Determinants of fertility of women in Bangladesh

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1. Introduction

Bangladesh has been characterized by a large and declining Total Fertility Rate (TFR) in the last decades. Its TFR has declined from 6.4[1] in mid 1970s to 3.3 in 1994. Although TFR stagnated for about a decade (from 1994 to 2002) at 3.3, it has finally started declining again in 2004 and is at 2.7 in 2007. Some studies on Bangladesh (e.g., Cleland *et al.* (1994), Kabeer (2001), and Kabir *et al.* (2001)) suggest that increasing contraceptive use of women and declining child mortality rate caused the decline in TFR in the 1980s and 1990s. Studies on fertility in different countries conclude that fertility decision is usually determined by socio-economic characteristics of household and by frequency of coition, use of contraception, and abortion. In Bangladesh, although the coverage of women contraceptive use has increased at low steady rate in the last fifteen years (Table 1), which factors have directly affect women's fertility choice is still an open question.

Bangladesh is the eighth largest country in world by population, but the ninety-fifth largest by area.[2] Among the Millennium Development Goal (MDG) for Bangladesh is that, by 2015, infant mortality rate has to decline to 31 from 92 in 1991, and maternal mortality ratio has to decline to 144 from 574 in 1990.[3] In 2009-2010, infant mortality rate is 39 and maternal mortality ratio is 194.[4] Although declining infant mortality is on the right track, maternal mortality needs more attention.[5] Both infant and maternal mortality are directly related to

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[1] The value of 6.4 for TFR means each woman would have experienced 6.4 child births by the end of her childbearing period.
[2] https://www.cia.gov/library/publications/the-world-factbook/geos/bg.html ; Accessed on July 13, 2012.
[3] http://www.undp.org.bd/mdgs.php accessed on July 13, 2012.
[4] The value of 194 for maternal mortality rate means that there are 194 maternal deaths per 100,000 live births from any cause related to or aggravated by pregnancy or its mismanagement or incidental cause. The value of 39 for infant mortality rate means that 39 babies under one year of age died per 1,000 live births. Child mortality rate is according to the 2007 Bangladesh Demographic Survey and maternal mortality ratio is according to the 2010 Bangladesh Maternal Mortality Survey.
[5] http://www.undp.org.bd/mdgs/MDGs%20Score%20card. Accessed on July 13, 2012.

women's child birth, which indicates that if women's number of child birth declines, then infant and maternal mortality may decline as well. Moreover, government expenditure on both health and education sector are very low.[6] To achieve the MDG, it is important to understand which socio-economic factors affect the fertility decision of women, so that investment can be directed to those areas.

Empirical studies use either the number of surviving children born to a woman (e.g., Behrman and Wolfe (1984)) or the number of children ever born to a woman as a measure of fertility (e.g., Winkelmann and Zimmermann (1994) and Wang and Famoye (1997)). Several studies investigate fertility of either woman who completed their fertility (e.g., Behrman and Wolfe (1984), Melkersson and Rooth (2000), and Miranda (2010)) or women of all ages (such as age 14 to 49, 15 to 45 years) (e.g., Atella and Rosati (2000) and Nguyen-Dinh (1997)).

In this paper, I investigate the fertility determinants of women who completed their fertility. I use the number of children ever born to a woman as a measure for fertility. Although households are expected to choose the number of children they would like to have at the end of their fertility life disregarding required number of pregnancies, empirically actual number of children of households is different than expected number of children. This scenario is confirmed in my analysis for 2004 and 2007 Bangladesh Demographic and Health Survey data. Therefore, it becomes common practice to define women lifetime fertility as the number of child births by the end of their childrearing period. Some studies (e.g., Miranda (2010), Santos Silva and Covas (2000), and Melkersson and Rooth (2000)) on fertility determinants have commonly used count models (such as Poisson, negative Binomial, generalized Poisson, generalized gamma), since the

[6] In 2011-12, the Bangladesh government development expenditure on energy is BDT 79 bn, communication is BDT 61 bn, education is BDT 44 bn, and health is BDT 41 bn; whereas total government development expenditure is BDT 410 bn. (1 US $ = 81.75 BDT) (Muhith (2012)).

number of births is a positive and finite integer number. However, few studies on Bangladesh have used such models, but instead have relied on linear models (e.g., Kabeer (2001) and Kabir *et al.* (2001)).

When using count models, one has to determine whether the data is characterized by over or under dispersion. In this study, I encounter under-dispersion problem in fertility data set for Bangladesh. To overcome this issue, I first undertake a generalized Poisson model. Although generalized Poisson model captures the distinctive under-dispersion of data, this model fails to capture a potential important feature of the fertility data, i.e., that the zero and positive counts are generated from different mechanisms. The hurdle Poisson model can capture this unique feature of under-dispersed fertility data. In Bangladesh, the social norm is that couples should have children, so I believe that hurdle model is appropriate for this sample and also use a hurdle Poisson model.

Theoretical models on fertility consider that the determinants of women fertility are women wage and family income (Becker (1960)), relative income of family, household early life social characteristic (e.g., grew up in large family, born in rural area), supply side variables (e.g., age at women first cohabitation (Easterlin (1980)) and cultural association of the family (Pollak and Watkins (1993)). In line with these theoretical models, I analyze socio-economic and biological determinants of women's fertility. In my analysis, I see that the social norm that married women should have child explains observed fertility decision. I investigate whether parents' education and family income are related to women's fertility. I find that both parents' education and family income are negatively associated with women's fertility. The negative impact of education and income on fertility of women is interpreted as an opportunity cost of having children. I examine whether community average child death affects women's fertility. I also control for women who are married in 1970-75, a severe crisis period in Bangladesh, to analyze whether their fertility decision differs from woman married in different periods. I find that community average child death is positively related with fertility of women, which is interpreted as child mortality inducing women to have more children to ensure that some will survive. I that find women married in 1970-95 are expected to have less child birth.

This paper contributes to the literature on Bangladesh by using a Poisson hurdle model and by incorporating an important variable on social physical structure (i.e., community average child death) to analyze fertility decision of women.

This paper proceeds as follows. Section 2 presents a literature review on fertility determinants. Section 3 presents the data used in this paper. In Section 4, I outline the empirical strategy that uses the linear, Poisson, generalized Poisson, and Poisson hurdle models. I also include goodness of fit measure statistics for the models as well as test statistics for assessing dispersion problem in sample data. Section 5 provides and discusses results from all estimated models. In Section 6, I provide some concluding remarks.

2. Literature review

2.1. Theoretical framework

The economic model of fertility originated from the studies of Becker (1960) and Becker and Lewis (1973), which is known as 'Chicago-Columbia' model. Becker (1960) introduces the 'quantity-quality trade-off' concept of children. He assumes that children are equivalent to consumer durable goods to analyze the demand for children in the household. He also assumes that the preference for children is exogenous, i.e., it is not determined by economic factors. The demand for children depends on women's wage and family income. When women's wages increase, the opportunity cost of having children increases and the demand for children declines.

When family income increases, the effect on the demand for children depends on the relative strength of the income and the substitution effect. Households could increase both the number and the quality of children with an increase in family income. But an increase in the quality of children raises the cost of raising children which decreases fertility, which is known as the substitution effect. Becker (1960) states that higher family income results in fewer children of higher quality when the substitution effect is stronger than the income effect.

A crucial assumption of the 'Chicago-Columbia' model is that households can separate quality and quantity of children in their decision making process. Becker (1960) also assumes that in developed countries, the income elasticity of *quantity* of children is positive but small. However, the income elasticity of *quality* of children is relatively large due to social pressure, as rich (or poor) families have to maintain the quality of their children according to their status. He mentions that families with excess children cannot afford to increase the quality of children. With an increased use of contraceptive, family can increase the quality of children by reducing quantity (supply) of children. Moreover, Becker (1976) states that contraceptive knowledge also affects the demand for children. Thus, unequal distribution of contraceptive knowledge across regions may affect the demand for children.

Pollok and Watkins (1993) argue that the 'Chicago-Columbia' model does not consider cultural association of families, which significantly affect fertility decision of women. An alternative approach, known as the 'Pennsylvania' model, is due to Easterlin (1966), Easterlin and Crimmins (1985), and Easterlin *et al.* (1980). These papers assume that children are normal goods and the preference for having children is endogenous. Easterlin (1966) adopts the relative income approach, i.e., expected income versus actual income, to analyze fertility choice. According to Easterlin (1966), if expected income is higher than actual income, then the household's actual number of children will be lower than their expected number of children. He states that the couples' choice of the expected number of children depends on the parents' childhood experience. For instance, wives and husbands who grew up in large families tend to have a higher number child. Easterlin *et al.* (1980) also emphasize the role of biological or supply side factors, such as nutrition and health condition of women, age at women first cohabitation, in fertility determination.

2.2. Empirical studies

The studies by Behrman and Wolfe (1984), Ainsworth *et al.* (1996), Osili and Long (2008), Kabeer (2001), Kabir *et al.* (2001), and Lam and Duryea (1999) use a linear model (OLS) to estimate the determinants of women fertility.

Behrman and Wolfe (1984) attempt to relate both 'Chicago-Columbia' and 'Pennsylvania' models using data for women who completed their fertility. Behrman and Wolfe (1984) collected data for women in Nicaragua in 1977-78 and use the number of living children to a woman as the dependent variable. Women's education and household income are used as the 'Chicago-Columbia model' variables. They include women health status, women age, age at first marriage, age at first cohabitation, average length of breast feed, and average calorie intake as biological supply variables of the 'Pennsylvania' model. They also include type of marriage, number of sibling, birth rate, childhood residence as expectation building variable of the 'Pennsylvania' model. They find significant determinants in both 'Chicago-Columbia' and 'Pennsylvania' variables. They mention that since the 'Chicago-Columbia' model does not emphasize supply side variables, taste, and other factors for estimating fertility, models based uniquely on the 'Chicago-Columbia' model may over-estimate the effect of women's education and household income, leading sometimes to misleading results. For example, if women's schooling is negatively associated with fertility, then according to the 'Chicago-Columbia' model, increasing a year of schooling raises the opportunity cost of child rearing. However, according to the 'Pennsylvania' model, increasing years of schooling may lessen the disutility costs of contraception, which also affects fertility.

The studies by Ainsworth *et al.* (1996) and Osili and Long (2008) investigate whether women's schooling negatively affects fertility in African countries. Contrary to the previous study, these studies use children ever born for each woman as the dependent variable in their model. Ainsworth *et al.* (1996) estimate fertility of women of fourteen Sub-Saharan countries. They find that women's education is negatively related to fertility in thirteen Sub-Saharan countries, the only exception being Senegal. Using the 1999 Demographic and Health Survey from Nigeria, Osili and Long (2008) investigate whether the negative association between fertility and education was caused by the introduction of universal primary education. Their assumption is that schooling is endogenous to fertility determination, since fertility choice disrupts schooling. They use exposure to universal program as an Instrumental Variable (IV) for years of schooling of women. Using difference in difference method, they estimate the model in both OLS (without the instrument) and IV variable approach. In both cases, they find that the coefficient estimates are negative for women education, but the IV estimates are higher than OLS ones, which possibly means that the endogeneity of education leads to underestimation of the effect of an additional year of schooling on the expected number of children ever born.

Kabeer (2001) and Kabir *et al.* (2001) also use children ever born as a measure of women's fertility. Kabeer (2001) estimates separate model for different age groups (i.e., 12 to 19, 20 to 40, 40 above) using the 1989 Bangladesh Fertility Survey. She obtains that for all age groups, men and women's education, wealth, and working status of women are negatively related to fertility. In addition, Muslim women have higher fertility compare to other religions. She finds rural-urban difference for age group 20 to 40, and 40 above, but not for 12 to 19. This is expected, since women age 12 to 19 are less exposed to the socio-economic determinants of fertility as they are at their early stage of fertility. Kabir *et al.* (2001) use data set from 1989 Bangladesh Fertility Survey, Bangladesh Demographic and Health Survey 1993-1994, and 1996-1997. They estimate fertility determinants separately for each data set. They find that women fertility is negatively related to women's education, employment, place of residence, and access to mass media. They also find that women fertility is positively related with child mortality. They calculate child mortality by the number of child died of each woman. They use child mortality rate as an exogenous variable but in fertility decision this variable is endogenous. To avoid this problem, I use instead community average child death.[7]

Lam and Duryea (1999) investigate the effect of women schooling on fertility. They use data from the 1984 Brazilian Household Survey.[8] They use the number children ever born to a woman as dependent variable and women and husband years of schooling as independent variables. They find that both women and husbands education are negatively related to fertility.

A weakness of the above mentioned studies is the use of a linear model. It is unlikely to follow constant marginal change of dependent variables (i.e., either number of living children or number of children ever born) due to change in the explanatory variables.

For this reason, the studies by Nguyen-Dinh (1997), Wang and Famoye (1997), Atella and Rosati (2000), and Miranda (2010) use different types of Poisson model. The study by Kravdal (2002) uses a time-discrete Hazard regression model.

[7] The definition of community average child death will be provided in Section 3.2.
[8] Pesquisa Nacional de Amostra de Domicilios, in Portuguese.

Nguyen-Dinh (1997) focuses on accommodating cultural effects (Pollak and Watkins (1993)) on the determinants of fertility. Nguyen-Dinh (1997) estimates a Poisson model and an ordered-logit model using the 1988 Vietnam Demographic and Health Survey. He uses the number of children ever born to a woman as dependent variable. He constructs a community child mortality rate variable to capture community effect. The assumption is that families make their decision on the number of child births by observing the child mortality rate in their neighborhood. He finds that community child mortality rate is positively associated with fertility. Nguyen-Dinh (1997) also obtains that women working in sectors other than agriculture have fewer children than those working in the agricultural sector. The author also finds that the husband's sector of employment, husband, and wife education affect fertility. He states that it is unlikely that parental education raises the opportunity cost in agricultural economy like Vietnam, so education affects negatively fertility by affecting the preference for having children.

The study by Wang and Famoye (1997) is based on the 'Chicago-Columbia' model. They use US data from the Michigan Panel Study of Income Dynamics for 1968 and for 1989. They use number of children[9] in a family as dependent variable, which is over-dispersed. They include women employment status, women education, family income, ethnicity (white or non-white) dummy, and rural-urban dummy as independent variables. They estimate both Poisson and generalized Poisson models. They find that the standard errors of estimates are higher in Poisson model than generalized Poisson model, although both models give similar value for estimates. They find that mother's education, employment status, and family income have negative effects on fertility. They also find that fertility of non-whites is higher than that of whites. They expect that different levels of knowledge regarding contraception in the two ethnic groups may lead to

[9] Here the number of children means the total number of children up to 17 years in a family, not including children over 18 year as this data is unreported.

such difference in fertility choice (Becker (1960)). They find higher fertility in rural areas compare to urban areas, as the cost of child bearing is higher in rural areas than in urban areas.

Atella and Rosati (2000) investigate whether fertility depends on expected survival rate of children and the uncertainty associated with it. They analyze data from the 1994 Human Development of India Survey. They use number of child births of women as the dependent variable. They include women and their husband age, marriage duration, wealth, education of women and husband, religion, male and female wage rate, number of children death, expected survival rate of children, and uncertainty of child survival rate. They use village mean survival rate of children age under 5 as expected survival rate of children, and village variance of survival rate of children age under 5 as uncertainty of child survival rate of children. They use both Poisson and Poisson hurdle models. They use hurdle at zero for the dependent variable. As the hurdle model helps to identify which set of explanatory variables that affect differently the decision whether to have children and the decision regarding the number of children. Therefore, they find that hurdle model is the preferred model for their sample data. They obtain that both expected child survival rate and uncertainty of child survival rate are negatively related to fertility. They find that Muslim women have higher fertility than women belonging to other religions. They also find that women's education is negatively related to fertility choice, but husband's education is not related to fertility.

Miranda (2010) argues that the double hurdle model is more appropriate for fertility data of Mexico than the single hurdle model. He mentions that socio-economic characteristics affect women's fertility decision to transition from low to higher birth order in Mexico. He uses the double hurdle Poisson model using data from the 1997 Mexican Survey of Demographic Dynamics. He uses number of children ever born to a woman who completed fertility as the dependent variable. He includes women's age, women birth location, religion (Catholic), women's education,[10] and ethnicity,[11] as explanatory variables. He finds that the dependent variable is over-dispersed. He also finds that the difference between the standard Poisson distribution and the observed data distribution is higher when number of children is higher than three. This indicates that the standard Poisson model is not the appropriate specification for this sample. He assumes that women having more than three children have lower opportunity cost to having one more child than women having less than three children. He also assumes that women's having a fourth child could permanently withdraw them from labor market. For the model, he constructs two hurdles, first at number zero and second at number three. He finds that education and Catholicism reduces the probability for women to have more than three children. For women having more than three children born in the South region, he finds that Catholics have higher fertility than non-Catholic, and indigenous language speaker have higher fertility than non indigenous language speaker.

Kravdal (2002) estimates a discrete-time Hazard regression model using the Demographic and Household Surveys for twenty two Sub-Saharan countries. He carries out Monte Carlo simulation to examine how educational distribution affects total fertility of women. He estimates two separate models for twenty two countries. The first is for women having first birth and the second for women having more than one birth. In the first model, he follows women who do not have child until first child birth in three months interval for two years period. In the same way, he follows the women who have higher order birth. He uses individual women education, average length of education of each community, rural versus urban, proportion of Muslim, proportion of other religion, and wealth indicator as explanatory variables. He obtains

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[10] Education is measured as whether women completed primary education by 12 years age or not and the value is bounded from zero to six; birth locations are categorized as MexCity (base group), North, Centre and South.
[11] Ethnicity is measured as whether women can speak an indigenous language or not.

that women's education strongly affects the first-order birth, but the effect becomes weaker in higher order birth. He also obtains average length of education of the community influences fertility of women negatively.

Using the 1989 Bangladesh Fertility Survey, Cleland *et al.* (1994) investigate the reason behind fertility declines in the 1970s and 1980s in Bangladesh despite unfavorable social, economic and institutional scenarios during these periods. They find that women fertility decline due to the drop in mortality.[12] They mention that increasing poverty and landlessness negatively affects fertility decision.[13] They also mention that occupation changes from the agricultural sector to other sectors affect fertility decision negatively. They strongly state that acceptability and access to contraceptive plays a vital role for this decline, and not the severe economic condition. Moreover, Cleland *et al.* (1994) mention that fertility decision is affected by son preference for child birth. They also mention that the gap between the family's desired number of children and the actual number of child births decreases due to decreasing rate of child mortality, which is known as the child replacement hypothesis.

In sum, the literature seems to agree that the following factors are important fertility determinants: a) wages of women; b) household income; c) parental education; d) biological supply factors (e.g., starting age of cohabitation) e) social factors (e.g., child sex preference, community/ethnicity effect, preference on certain number of child, rural versus urban). In this study, I use parent's education, household wealth, starting age of cohabitation and social factors as control variables for number of child birth of women. It is worth mentioning that women's contraceptive use is not used as a control variable in this study, as women's contraceptive use depends on their fertility decision. This is in line with many studies (e.g., Nguyen-Dinh (1997),

[12] Crude death rate (per 1000 people) declines from 19.98 to 11.68 from 1974 to 1991.
[13] The number of landless household increases 2.05 percent annually from 1960 to 1982.

Melkersson and Rooth (2000), and Miranda (2010)) on completed fertility that do not include women's contraceptive use as a control variable.

3. Data

In this paper, I use data from the 2004 and 2007 Bangladesh Demographic and Health Survey (BDHS). The BDHS is a nationally representative micro-data set containing detailed demographic, health, and socio-economic information for households. It is carried out under the authority of the National Institute of Populating Research and Training of Ministry of Health and Family Welfare, Bangladesh. U.S. Agency for International Development (USAID/ Bangladesh) provides financial support and Macro International Inc. provides technical support through MEASURE DHS program.

The 2004 BDHS contains information for 11,440 women aged 15 to 49 years and 4,297 men aged 15 to 54 years from 10,500 households covering 361 clusters[14], 122 in urban areas and 239 in the rural areas. The 2007 BDHS contains information for 10,996 women aged 15 to 49 years and 3,771 men aged 15 to 54 years from 10,400 households covering 361 clusters throughout Bangladesh, 134 in urban areas and 227 in the rural areas. It should be mention that both clusters and women are not same in 2004 and 2007, since the BDHS is not a panel data set.

Since the main concern of this study is women who completed their fertility, the sample is restricted to women aged 35 years or above at the time of interview. Given this restriction, 14,818 women less than 35 years of age are excluded from the sample and 7,618 women remain in the sample. It is assume that this group of women is most probably old enough to have completed their fertility. Out of 7,618 women, 7,435 women have at least one child and only 62

[14] In the BDHS, 361 Enumerating Areas (EAs) are selected for the survey, and then the EAs are used as base of each cluster. Each EA consists of on average 100 households.

women are pregnant at the time of interview. Pregnant women at the time of interview are dropped from my sample. So the total sample size is 7,556 with 3,704 observations for 2004, and 3,852 observations for 2007.

3.1. Dependent variable

The dependent variable in my study is the number of children ever born to a woman. This measure of fertility does not include abortion and miscarriage. The dependent variable may underestimate the number of children ever born for each woman if women have children after the survey period. Since I restrict the sample to women aged 35 or more, I believe that I minimize this problem. The mean number of child ever born to a woman is 4.46 and the variance is 5.08. Since the variance is larger than the mean, the dependent variable is over-dispersed.[15] Table 2 compares the observed distribution of the dependent variable with a Poisson distribution with mean 4.46. It is evident that there is no relatively excess number for any particular value in observed data than Poisson distribution.[16] I see that both observed distribution and the Poisson distribution probability concentrate on 3, 4, and 5, which implies that women are most likely to have three to five child birth experiences.

3.2. Explanatory variables

Education

Educational level for both women and their husband is categorized in four levels: no education, primary level education (1 to 5 years of schooling), secondary level education (6 to 10 years of schooling), and higher than secondary level education (more than 10 years of schooling). I create

[15] If a variable is assume to follow a Poisson distribution, and its mean is greater than its variance, then this variable is over-dispersed. This issue will be discussed in more details in Section 4.
[16] There is excess zero and two in fertility data of some countries (e.g., Sweden (Melkersson and Rooth (2000)), but not in fertility data of Bangladesh.

dummy variables for each level of education, where 1 indicates that the individual has attained the particular level of education and 0 otherwise. I use no education for both women and their husband as the base case, since this group is the most frequent for both women and their husband (see Table 3).

Women's age

I use women's age at first marriage as a proxy for starting age of cohabitation since cohabitation outside marriage is not permitted and culturally accepted in Bangladesh. For similar reasons, it is also assumed that most women start their coition after their marriage. In the BDHS, there is no data on starting age of coition. It should be mentioned that although the legal age for women to get married is 18, most of the women are married below that age. I also use women's age at time of interview as a control variable.

I construct a dummy variable for women who are married between 1970 and 1975. In Bangladesh, people livelihood was severely damaged in this period due to devastating tropical cyclone in coastal region in 1970, nine months war of independence in 1971, famine in 1974, severe economic and political instability from 1970 to 1975.[17]

Community average child death

As community average child death is an indicator of socioeconomic and physical community environment, the decision of having children may be conditioned or influenced by the couples' observed child survival in their community or neighborhood. In this study, I aggregate child mortality at the community level. The clusters of the BDHS are used as community. In the

[17] In the 1970 cyclone and tidal wave, there were 200,000 to 500,000 deaths (Chen (1973)). In 1971 war of independence, there were at least 500,000 deaths (Curlin *et al.* (1976)). In 1974 famine, officially, there were 30,000 deaths (Majlis, (1977)), although the number is much higher in some estimates (e.g., 500,000 in study by Baldwin (1977); 80,000 in Rangpur district alone in study by Haque *et al.* (1977).

BDHS, 361 clusters are constructed by households living in same location, which equivalent to a *mauza* in rural areas and a *mohallah* in urban areas.[18] 239 clusters are in rural areas and 122 in urban areas in 2004 and 227 clusters are in rural areas and 134 in urban areas in 2007.[19] Each cluster includes on average 30 households. The construction of community average child death is as follows. First, the number of child deaths for each woman is calculated by subtracting the number of living children from the number of children ever born. Then, I divide the total number of child deaths in each community by the number of women in that community. I prefer this approach to including the number of child deaths for each woman, as child death of an individual woman is endogenous. The underlying assumption is that the number of children deceased for an individual woman does not significantly affect the community average child death. An alternative method is followed by Nguyen-Dinh (1997). He divides the number of deceased children for each woman by the number of potential child-years, which is the sum of the ages of each woman's children if no child death occurs. He assumes that the risk of death for each child is the same in different time periods. Since I do not have data on the time or year of child death, I could not follow Nguyen-Dinh (1997) method.

Place of living

The data set is categorized by place of living for women, i.e., by rural-urban residence and by six administrative divisions, i.e., Barishal, Chittagong, Dhaka, Khulna, Rajshahi, and Sylhet. Administrative divisions divide the whole population in six geographical locations. I use these divisions as control variables assuming that women fertility differences are related with geographical location. I create a dummy variable equal to 1 for living in urban areas, and 0 for living in rural areas. I also use binary value 0 and 1 for living in each division (e.g., 1 if live in

[18] Mouza is equivalent to village, mohalla is equivalent urban block.
[19] In 3 communities, there are women from both rural and urban areas in the 2007 BDHS.

Dhaka, otherwise 0). It is assumed that urbanization reduces the fertility level, so living in urban area may affect preferences for children. Since the cost of living in urban area is higher than rural area, the cost of child rearing is also higher in urban area than rural areas. So the opportunity cost of having children is higher in urban areas than rural areas.

Wealth index

One shortcoming of the BDHS is there is no data on household and women income. However, the BDHS contains a wealth index. The wealth index is constructed by assigning weights on household assets including durable goods (such as televisions and bicycles) and dwelling characteristics (such as source of drinking water and sanitation facility). This index divides the whole population into five quantiles, i.e., poorest, poorer, middle, rich, and richer. I use wealth index as a proxy for family income. I create dummy variables for each quantile and use poorest as base case.

Expected number of children

The BDHS contains data on the ideal number of children to measure the fertility preference of women. Ideal number of children is defined as the desired number of children, if a woman would start afresh her fertility. This information provides an idea on future fertility plans of women who do not have a child yet and on unwanted fertility of women who have a child. I use data on the ideal number of children as expected number of children for women who completed their fertility. It is assumed that the expected number of children of women affects their number of child birth. In the BDHS, this data is reported as 0 to 10.[20]

[20] Some respondents choose to answer "whatever God gives" or nonnumeric. These observations are treated as missing value.

Employment status

I include women current employment status as a control variable assuming employment decision affects fertility choice.

Religion

I also use religion as a control variable, i.e., whether a woman is Muslim or has another religion. It is worth mentioning that marriage across religions is not common, and the majority of people are Muslim in Bangladesh.

Table 3 shows descriptive statistics for the dependent variable and all explanatory variables. I find that the maximum number of children ever born of a woman is 15, the range for age at the first marriage is from 10 to 39 year, and the average number of children deceased per woman in the community is 0.38. I also see that the maximum value for community average child death is 1.37 which means each woman has on average at least one child death in some communities. [21] The average number of child birth is 4.46 whereas the expected ideal number of children is 2.51, which indicates excess child births to each woman. I find that 51 percent of women are uneducated, 28 percent have primary education, 16 percent have secondary education, and only 5 percent have higher secondary education. In addition, 39 percent of women's husband are uneducated, 23 percent have primary education, 24 percent have secondary education, and only 14 percent have higher secondary education. The proportion of uneducated is higher for women than for men; the proportion of individuals with higher than secondary education is low for both men and women. Regarding the wealth index, I find that the proportion of both poorest (16 percent) and poor (17 percent) are lower than either middle (19 percent), rich (21 percent) or richer (28 percent). I see that 88 percent women are Muslim and 26

[21] Community average child mortality rate is zero in 10 communities.

percent women are married in 1970-1975. In addition, only 29 percent women are currently employed and 37 percent women are living in urban areas.

4. Empirical strategy

I estimate four types of model, i.e. linear, Poisson, generalized Poisson, and Poisson hurdle, for determinants of women fertility. In those models, the dependent variable is the number of children ever born for each woman, X_i is a set of explanatory variables, and β is a vector of coefficients associated with each explanatory variable.[22] I use maximum likelihood method to estimate parameters of above three types of Poisson model and OLS method for linear model. The empirical strategy of this paper is to move from linear to standard Poisson, then generalized Poisson, and Poisson hurdle at the end. I use standard Poisson model as a base model to compare among alternative Poisson models, because the Poisson model is the most restrictive model for count data. I estimate linear model as some studies on Bangladesh use this model.

4.1. Linear model

The estimated linear regression model is as follows:

$$Y_i = X_i \beta + \varepsilon_i$$

Here ε_i represent the error terms. The dependent variable of this regression is bounded in integer values from 0 to 15. β represents marginal effect for each explanatory variable to dependent variable and it is constant. But constant value for marginal effect is unlikely for count data. Due to the intrinsic nature of the dependent variable and unlikely constant marginal effect, a linear method is not appropriate one for such study and is used here only as a benchmark.

[22] Except in the first stage of the Poisson hurdle model where Y_i takes only the value 0 and 1.

4.2. Poisson model

In a Poisson model, Y_i is assumed as a Poisson random variable with a mean μ_i, where the mean is a function of X_i. In a Poisson model, the probability of observing Y_i is expressed as follows:

$$f(Y_i) = \frac{{\mu_i}^{Y_i} e^{-\mu_i}}{Y_i!}$$

The log-likelihood function of the Poisson regression is as follows:

$$\ln L\ (\mu_i; Y_i) = \sum_{i=1}^{n} \{Y_i \ln(\mu_i) - \mu_i - \ln(Y_i!)\}$$

The crucial assumption of a Poisson regression is that the conditional mean and the conditional variance are equal; i.e.:

$$\mu_i = E(Y_i|X_i) = Var\ (Y_i|X_i) = e^{X_i\beta}$$

If this assumption is violated, over or under dispersion occurs. Over-dispersion occurs when the conditional mean exceeds the conditional variance, and under-dispersion occurs when the conditional mean falls behind the conditional variance. Both over-dispersion and under-dispersion affects the significance level of the parameters of the estimated model. I carry out a test for over-dispersion and under-dispersion of a Poisson regression by using the value of Pearson statistic divided by degree of freedom (Hilbe (2011)). If it is greater than one, then there is over-dispersion, and if it is less than one than, then there is under-dispersion.

4.3. Generalized Poisson model

To handle over dispersion or under dispersion of a Poisson model, the generalized Poisson model is a useful alternative model (Famoye (1993)). In a generalized Poisson model, Y_i is assumed to be a generalized Poisson random variable. The probability distribution function of a generalized

Poisson variable is different from that of a Poisson random variable. The probability distribution function of Y_i is as follows:

$$f\ (\mu_i, \alpha; Y_i) = \left(\frac{\mu_i}{1+\alpha\mu_i}\right)^{Y_i} \frac{(1+\alpha\mu_i)^{Y_i-1}}{Y_i!} exp\left(-\frac{\mu_i(1+\alpha Y_i)}{1+\alpha\mu_i}\right);$$

where μ_i is the mean which is function of all exogenous variables.

$$\mu_i = E(Y_i|X_i) = e^{X_i\beta}\ ; \quad Var(Y_i|X_i) = \mu_i(1+\alpha\mu_i)^2$$

Here α is a dispersion parameter.[23] When α equals to zero,[24] the generalized Poisson model reduces to a Poisson model. When α is positive, there is over-dispersion, and when α is negative then there is under-dispersion. I carry out the test[25] for the significance of the dispersion parameter to check whether the generalized Poisson model is an appropriate alternative model. The log-likelihood function of the generalized regression is as follows:

$$\ln L\ (\mu_i, \alpha\ ; Y_i) = \sum_{i=1}^{n} \{Y_i \ln\left(\frac{\mu_i}{1+\mu_i}\right) + (Y_i - 1)\ln(1+\alpha Y_i) - \frac{\mu_i(1+\alpha Y_i)}{1+\alpha Y_i} - \ln(Y_i!)\}$$

4.4. Poisson hurdle model

It is plausible to estimate a Poisson hurdle regression if zero outcomes and strictly positive outcomes come from different data generating process. In the case of fertility decision, it means that the decision of not having child is qualitatively different from the decision of having child. It has been already mentioned that the social norm in Bangladesh is that women should have at least one child. So, it is reasonable to assume that the determinants for not having children are different from the determinants for having children. One plausible reason for women not having

[23] A negative binomial model can be used for over-dispersion, i.e. when $\alpha>0$. But if the true value is $\alpha=0$, then the negative binomial model will not converge (Hilbe (2011)). In this study, the problem is under-dispersion in conditional data, so we use a generalized model as an alternative to Poisson model.
[24] If $\alpha=0$, then $E(Y_i|X_i)=Var(Y_i|X_i)$.
[25] The hypothesis test for significance of dispersion parameter is $H_0:\alpha=0$ and $H_a:\alpha\neq0$. If the t-statistics is outside the (-1.96, 1.96) interval, then dispersion is significant.

child is infertility in either woman or husband or both. The Poisson hurdle model (Mullahy (1986)) is estimated in two stages; the probability functions of Y_i of two stages are as follows:

$$\text{First stage: } f\ (Y_i = j) = \exp(-\mu_i) \quad if\ j = 0;$$

$$\text{Second stage: } f(Y_i = j) = [1 - \exp(-\mu_i)]\ f(Y_i | Y_i > 0) \qquad if\ j > 0;$$

where j= 1, …, n and n = number of child birth.

In the first stage of the model, the dependent variable is divided in two outcomes, i.e. 0 for not having child birth and 1 for having at least one child birth. I use a logistic regression in this stage, assuming that the error terms follow logistic distribution. The coefficient of a logistic regression provides the log of odd ratio for having children for each explanatory variable. In the second stage, I estimate a Zero Truncated Poisson (ZTP) regression for all strictly positive outcomes. The log-likelihood function of this stage is as follows:

$$\ln L\ (\mu_i; Y_i | Y_i > 0) = \sum_{i=1}^{n} \{Y_i \ln(\mu_i) - \mu_i - \ln(Y_i!)\} - \ln\{1 - \exp(-\mu_i)\}$$

In the second stage, it is assumed that conditional mean and conditional variance are equal; i.e.:

$$\mu_i = E(Y_i | X_i) = Var(Y_i | X_i) = e^{X_i \beta} \text{ when } Y_i > 0$$

In all the above Poisson models, the percentage change of expected value of the dependent variable can be calculated with estimated value β_k for changing the categorical value of explanatory variable x_k; i.e. $100[exp(\beta_k \Delta x_k) - 1]$.

4.5. Comparison of models

It is reasonable to check performance of alternative models by using a goodness of fit measure. One of the most commonly used measures is the Akaike Information Criterion[26] (AIC), which is:

$$AIC = 2(-Ln\mathrm{L} + K)$$

[26] See Akaike (1974).

where LnL is the log-likelihood value of the estimated model and K is the number of estimated parameters. I also use the Bayesian Information Criterion (BIC), which is:

$$BIC = -2LnL + K \ln(n)$$

where LnL is the log-likelihood value of the estimated model, K is the number of estimated parameters and n is number of observations. The selection criterion for both AIC and BIC is the smaller the value, the better the fit of model. Another commonly used measure is the Pseudo-R^2 statistic, which is:

$$R_p^2 = 1 - \frac{LnL_F}{LnL_I}$$

Where R_p^2 is Pseudo-R^2, LnL_F is the log-likelihood of full model, and LnL_I is the log-likelihood of the intercept only model. The selection criterion is very low value of Pseudo-R^2 may indicate a lack of fit, but high value of Pseudo-R^2 does not indicate a better fit. I also use a likelihood ratio test to compare the equality of coefficients between Poisson (and generalized Poisson) to Poisson hurdle model.[27]

5. Empirical results

Table 4 presents the comparison of estimated coefficients in the linear, the Poisson, the generalized Poisson and the Poisson hurdle models. Table 4 also contains several goodness of fit measures including AIC, BIC, and Pseudo-R^2. First, I explain the results from the Poisson model, and then I will compare the result between the Poisson and the generalized Poisson models, and between the Poisson and the Poisson hurdle models. Second, I will briefly compare the linear model with the ZTP model.

[27] $Ln\,L_{hurdle} = 2(Ln\,L_{logistice} + Ln\,L_{ztp} - Ln\,L_{Poisson})$.

5.1. Poisson model

To explain results from the Poisson model, I will first check the sign of the coefficients and then explain the percentage change of the expected value of number of children ever born to a woman for changing one characteristic, with remaining explanatory variables held constant.

Characteristics related to women

In the Poisson model, the coefficient for *medu_pr* is positive and statistically significant. I obtain that primary level educated women are expected to have 3.3 percent[28] more child birth than uneducated women are. The difference between these two groups of women is not very high. Although I expect no significant difference between primary educated and uneducated women in the fertility decision, since primary education curriculum does not cover health related issues and most of primary educated people cannot read and write. Moreover, the positive value for the *medu_pr* coefficient is puzzling. The sign of coefficients for both *medu_sc* and *medu_h* are negative, but only the *medu_h* coefficient is statistically significant. This is in line with the expectation that women's secondary and higher educational levels are inversely related to number children ever born, although secondary and high school curriculum does not cover fertility issues due to conservative attitude toward sex education. Since most secondary educated people can read and write, they are able access knowledge on fertility by themselves. I see that higher secondary educated women are expected to have 16.5 percent fewer children ever born than uneducated women, with remaining characteristics held constant.

[28] The value for *medu_pr* coefficient is -0.033. Therefore, the change of expected value of dependent variable is $[\exp(-0.033)-1]\times 100$, which equals 3.3 percent.

The negative value (-0.079) for *mwork* suggests that currently employed women are expected have 7.6 percent fewer children than unemployed woman. This may be due to the higher opportunity cost of having child birth for employed women.

The coefficient for *mfage* is negative and statistically significant. This means that if woman's age at first marriage increases by one year, she is expected to have 3.9 percent fewer children, with remaining characteristics held constant. It indicates that women married at early age have higher likelihood of having higher number of children ever born. The coefficient for *mage* is positive and statistically significant, which is expected. The negative value for variable *m70_75* suggests that women born in 1970 to 1975, are expected to have fewer number children ever born (4.3 percent less) than those born in other periods of time. Although it indicates that fertility of woman is negatively affected by severe economic crisis, the rate of responsiveness is not very high.

The coefficient for *muslim* implies that Muslim women are expected have 12.1 percent higher number of children ever born than women of other religion. So, there is a high difference in fertility decision among Muslim and another religion. This result is consistent with the studies of Kabeer (2001) and Kabir *et al.* (2001).

Characteristic related to husband

I find that the coefficients for both *hedu_pr* and *hedu_sc* are not statistically significant and the coefficient for *hedu_h* is negative and statistically significant, which indicates that women whose husbands have higher secondary education are expected to have less child births (7.0 percent) as compare to women whose husbands are not educated. Thus, there is a negative correlation between highly educated husbands and the fertility choice of women.

Household wealth

The coefficients for *poorer*, *middle* are not statistically significant, which means that women who are in poorer and middle wealth index are not different from those who are in poorest wealth index. The coefficients for both *rich* and *richer* are negative and statistically significant. I see that women in *rich* index are expected to have 5.3 percent less number of child birth than women in *poorest* index have. I also see that women in *richer* index are expected to have 9.0 percent less number of child births than women in *poorest* index have. So, woman in the highest wealth index are expected to have the lowest number of child birth among women in all wealth index categories. This result is consistent with the hypothesis that if family income increases, households prefer to have less children, but higher quality of children.

Expected number of children

The positive and statistically significant value for *idealch* indicates that higher the expected number children of women, higher the number of child birth of women. I obtain that if women's expected number of children increases by one, then women's number of child birth increases by 8.8 percent.

Community average child death

The coefficient for *com_chdeath* is positive and statistically significantly. This means that if community child mortality rate increases by one percent, then number of children ever born of a woman increases by 0.39 percent. It indicates that household decision in fertility is correlated with community child mortality rate. This result supports the hypothesis of household's child replacement.

Place of living

I now investigate whether the women's place of living, either rural versus urban or any geographical location, affect women's fertility. The coefficient for *urban* is not statistically significant which indicates there is no significant difference in women fertility due to live in rural or urban areas. One plausible reason is that either expected number of children of women or community average child death may explain the rural-urban difference in fertility choice. I see that both the expected number of children of women and child death incidence are higher in rural areas than urban areas (See Table 5 and Table 6). I estimate two restricted Poisson models; i.e. the first restricted model is full Poisson model excluding only variable *idealch*, and the second one is full Poisson model excluding variable *com_chdeath*. I obtain that the coefficient for *urban* is not statistically significant in the first restricted model, but it is statistically significant and negative in the second restricted model (see Table 7). This result indicates that community average child death may explain the rural-urban difference in fertility decision.

I see that the signs for *chittagong* and *sylhet* are positive, but the sign for *dhaka, rajshahi*, and *khulna* are negative; that implies fertility of women differs across geographical region. For instance, the value for *chittagong* suggests that women living in Chittagong division are expected to have 7.5 percent higher number of child births than women live in Barishal region. The plausible reason for such difference is people live in Chittagong and Sylhet are comparatively more religious than those who live in other divisions (Kabeer (2001)). Finally, the negative value for dummy variable *year07* indicates that fertility of woman declines significantly in year 2007 than in year 2004.

The estimated Poisson model has significant under-dispersion as dispersion statistics[29] is less than one. To accommodate under-dispersion, I estimate a generalize Poisson model.

5.2. Generalized Poisson model

I see that there is no difference in the estimated values for coefficients between generalized Poisson and Poisson models. This is expected since the value of dispersion parameter α of generalized Poisson model is not significantly different from zero. So the generalized Poisson model reduces to a Poisson model. There are very slight (negligible) differences in standard error of coefficients between these two models, as generalized Poisson data generating process accounts for the under-dispersion characteristic of the data. I obtain that both AIC and BIC is lower in the Poisson model than in the generalized Poisson model, so I could choose a Poisson model. So using a generalized Poisson does not yield any significant benefit even if it accommodates the under-dispersion of the data.

5.3. Poisson hurdle model

As mentioned above, the Poisson hurdle model is estimated in two stages. I expect that the signs and significance of coefficients of the two stages provide any indication for whether women who have child birth and women who does not have child birth are differently associated with explanatory variables. At the first stage[30], I find that only some explanatory variables, *mfage*, *medu_pr*, *medu_sc*, *medu_h*, *m70_75*, and *idealch* , are statistically significant. I see that women married at higher age are less likely to have child births, as the coefficient for *mfage* is negative. Interestingly, most of the variables, i.e., family wealth index, community average child death, religion, husband's education, place of living, do not affect decision in fertility in first stage

[29] The value for dispersion statistics, (1/df) Pearson, is 0.751.
[30] It is already mention in Section 4.4 that I estimate a logistic regression in the first stage.

model, whereas these variables significantly affect fertility decision in the second stage of the model. In comparison with uneducated women, primary educated are 1.59 times higher likelihood of having child birth.[31] Similarly, secondary educated women are 2.93 times higher, and higher secondary educated women are 3.64 times higher likelihood of having child birth than that of uneducated women. So, the higher the women's education of women, the higher is the likelihood to have a child birth, as coefficients for educational levels are positive. This result strongly suggests that women are more desire to have children than not to have. This result is consistent with the hypothesis that having children is the social norm in Bangladesh.

In the second stage of the Poisson hurdle model, i.e. the ZTP model, the signs of both *medu_sc* and *medu_h* are negative and statistically significant. This result is consistent with the hypothesis that the opportunity cost of having child rearing increases with the higher level of women's education. In comparison with Poisson model, in the ZTP model the magnitudes for *medu_pr*, *medu_sc*, and *medu_h* are smaller and the coefficient for *medu_sc* becomes statistically significant. Besides, statistically significant (at 10 percent level) positive value for *medu_pr* indicates that primary educated women are expected have more child birth than uneducated women have, which still remains puzzling.

Compare to the Poisson model, in the ZTP model the magnitudes for *hedu_pr*, *hedu_sc*, and *hedu_h* are smaller. The coefficient for both *hedu_sc* and *hedu_h* are negative and statistically significant in the ZTP model, but only *hedu_h* is significant in the Poisson model. This outcome emphasizes that in the ZTP model, secondary educated husband are negatively associated with women fertility decision compare to uneducated husband, whereas in Poisson model there is no significant difference in women fertility choice for whether their husband are secondary educated or uneducated. I find that the coefficient for *idealch is* positive but smaller

[31] Where coefficient for *medu_pr* is 0.464, so *exp*(0.464) is 1.59.

in the ZTP model than that in the Poisson model, which indicates that the Poisson model possibly overestimates the relation between household expected number of children and fertility decision of women. In the ZTP model, same as the Poisson model, the positive value for *com_chdeath* indicates that fertility of women is responsive to community average child death. By comparing AIC and BIC statistics, I find that the ZTP model is better fit for this sample. Moreover, the likelihood ratio test statistics[32] reject equality of coefficients between the Poisson hurdle and the Poisson models, which indicates that the Poisson hurdle does not reduce to a Poisson model. Finally, the Poisson hurdle model has allowed us to identify set variables that affect differently the decision whether to have child birth and the decision regarding the number of the child birth. This finding highlights the importance to use the Poisson hurdle model as a better alternative model in studying determinants of women fertility.

5.4. Linear model

The coefficients of the linear and Poisson models are not directly comparable and the meanings of the coefficients are very different in these two models as well.[33] To compare the linear model with the Poisson model, I will check whether the variables are significant or not. For instance, the coefficient for *medu_sc, medu_h, hedu_sc,* and *hedu_h* are not statistically significant in the linear model, but these coefficients are significant in the ZTP model. It indicates that the relation between parents' education and women's number of child birth is not explained in linear model by controlling other determinants. Comparing goodness of fit measures, i.e. both AIC and BIC, the linear model has the highest value among four models, which means the linear model has the highest of lack of fit for such sample.

[32] The likelihood ratio statistics equals 195.37 which is significant at the 1 percent level.

[33] Coefficient of the linear model represents marginal effect as $\frac{\partial E(y|x)}{\partial x_k} = \beta_k$, whereas in the Poisson model marginal effect is $\frac{\partial E(y|x)}{\partial x_k} = exp(x\beta)\beta_k$.

6. Conclusion

In this paper, I have analyzed the determinants of fertility using four statistical models. Based on several measures of overall model performance, I find that the Poisson hurdle model does better than either the linear, the Poisson or the generalized Poisson model. I find that the estimated coefficients for women's educational level differ among these models. In all the Poisson type models, higher than secondary education of both women and husband is negatively related women's number of child birth in three types of the Poisson model. But only in the ZTP model, secondary education of both women and husband are significant negative related with women's number of child birth. This result is consistent with the existing literature that higher level education of parents negatively affects their fertility choice. However, the result that primary educated parents have higher number of child birth than uneducated parents is still puzzling. The plausible reason for difference in coefficients for determinants of fertility decision in the ZTP model, with the Poisson model, is exclusion of women with no child birth experience. It is reasonable that women having child birth are different in response to the characteristics than women have no child birth experience. By using hurdle approach, I accommodate the behavioral difference of those two groups of women.

I find that women fertility decision is responsive to community average child death. This may indicate that families are risk averse with respect to the fertility decision. This will probably lead to fertility decline in Bangladesh, as the child mortality rate declines impressively from 2007 to 2004 (see Table 1). I also find that women fertility is positively related with expected ideal family size. And negative gap between average number of expected children and average number of child births indicates room for enhancing contraceptive use.

The result shows that employment status of women and family wealth have negative effect on fertility. This evidence is consistent with increasing opportunity cost of having more children and with husband's role in fertility decisions in Bangladesh. I see that the group of women who passed through sever crisis period (1970 to 1975) of the country has lower number of child births than women married in different periods. Among other things, I find that there is significant difference in fertility of women across Muslim and other religions, and across geographical locations.

References

Ainsworth, M., Beegle, K. and Nyamete, A. (1996). The impact of women's schooling on fertility and contraceptive use: a study of fourteen Sub-Saharan African countries. *World Bank Economic Review*, 10(1):85-122.

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, 19(6): 716–723.

Atella, V. and Rosati, F. C. (2000). Uncertainty about children's survival and fertility: a test using indian microdata. *Journal of Population Economics*, 13(2):263-278.

Baldwin, C. S. (1977). Catastrophe in Bangladesh: an examination of alternative population growth possibilities 1975-2000. *Asian Survey*, 17(4):345-357.

Becker, G. S. (1960). *An economic analysis of fertility in demographic and economic change in developed countries*, Princeton University Press and NBER Chicago.

Becker, G. S. (1976). *The economic approach to human behavior*, The University of Chicago Press.

Becker, G. S. and Lewis, H. G. (1973). On the interaction between the quantity and quality of children. *Journal of Political Economy*, 81(2 part 2):S279-S288.

Behrman, J. R. and Wolfe, B. L. (1984). A more general approach to fertility determination in a developing country: the importance of biological supply considerations, endogenous tastes and unperceived. *Economica*, 51(203):319-339.

Central Intelligence Agency (2012). *The World Factbook,* Washington, DC: https://www.cia.gov/library/publications/the-world-factbook/geos/bg.html, Accessed on July 13, 2012.

Chen, L. C. (1973). *Disaster in Bangladesh: Health Crisis in a Developing Nation*, New York: Oxford University Press.

Cleland, J., Phillips, J. F., Amin, S. and Kamal, G. M. (1994). *The determinants of reproductive change in Bangladesh: success in a challenging environment*. Washington, DC, World Bank.

Curlin, G. T., Chen, L. C. and Hussain, S. B. (1976). Demographic crisis: the impact of the Bangladesh civil war (1971) on births and deaths in a rural area of Bangladesh. *Population Studies*, 30(1):87–105.

Easterlin, R. A. (1966). On the relation of economic factors to recent and projected fertility changes. *Demography*, 3(1):131-153.

Easterlin, R. A. and Crimmins, E. M. (1985). *The Fertility Revolution, Supply-Demand Analysis.* University of Chicago Press, Chicago.

Easterlin, R. A., Pollak R. A. and Wachter, M. L. (1980). Toward a more general model of fertility determination: endogenous preferences and natural fertility. In: Easterlin RA (ed) *Population and Economic Change in Developing Countries.* University of Chicago Press, Chicago, 81–149.

Famoye, F. (1993). Restricted generalized Poisson regression model. *Communications in Statistics-Theory and Methods,* 22(5):1335–1354.

Guinnane, T. W., Moehling, C. M., Gráda, Ó. C. (2006). The fertility of the Irish in the United States in 1910. *Explorations in Economic History*, 43(3):465-485.

Haque, W., Mehta, N., Rahman, A. and Wignaraja, P. (1977). Towards a theory of rural development. *Development Dialogue*, 2:11-67.

Hilbe, J. M. (2011). *Negative binomial regression*, second edition, Cambridge University Press.

Kabeer, N. (2001). Ideas, economics and 'the sociology of supply': explanations for fertility decline in Bangladesh. *Journal of Development Studies*, 38(1):29-70.

Kabir, A., Barbhuiya, M. A. K. and Islam, M. S. (2001). Determinants of fertility in Bangladesh: evidence from the three national surveys. *The Sciences*, 1(5): 302-307.

Kravdal, Ø. (2002). Education and fertility in Sub-Saharan Africa: individual and community effects. *Demography*, 39(2):233-250.

Lam, D. and Duryea S. (1999). Effects of schooling on fertility, labor supply and investments in children, with evidence from Brazil. *Journal of Human Resources,* 34(1):160–192.

Majlis, D. (1977). A basketful of hope. *Far Eastern Economic Review*, (23 September):22-25.

Melkersson, M and Rooth, D. (2000). Modeling female fertility using inflated count data models. *Journal of Population Economics,* 13(2):189-203.

Miranda, A. (2010). A double-hurdle count model for completed fertility data from the developing world. *DoQSS Working Paper*, No. 10-01.

Muhith, A. M. A. (2012). *A Chronicle of Last Three Years: Building the Future Budget Speech 2012-13***,** Minister, Ministry of Finance, Government of People's Republic of Bangladesh, Dhaka.

Mullahy, J. (1986). Specification and some testing of modified count data models. *Journal of Econometrics*, 33(3):341-365.

National Institute of Population Research and Training (NIPORT), Mitra and Associates, and ORC Macro. 2005. *Bangladesh Demographic and Health Survey 2004.* Dhaka, Bangladesh and Calverton, Maryland [USA]: National Institute of Population Research and Training, Mitra and Associates, and ORC Macro.

National Institute of Population Research and Training (NIPORT), Mitra and Associates, and Macro International. 2009. *Bangladesh Demographic and Health Survey 2007.* Dhaka, Bangladesh and Calverton, Maryland, USA: National Institute of Population Research and Training, Mitra and Associates, and Macro International.

National Institute of Population Research and Training (NIPORT), International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B), Mitra and Associates, Associates for Community and Population Research (ACPR) and MEASURE Evaluation. 2011. *Bangladesh maternal Mortality and Health Care Survey 2010.*

Nguyen-Dinh, H. (1997). A socioeconomic analysis of the determinants of fertility: the case of Vietnam. *Journal of Population Economics*, 10(3):251-271.

Osili, O. U. and Long. B. T. (2008). Does female schooling reduce fertility? Evidence from Nigeria. *Journal of Development Economics*, 87(1):57-75.

Pollak, R. A. and Watkins, S. C. (1993). Cultural and economic approaches to fertility: proper marriage or mesalliance? *Population and Development Review*, 19(3):467-496.

Santos Silva, J. M. C. and Covas, F. (2000). A modified hurdle model for completed fertility. *Journal of Population Economics*, 13(2):173-188.

United Nations Development Programme, Bangladesh. *Millennium development goal, MDGs in Bangladesh*, http://www.undp.org.bd/mdgs.php, Accessed on July 13, 2012 http://www.undp.org.bd/mdgs/MDGs%20Score%20card, Accessed on July 13, 2012.

Wang, W. and Famoye, F. (1997). Modeling household fertility decisions with generalized Poisson regression. *Journal of Population Economics*, 10(3):273-283.

Winkelmann, R. (1995). Duration dependence and dispersion in count-data models. *Journal of Business and Economic Statistics*, 13(4):467-741.

Winkelmann, R. and Zimmermann, K. F. (1994). Count data models for demographic data, *Mathematical Population Studies: An International Journal of Mathematical Demography*, 4(3):205-221.

Appendix

Table 1: Fertility rate, contraceptive use, and child mortality rate in Bangladesh.

Survey	Total fertility Rates	Contraceptive use: Any method	Mortality rate: Under-5 mortality
2007 BDHS	2.7	55.8	74
2004 BDHS	3	58.5	97
1999-00 BDHS	3.3	54.3	110
1996-97 BDHS	3.3	49.8	128
1993-94 BDHS	3.4	44.9	150

Table 2: Observed distribution of dependent variable and the Poisson distribution.

No. of child ever born	Observation	Observed distribution	Poisson distribution
0	183	0.024	0.012
1	321	0.042	0.052
2	958	0.126	0.115
3	1,316	0.173	0.171
4	1,471	0.193	0.191
5	1,103	0.145	0.170
6	896	0.118	0.126
7	608	0.080	0.081
8	383	0.050	0.045
9	208	0.027	0.022
10	107	0.014	0.010
11	27	0.004	0.004
12	26	0.003	0.001
13	8	0.001	0.001
14	1	0.000	0.000
15	2	0.000	0.000
Total	7,618	1.000	1.000

Note: Dependent variable is number of child ever born of women. In The Poisson distribution, the mean is 4.46.

Table 3: Descriptive statistics.

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
Y	No. of children ever born	7,556	4.46	2.25	0	15
medu_no	Women-No education	7,555	0.51	0.50	0	1
medu_pr	Women-Primary education	7,555	0.28	0.45	0	1
medu_sc	Women-Scondary education	7,555	0.16	0.37	0	1
medu_h	Women-Higer secondary education	7,555	0.05	0.21	0	1
hedu_no	Husband-No education	7,545	0.39	0.49	0	1
hedu_pr	Husband-Primary education	7,545	0.23	0.42	0	1
hedu_sc	Husband-secondary education	7,545	0.24	0.43	0	1
hedu_h	Women-Higher secondary education	7,545	0.14	0.34	0	1
mage	Women's age	7,556	41.36	4.39	35	49
mfage	Women's age at first marriage	7,556	14.91	3.02	10	39
mwork	Women current employment status	7,553	0.29	0.46	0	1
m70_75	Women married between 1970 and 1975	7,556	0.26	0.44	0	1
poorest	Wealth index-Poorest	7,556	0.16	0.36	0	1
poorer	Wealth index-Poorer	7,556	0.17	0.37	0	1
middle	Wealth index-Middle	7,556	0.19	0.39	0	1
rich	Wealth index-Rich	7,556	0.21	0.41	0	1
richer	Wealth index-Richer	7,556	0.28	0.45	0	1
urban	Women living in urban area	7,556	0.37	0.48	0	1
muslim	Women religion if Islam	7,555	0.88	0.32	0	1
com_chdeath	Community average child death	7,556	0.38	0.21	0	1.37
idealch	Expected number of children	7,164	2.51	0.88	0	10
barishal	Women living in Barishal region	7,556	0.13	0.33	0	1
dhaka	Women living in Dhaka region	7,556	0.21	0.41	0	1
chittagong	Women living in Chittagong region	7,556	0.17	0.38	0	1
khulna	Women living in Khulna region	7,556	0.15	0.36	0	1
rajshahi	Women living in Rajshahi region	7,556	0.21	0.41	0	1
sylhet	Women living in Sylhet region	7,556	0.13	0.33	0	1
year07	Women in year 2007	7,556	0.51	0.50	0	1

Table 4: Estimated coefficients of the linear, the Poisson, the generalized Poisson, and the Poisson hurdle models.

Variable	OLS	Poisson	Generalized Poisson	Poisson Hurdle 1st stage Logistic	Poisson Hurdle 2nd stage Zero truncated Poisson
medu_pr	0.126*	0.033**	0.033**	0.464*	0.026*
	(0.056)	(0.012)	(0.012)	(0.224)	(0.012)
medu_sc	-0.101	-0.030	-0.030	1.086**	-0.055**
	(0.075)	(0.018)	(0.018)	(0.418)	(0.019)
medu_h	-0.188	-0.180***	-0.180***	1.294*	-0.291***
	(0.115)	(0.034)	(0.034)	(0.566)	(0.040)
hedu_pr	0.105	0.025	0.025	0.316	0.022
	(0.065)	(0.014)	(0.014)	(0.242)	(0.013)
hedu_sc	-0.130	-0.026	-0.026	0.370	-0.033*
	(0.066)	(0.015)	(0.015)	(0.258)	(0.015)
hedu_h	-0.305***	-0.073**	-0.073**	0.222	-0.085***
	(0.092)	(0.023)	(0.023)	(0.438)	(0.023)
mage	0.112***	0.026***	0.026***	0.024	0.027***
	(0.007)	(0.001)	(0.001)	(0.024)	(0.001)
mfage	-0.143***	-0.039***	-0.039***	-0.195***	-0.037***
	(0.009)	(0.003)	(0.003)	(0.022)	(0.003)
mwork	-0.334***	-0.079***	-0.079***	-0.265	-0.078***
	(0.049)	(0.012)	(0.012)	(0.167)	(0.012)
m70_75	-0.158*	-0.044**	-0.044**	-0.529*	-0.036*
	(0.076)	(0.015)	(0.015)	(0.261)	(0.015)
poorer	0.017	0.000	0.000	0.514	-0.008
	(0.087)	(0.018)	(0.018)	(0.287)	(0.018)
middle	-0.094	-0.018	-0.018	0.509	-0.029
	(0.085)	(0.018)	(0.018)	(0.279)	(0.018)
rich	-0.239**	-0.054**	-0.054**	0.037	-0.059**
	(0.087)	(0.018)	(0.018)	(0.264)	(0.018)
richer	-0.396***	-0.094***	-0.094***	0.072	-0.104***
	(0.097)	(0.021)	(0.021)	(0.326)	(0.021)
urban	-0.059	-0.017	-0.017	-0.064	-0.017
	(0.054)	(0.012)	(0.012)	(0.208)	(0.012)
muslim	0.464***	0.114***	0.114***	0.014	0.124***
	(0.064)	(0.017)	(0.017)	(0.245)	(0.017)
com_chdeath	1.899***	0.385***	0.385***	0.633	0.388***
	(0.140)	(0.028)	(0.028)	(0.494)	(0.028)
idealch	0.433***	0.084***	0.084***	0.433**	0.082***
	(0.030)	(0.006)	(0.006)	(0.134)	(0.006)
dhaka	-0.217**	-0.048**	-0.048**	0.141	-0.056**
	(0.079)	(0.018)	(0.018)	(0.350)	(0.018)
chittagong	0.362***	0.082***	0.082***	-0.066	0.087***
	(0.083)	(0.018)	(0.018)	(0.353)	(0.018)
khulna	-0.517***	-0.127***	-0.127***	-0.108	-0.136***
	(0.083)	(0.020)	(0.020)	(0.356)	(0.020)
rajshahi	-0.412***	-0.099***	-0.099***	-0.379	-0.100***
	(0.079)	(0.018)	(0.018)	(0.334)	(0.018)
sylhet	0.211	0.051*	0.051*	-0.620	0.068**
	(0.109)	(0.023)	(0.023)	(0.365)	(0.022)
year07	-0.184***	-0.047***	-0.047***	0.045	-0.051***
	(0.046)	(0.010)	(0.010)	(0.172)	(0.010)
Constant	0.305	0.674***	0.674***	4.317***	0.612***
	(0.322)	(0.076)	(0.076)	(1.194)	(0.077)
alpha			2.29e-23		
			(2.72e-23)		
Log-likelihood	-14553.445	-14409.486	-14409.486	-692.728	-13619.073
AIC	29156.890	28868.972	28870.972	1435.457	27288.146
BIC	29328.758	29040.840	29049.715	1607.325	27459.449
Pseudo-R^2	0.079		0.096	0.083	
N	7,149	7,149	7,149	7,149	6,989

Notes: Robust standard errors are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. *alpha* is dispersion parameter.

Table 5: Expected number of children by rural and urban areas.

Expected number of children	Rural	Urban
0	6	3
1	105	112
2	2,529	1,742
3	1,098	565
4	588	278
5	68	21
6	29	3
7	3	3
8	4	0
9	2	0
10	5	0
Total	4,437	2,727

Table 6: Child death by rural and urban areas.

Child death	Rural	Urban
0	10,421	6,313
1	2,620	1,257
2	888	344
3	289	84
4	104	40
5	33	9
6	14	3
7	8	3
8	1	1
9	1	0
10	1	0
11	0	1
12	1	0
Total	14,381	8,055

Note: Data is for women age 15-49 years old.

Table 7: Estimated coefficients the two restricted Poisson models.

	Poisson (excluding *idealch*)	Poisson (exluding *com_chdeath*)
	(0.018)	(0.019)
medu_pr	0.027*	0.029*
	(0.012)	(0.012)
medu_h	-0.215***	-0.191***
	(0.035)	(0.034)
hedu_sc	-0.032*	-0.030*
	(0.015)	(0.015)
hedu_pr	0.028*	0.027
	(0.014)	(0.014)
hedu_h	-0.073**	-0.080***
	(0.023)	(0.023)
mage	0.025***	0.026***
	(0.001)	(0.001)
mfage	-0.040***	-0.041***
	(0.003)	(0.003)
mwork	-0.088***	-0.080***
	(0.012)	(0.012)
m70_75	-0.045**	-0.047**
	(0.015)	(0.015)
poorer	0.001	0.000
	(0.018)	(0.018)
middle	-0.019	-0.031
	(0.018)	(0.018)
rich	-0.060**	-0.074***
	(0.018)	(0.019)
richer	-0.091***	-0.133***
	(0.021)	(0.021)
urban	-0.022	-0.042***
	(0.012)	(0.012)
muslim	0.142***	0.124***
	(0.017)	(0.017)
com_chdeath	0.421***	
	(0.028)	
dhaka	-0.056**	-0.036*
	(0.018)	(0.018)
chittagong	0.104***	0.090***
	(0.017)	(0.018)
khulna	-0.146***	-0.154***
	(0.020)	(0.020)
rajshahi	-0.112***	-0.121***
	(0.018)	(0.018)
sylhet	0.080***	0.128***
	(0.022)	(0.022)
year07	-0.055***	-0.069***
	(0.010)	(0.010)
idealch		0.091***
		(0.006)
constant	0.871***	0.850***
	(0.074)	(0.075)
Log-likelihood	-15439.685	-14485.637
AIC	30927.371	29019.273
BIC	31093.646	29184.267
Pseudo-R^2	0.073	0.074
N	7,541	7,149

Notes: Robust standard errors are in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%.