

Effect of religious rules on time of conception in Romania from 1905 to 2001

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STUDY QUESTION: Does the interdiction of sexual intercourse during Nativity and Lent fasting periods have any effect on when babies are conceived in Romania, in the 20th century?

SUMMARY ANSWER: Based on date of birth records from the 20th century, Lent had a greater effect than the Nativity fast on conception within the Eastern Orthodox (ORTHD) population.

WHAT IS KNOWN ALREADY: Seasonality of births (and therefore of conception) is affected by geographical factors (latitude, weather, day-length). Other demographic, economic and socio-cultural characteristics (education, ethnicity, religion) have been proved to have an influence on conception.

STUDY DESIGN, SIZE, DURATION: The analyzed data consists of registered daily birth records for a long time series (35 429 points = 365 (days/year) × 97 years + 24 leap years), with 24 947 061 births in Romania over the period 1905–2001. The data were obtained from the 1992 and 2002 censuses.

PARTICIPANTS/MATERIALS, SETTING, METHODS: Based on the reported birth date of each person, the estimated date of conception is computed using a standard gestation period of 280 days. The population was grouped into two categories (ORTHD and Non-Orthodox (NORTH)) based on religious affiliation. Data analysis is performed in the same manner for both groups. Preliminary data analyses regarding seasonal variations in conception are considered first. Econometric models are applied and tested. The dependent variable in these models is the calculated date of conception, while the independent variables are: (i) religious affiliation; (ii) dates of Nativity and Lent fasts (the latter varies slightly from year to year); (iii) rural versus urban residence; (iv) length of day-light; (v) non-working days and (vi) trend. The models are tested for validity using analysis of variance while the regression coefficients are tested by the Student *t*-test.

MAIN RESULTS AND THE ROLE OF CHANCE: All models are statistically valid ($P < 0.01$); all regression coefficients for the ORTHD group are valid ($P < 0.01$, except for rurality between 1990 and 2001, with $P < 0.05$). The data analysis indicates smaller standard error bars on the parameters for the ORTHD group as compared with the NORTH group. The conclusion is that religious affiliation is an important factor in date of conception.

LIMITATIONS, REASONS FOR CAUTION: The data do not refer to all births during the analyzed period, but only to those persons still alive at the 1992 and 2002 censuses. The date of conception was estimated assuming 280 days for gestation, which is a medically accepted time interval but will undoubtedly vary. However, the primary independent variables (Lent and Nativity fast at 48 and 40 days, respectively) are long enough to overlap the uncertainty in the conception date following the sexual intercourse event. We also must assume that the religious affiliation of the parents is well defined, based on the information given by their offspring at census time, and is the same for both parents.

WIDER IMPLICATIONS OF THE FINDINGS: Our findings are consistent with other studies, which show differences between religious groups on date of conception, although we reach different conclusions regarding the influence of weather on fertility in Romania.

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Key words: religion / date of conception / Eastern Orthodox / Nativity fast / Lent

Introduction

Babies are born and therefore conceived non-uniformly over the year. The worldwide trend is affected by seasonality (Quetelet, 1826; Lam and Miron, 1991; Cancho-Candela *et al.*, 2007). The determinant factors producing these seasonal effects can be grouped (Friger *et al.*, 2009) into the so-called 'natural' characteristics (latitude, weather conditions, day length (DL)) and 'artificial' ones (demographic, economic, socio-cultural, including religion).

The seasonal effects of natural factors have been extensively studied. The study populations are spread all around the world (Lam and Miron, 1994; Friger *et al.*, 2009; Dorélien, 2013; Hubert, 2014; Martinez-Bakker *et al.*, 2014), but very rarely were they focused on Romania (except for Huber and Fieder, 2011). The findings on climate effects vary across time and geographical location. They have been extensively analyzed, the importance attributed to them ranging from high (Villerme, 1831) to 'as unimportant' in, for example, some French populations (Regnier-Loilier and Rohrbasser, 2011) or seen as acting jointly with economic development (Seiver, 1985; Huber and Fieder, 2011) due to the reasoning that poor populations are negatively affected by low temperatures during winter or, on the contrary, by hot summers without air conditioning. Other researchers (Macfarlane, 1974; Lam and Miron, 1994) stated that weather affects the seasonality of births as long as there are major temperature differences over the year. Other natural factors like DL (Rojansky *et al.*, 1992; Bronson, 2004) or moon phases (Criss and Marcum, 1981; Jongbloet, 1983) were also tested for their possible connection to birth seasonality.

From the artificial factors which were recorded as having some influence over the seasonality of births, let us mention the demographic ones: age, marital status, education, intergenerational effects (Bobak and Gjonca, 2001; Huber and Fieder, 2011) and economic ones: income, rurality (Kestenbaum, 1987; Vitzthum *et al.*, 2009) as well as socio-cultural characteristics: religion, ethnicity (Friger *et al.*, 2009; Hubert, 2014). Research on the influence of the artificial factors is rare, perhaps due to some lack of precise data. In this context, our study aims to investigate the influence of religiosity on the seasonality of dates of conception and of birth. More precisely, did the interdiction of sexual intercourse during fast periods has any effect on date of conception in 20th century Romania?

Context

Romania is a country with a large majority (>86% nowadays) of Eastern Orthodox (ORTHD) population, as can be observed in Fig. 1, which is based on censuses performed across Romanian territories in the last 150 years. Other religious denominations have been present in different proportions during the last 150 years in regions that are now part of Romania. For example, it is apparent that Transylvania is the most heterogeneous Romanian territory with regard to religious diversity (Herteliu, 2013). However, this effect is apt to be minor, and our current analysis is conducted at the national level, without distinguishing regions.

It is known that the operation of complex mechanisms acting on or related to religion is not an easy task to investigate (Herteliu, 2007; Herteliu and Isaic-Maniu, 2009; Ileanu *et al.*, 2012). In this context, to achieve some statistical balance given the vast ORTHD majority, the Non-Orthodox (NORTH) segments are grouped together, thus transforming the religious affiliation into a simple yes or no variable. Even if some other religions grouped into the category 'NORTH' have periods of fasting during the year, due to their particularities (such as the use of a different calendar, different dates for Easter, different rules for fast periods, or other features specific to various religious sects or denominations) their exclusion from the well-defined ORTHD group was preferred for the sake of simplicity.

It is rather well known that in the ORTHD tradition, in addition to abstaining from particular types of food and drinks during fasting periods, individuals should also avoid sexual intercourse. Support for these extensive fasting interdictions specific to the ORTHD tradition (http://orthodoxinfo.com/praxis/fasting_sex.aspx, retrieved in March 2015) are based on interpretations of certain quotes from the Bible (such as Romans 8:12–14 or Galatians 5:16–17) (The Holy Bible, 2014). One of our goals is to find whether these constraints have been implemented.

Materials and Methods

Data sources

The analysis is based on a very long (35 429 points = 365 (days/year) × 97 years + 24 leap years) daily time series representing all births (24 947 061) of persons alive at the 1992 or 2002 censuses (similar to Kestenbaum, 1987). Other long data series have been studied before (Cancho-Candela *et al.*, 2007; Ausloos *et al.*, 2015; Rotundo *et al.*, 2015) using different methodologies. In the present case, data points were recorded for 1 January 1905 to 31 December 1991 (31 776 points) from the 1992 census, while the other 3653 points (corresponding to the period 1 January 1992 to 31 December 2001) are from the 2002 census. The data source is the Romanian National Institute of Statistics (NIS) via a query tool available within NIS's intranet (<http://happy:81/PHC>; 11 December 2013, date last accessed) regarding 2002 and 1992 censuses. For convenience, in the current research, the terms 'born per day' will be used instead of 'number of births on a given day for persons still alive at the 1992 and respectively at 2002 Census'. The data for DL and moon phase (proportion of moon disc illumination) were obtained from <http://www.timeanddate.com>; 13 December 2013, date last accessed. For daily temperatures, the source for data is Romanian National Meteorological Agency (via <http://www.ecad.eu/dailydata/customquery.php> (12 December 2013, date last accessed)). The dates for Easter in the ORTHD religion during the last 110 years are obtained from <http://www.smart.net> (13 December 2013, date last accessed).

Variables

Variables from censuses (and their derivatives)

Data were based on a persons' self-declared birthday. In addition, we use data about: (i) religion: distinguishing ORTHD and NORTH affiliation.

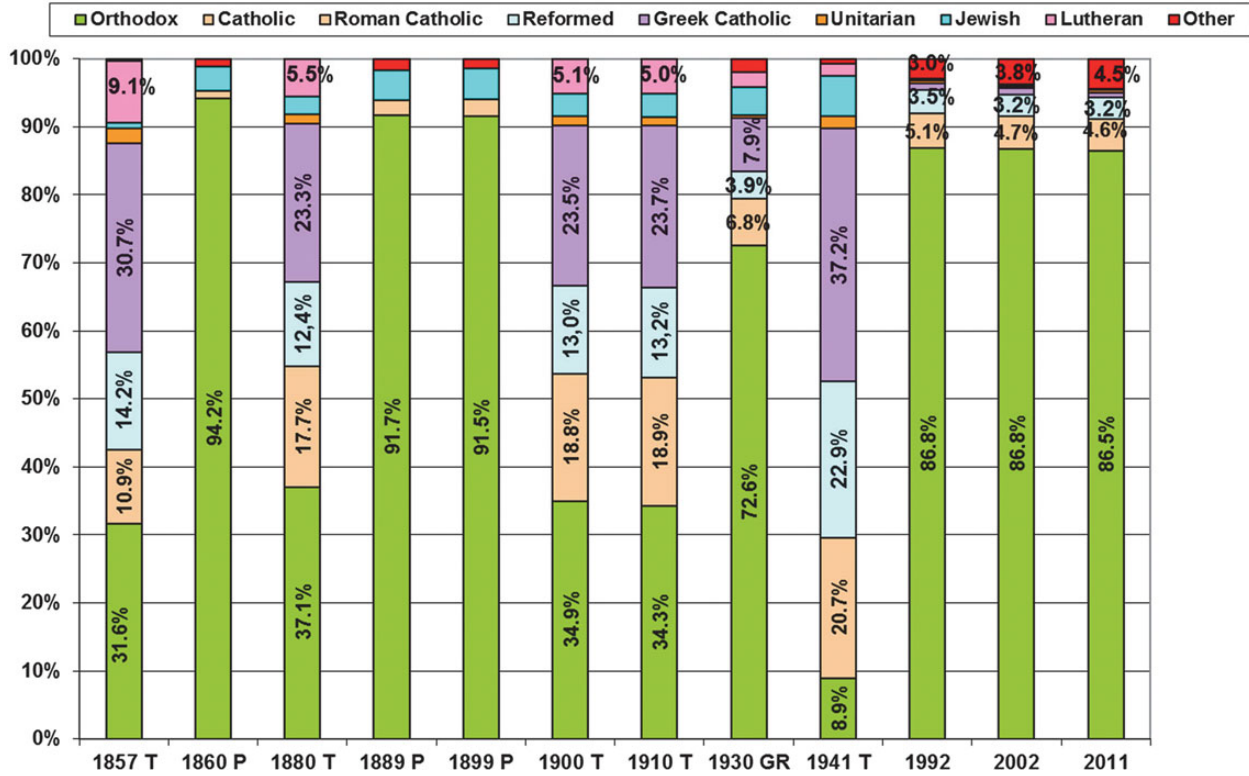


Figure 1 Religious affiliation in Romania. The figure includes data on Romanian territories while they were organized or grouped differently from today. T, Transylvania; P, Romanian Principalities (Moldavia and Wallachia); GR, Greater Romania. Source of data: Censuses performed across Romanian territories in the last 150 years. Please note that in the communist era four censuses were performed (1948, 1956, 1966 and 1977). Due to political bias, none of them included the questionnaire items regarding religious affiliation.

We must assume that the religious affiliation of the parents is well defined, based on the information given by their offspring at census time, and is the same for both parents. Even so, the available statistical information showed that the level of changing religious affiliation across the Romanian population is very low (Ileanu et al., 2012); (ii) rurality: the percentage of people located in rural or non-rural areas. This introduces a double filter: rurality ORTHD (rORTHD) and rurality NORTHD (rNORTHD).

After subtracting 280 days from the registered birthday, an estimate of the conception day was obtained (Seiver, 1985; Russel et al., 1993; Lam and Miron, 1996). However, date of birth evidence can only point to sexual intercourse leading to successful pregnancies. It is known that Lent is 48 days long while the Nativity fast lasts 40 days. The uncertain conception date, since not every child is born exactly 280 days after conception (Jukic et al., 2013; Pana et al., 2015), overlaps the 40 or 48 day fast. We assume that the birth rate is correlated with the rate of intercourse. Practically, family planning and contraception methods have not been very common in Romania (it was certainly not encouraged by the communist regime between 1966 and 1989) (Chelbeagan, 2010). We assume that the birth rate is correlated with the rate of intercourse. Recall that this *a posteriori* estimate of sexual intercourse resulting in a birth is made primarily to correlate to 'natural' variables, i.e. weather conditions and daylight (or night) duration, at the time of the sexual activity.

For each year, the fraction of births y_i on given day, i , was computed separately for the ORTHD y_i^{ORTHD} , and NORTHD populations y_i^{NORTHD} , using

$$y_i^{ORTHD} = \frac{n_i^{ORTHD}}{\sum n_i^{ORTHD}} \quad (1)$$

where n_i^{ORTHD} is the number of births on the specific day i for ORTHD and $\sum n_i^{ORTHD}$ is the total number of births during that year for ORTHD.

$$y_i^{NORTHD} = \frac{n_i^{NORTHD}}{\sum n_i^{NORTHD}} \quad (2)$$

where n_i^{NORTHD} is the number of births on the specific day i for NORTHD and $\sum n_i^{NORTHD}$ is the total number of births during that year for NORTHD.

The dependent variables in the regression models are calculated by dividing the daily fraction of births (1) and (2) by the daily expected (uniform) distribution (UD) across the year which is $y^{UD} = 1/365$ for non-leap years and $y^{UD} = 1/366$ for leap years. Therefore, we define the following two dependent variables:

$$dORTHD_i = \frac{y_i^{ORTHD}}{y^{UD}} \quad (3)$$

for ORTHD and

$$dNORTHD_i = \frac{y_i^{NORTHD}}{y^{UD}} \quad (4)$$

for NORTHD populations, respectively, and using y^{UD} as appropriate for leap and non-leap years.

Nativity and Lent fast variables

We used a countdown variable (in days) to Christmas or Easter for each day of Nativity or Lent fast, instead of a simple binary variable indicating whether or not conception occurred in the fasting period. We preferred this because it is possible that religious constraints were observed more scrupulously the closer one was to either Easter or Christmas. This countdown variable was computed having the conception date as the reference point. Subsequently, Days Before Christmas (DBC) was computed from the following equation:

$$DBC = \begin{cases} 0 & \text{if conception occurs outside Nativity fast} \\ t & \text{if conception occurs within Nativity fast} \end{cases} \quad (5)$$

where *t* represents the number of days to Christmas.

Similarly, Days Before Easter (DBE) was computed from the following equation:

$$DBE = \begin{cases} 0 & \text{if conception occurs outside Lent} \\ t & \text{if conception occurs within Lent} \end{cases} \quad (6)$$

where *t* represents the number of days to Easter.

For completeness, we note that Romania adopted the Gregorian calendar in 1919. Therefore, 31 March 1919 was followed by 14 April 1919. Moreover, the Romanian ORTHD Church is using an updated form of the Julian calendar. Thus, Christmas is celebrated in Romania on 25 December. However, Easter for the Romanian ORTHD Church is usually not synchronized to that of the Roman Catholic Church. Even so, it is emphasized that these specific calendar change details do not interfere with the results of our research, since the data regarding registered birthdays in the 1992 and 2002 censuses were based on the Gregorian calendar.

Time interval-related variables

Some binary variables were inserted in order to mark some particular time windows during which the conception date might have occurred and influenced by global events or days of the week. These are: (i) First World War (1stWW) taking the value 1 for conception days between 28 July 1914 and 11 November 1918 and 0 outside this timespan; (ii) Second World War (2ndWW) having a 1 value for conception days between 1 September 1939 and 2 September 1945 and 0 outside this timespan; (iii) weekend days having a value = 1 if the conception day is on a Saturday or Sunday and 0 for Monday, Tuesday, Wednesday, Thursday and Friday and (iv) squared trend (t^2 for $t = 1$ to 35 429).

Natural variables

The effect of some natural variables is also analyzed through: (i) DL measured as the number of minutes of daylight during each 24 h of a day. This information refers to Bucharest as the capital city of Romania, but is taken to be the same for every place in Romania; (ii) temperature in Celsius degrees (mainly measured for Bucharest) (A) should go here and (iii) proportion of the moon disc being illuminated (with Bucharest as the reference point), within the same approximation. (A) Due to the usual intrinsic error bars on meteorological measurements (and variation across the country and throughout the day, using Bucharest temperatures is a rough approximation to local temperature.

Statistical analyses

The analysis began qualitatively to determine whether births (or conception) vary throughout the year. Graphs were drawn with various software packages (Synergy Kaleidagraph, USA; IHS-EViews, USA; Microsoft Excel, USA; Microsoft Power Point, USA). Subsequently, the daily average conception within and outside fasting periods was computed. Prior to the econometric modeling, we checked a possible periodicity via a Fast Fourier Transformation performed with the Statistical Package for the Social Sciences (IBM-SPSS, USA) for 2¹⁵ cases (the last 32 768 days).

The final step in the data analysis consists of the design of several econometric models. Breaking points in the trend of the dependent variables were identified with Cusum SQ Test performed with IHS-EViews. Regressions were performed with IBM-SPSS (Ordinary Least Square – OLS estimations), the same model being run for each phase/cycle (identified after a Cusum SQ Test). At this stage, factors suspected of being collinear were removed (e.g. DL was chosen instead of temperature) from the regression models. The same procedure was performed for factors with low statistical significance (e.g. moon phases). A $P < 0.05$ was considered significant.

Results

Preliminary data inspection

As shown by Huber and Fieder (2011) for women born between 1920 and 1955 and older than 45 years (completed fertility), Romanian births register a non-uniform distribution across the year with a maximum in June and minimum in December and January, as obtained from monthly data. It is worth noting that Huber and Fieder (2011) used monthly data while the present data analysis is performed on reported birthdays. This approach avoids spurious averaging effects.

Our raw data contains the number of births on each day of the year (ORTHD and NORTHD) for a long period (97 years). In order to present this extensive data in a concise way, a pivot table was designed separately containing monthly and daily aggregated values for ORTHD and NORTHD. For both populations, the mean and median are very close to each other (<0.4%) while the standard deviations for the means are quite low (15% of the mean for ORTHD and 11.6% for NORTHD). The statistics of both populations are slightly asymmetric and leptokurtic. Other descriptive statistical characteristics are available in Table I. Next, the aggregated date were sorted into quintiles (Giuclea and Popescu, 2009; Dedu et al., 2014). The following intervals were

Table I Descriptive statistics for daily aggregated data in a study on the effect of religious rules on time of conception in Romania from 1905 to 2001.

Indicator		ORTHD	NORTHD
N (days)	Valid	366	366
	Missing	0	0
Mean		59 219.15	9082.18
Median		59 418.00	9050.00
Std. deviation		8906.85	1049.23
Skewness		0.93	2.21
Std. error of skewness		0.13	0.13
Kurtosis		13.52	37.59
Std. error of kurtosis		0.25	0.25
Minimum		11 291	1904
Maximum		131 311	20 016
Sum		21 629 796	3 317 265
Percentiles	20	53 554.80	8452.80
	40	57 996.20	8851.80
	60	60 449.60	9209.20
	80	65 141.40	9618.60

ORTHD, Eastern Orthodox; NORTHD, Non-Orthodox.

obtained for ORTHD (Fig. 2): (q1) days having under 53 554.8 births labeled in red; (q2) days having between 53 554.8 and 57 996.2 births labeled in orange; (q3) days having between 57 996.2 and 60 449.6 births labeled in yellow; (q4) days having between 60 449.6 and 65 141.4 births labeled in light green and (q5) days having over 65 141.4 births labeled in dark green. Similarly for NORTHD (Fig. 3), the quintile intervals are (q1) days having under 8452.8 births (red); (q2) days having between 8452.8 and 8851.8 births (orange); (q3) days having between 8851.8 and 9209.2 births (yellow); (q4) days having between 9209.2 and 9618.6 births (light green) and (q5) days having over 9618.6 births (dark green).

This sorting by quintiles of almost one century of data can (by avoiding compensation through averaging over unequal size month) provide some statistically significant differences among daily distributions across the year. It can easily be seen that this compensation does not occur in our case. Therefore, it may be deduced that the outlined monthly or daily differentiation does not lead to a random outcome.

Referring to Fig. 2, for the ORTHD population, there are important differences between November, December and January and the rest of the year, and also between the first two-thirds of a month compared with the last third. These monthly differences were tested by a χ^2 test and are statistically significant (computed χ^2 was 131 285.4, $P < 0.001$). Again referring to Fig. 2, the lowest aggregate number of births for a specific day was, naturally, on 29 February (11 291 births) while the maximum was on 1 January (131 311 births). We will comment on the large number of births on 1 January below.

In the case of the NORTHD population (see Fig. 3), the lower birth figures in November and December are consistent with lower number of births in those months in the ORTHD population, while January is not so distinct as in the NORTHD case. The distribution of the daily figures outside the November–January time span seems to be more equally balanced for NORTHD, no persistent pattern is visible, in contrast to the ORTHD case. Similarly in the ORTHD and the NORTHD

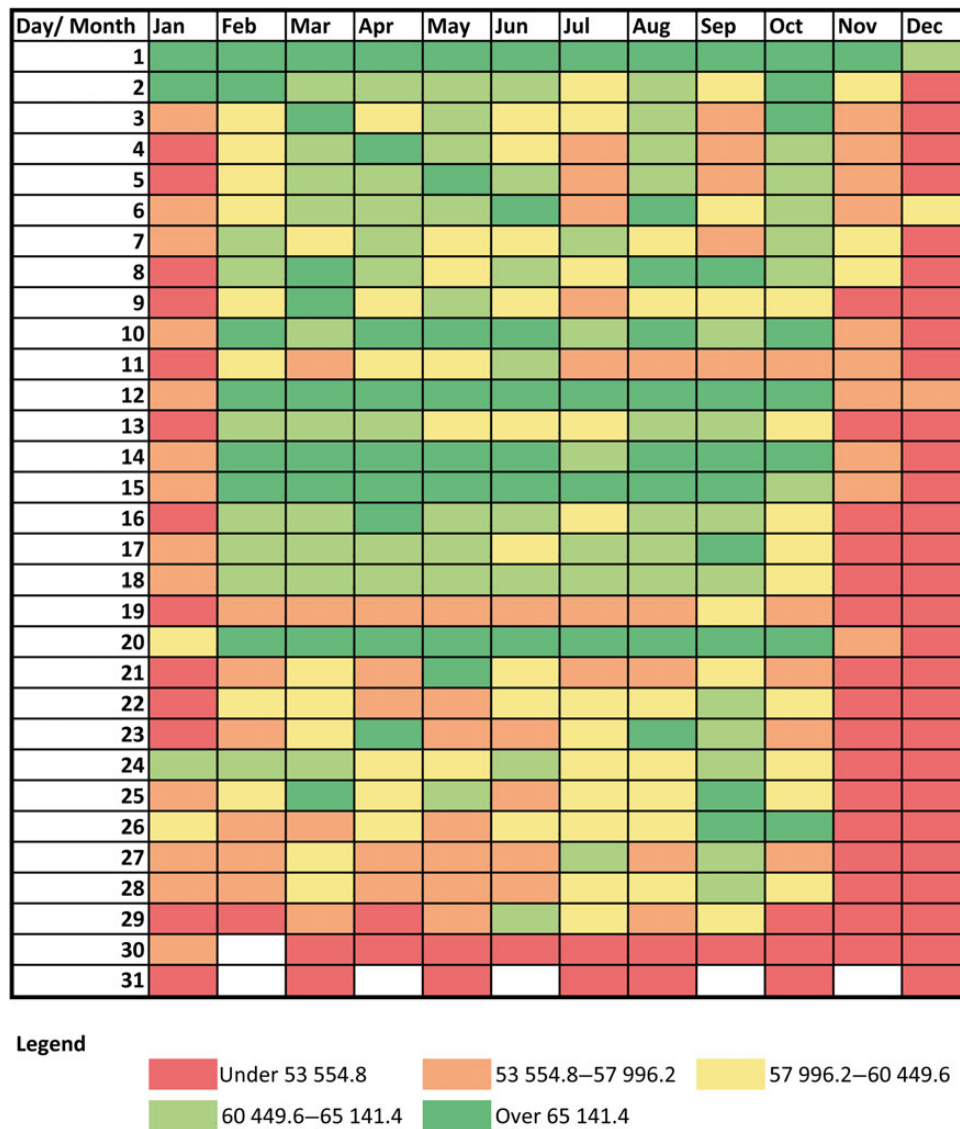


Figure 2 Quintile distribution of daily aggregated births for the Eastern Orthodox (ORTHD) population during 1905–2001.

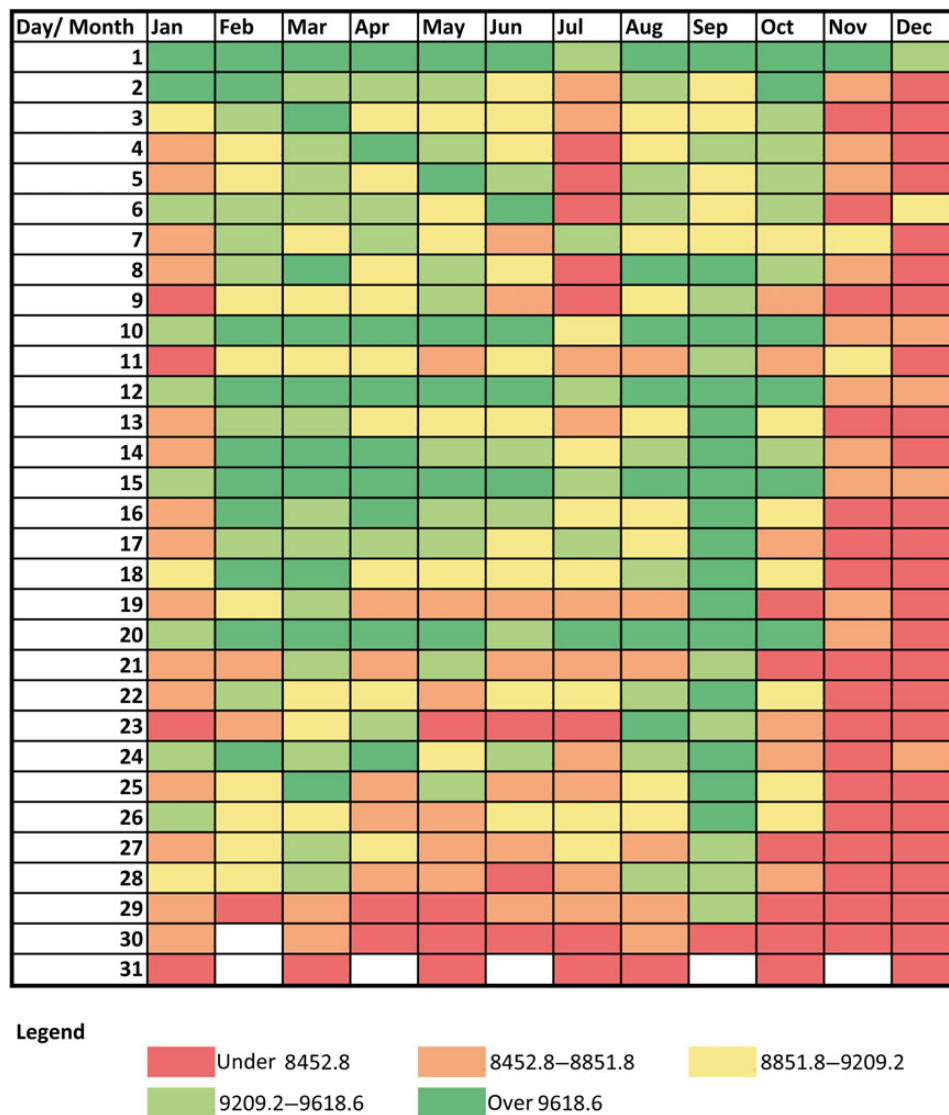


Figure 3 Quintile distribution of daily aggregated births for the Non-Orthodox (NORTHD) population during 1905–2001.

population, the minimum aggregate number of births was registered on 29 February (1904 births) while the higher one occurs on 1 January (20 016 births). For this group, the computed χ^2 was 9184.2 showing that the differences are statistically significant with a P value <0.001 .

For both (ORTHD and NORTHD) populations, Figs 2 and 3 show a noticeably high number of births (almost dark green) on the first day of any month and a low number of births on the last day of each month.

As noted above for both populations, there is an anomalously high number of births on 1 January. In fact, there are twice as many births on 1 January than on 2 January and almost four times as many births as on 31 December. We call this anomaly the '1st of January effect'; further work should be done on this subject. A similar effect was noted by MacFarlane (1974). In brief, possible explanations for this effect might be: (i) parents' psychological comforting thought that their child is considered to be 1 year younger if registered on 1 January instead of 31 December (a quite comfortable situation for both girls and boys since there would

be a delay of 1 year to the compulsory military training—effective in Romania prior to 2007); (ii) municipal recorders not working during winter holidays therefore increasing the likelihood of an incorrect record (despite the fact that children can be registered on 5 January mentioning the correct birth date); (iii) on 1 January, there is a very important holiday for the ORTHD (Saint Greater Basil), evidenced by many children born around this day named Basil (according to <http://www.capital.ro/peste-600000-romani-isi-serbeaza-ziua-onomastica-de-sfantul-vasile-142714.html> retrieved in December 24, 2014, there are almost 600 000 people in Romania named Basil or the female version) and (iv) mistaken registration (even if it is not statistically important, one co-author of the current paper has a brother registered as born on 1 January, even if the event certainly occurred on 2 January at 1:00 a.m.).

Since the variation of the number of births across the year is undoubtable, we now address the primary concern of this research: did major fast periods (i.e. before Christmas and Easter) affect conception or not?

First, note that several religions (Roman Catholic, Greek Catholic, Old Rite ORTHD) grouped within the NORTHD category still have different Lent and Nativity fast periods. Moreover, the fast periods (especially for Lent) are usually not similar to ORTHD. Therefore, a visual inspection of this variability (Figs 4 and 5) was conducted, only for ORTHD. Prior to this, it seems useful to compute for each year the daily average conceptions within such fast (or out of fast) periods.

Despite the long time series which certainly must depend on many local or general factors, Fig. 4 shows that the daily mean number of conceived children by ORTHD is significantly lower during Lent than during the

rest of the year. In the whole range of almost 100 years only two exceptions to this rule can be seen: (i) during the 1stVWW (more exactly, in 1916) and (ii) during 1989, a year which had a strong emotional impact on the Romanian population, when there was a revolution and a major change of political system. Even if births increased because of Ceausescu's decree, the number of conceptions 'out of fast' is still larger than the number of conceptions during fasting periods. Thus, even if in the short term (1967–1968) the Ceausescu Decree reduced the gap between 'out of fast' and 'during the fast' on the long term, the decree had not enough force to completely eliminate the effect of ecclesiastical admonitions.

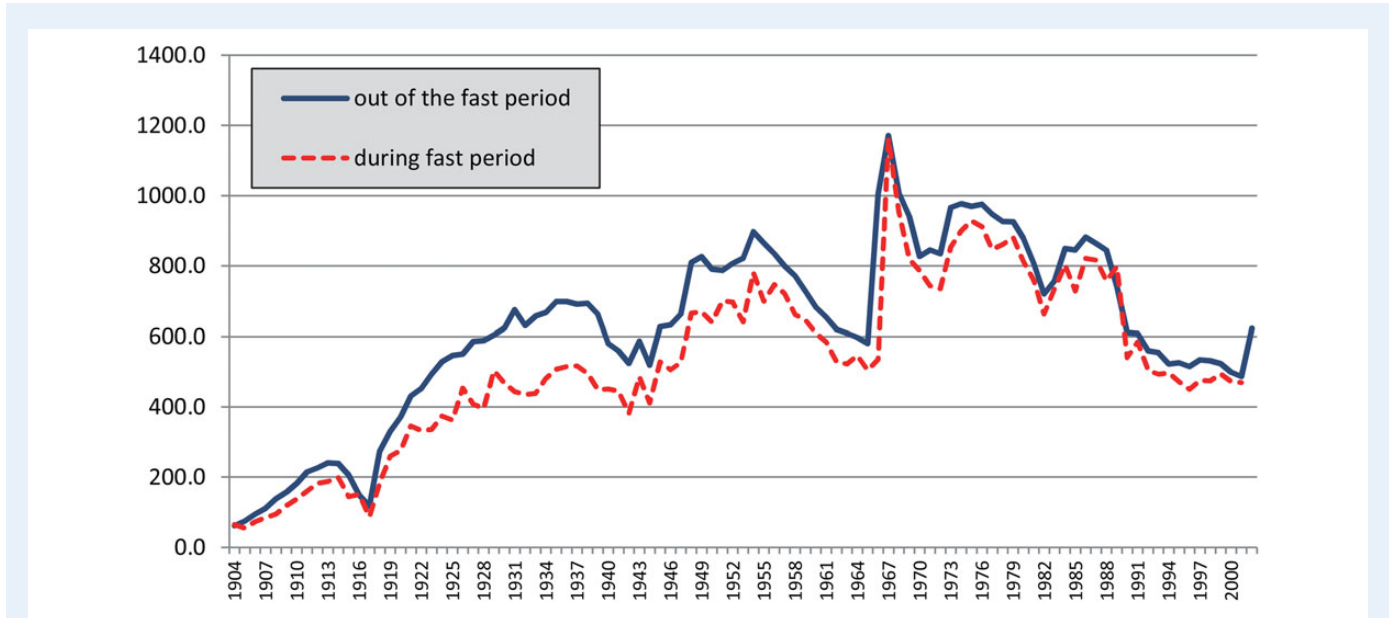


Figure 4 Daily average number of conceptions during Lent fast/out of fast period for ORTHD.

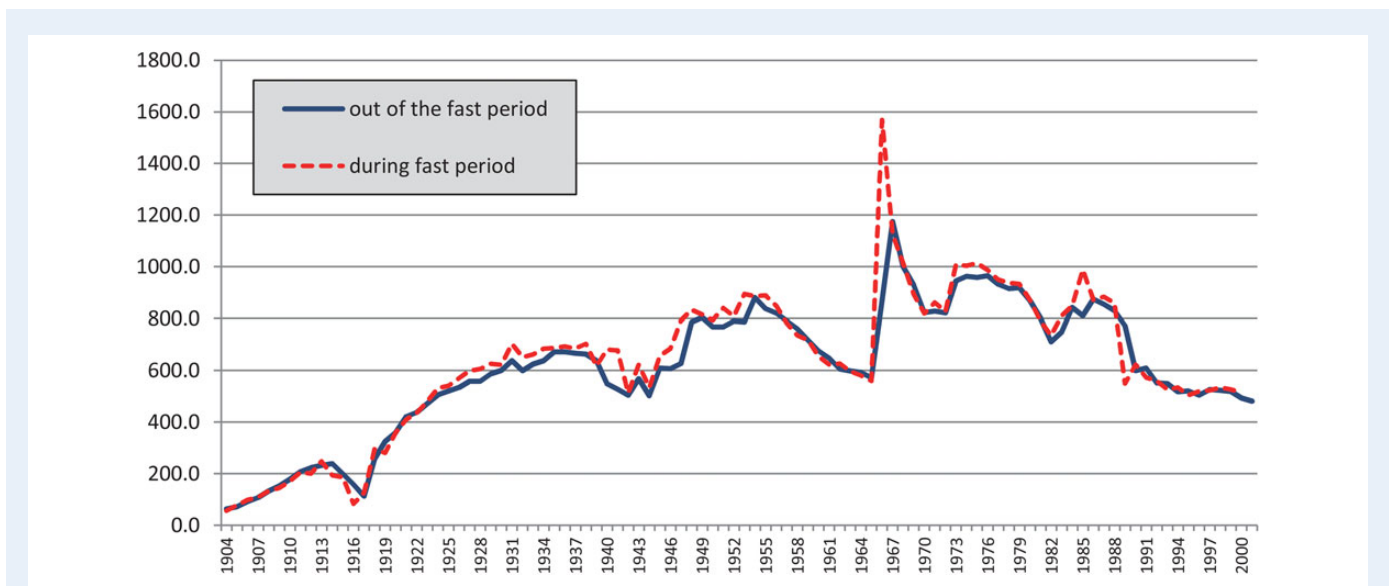


Figure 5 Daily average number of conceptions during Nativity fast/out of fast period for ORTHD.

Similar plots of conception within and without the Nativity fast (Fig. 5) show dramatically different behavior. In this case, the rule of 'fewer conceptions during fast periods' was broken in 67 from all 97 available years.

To complete the basic statistical analysis, an enhanced econometric analysis is described and performed in the Econometric models section.

Identification of periodicity

The analytical approach of our paper is an econometric one. However, before applying econometric model, it is useful to test whether the main dependent variable of interest for ORTHD is affected by some periodicity (Fig. 6) in order to avoid such a specific trend. A spectral analysis is thereby performed, using SPSS (Tukey–Hamming method, Brillinger and John, 2002). Such a spectral analysis may be performed when the number of data points is a power of 2. Therefore, in order to have the maximum set of points, 2^{15} (=32 768 cases), the first 2661 data points were deleted, whence shortening our dataset to the 14 April 1912–31 December 2001 interval.

The major peak (we use a log2 scale in order to slightly enhance the x-axis) is about half a year (183 days or a little bit more than 26 weeks). The next largest peaks occur ca. 372 days (ca. 53 weeks), 4 months (120 days) and 1 month (30 days); such 'periods' are quite similar to those found in Cancho-Candela et al. (2007).

Econometric models

In the current analysis, classical multiple regression models are considered, with various components and variables measured on a daily time scale. Several versions of the models were tested, starting from the 'general linearized multifactorial' model (Andrei and Bourbonnais, 2008). All factors mentioned in the Materials and Methods section

were initially included in the models. Based on the goodness of fit of these, taking into account the statistical significance of the regression coefficients (with a Student *t*-test), an optimum model was obtained and it will be the only model outlined below. As in other research (e.g. Lam and Miron, 1996), the best results are obtained when considering the logarithmic variable as a dependent variable.

(A) Model for the ORTHD population; components and variables

In such a case, the dependent variable, dORTHD and covariates are: DBC, DBE, rORTHD, DL, World wars, through 1stWW and 2ndWW variables, weekends, trends (long-term tendencies, a stable component and core of the time series) and a stochastic component (ε). The variables are described in a subsection of the Materials and Methods section. A formalized version of the model could be described as the following:

$$\text{dORTHD} = e^{\alpha_0 + \alpha_1 \text{DBC} + \alpha_2 \text{DBE} + \alpha_4 \text{rORTHD} + \alpha_5 \text{1stWW} + \alpha_6 \text{2ndWW} + \alpha_7 \text{Weekend} + \alpha_8 \text{trend}^2 \cdot \text{DL}^{\alpha_3} e^{\varepsilon}} \quad (7)$$

which after applying the logarithmic transformation becomes

$$\ln(\text{dORTHD}) = \alpha_0 + \alpha_1 \text{DBC} + \alpha_2 \text{DBE} + \alpha_3 \ln(\text{DL}) + \alpha_4 \text{rORTHD} + \alpha_5 \text{1stWW} + \alpha_6 \text{2ndWW} + \alpha_7 \text{Weekend} + \alpha_8 \text{trend}^2 + \varepsilon \quad (8)$$

(B) A similar model can be specified for the NORTHD population

A similar model can be specified for the NORTHD population, i.e. with almost the same explanatory variables but instead having the dependent variable, dNORTHD = the normalized number of NORTHD conceptions. Moreover, instead of covariates 'share of ORTHD in the

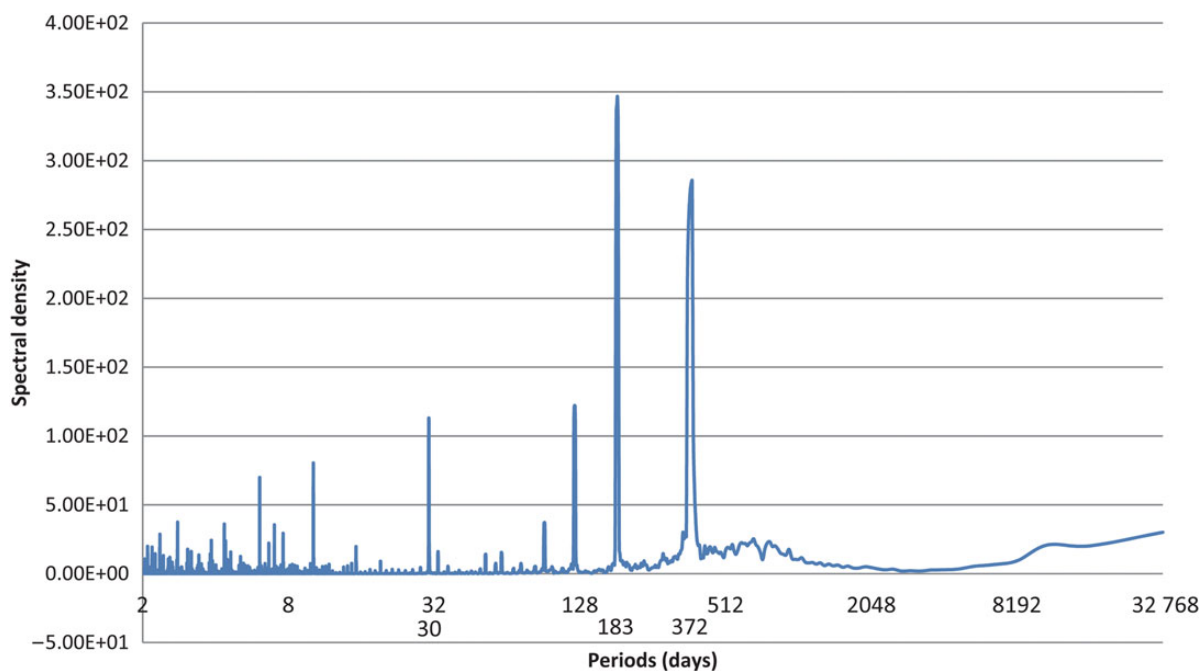


Figure 6 Fast fourier transformation for the dORTHD. The ORTHD dependent variable (dORTHD) in the regression models is calculated by dividing the daily fraction of births by the daily expected (uniform) distribution across the year.

rural area', the 'share of NORTHD in the rural area' is introduced (rNORTHD), which may be more suggestive. In this context, the following model is to be considered:

$$dNORTHD = e^{\beta_0 + \beta_1 DBC + \beta_2 DBE + \beta_4 rNORTHD + \beta_5 1stWW + \beta_6 2ndWW + \beta_7 Weekend + \beta_8 trend^2} \cdot DL^{\beta_3} e^{\varepsilon} \quad (9)$$

which after applying the logarithm function becomes:

$$\ln(dNORTHD) = \beta_0 + \beta_1 DBC + \beta_2 DBE + \beta_3 \ln(DL) + \beta_4 rNORTHD + \beta_5 1stWW + \beta_6 2ndWW + \beta_7 Weekend + \beta_8 trend^2 + \varepsilon \quad (10)$$

(C) Structural break identification

Since the series covers a very long time interval (97 years = 35 429 days), parameters might vary somewhat. Perhaps as a result, the overall model (M0, presented in Table I) appears not to be very efficient in that some variables, such as the Christmas fast, seem to be insignificant. As in [Cancho-Candela et al. \(2007\)](#), a segmentation of the long time span into shorter sub-periods seems an interesting procedural test.

In order to do so, the CUSUM SQ ([Young, 2011](#)) test was applied to the overall estimated model (M0). The CUSUM SQ graphic presented in [Fig. 7](#) suggests that at a 5% level of significance multiple changes are likely during the analyzed timespan.

It can be observed that the breaking points are ca. 1911, 1918, 1947, 1966 and 1990. Consequently, there are six suggested sub-periods of stability for the models (Mi): (i) 1905–1910 (M1); (ii) 1911–1918 (M2); (iii) 1919–1946 (M3); (iv) 1947–1966 (M4); (v) 1967–1989 (M5) and (vi) 1990–2001 (M6). Each break point is in fact well related to a social/ political/historical event: e.g. during the period for 1907–1910, there were peasants' uprisings; at the end of the second and third sub-period, there were events which determined the decrease of the number of births: the 1stWW and the 2ndWW, respectively. Also, this observation suggests how to specify the trend component of the models. Therefore, the econometric models were reworked for each of the sub-periods taking into account these remarks: (i) for model M1 a non-linear (let us take it squared, within usual series

expansion approximations) trend of births during the entire period is introduced; (ii) for model M2 and M3, similar squared trends can be also assumed; (iii) the same assumptions are introduced for models M4 and M5. According to national reports, such as (http://www.insse.ro/cms/files/publicatii/Evolutia%20natalitatii%20si%20fertilitatii%20in%20Romania_n.pdf, retrieved in November 30, 2014) during the period of 1956–1966, the Nativity rate decreased dramatically due to many factors such as abortion liberalization, better access to work and education for women; moreover, between 1985 and 1990, the social condition of Romanians significantly decreased. The Decree of Ceausescu outlawing abortion (1 October 1966) had effects only for a short period of time; (iv) finally, for the sixth model, the trend in the number of babies conceived and born decreased according to many factors like abortion liberalization (992 000 such operations occurred in 1990), but also post-communist socio-economic crisis, migration etc.

After applying estimations using SPSS methodology, the optimized results are given in [Tables II and III](#).

After performing an *F* test (analysis of variance), it has been found that the models for every sub-period for ORTHD and NORTHD populations are valid and statistically significant. The proportion of variance (R^2) explained for the dependent variable is between 12.7% (M0 and M5) and 32.3% (M3)—values similar to other studies ([Friger et al., 2009](#)). Almost all regression parameters are statistically significant (from a Student *t*-test) with slightly different degrees of significance (most of them having a $P < 0.01$). As expected, the model performed on the NORTHD population registered levels of R^2 lower than the previous ones. The maximum deviation occurs for M6 (10.5%) and the minimum for M2 (2.3%). Regression coefficients in this case fail to be slightly more often significant.

In addition, the sensitivity of the statistical models was tested by taking into consideration a gestation duration shorter by 1 and 2 weeks, respectively. The models' outcomes in these scenarios are found to be quite similar to the presented ones.

Discussion

Romanians following ORTHD religious beliefs or rules, that is the majority of religious persons in Romania, are taught to avoid sexual intercourse as well as abstain from particular food and drinks during fasting periods. The results of our time series analysis on birth rates show different behaviors during the major fasts. Conceptions during Lent Fast are consistent with religious constraints. The negative value of the coefficient (DBE) for Days to Easter during the Fast shows that as the Holiday gets closer, the estimated number of conceptions significantly decreases. It is worth mentioning here that the ORTHD religion grants some exception periods to believers for reasons mainly linked to health. In these 'grace periods', there might be increased conception. It is important to note that the standard absolute value of the coefficient of the variable, which measures the impact of Lent fast on conception (DBE), remains relatively stable in $[-0.25; -0.35]$ for all sub-periods. This points to the continuity and persistence of the ORTHD faith in general, and particularly regarding interdictions of Lent fasting throughout the almost 100 years of this study. This continuous adherence to faith is also highlighted by the values estimated in the second model ([Table II](#)) for the NORTHD sample where the estimated coefficient of the variable has statistically significant values, although half $[-0.04; -0.19]$ that for the ORTHD population.

On the other hand, the Nativity Fast no-sex constraint does not seem to have a great significance for ORTHD Romanians nowadays: the

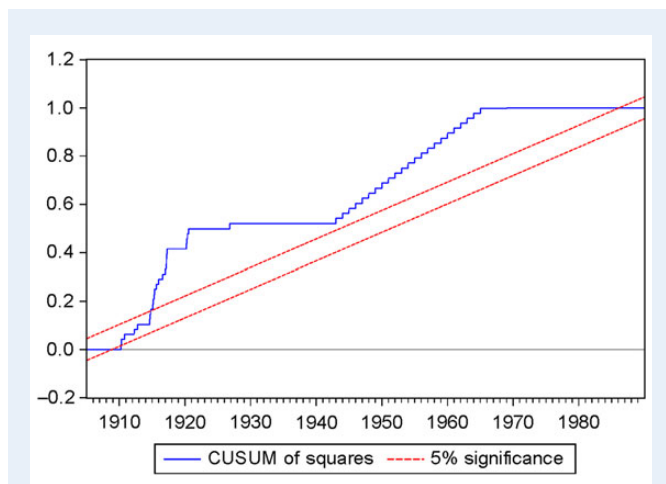


Figure 7 Breaking points identification using CUSUM SQ test.

Table II Dependent variable: $\ln(\text{dORTHD})$ = the logarithm of the ratio of conceived orthodox babies relative to assumed uniform daily value for 1 year.

Model	Intercept	DBC	DBE	DL	Rurality (rORTHD)	Trend ²	Weekend	1stWW	2ndWW	Adjusted R ²	Model validity (Sig F)
M0 Overall 1905–2001	***	0.002	−0.332***	0.051***	0.073***	0.087***	0.028***	−0.055***	−0.004	0.127	0.00
M1 1905–1910		−0.0849***	−0.2676***	−0.0596***	0.2414***	0.1557*	0.0344***			0.187	0.00
M2 1911–1918	***	−0.0360**	−0.2534***	0.1252***	0.3107***	0.0586***	0.0838***	−0.0715***		0.229	0.00
M3 1919–1947	***	0.0194**	−0.3034***	0.0105	0.8986***	0.0578***	0.8427***		−0.048***	0.323	0.00
M4 1948–1966	***	0.0271**	−0.3457***	0.0276**	0.1139***	0.0510***	−0.0574***			0.146	0.00
M5 1967–1989	***	0.0487***	−0.2897***	0.1684***	0.1020***	−0.0313***	0.0445***			0.127	0.00
M6 1990–2001	***	0.0577***	−0.3316***	0.2172***	0.0653***	−0.2841***	0.0207***			0.235	0.00

Note: The regression coefficients shown are the standardized ones (prior to estimation all independent variables are standardized). Factors (independent variables) are: Days Before Christmas (DBC), Days Before Easter (DBE), Day Length in minutes (DL), Rurality for ORTHD, squared trend (t^2 for $t = 1$ to 35 429), Binary variables: (i) First World War (1stWW) taking the value 1 for conception days between 28 July 1914 and 11 November 1918 and 0 outside this timespan; (ii) Second World War (2ndWW) having a 1 value for conception days between 1 September 1939 and 2 September 1945 and 0 outside this timespan; (iii) weekend days having a value = 1 if the conception day is on a Saturday or Sunday and 0 for Monday, Tuesday, Wednesday, Thursday and Friday. Bold values denote the model's goodness of fit, adjusted by number of independent variables.

*Statistically significant at level 10%.

**Statistically significant at level 5%.

***Statistically significant at level 1%.

Table III Dependent variable: $\ln(dNORTH D)$ = the logarithm of the ratio of conceived Non-Orthodox babies relative to assumed uniform daily value for 1 year.

Model	Intercept	DBC	DBE	DL	Rurality (rNORTH)	Trend ²	Weekend	1stWW	2ndWW	Adjusted R ²	Model validity (Sig F)
M0 Overall 1905–2001		0.007***	−0.157***	0.0071***	0.006***	0.0020***	0.042***	−0.094***	−0.004	0.047	0.00
M1 1905–1910		0.0154	−0.0420**	−0.0285	0.0980***	0.0252	0.1007***			0.023	0.00
M2 1911–1918	***	0.0438**	−0.1401***	0.0942***	0.1031***	0.1143***	0.0953***	−0.2754***		0.092	0.00
M3 1919–1947	***	0.0831***	−0.1794***	0.0304***	0.1712***	0.0890***	0.1112***		0.0010	0.073	0.00
M4 1948–1966	***	0.0658***	−0.1919***	0.1000***	0.0490***	−0.0338***	0.0688***			0.055	0.00
M5 1967–1989	***	0.1052***	−0.1888***	0.1948***	−0.0035	−0.0023	−0.0517***			0.072	0.00
M6 1990–2001	***	0.0969***	−0.1783***	0.1040***	0.0013	0.0240	−0.2468***			0.105	0.00

Note: The regression coefficients shown are the standardized ones (prior to estimation all independent variables are standardized). Factors (independent variables) are: Days Before Christmas (DBC), Days Before Easter (DBE), Day Length in minutes (DL), Rurality for NORTH D, squared trend (t^2 for $t = 1$ to 35 429), Binary variables: (i) First World War (1stWW) taking the value 1 for conception days between 28 July 1914 and 11 November 1918 and 0 outside this timespan; (ii) Second World War (2ndWW) having a 1 value for conception days between 1 September 1939 and 2 September 1945 and 0 outside this timespan; (iii) weekend days having a value = 1 if the conception day is on a Saturday or Sunday and 0 for Monday, Tuesday, Wednesday, Thursday and Friday. Bold values denote the model's goodness of fit, adjusted by number of independent variables.

**Statistically significant at level 5%.

*** Statistically significant at level 1%.

coefficient of the variable (DBC) which measures this impact is positive after the 1stWW, showing that as Christmas day gets closer, the number of conceptions increases significantly. In contrast to the case of the Lent Fast the coefficient remains stable in time, in the case of the Nativity Fast the standard value is increasing in time, showing that when approaching the Nativity date, the population practices a more liberal lifestyle, obeying fewer constraints during the fasting period. For example, in the period 1990–2001, the value of the coefficient is approximately three times higher than the one estimated for the period before the 2ndWW. This can be likely explained from a rural habit: weddings are traditionally performed in rural Romania in the last part of autumn, after the harvest (Trebici, 1979). Moreover, the fermentation process of the new wine is stopped, thus rendering the liquid more drinkable, in particular at weddings. It has been shown (Trebici, 1979) that usually ~9–10 months later, the first baby of a new couple is delivered. Another point is based on the psychological idea that the Christmas holiday is a more joyful event compared with Easter (in agreement with others, like Seiver, 1985). We can also propose as a cause that, in rural Romania, there are fewer household duties (see Lam and Miron, 1991; tangential Becker, 1991) occurring outside the house during the Nativity fast than during spring Lent. And lastly, the DL (and of course night length) needs to be mentioned as there was a lack of electricity until the middle of the 20th century and also a lack of other indoor sources of entertainment, thus increasing the likelihood of sexual encounters at those times.

Therefore, the proposed models highlight the impact of fasting periods controlled by religion on conception, besides the existence of other factors with persistent or temporary influence. For instance, the DL variable reveals the significant influence of several factors such as the regularity of daily activities determined by the season and the temperature (these two factors were included in the initial models and eliminated due to the multicollinearity effect). With one exception (M1), our analysis reveals a photoperiodicity-related cause for baby conception as found for European Countries such as France, England and Sweden (Lam and Miron, 1994) on monthly data. Of course, due to multicollinearity, the photoperiodicity could have only an apparent effect as a proxy for factors like the temperature, outside household duties or the lack of available inside sources of entertainment.

A weekend is a factor inserted into our models that tends to function as a proxy for holidays, and more permissive sexual activity. Previous research (Bobak and Gjonca, 2001) suggests that during holidays, the frequency of conception seems to be higher. Our data analysis generally agrees with these findings. Therefore, for ORTHD population, weekends seem to have a positive impact on conception with the exception of model M4. Furthermore, the same influence is reflected on the NORTHD population, also until 1966 (models M1–M4). Thereafter, weekends are shown to have a negative influence.

It also needs to be stated that despite other researchers' findings (Jongbloet, 1983), the proportion of illuminated moon disc was found to be insignificant from a statistical viewpoint (Student *t*-test).

Furthermore, the values of the regression coefficients specific to the ORTHD persons in the rural environment illustrate that behavioral patterns in these geographical areas are much more prone to seasonal elements in child conception as compared with urban areas, where these differentiations are diminished.

The trend of the series for each analyzed sub-period confirms the expectations stated above. Thus, in each major timespan here analyzed, there are years of maximum increases followed by a descending

evolution. The only exception to this rule is the years between 1948 and 1966, when the maximum points of the number of conceived babies are at the ends of the interval. On the one hand, this could be determined by the 'necessity' to cover the disaster caused by the war; on the other hand, it shows the significant impact of Ceausescu's decree.

Finally, the splitting of the populations into ORTHD and NORTHD categories is relevant. The model for all sub-periods analyzed is much weaker (from an econometrics viewpoint) for the NORTHD population which does not have Nativity or Lent fasts or, if it does, with time delays versus the ORTHD population. Moreover, the standardized coefficient that measures the impact of Lent Fast on conception has in general the largest absolute value. It is followed in absolute value by the rurality (rORTHD) coefficient, both values strengthening the value of the ORTHD tradition and faith, factors which are underestimated or missing in previous research on the timing of human conception.

In brief, the primary result of the current investigation is that the non-uniformity across the year of the conception of babies in Romania during the last century is affected not merely by seasonality but by a double filter: season and religion.

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Authors' roles

C.H. and B.V.I. obtained data. C.H., B.V.I., M.A. and G.R. performed data analysis, manuscript design and revised version design. C.H. coordinated the teamwork.

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Conflict of interest

B.V.I., M.A. and G.R. have nothing to declare regarding competing interests. There is no connection to the current paper, but C.H. declares that (i) he is currently conducting a research entitled 'Chronic Diseases' Direct Costs within the Romanian Health System' funded by Local American Working Group; (ii) his wife is employed by a Romanian company (A&D Pharma) with activities in the pharmaceutical sector.

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