Advanced Parental Age and Wide Age Gap Effects on Human Secondary Sex Ratio in Romania

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ABSTRACT

This paper aims to analyze the effects of parental age (especially advanced parental age) and age difference between parents on the probability of having a male/female offspring. The rationale of choosing this topic is based on the tendency of women to give birth at advanced age (>=35 years) and the increased frequency of couples with wide age gap. In order to conduct a successful research the data was obtained via survey, administrated online to the largest community of mothers in Romania. Using logistic regression models and statistical analysis we highlight the influence of maternal age, paternal age and the age gap on offspring gender. The paper brings new empirical evidence that advanced maternal age can shift the sex ratio in favor of male offspring and that a wide age gap between parents have influence on offspring's gender. The study is outstanding since the literature regarding the subject worldwide is conflicting and the one regarding Romania is very poor or nonexistent.

Keywords: *sex ratio, survey, logistic regression, advanced maternal age, age gap*

JEL Classification: *C53, C83, J13*

1. INTRODUCTION

Maternal age at delivery has increased in the last decades because of women's desire to reach a top position, a successful career and a high educational level. The postponement of the first birth has implications on the ability of women to conceive and of parents to produce additional offspring. The exceptionally large postponement is associated with the disparity between the optimal biological period for women to have children and obtaining additional education or building a career. The main reasons that contribute to this shift of maternal age can be considered the evolution of contraceptives industry, increase of women education and participation in labor markets, change of values, gender equality, living conditions, economic uncertainty and absence of supportive policies for parenthood.

It has been stated by some researchers that maternal age has a pronounced influence on the gender of the offspring. Some of them observed a tendency for the sex ratio to decrease as the age of the mother increases, others on the contrary, revealed higher sex ratios associated with advanced maternal ages. However, numerous examinations of parental age have given conflicting results, their conclusions being unable to prove any consistent relationship between sex ratio at birth and the maternal age, paternal age or the difference in age of the two parents.

Given the new tendency of advanced maternal age at birth (>=35 years) and the increasingly higher age gap between parents and also the conflicting results existing in the literature we aimed to investigate the possible effects of maternal age (especially over 35 years), paternal age and age gap (with focus on age gap over 15 years) using a sample obtained via survey methodology.

In the last decades there has been an important increase in the number of women giving birth at age of over 35 years. The reasons why people postpone parenthood include:

- Educational level of women has increased
- Women are frequently working in male-dominated fields, not understanding and supporting motherhood
- Cultural and values changes
- Lack of childcare, low benefit levels and workplace policies that cautions women that they cannot achieve a great career and be a mother at the same time
- Divorce, having multiple partners before settling down leads some people to delay parenthood
- Economic or housing uncertainty, unemployment, temporary work, unstable labor markets
- Fertility treatments

Reproduction is costly, as Parental Investment Theory states. The capacity of people to devote their time and resources to producing and raising a child is limited since such expense can also be harmful to their future situation, outliving and reproduction outcome in future. Parents are selected such that to maximize the difference between benefits and costs and parental care will only exist where benefits are massively greater than the costs.

The rest of the paper is structured as follows: Section 2 provides an overview of the existing literature, Section 3 give information on data and methodology, whilst Section 4 examines parental age and age difference between parents effects on offspring gender using a data set obtain via survey within Romanian mothers by employing logistic regression models. The last section states our conclusions, followed by references.

2. LITERATURE REVIEW

Many studies on the variation of human sex ratio (the number of males per hundred females) have shown a lower number of male births than expected during wars, earthquakes or economic collapse. This can easily be explained by the fact: it is proved that male embryos are more vulnerable and at higher risk of intrauterine death compared to female embryos. Also, there exists an association between complications in pregnancy such as fetal death or preterm delivery and a relatively higher proportion of male offspring. These complications are frequently associated with advanced age of mother. Catalano [2005] found that high maternal age can be considered a stress factor in pregnancy and that there is evidence that female offspring are overrepresented in stressful pregnancies.

The study conducted by Takahashi [1954] suggested that the sex ratio is increased at high maternal age, while Lowe and McKeown [1950] revealed a relatively lower proportion of male births associated with increased maternal and paternal ages. Rueness et al. [2011] study among 2.3 million births from 1967 to 2006 in Norway led to the conclusion that there was no overall association of maternal age at delivery with offspring sex ratio, while the sex ratio (1.06) did not substantially change during the 40 years period.

Matsuo, Ushida, Udolf [2009] analysis on 3049 deliveries shown that increasing paternal ages decrease the male to female birth ratio sinergistically. Paternal age > or = 40 years showed smaller sex ratio, 0.75 compared to 1.17. Advanced maternal age was also associated with smaller sex ratios, for age 35-39 – 0.85 vs. 1.12 and for age > or = 40 - 0.63 vs. 1.12. Sex ratios for parental ages > or = to 40 years were significantly smaller than for ages 30-34 (0.52 vs 1.17).

It seems that it is generally agreed that the probability of a male offspring decreases with increasing birth order. Manning et al. [1997] hypothesized that the increased sex ratio in the early to mid 20th century might be related to the increased age difference between parents. Moreover, Astolfi et al. [1999] observed a strange excess of males among children born in Lombardy (Italy) to a particular subsample of parents, with wide age gap (>15 years).

There are also studies that investigated whether different women job types are associated with child gender at birth, testing the hypothesis that women having „high stress" job types are more likely to give birth to a female offspring than a male, as males are more vulnerable to unpropitious conditions during conception, pregnancy and after birth. For instance, Ruckstutil et al. [2010] investigated the effects of mother's age, maternal and paternal job type and paternal income on sex ratio at birth. The analyses were based on 16384 incidents of births from a six year childbirth dataset from a hospital in Cambridge, UK. The study concluded that women categorized in „high stress" job types were indeed more likely to give birth to daughters, while „low stress" job type women had equal sex ratios or a slight male bias in offspring.

3. DATA AND METHODOLOGY

Data collection and analysis

Survey methodology was used for sample identifying, data collection, statistical adjustment of data, data processing and data analysis. The survey was conducted in November-December 2016. Data was registered in a Microsoft Excel spreadsheet. All analysis were performed using the SPSS software.

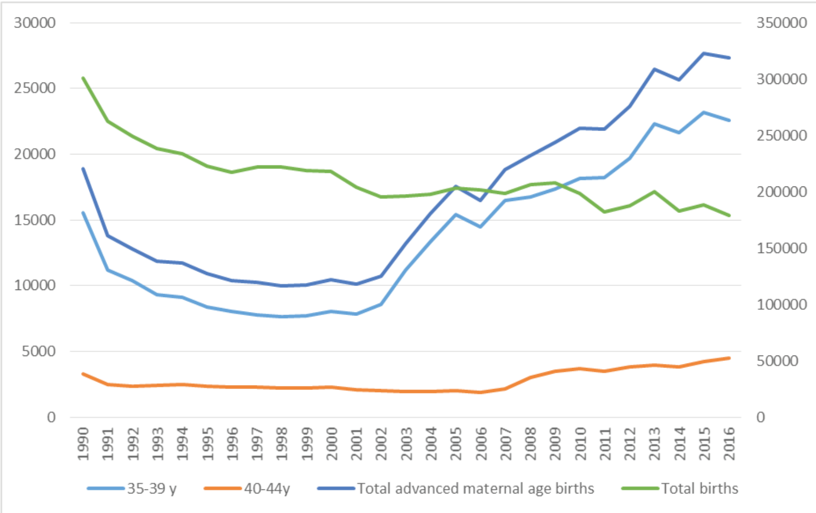
Since the success of the research is dependent on the representativeness of the sample with respect to the target population of interest (i.e. parents) we have administrated the survey online to mothers which are members of the largest online community of mothers in Romania. The method of collection was the questionnaire and the individual questions became data used for statistical analysis. The survey focused on maternal age, paternal age and offspring gender at birth. The number of total responses to the survey was 1109 of which only 1078 were assessed as valid answers after data verification.

The questionnaire was constructed in a simple way so that respondents do not get bored, understand the questions and be able to respond quickly. The mothers were asked the following information in the questionnaire: 1. Maternal age at birth, 2. Paternal age at birth, 3. Offspring's gender at birth (the response was M in the case of male offspring and F in case of female).

The tendency to delay parenthood is present all over the world. Looking at the Romanian data, provided by the National Institute of Statistics we find that today, 15% of mothers giving birth are 35 years and older, up from 8.64% in 2005 and 6% in 1990. It should be noted that the number of births associated with advanced maternal age (>=35 years) has greatly increased despite the fact that the overall number of births have decreased.

Advanced maternal age and births evolution

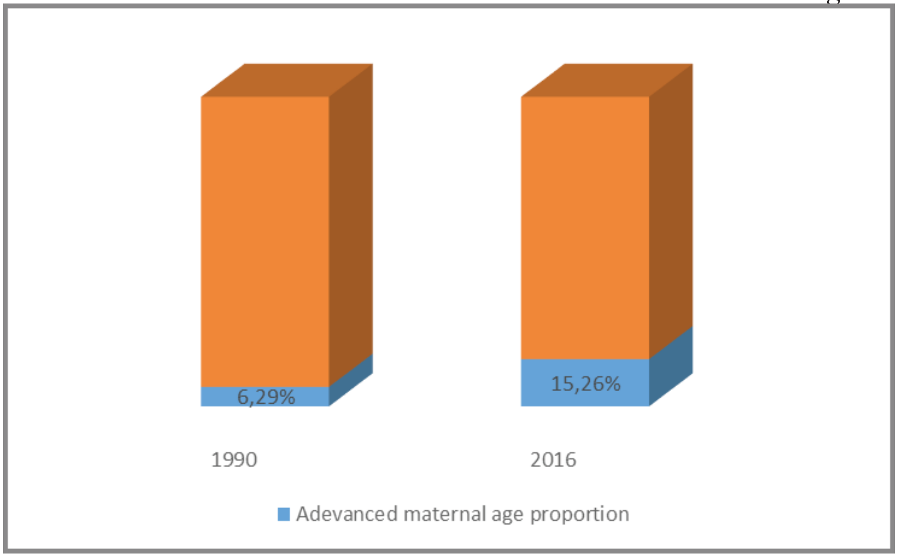
Figure 1



The survey error calculated as the difference between the mean of the maternal age in the population (provided by the National Institute of Statistics) and the estimate of the mean based on the sample survey is of 2.11% < 5% which suggests that the sample is a fair representation of reality. Moreover, looking at the presence of maternal age subgroups in the sample it can be concluded that the distribution of maternal age in the sample is satisfactory enough and can be used for further analysis.

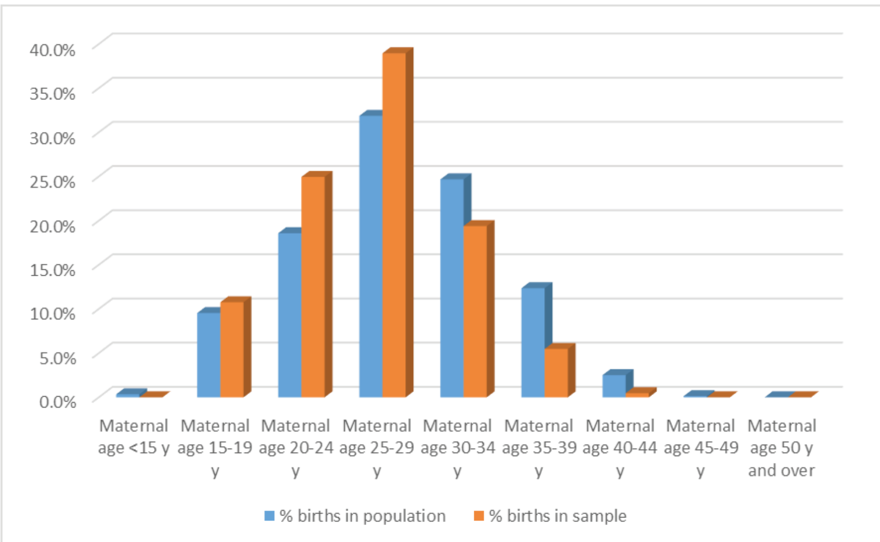
Advanced maternal age no. of births proportion evolution

Figure 2



Maternal age representativeness in sample

Figure 3



Logistic regression

Logistic regression is one of the most frequently used tools in applied statistics and data analysis. In logistic regression, the dependent variable is binary or dichotomous, i.e. it can only take values such as 1 or 0 (male vs. female, true vs. false, etc.).

The objective of the logistic regression is to find the best model that fits the data which describes the relationship between the dichotomous characteristic of interest (dependent variable = response or outcome variable) and one or more independent (predictor or explanatory) variables.

Formally, the logistic regression model has the following form:

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k \tag{1}$$

p being the probability of presence of the characteristic of interest.

The logit transformation is defined as the logged odds:

$$odds = \frac{p}{1-p} = \frac{probability\ of\ presence\ of\ characteristic}{probability\ of\ absence\ of\ characteristic} \tag{2}$$

And

$$logit(p) = \ln\left(\frac{p}{1-p}\right) \tag{3}$$

In this study, binomial logistic regression was used to determine whether the offspring gender could be predicted from maternal age, paternal age and the age difference between parents.

4. RESEARCH RESULTS

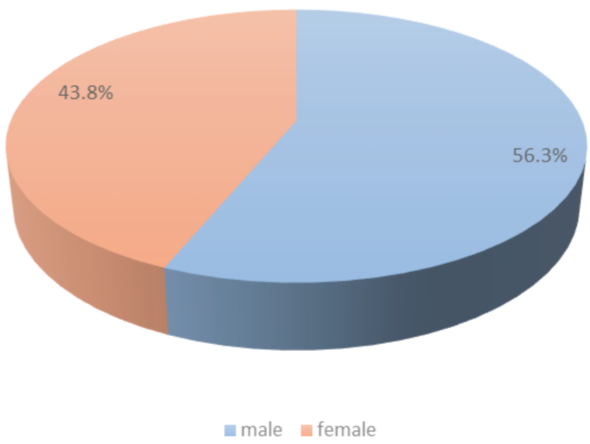
We have started our analysis by displaying descriptive statistics such as mean, min, max and standard deviation. It should be noted that if we compare the means of parental ages and age gap, they do not differ significantly between groups. For instance, the mean paternal age of female offspring group is 30.06, while of male group is 30.04. The Independent samples t-test also led to this conclusion. Another information that should be noted is the average age gap, of around 4.5 years.

Investigating the sex ratios (SR) for all subsamples of ages separately for mother, father and both of them we observed that the odds are more favorable to male offspring at all parental ages, except the situation when the father age is between 35-39 years (SR=0.96) and when both parents are 35-39 years (SR=0.92). For the overall sample the SR is 1.14. The opposite case, i.e. the highest SR, can be found for advanced maternal ages (>=35 years) and when both parents are very young (age <=19 years).

Logistic regression analysis was selected as the statistical method to assess the probability of having a male offspring. The first hypothesis selected to test is that advanced maternal age affects the offspring gender. In the overall sample of ages, maternal age does not significantly contribute to the determination of offspring gender. However, when looking at data associated with advanced age mothers, we observed a male offspring bias. Having this in mind, we built the logistic regression model by selecting only cases when maternal age was over or equal to 35 years.

Offspring gender for advanced age mothers

Figure 4.



The logistic regression using advanced_maternal_age as independent variable, estimated using SPSS software has the following form:

$$\ln\left(\frac{P(newborn\_gender = 1)}{1 - P(newborn\_gender = 1)}\right) = -11.585 + 0.325 * advanced\_maternal\_age \quad (4)$$

The Omnibus test of model coefficients table gave the result of Chi-squared test which indicates whether the inclusion of advanced_maternal_age variable contributes significantly to the improvement of the model fit (compared to the null model = the model containing only the intercept). The P-value = 0.03 < 5% indicates that model is a significant improvement of the null one.

Analyzing the variables in the equation, we focus on P-values associated with the Wald test which indicates whether the estimates are statistically significant (<>0). P-value for both advanced_maternal_age and intercept do not exceed 5.8% which confirms statistically significance with a confidence of over 94%.

Model 1 estimation using SPSS

Table 1.

Model 1	Coefficient	S.E.	Wald statistic	P-value
advanced_maternal_age	0.325	0.168	3.719	0.054
Constant	-11.585	6.116	3.588	0.058

Using a range of advanced maternal age we have simulated the probability of having a male offspring using Model 1 presented above. It should be noted that the odds of giving birth to a son increases with the maternal age. This is also suggested by the positive sign of advanced_maternal_age coefficient. Thus, Model 1 led to the conclusion that advanced maternal age could shift the sex ratio in favor of male offspring, by increasing it.

Results generated via Model 1

Table 2.

Maternal age	P(offspring gender=male) via Model 1
35	44.77%
36	52.87%
37	60.83%
38	68.24%
39	74.84%
40	80.46%
41	85.07%
42	88.75%
43	91.61%
44	93.79%
45	95.43%

Using the whole set of data we have also built a model that has newborn_gender as dependent variable, paternal_age as the independent variable and maternal_age as selection variable with the rule maternal_age>=35.

The resulting model with the constraint of advanced maternal age, estimated using SPSS software, is:

$$\ln\left(\frac{P(newborn\_gender = 1|maternal\_age \geq 35)}{1 - P(newborn\_gender = 1|maternal\_age \geq 35)}\right) = -4.239 + 0.121 * paternal\_age \quad (5)$$

The Omnibus test of model coefficients displays P-value = 0.018 << 5% which indicates that the model is a significant improvement of the null one.

Now, looking at the variables in the equation, we are interested in the P-values associated with the Wald test which indicates whether the estimates are statistically significant (<>0). It can be easily observed from the table below that P-Value is under 5% threshold for both paternal_age and intercept.

Model 2 estimation using SPSS

Table 3.

Model 2	Coefficient	S.E.	Wald statistic	P-value
paternal_age	0.121	0.055	4.840	0.028
Constant	-4.239	2.053	4.261	0.039

Model 1 and Model 2 give a very useful outcome since one can, only by replacing maternal and paternal age, find the probability of having a male offspring (or female by calculating the reverse probability), if the mother is of age greater than 35 years.

Backtesting Model 2, we find that for paternal age = 35 years the probability of having a male offspring is of 49%. This result is in accordance with the one achieved by analyzing the sex ratios in the raw data, i.e. for father aging between 34-39 years there is a greater probability of having a female offspring.

The study aims also to test the hypothesis that a large age difference between parents can influence human secondary sex ratio (sex ratio at birth). We observed an excess of males born in the particular subsample of parents with wide age gap (>=15 years), i.e. 64% of offspring were males. However, in the overall sample the age gap does not significantly contribute to the determination of the offspring gender.

We have tested several models which embedded as independent variable age_gap and the outcome was surprising. We managed to build a model having age_gap and paternal_age as independent variables, offspring gender as dependent one, but only under the constraint of advanced maternal age (selection variable rule: Maternal_age>=35). For all maternal ages there is no evidence that age_gap has a contribution in determining offspring gender.

Hence, the resulting model is:

$$\ln\left(\frac{P(newborn\_gender = 1|maternal\_age \geq 35)}{1 - P(newborn\_gender = 1|maternal\_age \geq 35)}\right) = -6.482 + 0.206 * age\_gap + 0.161 * paternal\_age \quad (6)$$

The Omnibus test of model coefficients indicates that the inclusion of age_gap and paternal_age variables contributes significantly to the improvement of the model fit (P-value = 0.005 <<5%). From the values of the pseudo-R2 we can conclude that between 15.3% and 20.5% of the variation in offspring gender can be explained by age gap and paternal age.

Regarding the variables in the equation, we are interested in the value of the P-value associated with the Wald test which indicates whether the estimates are statistically significant (<>0). It can be easily observed from the table below that P-Value is under 5% threshold for all variables in the model.

Model 3 estimation using SPSS

Table 4.

Model 3	Coefficient	S.E.	Wald statistic	P-value
age_gap	0.206	0.098	4.395	0.036
paternal_age	0.161	0.064	6.392	0.011
Constant	-6.482	2.513	6.652	0.010

Backtesting Model 3, we find that for age gap 0 and paternal age 35 (thus the mother has also 35 years) the probability of having a male offspring is of 30%. This result is in accordance with Model 2 outcome and with the one achieved by analyzing the sex ratios in the raw data, i.e. for both parents aging between 34-39 years there is a greater probability of having a female offspring.

Model 4 gives a more interesting definition of age gap. We have computed a categorical version of age_gap variable which takes value 0 if the age gap is normal (<15 years) and 1 if there is a wide age gap between parents. Using this new variable we have tested several combinations of variables in the model, but the one that best fitted the data is:

$$\ln\left(\frac{P(newborn\_gender = 1|paternal\_age \geq 45)}{1 - P(newborn\_gender = 1|paternal\_age \geq 45)}\right) = 1.946 - 1.946 * age\_gap\_cat \quad (7)$$

Thus, this time advanced paternal age and age gap category influence the offspring's gender.

Model 4 estimation using SPSS

Table 5

Model 4	Coefficient	S.E.	Wald statistic	P-value
age_gap_cat	-1.946	1.242	2.454	0.117
Constant	1.946	1.069	3.313	0.069

Using Model 4 we have simulated the outcome:

Results generated via Model 4

Table 6.

Age gap category	P(gender=male|paternal_age>=45) via Model 4
0 (normal gap)	87.50%
1 (wide gap)	50.00%

Therefore, the results show that if the father is of advanced age (>=45) and the age difference between parents is greater than 15 years (usually the mother is younger), the chances of having a male or female offspring is equal. In the normal age gap category (<15 years) and advanced age father scenario the odds are in favor of having a male offspring.

We have performed Hosmer-Lemeshow test for each model, a chi-square statistic being computed comparing the observed frequencies with those expected under the linear model. In our case, Hosmer-Lemeshow goodness of fit test suggests that the models are a good fit to the data as P-values > 5% (for instance, P-value= 0.695 for model 3).

CONCLUSIONS

For all species, especially humans, reproduction is costly, as Parental Investment Theory states. The capacity of people to devote their time and resources to producing and raising a child is limited since such expense can also be harmful to their future situation, outliving and reproduction outcome in future. The tendency to delay parenthood is present all over the world. Looking at the Romanian data, provided by the National Institute of Statistics we find that today, 15% of mothers giving birth are 35 years and older.

Investigating the sex ratios (SR) for all subsamples of ages separately for mother, father and both of them we observed that the odds are more favorable to male offspring at all parental ages, except the situation when the father age is between 35-39 years (SR=0.96) and when both parents are 35-39 years (SR=0.92). For the overall sample the SR is 1.14. The opposite case, i.e. the highest SR, can be found for advanced maternal ages (>=35 years) and when both parents are very young (age <=19 years).

Logistic regression analysis was selected as the statistical method to assess the probability of having a male offspring. Testing our first hypothesis (advanced maternal age affects the offspring gender) via two logistic models led to a very interesting outcome. Using Model 1 and Model 2 one can calculate the probability of having a male or female offspring by replacing the variables maternal age and paternal age with the constraint maternal age >=35. Model 1 showed that the advanced age of the mother can shift the sex ratio in favor of male offspring, by increasing it.

The study aimed also to test the hypothesis that a large age difference between parents can influence offspring's gender. We observed an excess of males born in the particular subsample of parents with wide age gap (>=15 years), i.e. 64% of offspring were males. Therefore, the results show that if the father is of advanced age (>=45) and the age difference between parents is greater than 15 years, the chances of having a male or female offspring is equal. In the normal age gap category (<15 years) and advanced age father scenario the odds are in favor of having a male offspring.

In conclusion, using data obtained via survey in Romania, this paper brings new empirical evidence that advanced maternal age, advanced paternal age and a wide age gap between parents have influence on offspring's gender. The study is outstanding since the literature regarding the subject worldwide is conflicting and the one regarding Romania is very poor or nonexistent.

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