THE SCORING MODEL OF FERTILITY: ESTIMATION OF PROBABILITY OF SECOND BIRTHS IN RUSSIA

Oksana Shubat – Anna Bagirova

Abstract

The growth of higher-order births is extremely important for demographic future of Russia and overcoming the depopulation trend in the country. Actually, in modern Russia the one-child family is a modal tendency.

The article presents a scoring model of fertility, which enables to estimate the probability of second births for Russian women. Binary logistic regression is used to identify the determinants of fertility. Among the latter were detected by both objective and subjective factors. ROC-analysis is used to identify the optimal cut-off value and to improve the quality of binary classifiers.

The survey of 1,296 pregnant women is the empirical basis for modeling. This survey was conducted in Russian antenatal clinics and parenting hospitals in 2011.

The developed model enables to expand the idea of stimulating the birth rate in Russia and to improve measures of state support for families. In particular, it allows defining the target audience of implementing demographic policies. The scoring model of fertility makes it possible to evaluate the effect of the ongoing pro-natalist policies and to predict the prospects of demographic processes in Russia on the basis of the calculated probabilities of higher-order births for different socio-demographic groups of women

Key words: fertility, determinants of fertility; second births; logistic regression, scoring model.

JEL Code: J11, J13, C51

Introduction

Forecasting of birth rate is of great practical importance in modern Russia. Issues of development of forecasting methods are topical and in demand, as the dynamics of the main demographic indicators does not have a monotonous (consistently increasing or decreasing) trend in Russia. For example, after a long 17-year period of depopulation, the growth of the population (although quite small) was observed in 2010-2012. However, adverse changes in its structure do not give a reason for optimism. Over the past decade (from 2002 to 2012) the

population of Russia decreased by 1.5% and the population of children has decreased by 10.5% ("Demographic indicators of," 2013).

In order to overcome the negative trend in fertility dynamics the growth of higher-order births is extremely important. Thus, the statistical and demographic techniques aimed at the prediction of the second and subsequent births are relevant in today's Russia. It should be noted that the Russian Federal State Statistics Service does not practice the systematic collection of data on order of birth since 1999. Therefore, the conventional approaches to fertility forecasting (such as the simple extrapolation, fitting a function, reference class forecasting) cannot be applied due to lack of data.

We believe the most promising method for the prediction of higher-order births in Russia is the construction and application of scoring models of fertility. Different types of scoring (application, behavior, collection and fraud) are widely used in the financial sector to assess the borrower. Most often, it is a quantitative assessment which can be obtained by parametric and nonparametric statistical methods. The adoption of scoring models in demographic predictions makes it possible to obtain such forecast estimates of second births which are fundamentally different from the traditional ones. Thus, we applied the logistic regression analysis to construct a scoring model of fertility and estimate the probability of second births in the age groups of Russian women.

Data and Methods

To estimate the probability of second birth we use a logit transformation:

$$p = \frac{1}{1 + e^{-y}} , \qquad (1)$$

where y – multiple regression.

Typically, if this value is greater than 0.5, it is assumed that the event will occur (in our case, it would mean the second birth), otherwise it is assumed that the event will not occur. However, we used the ROC-analysis to determine the optimal cut-off value and improve the quality of binary classifiers.

Selecting the best set of regression predictors is one of the key issues of the research. Essentially, we are talking about the selection of determinants of second births. It is important to note there is a well-established practice of studying the determinants of fertility (based on both official statistics and survey sampling) in the European science. These include both the objective socio-demographic factors (age, education level, marital status, type of settlement, etc.) and subjective factors (Balbo, Billari & Mills, 2013; Berinde, 1999; Brodmann, Esping-

Andersen & Güell, 2007; Del Boca, 2002; Hoem, 1990; Köppen, 2006; Lappegard & Ronsen, 2005). However in Russian studies mainly the objective factors are discussed as the determinants of fertility. Among the subjective factors only the respondents' opinions about the ideal, wanted and expected numbers of children are mentioned (Maleva & Sinyavskaya, 2007).

In our study, both objective and subjective factors were considered as potential determinants of second births. The first group included the following factors: age of woman; her educational level; marital status; the number of children in the parents' family; income per household member; labor force status; type of settlement). The second group consisted of the following factors: women's perceptions of the number of children in the family (ideal, wanted and expected), their estimations of the advantages and disadvantages of having children, estimations of the impact of political and socio-economic background on the decision-making about the birth.

Our study was held in 2011. We interviewed 1,296 pregnant women in Russian antenatal clinics and parenting hospitals.

Results

Initially, all potential determinants of fertility were included in the analysis. But in the final equation the following seven indicators were the predictors (significant at the 1% level):

X_1 – ideal number of children in the family;

X_2 – the belief that children are the obstacle to self-realization in professional activities (dummy variable has the value 1 for agreement and the value 0 for disagreement);

X_3 – the belief that children are the obstacle for enjoyment of life (dummy variable has the value 1 for agreement and the value 0 for disagreement);

X_4 – the belief that the optimal age is the actual motive of birth (dummy variable has the value 1 for agreement and the value 0 for disagreement);

X_5 – age;

X_6 – educational level (dummy variable has the value 1 for non-tertiary education and the value 0 for higher education);

X_7 – marital status (dummy variable has the value 1 for a married woman and the value 0 for an unmarried woman).

Thus, the probability of second birth is estimated by the equation (1),

where $y = -19,079 + 1,818X_1 + 1,582X_2 - 2,000X_3 + 1,929X_4 + 0,391X_5 + 1,098X_6 + 1,904X_7$.

The equation can be used as a classifier, i.e. a sort of "scoring fertility model". It is characterized by a relatively high quality and correctly classifies 84.6% of the respondents (Table 1). Additionally the quality of the classifier was assessment using the ROC-analysis. The area under the ROC-curve is 0.880, which also indicates the high quality of our model (Table 2).

Tab. 1: Classification Table[1, 2]

Observed		Predicted		
		Birth Number		Percentage
		First	Second	Correct
Birth Number	First	744	72	91.2
	Second	120	312	72.2
Overall Percentage				84.6

[1] Data were obtained by econometric modeling; binary logistic regression was applied.
[2] The cut value is 0.5.

Tab. 2: Area Under the Curve[1]

Area	Standard Error	Asymptotic Significance	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.880	0.012	0.000	0.857	0.903

[1] Data were obtained by econometric modeling; binary logistic regression was applied.

Further, we tried to improve the quality of classification, simultaneously maximize both sensitivity and specificity of the model by selecting the optimal cut-off value. The calculations confirmed the value of 0.339 as the optimal cut-off point. Thus, if the probability of second birth will exceed 0.339 (not 0.5), we can assume that the event (the second birth) will occur. Note that in this case, the proportion of correctly classified second births increased markedly – from 72.2% to 83.3% (Table 3).

Tab. 3: Classification Table[1, 2]

Observed		Predicted		
		Birth Number		Percentage
		First	Second	Correct
Birth Number	First	672	144	82.4
	Second	72	360	83.3
Overall Percentage				82.7

[1] Data were obtained by econometric modeling; binary logistic regression was applied.
[2] The cut value is 0.339.

The proposed equation can be applied to model the reproductive behavior of women. And at the same time it allows to create a kind of socio-demographic "portraits" of women of reproductive age. The paper presents some of the most striking portraits.

The first portrait – young woman of 22 years who has just graduated. This is the woman of European type focused on her professional career; her ideal is the one-child family. Possibly, she lives in the large city offering various entertainments. And she doesn't refuse these pleasures for the sake of a two-child family - very doubtful benefit, in her opinion. This may be due to her youth or the "one-child" type of thinking, which was formed by its parent family or other reference group. If her opinion is maintained the probability of second birth for this young woman is lowest (0.01) and it doesn't depend on whether she is married or not.

The second portrait – the young 24-year-old woman with a higher education and professional experience. She considers children are the obstacle to self-realization in her job. Probably, in preparation for the birth of her first child, she had difficulty in combining two social roles - the employee and the expectant mother. But her motherhood is consciously, she thinks it is possible to enjoy life and "even" to bring up two children. The probability of second birth for this woman is 0.34 (i.e. it is possible to predict she will implement her ideal model of two-child family). If she is getting older and her views do not change, the probability of second birth will increase markedly (for example, when she is 30 years old, it would be 0.84).

The third portrait – young 25-year-old woman without higher education. She believes children are the obstacle to self-realization in her job, but do not prevent to enjoy life; she is focused on a two-child family. Most likely she hopes closest relatives to help her bring up children. She lives in a small town where upbringing of children easier due the territorial proximity and a little choice of means and tools of parenting. The probability of second birth for this woman depends on her marital status markedly: it varies from 0.25 if she is not married to 0.68, if she is in a registered marriage.

And the last portrait – woman who believes that the ideal is a three-child family. She believes that children complicate the professional activity, but do not interfere with enjoying life. The probability of second birth for this woman is rather high even from the age of 20 years. It depends only on two factors: her educational level (if she has a higher education, the probability is 0.4, if she has not – 0.65) and her marital status (at the age of 22 the probability of second birth overcomes the cut-off value even if the woman is not married).

Further we estimated the probability of second births for those groups of women, whose contribution to the Russian birth rate is the most considerable. These are the following age groups of women: 20-24, 25-29 and 30-34 years.

Feature set that provides a second birth for women aged 20-24 years, is the following:

a) her marital status – married;

b) her ideal number of children – three;

c) she believes children are the obstacle to professional self-realization;

d) she believes children are not an obstacle to enjoyment of life.

At the age of 25-29 there are 2 typical groups:

1) married women with higher education who believes the family is best to have 2 or 3 children. These women are convinced that children make self-realization more difficult, but they don't prevent to enjoy life. Their chance to give birth to the second child is rather high;

2) married women without higher education, but with the same beliefs, have a higher chance to give second birth. Their opinion about ideal number of children in the family doesn't affect the probability of second birth.

Women in 30-34 are "critical" group. It is very hard to predict the effect of the stimulation of second births for this group of women. This is due to the age of births in Russia. Therefore, we have identified groups of women whose chance to give second birth is the lowest. First of all, these are women who consider that the ideal number of children in the family is only one. If a woman considers that in a family it is better to have two children, but she is not married, her probability of second birth is low. Married women without higher education, most likely, will not give birth to her second child if they believe that children prevented enjoying life.

At the same time, we have identified a category woman in the age 30-34 years, whose chance of having her second child is quite high. These are married women with higher education, who belief that the family must have at least two children. Regardless of their views about the value of children, work, and the possibility to enjoy life, their chance of having a second child is high enough. This result inspires a certain optimism about demographic prospects of Russia.

Conclusions

The proposed method allows us to identify determinants of second births in Russia. The results of our study confirmed that the decision on second birth is influenced by both

objective and subjective factors. We also suggest that our results may be supplemented by other social and psychological determinants of higher order births.

The developed scoring model enables to expand the idea of stimulating the birth rate in Russia and to improve measures of state support for families. In particular, it allows defining the target audience of implementing demographic policies. The scoring model of fertility makes it possible to evaluate the effect of the ongoing pro-natalist policies and to predict the prospects of demographic processes in Russia on the basis of the calculated probabilities of higher-order births for different socio-demographic groups of women.

Acknowledgements

References

- Antonov, A.I. (2012). *Sociology of the Family.* Moscow: INFRA-M.
- Balbo, N., Billari, F. C., & Mills, M. (2013). Fertility in advanced societies: A review of research. *European Journal of Population*, *29*(1), 1-38. doi: 10.1007/s10680-012-9277-y.
- Berinde, D. (1999). Pathways to a third child in Sweden. *European Journal of Population*, *15*(4), 349-378. doi: 10.1023/A:1006287630064.
- Brodmann, S., Esping-Andersen, G., & Güell, M. (2007). When fertility is bargained: Second births in Denmark and Spain. *European Sociological Review*, *23*(5), 599-613. doi: 10.1093/esr/jcm025.
- Del Boca, D. (2002). The effect of child care and part-time opportunities on participation and fertility decisions in Italy. *Journal of Population Economics*, *15*(3), 549-573. doi: 10.1007/s001480100089.
- *Demographic indicators of Russian Unified Interdepartmental Statistical Information System*. (2013, March 26). Retrieved from http://www.fedstat.ru/indicators/org.do?id=1
- Hoem, J. (1990). Social policy and recent fertility change in Sweden. *Population and Development Review*, *16*(4), 735-748. doi: 10.2307/1972965.
- Köppen, K. (2006). Second births in western Germany and France. *Demographic Research*, 14(14), 295-330. doi: 10.454.DemRes.2006.14.14.
- Lappegard, T., & Ronsen, M. (2005). The multifaceted impact of education on entry into

motherhood. *European Journal of Population*, *21*(1), 31-49. doi: 10.1007/s10680-004-6756-9.

- Maleva, T., & Sinyavskaya, O. (2007). Socio-economic factors of fertility in Russia: Empirical measurement and social policy challenges. In T. Maleva & O. Sinyavskaya (Eds.), *Parents and Children, Men and Women in Family and Society* (pp. 171-216). Retrieved from http://www.socpol.ru/publications/pdf/PiDMiG1_end.indd.pdf.

Contact

Oksana Shubat

Ural Federal University

620002, Ekaterinburg, ul. Mira, 19

o.m.shubat@ustu.ru

Anna Bagirova

Ural Federal University

620002, Ekaterinburg, ul. Mira, 19

a.p.bagirova@ustu.ru