Moav (2003). However, studies using long-run historical data (Lucas, 2002) and studies which do not assume a linear functional form of the income-fertility relationship (Strulik and Sikandar, 2002) clearly show that the relationship is actually an inverted-U shaped one. Hence, a positive income-fertility relationship is likely to arise within high poverty contexts. Among theses settings, households experiencing improvements in economic characteristics will first tend to have higher fertility rates than extremely deprived households. Theoretical explanations for this statistical evidence have also been brought, for instance in Tabata (2003). More specifically, Morand (1999) provides a theoretical framework to explain why households stuck in a poverty trap tend to have more children when their income increases. All in all, the result brought by our study concerning the relationship between living standards and fertility is coherent with the literature previously mentioned, as rural Senegal is still stuck in a poverty trap.

We also examined the potential effect of women's employment on fertility. Not surprisingly, we found that women who were maids ended their reproductive life with significantly lower fertility rates than housewives and other active women. The fact that there is no significant difference in fertility rates between these last two groups is certainly due to the nature of Niakhar's economy, as women reported as housewives dedicate their time to household's agricultural production activities.

As expected, the coefficient estimate for mother's age at first birth has in all specifications an unambiguous positive impact on fertility rates. This result supports the pursuit of family planning policies to delay the timing of entry into reproductive life in developing countries.

Among the various determinants of fertility, education has drawn the most attention among demographers and economists, and a consensus seems to have emerged regarding the education-fertility relationship: increased education is likely to raise the cost of childbearing and thus reduce fertility (Rosenzweig and Schultz, 1989). In our study, however, household's head educational attainment appears to be positively associated with fertility rates. This result shall be interpreted in the same vein as the one regarding living standards, as the education-fertility relationship may be more complex than a purely linear one. Indeed, education does not have identical repercussions in every society (Drèze and Murthi, 2001) and can be conditioned by a country's stage in economic development. For instance, based on long-period data collected retrospectively, Hull and Hull (1977) show that total fertility increases with education for a majority of Indonesian women. More specifically, educational attainments are most likely to curtail fertility when a series of socio-economic incentives as family planing programs or employment opportunities for women are aligned (Diamond et al., 1999), which was not the case for our study period. This also explains why the negative relationship mostly prevails in urban areas. Finally, concerns may be raised about the use of husbands' educational attainment - used because of data availability - to tackle the eduction-fertility relationship. However, studies which use data collected from each spouse show that their education level (Cleland and Rodriguez, 1988) or fertility desire (Bankole, 1995) have equal influence on fertility decision-making.

Fundamentally, this study highlights the crucial role that under five mortality plays in determining changes in households fertility behavior. Coefficient estimates for child mortality are overwhelmingly significant and robust across specifications.

The positive association between total fertility and child mortality is exhibited, in line with other empirical studies from the economic and demographic literature (Taylor et al., 1976; Balakrishnan, 1978; Olsen, 1980; Olsen and Wolpin, 1983; Rosenzweig and Schultz, 1983; Eckstein et al., 1999; Hossain et al., 2007). When looking at the *global effect* of child mortality, this positive association holds for both total and net fertility, as women who have experienced at least one child death have a total and net fertility that are respectively 1.47 and 1.12 times higher than women who have not, so that a precautionary demand for children is rising. More support would hence be given to the *child survival hypothesis* rather than the *replacement hypothesis*. Such a statement is also supported by the fact that one-to-one replacement has never been exhibited in the data, as estimated direct replacement rates have always been proven to be smaller than 0.5 (Kalemli-Ozcan, 2003). This statistical evidence is reported in each and every micro-studies that have directly tested the replacement effect. To our knowledge, only three empirical studies document both effects of child mortality on gross and net fertility (Schultz, 1997; Angeles, 2010; McCord et al., 2010), and solely at the macro-level.

Furthermore, crucial understandings are brought when analyzing more thoroughly the relationship. We show that the fertility response is non linear in the level and in the rate of child mortality, as the amplitude and the direction of the effect vary with the number of child losses. These results hold when accounted for the effect of child mortality both in level and in rate, and are robust to changes in econometric specifications. More specifically, an inverted-U shaped relationship between child mortality rates and total and net fertility is exhibited. There is a gap of 2 pregnancies between women who have not lost any child and the ones who have lost all of them, as their mean total fertility is around 4.5 and 2.5 respectively. Most interestingly, mothers with the largest number of survivors are the ones who have experienced relatively low child mortality rates.[10] An insurance mechanism is at work for non-zero but relatively low child mortality rates. When child mortality rates increase and reach dramatic values, fertility behaviors do not respond anymore

[10]And as women having lost only one child represent the largest share of mothers having experienced child mortality, the *global impact* on net fertility has been found to be positive.

to compensate for child losses, so that total and net fertility fall under the level where any child dies at all.

This study helps to explain why fertility rates in SSA are not decreasing as traditional demographic transition theories are expected. Indeed, the decrease in child mortality rates have not been steeper enough to really influence fertility behaviors. Therefore, we argue that any policy that aims to bring about the pursue of the fertility transition in SSA should include, along with the traditional family planning programs, measures to thoroughly reduce child mortality. And it is worth noticing that rapid progress in child survival is feasible in a short period of time (Bhutta et al., 2010).

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Annex

	Total Fertility		Net Fertility	
	Model 3	Model 5	Model 3	Model 5
CML1	$1/X$		$\sqrt{X}$	
CML2	X^3		X	
CMR1		$1/\sqrt{Y}$		$1/Y$
CMR2		$(1/\sqrt{Y})ln(Y)$		$(1/Y)ln(Y)$
CMR3		$(1/\sqrt{Y})ln(Y)^2$		$(1/Y)ln(Y)^2$
CMR4		$ln(Y)$		Y^2

where: X = (CML+1) and Y = (CMR+.0054945051670074)