Physica A 532 (2019) 121768

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

The influence of Lent on marriages and conceptions explored through a new methodology

Claudiu Herteliu [a], Peter Richmond [b], Bertrand M. Roehner [c,*]

[a] Department of Statistics and Econometrics, Bucharest University of Economic Studies, Bucharest, Romania
[b] School of Physics, Trinity College Dublin, Ireland
[c] Institute for Theoretical and High Energy Physics (LPTHE), University Pierre and Marie Curie, Sorbonne Université, Centre de la Recherche Scientifique (CNRS). Paris, France

HIGHLIGHTS

- The Orthodox religion has a high impact on marriages.
- Its impact on conceptions is 10 times weaker.
- Our measurement method does not depend on seasonality.

ARTICLE INFO

Article history:
Received 15 February 2019
Received in revised form 28 April 2019
Available online 19 June 2019

Keywords:
Religion
Birth
Marriage
Lent
Ramadan

ABSTRACT

What is the influence of religion on the actual behavior of people? The present paper introduces a methodology which permits a quantitative assessment. [1] have elsewhere analyzed the impact of Lent (prior to Easter) and Advent (prior to Christmas) on births in Romania. Here we broaden the analysis (i) by studying the effect of Lent on marriages as well as births (ii) by analyzing a number of other countries which allows a comparison with non-Orthodox countries. We also introduce a new methodology (that we call the "overlap probe") which treats the data in a way that avoids any bias related to seasonal patterns.

The comparison between the effects on marriages and conceptions appears of particular interest for it permits to assess the respective weights of social pressure on one hand and personal behavior on the other hand. Our analysis reveals a strong effect of Lent on marriages with a reduction by 80% in Eastern Orthodox countries and 40% in West European Catholic and Protestant countries. Since the influence of Lent on conceptions is independent of any form of direct social control one expects this effect to be much smaller. This is born out by our results which show that the birth effect is about 10 times smaller than the marriage effect.

The overlap methodology is so accurate that it allows us to determine the average length of pregnancy (from intercourse to birth) with a precision of 2 or 3 days.

This methodology is also used to investigate the impact of the month of Ramadan on birth and suicide rates.

* Corresponding author.
E-mail addresses: claudiu.herteliu@gmail.com (C. Herteliu), peterrichmond@ymail.com (P. Richmond), roehner@lpthe.jussieu.fr (B.M. Roehner).

https://doi.org/10.1016/j.physa.2019.121768
0378-4371/

1. Introduction

Many social phenomena (e.g. births, marriages, suicides, deaths,) have seasonal components.[1] Because such components change annually they act as a kind of background noise which hinders and blurs observation. Here, we introduce a methodology which allows us to completely bypass seasonal patterns.
In physics improving the accuracy of observations mainly relies on the ability to reduce the background noise. In the present paper we have the same goal.

The paper aims to understand some specific and puzzling observations about vital events that are related to the influence of religion on society. In contrast to seasonality, this is a topic which has received only scant attention; one can mention the works of Kadhel et al. [2], Lesthaeghe [3], McQuillan [4], Requena [5], Adserá [6], Friger et al. [7], Ruiu and Breschi [8], Lledó et al. [9]. The first paper investigates the years 2000–2010 to see whether the Carnival period in Guadeloupe (French West Indies) was marked by an increase in conceptions. Interestingly, it is the comparison between 2009 in which there was no Carnival (due to a general strike) and the other years which gives the most convincing evidence. The last paper is probably the one which is closest in spirit to our study although the techniques that are used are very different.

Although nowadays it is fairly uncommon to start a paper by describing intriguing facts, [2] in the present case we felt that this presentation could be useful because, beyond the specific issues treated here, it will also emphasize that comparative analysis can be of great help in solving such riddles.

1.1. Selection of the time period

Before we start the discussion we must explain why we focused mainly on the time period before 1940. There are two (fairly related) reasons.

(1) In a general way when one wants to study a given phenomenon it is best to select a case where this effect appears most clearly. A physicist who wishes to study the period of a pendulum will not select data of movements whose amplitude is $\pm$1degree for that would give very poor accuracy. A less trivial example is that to study black holes one will focus on the nearest and most massive.

(2) Similarly, when one wants to study the influence of religion on the behavior of people it would not be appropriate to select cases (such as present-day European countries) where the social role of religion has become negligible. We will see later on (Table 2b) that even in 20th century France the influence of religion on conceptions was already so small as to be almost hidden by the background noise. In Herteliu et al. [10], p.1059) there is a graph which compares the declining influence of religion over past decades in France and Romania. Although there was a decrease in both countries after 1946 in Romania the reduction was 6 times faster than in France. This is the main reason why we selected a time period before the Second World War.

In the last part of the paper where we study the effect of Ramadan on suicides the same argument led us to select a more recent time period because the social influence of Islam has in fact become stronger in recent years. It is true that in this case so few data were available that our freedom of choice was rather limited.

1.2. Marriage rates in March

Our first intriguing observation is the strange pattern of marriage numbers during the month of March in Bulgaria (Fig. 1a). Such a quasi-periodic plot is reminiscent of seasonal fluctuations except that here the curve shows *annual* variations in a *given month*. Why should the number of marriages in March 1929 be over 10 times larger than in March 1928?

Can comparisons with other countries help us to identify the origin of this mysterious pattern?

As a first test, it is natural to try a distant country (like Japan) which differs from Bulgaria in many respects. Fig. 1a shows that what we see in Bulgaria is not a "universal" regularity but rather one tied to a specific aspect of Bulgaria.

As a second test let us consider another European country, for instance France. The French marriage numbers display fluctuations which are somewhat similar to those in Bulgaria although of much smaller amplitude and not exactly in sync (Fig. 1b). This observation makes us suspect that in France there is a factor similar, yet not identical, to the one at work in Bulgaria.

Greece and Romania have a common border with Bulgaria. Although their curves cover only the final few years of the time interval, the fact that they are highly synchronized suggests the existence of the same factor as in Bulgaria. The three countries all follow the Orthodox Christian tradition. Is this the factor which explains the observed fluctuations?

---

[1] There are numerous papers on the topic of seasonality despite the fact that it is a notion that is too broad in the sense that almost any factor may have an influence, whether large or small, on the distribution of vital events. In addition, such factors change across country and in the course of time. The present paper is *not* about seasonality. On the contrary, it develops a methodology which allows us to ignore seasonal patterns.

[2] In contrast, during the 18th and 19th centuries, it was common for Academies of Sciences to organize academic contests (rewarded by a cash prize) in which the participants had to explain some challenging facts. For instance, one of those competitions which took place in France in 1818, led to the discovery of the so-called Arago spot, a bright dot at the center of the shadow of an opaque circular object. Subsequently, this unexpected and astounding observation became a key argument in favor of the wave theory of light.

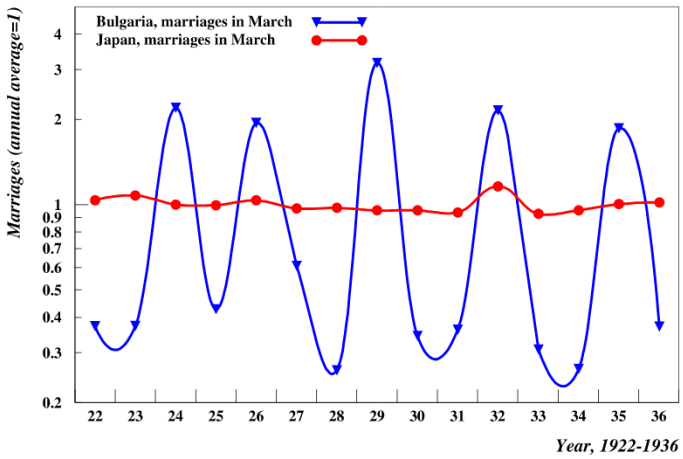

Fig. 1a. Number of marriages during March in Bulgaria and Japan, 1922–1936. For the purpose of comparison the two series were normalized so that their average becomes equal to 1. Note the broad range (from 1 to 10) of the Bulgarian changes. Clearly there is a factor at work in Bulgaria which does not exist in Japan.
Source: Bunle [11], p. 249 and 258.

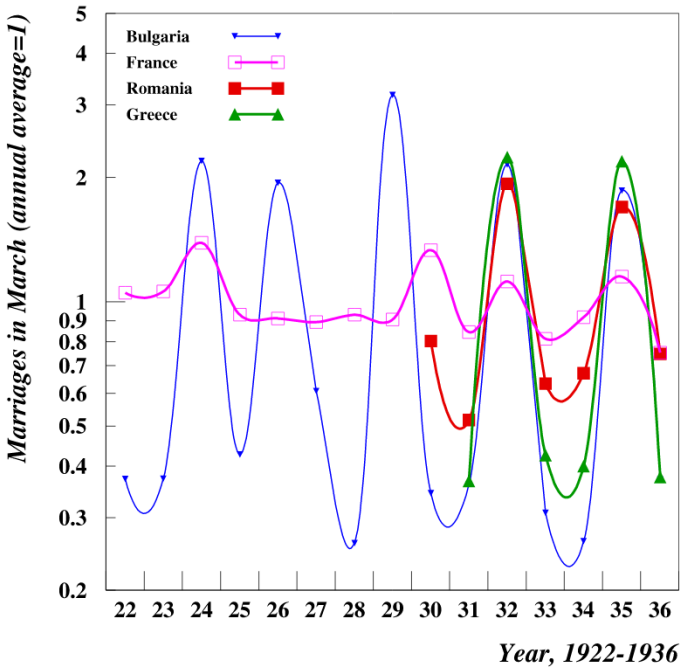

Fig. 1b. Number of marriages during March in Bulgaria, France, Romania and Greece. For Romania and Greece the data are available only from 1930 and 1931 on. For France the fluctuations are somewhat similar to those in Bulgaria yet not as identical as those of Romania and Greece.
Source: Bunle [11], p. 249–251 and 255.

A possible mechanism comes to mind.

In the Christian religion the time preceding the Easter Sunday is called Lent. In the Orthodox religion Lent lasts 7 weeks (i.e. 49 days). As Lent is a time of fasting and penance it is understandable that people will avoid celebrating their marriage during Lent. Can this mechanism account for the fluctuations observed in the number of marriages?

In order to get an insight let us observe two extreme cases, namely March 1928 (613 marriages) and March 1929 (7,462 marriages). In 1928, Orthodox Lent started on 27 February and ended on 14 April which means that the whole month of March was included in the Lent period. On the contrary, in 1929, Lent started on 18 March which means that only 13 days were included in Lent.

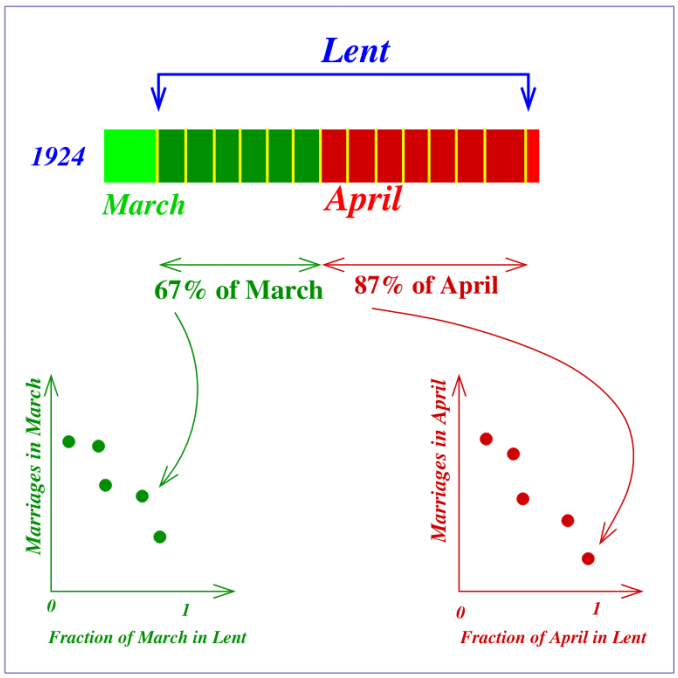

Fig. 2. Procedure for determining the correlation between Lent-month overlap and the number of marriages in that month. In 1924 the Orthodox Lent lasted from 10 March to 26 April. There will be a different plot for each month. It is important to keep the graphs of successive months separate in order to avoid any interference caused by the seasonal profile of marriages.

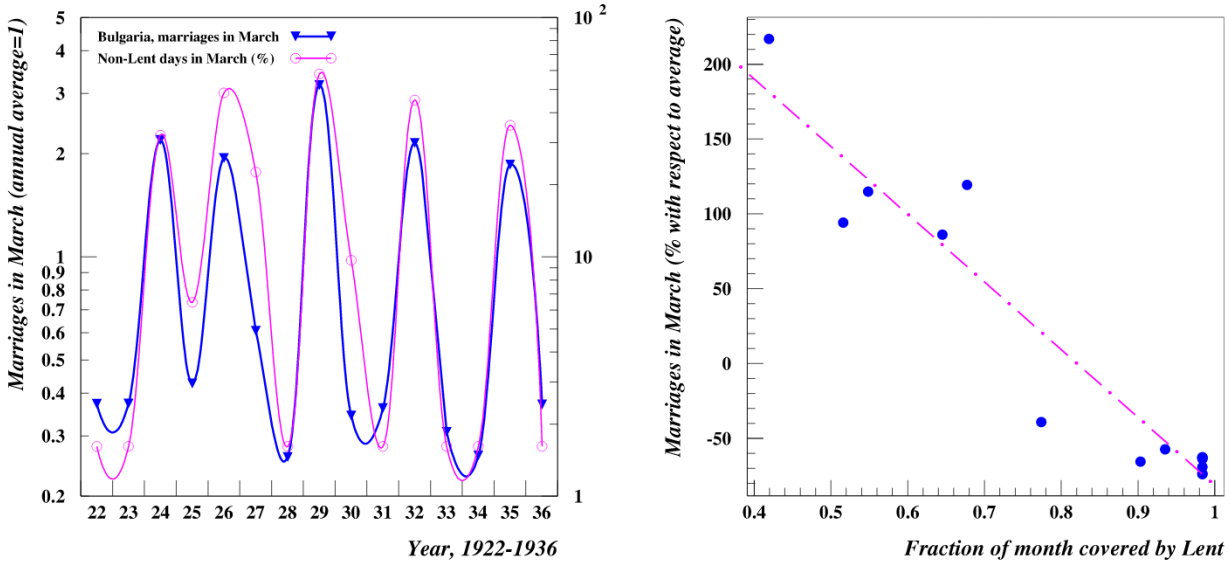

Fig. 3a,b. Number of marriages during March in Bulgaria versus Lent in March. **(a)** Marriages versus non-Lent days. The scale for the non-Lent days is on the right-hand side. **(b)** Scatter-plot for the same data: x=Fraction of Lent days in March, y=marriages in March. The correlation of the two series is $r = -0.96$ and the slope is $a = -452 \pm 75$.
Source: Bunle [11], p. 249.)

Repeating this procedure (which is summarized in Fig. 2) for all the years, we get the curves shown in Figs. 3a,b and 3c.

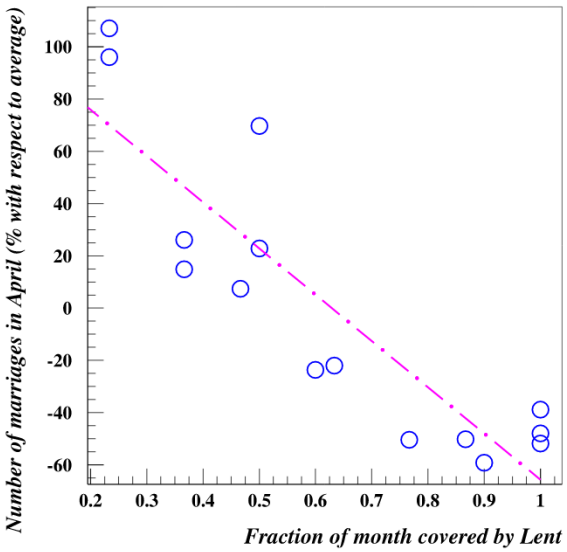

Fig. 3c. Number of marriages during April in Bulgaria versus Lent in April, 1922–1936. Scatter-plot for: x=Fraction of Lent days in April, y=marriages in April. The correlation is $r = -0.88$ and the slope is $a = -177 \pm 51$. This plot is given for the purpose of comparison with the case of March. The slope here is much smaller than in March which is due to the fact that in March the highest monthly numbers of marriages are twice as high than the highest of April. This shows clearly that mixing different months would lead to unreliable results.
Source: Bunle [11], p. 249.)

Whereas for Bulgaria one gets a high correlation, we can now also understand why the curve of the marriages in France was out of sink. This is because, except in a few years, the western Lent (i.e. Catholic or Protestant) does not coincide with the Orthodox Lent. The former starts earlier and is somewhat shorter. It lasts 46 days instead of 49. [3]

The same procedure can be repeated for all months with which Lent overlaps, that is to say February, March and April. The fact that we get separate estimates for each month is a distinct benefit of this procedure for it permits to completely bypass the nagging difficulty of how to get rid of the seasonal fluctuations of vital rates. [4]

1.3. Reduction in marriage numbers during Lent in Orthodox countries

In Orthodox countries the clergy is very reluctant to celebrate marriages during Lent. Thus, if all marriages were celebrated in a religious way the number of marriages during Lent would fall almost to zero. As shown in Figs. 3a,b, 3c and Table 1a, a sizable number of marriages nonetheless take place during Lent; this gives an estimate of the number of purely civilian marriages.

Table 1a gives the correlation and regression results for Bulgaria, Romania and Greece. Lent has a drastic effect on the number of marriages: on average they are nearly divided by 4 and by 10 in the most extreme cases such as March 1928, 1929 considered previously.

1.4. Marriage reduction during Apostles' fast in Orthodox countries

In Orthodox countries, apart from Lent and Advent there is also the Apostles' Fast (also called "Peter and Paul Fast"). In a sense this is an ideal case for applying the overlap methodology explained in Fig. 2 for this fast falls always in June and is of variable length. It starts on a date which can move from early to late June and ends always on 29 June.

Applying the overlap procedure for Bulgaria in 1921–1936 one obtains for the correlation between fraction of June covered by fast on the one hand and marriage rate on the other hand, a value of -0.39 (instead of -0.96 for Lent) which shows that this fast is enforced with more flexibility both by the Orthodox Church and by the population. As a matter of fact, in some denominations there has been a secular tendency to reduce this fast to a few days instead of its traditional length.

The same observation probably also applies to Advent. However, in this case, since it is not a mobile time interval one cannot apply the overlap methodology.

---

[3] The western Lent lasts from "Ashes Wednesday" to the Saturday before Easter. Actually the time for fasting lasts only 40 days because the 6 Sundays are excluded. Because, nonetheless all 46 days are a time of penance, we treated them in a uniform way. The same remark applies to the three days before Easter which in some sources are not included in Lent.

[4] Ad hoc corrections can be tentatively defined in various ways but lack clear theoretical justification; moreover there is always the suspicion that the observed effect has in some way been created (or at least modified) by such corrections.

Table 1a
Reduction in the number of marriages during Lent in Orthodox countries.
Source: Bunle [11], (p. 248–251).

	March	April	Mar–Apr average
Bulgaria, 1922–1936			
Correlation (l, m)	−0.96	−0.88	−0.92
Reduction, % (h)	−452± 74	−177± 51	-314± 44
Romania, 1930–1936			
Correlation (l, m)	−0.98	−0.91	−0.95
Reduction, % (h)	−291± 38	−70± 28	−180 ± 23
Greece, 1931–1936			
Correlation (l, m)	−0.99	−0.99	−0.99
Reduction, % (h)	−443±57	−184± 19	−313 ± 27
Average			
Correlation (l, m)			−0.95
colorred Reduction, % (h)			-269± 22

Notes: In the correlation m denotes the number of marriages whereas l designates the overlap fraction between Lent and the month under consideration. The reduction h is the decrease in marriage number for a month completely included in Lent, i.e. when the overlap fraction increases from 0 to 1. The error bars are confidence intervals for a confidence probability of 0.95. On average, during Lent the reduction is -269% which means that the number of marriages is divided by 3.7. The results for February were omitted because the rare overlaps produce too few data points.

Table 1b
Reduction in the number of marriages during Lent in Catholic and Protestant countries.
Source: Same as for Table 1a.

	February	March	April	Feb–Apr average
France, 1922–1936				
Correlation (l, m)	−0.92	−0.63	−0.85	−0.80
Reduction, % (h)	−46± 15	−90± 59	−25± 8	-53± 16
Netherlands, 1922–1936				
Correlation (l, m)	−0.88	−0.083	−0.70	−0.55
Reduction, % (h)	−39± 15	−6± 41	−22± 12	−22 ± 13
Spain, 1922–1936				
Correlation (l, m)	−0.45	−0.57	−0.77	−0.60
Reduction, % (h)	−28± 41	−62± 49	−31± 13	−40 ± 20
Average				
Correlation (l, m)				-0.65
Reduction, % (h)				-38± 9
Finland, 1922–1936				
Correlation (l, m)	−0.83	−0.55	+0.43	
Reduction, % (h)	−34± 17	−44± 37	+15± 18	
Sweden, 1922–1936				
Correlation (l, m)	−0.76	−0.25	+0.77	
Reduction, % (h)	−29± 18	−27± 58	+40± 18	

Notes: The meanings of l, m, h are the same as in Table 1a. In France, the Netherlands and Spain, on average, the reduction due to Lent is: −38%. In Finland and Sweden during the month of April instead of a reduction one observes an increase in the number of marriages together with Lent overlap. The reason of this effect remains an open question. As for Finland and Sweden the April results Do not have the right sign, it would have little meaning to show the Feb–Apr averages.

1.5. Changes in marriage numbers in Catholic and Protestant countries

Table 1b documents the effect of Lent on marriages in two Catholic countries namely France and Spain, one mixed Catholic–Protestant country, namely the Netherlands and two Protestant countries, namely Finland and Sweden.

Two main observations emerge.

• The impact of Lent on marriages is much smaller than in Orthodox countries; in term of percentage it is seven times smaller: 38% as compared to 269%.

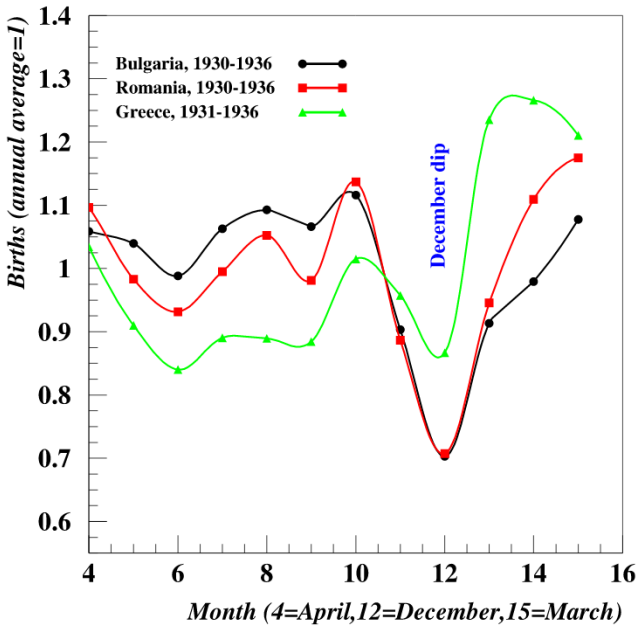

Fig. 4a. Number of births in Bulgaria from April of year y to March of year $y+1$. The curves were averaged over 7 years for Bulgaria and Romania and over 6 years in Greece. As there is a 9 month time interval between March and December one is led to suspect that the Nov–Dec–Jan. dip is brought about by a reduction of conceptions during Lent. However, at this point this is only a conjecture. A more compelling proof is provided by Fig. 4b.
Source: Bunle [11], p. 307,309,311).

• Whereas in the great majority of cases Lent reduces marriage numbers there are two cases where greater Lent overlap results in *higher* marriage numbers. This happened during the month of April in Finland and Sweden. [5] The reason remains an open question.

2. Effect of Lent on conceptions

2.1. Evidence for the effect of Lent on births 9 months later

In the first section it was suggested that the origin of the fluctuations of marriage numbers in Bulgaria could be identified through comparative analysis. The same message could be repeated here for indeed if considered alone the curves of Fig. 4a would not be easy to explain. They display a dip that extends over three months: November, December and January. Here too a comparison with Japan and France would suggest that this effect may be related with the Orthodox religion.

2.2. Two difficulties

The effect of Lent on births is more difficult to study than its impact on marriages for two reasons.

• By comparing Figs. 3a,b and 4b one sees that for births the effect is much smaller than for marriages. For marriages the range of the changes is $\pm 100\%$ whereas for birth it is $\pm 15\%$. This implies a greater relative incidence of background noise. Thus, one should not be surprised to see larger error bars.

• The length of time between sexual intercourse and birth is not known exactly In medical practice it is customary to define the length of pregnancy as the interval between the first day of the woman's last period and birth. Conception usually occurs two weeks later, however. If one accept the standard figure of 40 weeks (i.e. 280 days) for pregnancy (in the medical sense), it results in a conception–birth interval of 266 days. Subsequently, we will use the word "pregnancy" as referring to the length of time between sexual intercourse (which must occur zero, one or at most two days before ovulation) and birth; it will be denoted by G. Fig. 4b was drawn on the assumption that this time interval was 9 months (i.e. 273 days) but this is only an approximation. The analysis presented in the next subsection will allow us to determine the length of pregnancy that gives the highest statistical correlation.

[5] For Denmark there are no data available for 1931–1936. Other Protestant countries which could be tested (and for which data are available) are Australia, Norway, Scotland and the State of Massachusetts in the United States. This will be left for a subsequent study.

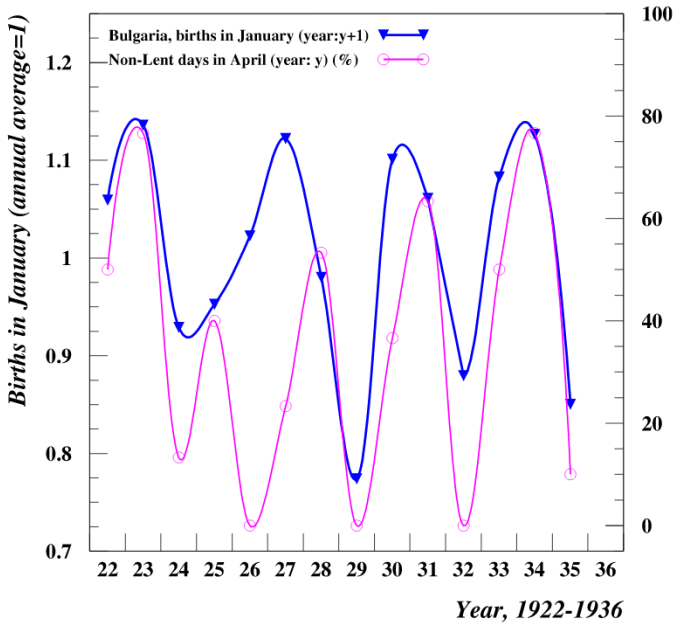

Fig. 4b. Number of births during January in Bulgaria versus number of non-Lent days in April of the previous year. The scale for the non-Lent days is on the right-hand side. The correlation of the two series is 0.72. This figure parallels Fig. 3a,b which showed the correlation between marriages and non-Lent days. However, in order for the conceptions of April to be mapped into births occurring in January of the following year, the pregnancy length (from conception to birth) has to be exactly equal to 9 months (i.e. 273 days). If its real average length is different (e.g. 280 days) the synchronicity between Lent and births will be affected.
Source: Bunle [11], p.307).

2.3. Analysis of the relationship between Lent and births

For each of the three months November, December and January the calculation was conducted in the following way (the explanations are for November 1920).

(1) First, the Lent interval of 1920 was moved G days to the right to an interval (i_1, i_2).

(2) Secondly, the overlap of (i_1, i_2) with November was determined. We call it L.

(3) The number m of births in November 1920 was taken from Bunle [11].

(4) Once the pairs (L, m) have been computed for each of the years under consideration (e.g. 1920–1936) the correlation r and the regression of the (L, m) scatter-plot were computed.

From the regression slope one derives the change of m when L changes gradually from 0 to 1. Once expressed in percent, this change is denoted by h. As for higher L it is a fall in birth numbers that is expected, r and h should be negative; therefore it is natural to consider as optimum the values of G which give the most negative correlations.

(5) As in the procedure used for marriages the months of November, December and January are treated separately. Thus, our results are independent of the seasonal distribution of births. As already emphasized, this is a crucial advantage. However, if one wishes to get synthetic indicators one can take the averages $\overline{r}$ and $\overline{h}$ of the three values r_1, r_2, r_3 and h_1, h_2, h_3. An additional benefit of averaging is to reduce the error bars by a factor $\sqrt{3}$.

2.3.1. Testing the procedure

In order to test the previous procedure a simulated birth series was built. We started with a constant daily series of birth numbers; then, in each year, for the days belonging to Lent plus G days (with real dates for Lent) the birth numbers were reduced by q percent. After that, the daily series was converted into a monthly series. [6] Finally, a variable amount of random noise could be added to make the series look more realistic. However it is with a purely deterministic series (i.e. without noise) that the most interesting tests can be done. In this case one should get $r_1 = r_2 = r_3 = 1$ and $h_1 = h_2 = h_3 = q$ which is indeed what was verified.

Another instructive test is with respect to the value of G. This point is explained in the next subsection.

[6] In this study a simple but important tool was a computer macro which for any day defined by its date (year $= y$, month $= m$ and day of month $= j$) computes its position index i in number of days with respect to a given origin, for instance 1 January 1920.

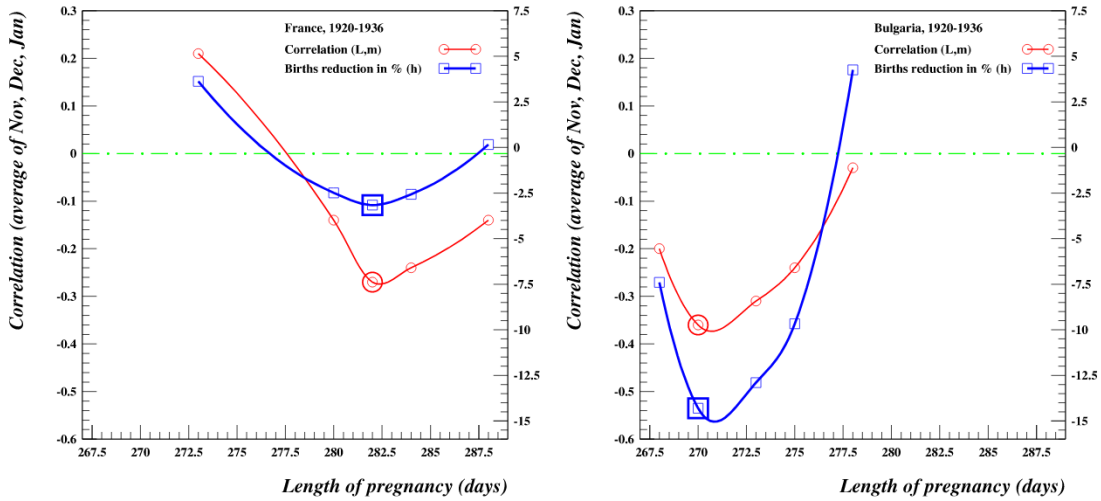

Fig. 5a,b. Relationship between Lent and number of births as a function of assumed pregnancy length G, **France (on left), Bulgaria (on right).** In the correlation (L, m), the variable L represents the overlap of Lent+G with the month under consideration; m represents the number of births in the same month. The graph shows the average correlation for the three months of November, December and January (of the next year). In the reduction h represents the birth reduction which occurs when the month is completely included in Lent with respect to the case when Lent does not overlap with this month. The comparison of **(a)** and **(b)** shows that whereas the correlation (red curve) is approximately the same in France and Bulgaria the effect of Lent on births (blue curve) is about three times larger in Bulgaria. The observation of different optimum values in France and Bulgaria can be related to the fact that natural variations in pregnancy length are larger than suspected until recently [12]. It can be noted that in Romania and Greece the optimum G value is also around 272 days as in Bulgaria.

2.4. Influence of pregnancy length and its significance

Fig. 5a,b shows that the value of the assumed pregnancy length G used in the analysis strongly affects the results. In order to assess the significance of these results it is helpful to use again the simulation already introduced above.

In this test we built the simulated series with a pregnancy length G_1 and we analyzed it with a different pregnancy value G_2. This test shows that even a small difference between G_1 and G_2 may lead to greatly reduced correlations. For instance, with $G_1 = 273$ days and $G_2 = 276$, the value of r_2 falls from 1 to about 0.5 whereas r_1 and r_3 are hardly affected. This difference between r_2 on the one hand and r_1, r_3 on the other hand is of course related to the positions of "Lent+G". Because in most years a large part of December (or even the whole of it) is included in "Lent+G", most of the L values of this month are close to 1. This makes the scatter plot of December fairly unstable which explains that even a small difference in G may change it completely.

This test suggests that the differences documented in Fig. 5a,b are of significance and that the value of G which gives the highest correlation identifies the G of the real world. In order to substantiate this judgment it would be helpful to find accurate estimates of pregnancy length in different countries. In spite of the fact that this is a topic of great practical interest very few studies could be found in medical journals. Accurate measurement requires exact determination of the moment of ovulation which in turn relies on daily blood tests for hormone levels. As this is a demanding procedure it is understandable that it is not done in many countries. However, when dedicated campaigns were set up they revealed larger standard deviations than expected [12,13]. Within a given country the standard deviation is about 7 days but this does not tell us cross-country variability.

2.5. Strength of the Lent effect in Orthodox countries

Fig. 5a,b shows the Lent effect is about three times smaller in a western country like France than in an Orthodox country like Bulgaria. The fact that the effect is smaller also means that it is more difficult to measure. Table 2a summarizes the results for Bulgaria, Greece and Romania. It appears that the strength of the Lent effect is strongest in Greece. Table 2b gives results for France but the effect is so small that it is almost hidden by the background noise.

2.6. Impact of marriages on conception data

Before we leave the question of marriage and conception we wish to examine what is the impact of marriage on birth data.

Newly married couples might be expected to conceive a child shortly after being wed. If so, fluctuations in marriage rates would induce similar fluctuations 9 months later in birth numbers. There can be little doubt that such an effect exists but the real question is how strong it is. If it is massive then reduction in births would be, so to say, a mechanical

Table 2a
Reduction in the number of conceptions during Lent in Orthodox countries, 1930–1936.
Source: Bunle [11], (p.307–311).

	Bulgaria	Greece	Romania
(1) Reduction h expressed in %, Nov,Jan	−32± 22	−44± 11	−16± 15
(2) Reduction h expressed in %, Nov,Dec,Jan	−13±18	−27± 8	−9.5± 11

Notes: h is the reduction in birth number (expressed in percent with respect to the situation without Lent) when a given month is completely included in Lent. As explained in the text the December estimates are very uncertain because most L values are close to 1; here all December estimates in fact turn out to be positive. That is why we give the results in two forms: in (1) the average is restricted to Nov and Jan whereas in (2) the average includes all three months. Naturally, the estimates of (2) are lower but the ranking of the countries is not changed. Note that for Greece the time interval is 1931–1936 because the data for 1930 are not available.

Table 2b
Reduction in the number of conceptions during Lent in France.
Source: Sources: The monthly birth data for 1872–1891 are from "Statistique Générale de la France" (several years). The data for 1920–1936 are from Bunle [11], (p. 308).

	1872–1891	1920–1936
(1) Reduction h expressed in %, Nov,Jan	2.6±2.5	−2.0±4
(2) Reduction h expressed in %, Nov,Dec,Jan	−0.29± 4.6	−2.9± 3

Notes: The comments already made in Table 2a also apply here. As in Table 2a and for the same reason the inclusion of December whose regression slope is quite unstable (sometimes negative, sometimes positive) makes the results given in line 2 fairly uncertain. As the effect of Lent is about 5 to 10 times weaker than in Orthodox countries, the error bars are much larger in relative terms.

consequence of the diminution of marriages. On the contrary, if the marriage effect represents only a small fraction of the birth effect, then the latter is really a new and distinct phenomenon. In Appendix A it will be shown that it is the second answer which is correct. The conceptions occurring in the same month as marriages represent less than 5% of the total birth number. This is due to two main factors (which are developed in Appendix A).

(1) When couples have a total of 3 or 4 children, their first child represents only a fraction of all births.

(2) Even for couples who wish to have a child immediately after getting married, the likelihood that the first ovulation will lead to successful fertilization is fairly low.

3. Ramadan effects explored through overlap probes

With the encouragement of one of our reviewers who wanted us to show that the overlap methodology has a broad field of application, we undertook an investigation of the social effects of the month of Ramadan in Muslim countries. Like Lent, Ramadan is a mobile time interval but it does not move in the same way. Whereas the dates of Easter are more or less random but always concentrated in March and April, each year Ramadan begins about 11 days earlier than in the previous year. This means that for any given month there can be 3 beginning dates of Ramadan in successive years and likewise also 3 ending dates. Thus, there can be at most 6 intersection intervals between Ramadan and a single month but sometimes there are only 5 or 4.

We have investigated two social aspects, namely conceptions and suicides. We mention only briefly the firth one for in fact no clear effect was detected.

3.1. No visible effect of Ramadan on birth rates

As was done earlier for Orthodox countries, the first step is to see what are the precepts of Islam.

- Although marriage is not prohibited during Ramadan it is clear that the celebration (including the dinner) must take place after sunset which is quite inconvenient. So far, we were unable to find monthly wedding statistics in Islamic countries but one would expect them to confirm a decline during the month of Ramadan.
- During Ramadan one must not only refrain from eating and drinking from dawn until sunset, one must also abstain from sexual intercourse. However, since sexual relations are permitted during the night the situation in this respect is not very different from non-Ramadan months.

Thus, one would not expect any substantial reduction in conceptions. We tested the cases of Algeria and Egypt, two countries for which monthly birth data are given in the publications of the "Population Division" of the United Nations. [7] There was no clear conception effect.

[7] Note however that for marriages the "Population Division" publishes only annual data.

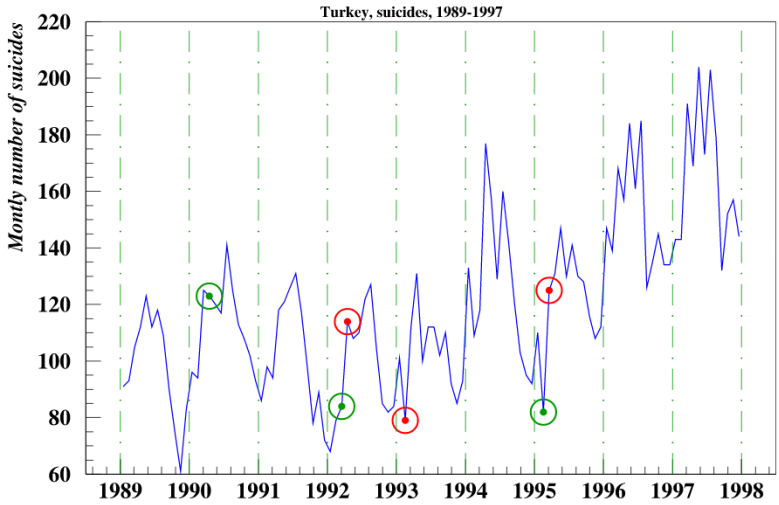

Fig. 6a. Monthly numbers of suicides in Turkey, 1989–1997. The green circles identify the months of February, March and April whose overlap with Ramadan was higher than 80%, whereas the red circles correspond to cases when the same months had an overlap of less than 20%. Note that the months for which there were less than 4 intersections were left out.
Source: Turkish Statistical Institute; see Appendix B.

3.2. The effect of Ramadan on suicides

Why should one expect a decrease of suicide during Ramadan? This prediction is based on the conception of suicide developed by the French sociologist Emile Durkheim (1858–1917) who was one of the founding fathers of the field of sociology. The observation that suicide is 2 or 3 times more frequent among bachelors or widowers than among married people naturally leads to the conjecture that suicide is favored by a lack of social contacts. Conversely, one expects that additional social contacts may prevent suicide.

"Iftar", the evening meal with which Muslims end their daily Ramadan fast, is not only an opportunity for families and friends to have dinner together, but in cities such as Cairo or Riyadh it also gives rise to large public gatherings. In short, during the month of Ramadan one expects an increase in social interactions and therefore, if the Durkheimian conjecture is correct, a reduction in suicides.

3.3. Suicide statistics in Islamic countries and Turkey

In Judaism, Catholicism, Anglicanism and Islam there is a strict prohibition against suicide. Usually, people who kill themselves are buried separately. In England and Wales suicide was considered a criminal offense [8] until the "Suicide Act" of 1961. Thus, one will hardly be surprised that before 1961 the recorded British suicide rates were far lower than in France or Germany.

For the same reason, suicide statistics are almost nonexistent in countries where Islam is the state religion. The only country where we could find such data is Turkey. However, even in Turkey the suicide rates are fairly lower than in most western countries. Because they are not easy to retrieve, for the convenience of the readers, such data are reproduced in Appendix B.

In Turkey Ramadan has a special characteristic in the sense that the day after the end of Ramadan is called Ramadan Feast, It is a public holiday during which schools and most businesses are closed. This day is devoted to visiting elderly family members and friends. Thus, from Durkheim's perspective, this day can be considered part of Ramadan.

3.4. Analysis of the period 1989–1997

The method that we used is basically the same as already explained for conceptions. However, it is simpler here in the sense that there is no need to introduce a 9-month delay between conception and birth. For suicides the events are recorded in their month of occurrence.

Fig. 6a shows monthly suicide data in Turkey over 1989–1997. There are two important features.

[8] In the sense that the belongings of persons who committed suicide were handed to the Crown and persons who failed in their suicide attempt were prosecuted. In at least some cases, there were sentenced to terms of a few weeks in prison (McDonald et al. 1991.

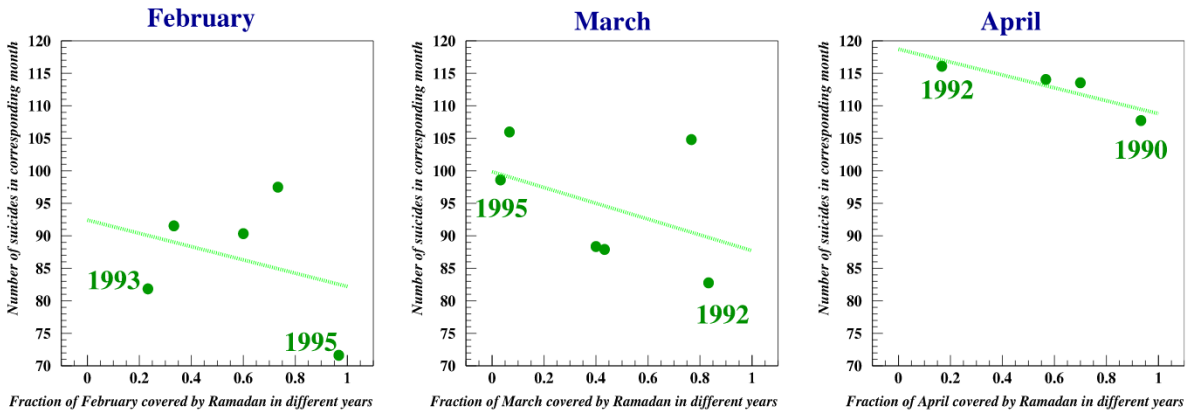

Fig. 6b. Monthly suicide numbers (in different years) as a function of the overlap with Ramadan. The correlations are −0.30, −0.42, −0.89 and the slopes of the regression lines are: −10.2, −12.1, −9.92.
Source: Calculations based on the data from the "Turkish Statistical Institute".

• There is a strong seasonal component; suicides are highest in spring and summer and lowest in November–December–January. This feature is common to almost all countries but the ratios between highest and lowest rates are country-dependent. Here this ratio is on average about 1.4.

• Although qualitatively the seasonal pattern is common to all years, its shape changes markedly from year to year. This is the feature which makes the series difficult to analyze for it cannot be deseasonalized in an effective way. That is why it would be nearly impossible to ascertain any possible suicide effect without the overlap probe. This is demonstrated by the green and red markers. Whereas the green circles signal months almost entirely covered by Ramada, the red circles correspond to months whose intersection with Ramadan is less than 20%. Naturally, since in 1989–1997 Ramadan was concentrated on only 4 months from January to April all the data points from May to December are not influenced by Ramadan either but these points are too distant from the green circle months to allow any significant comparison.

Fig. 6b shows the number of suicides as a function of the fraction of overlap for the months of February, March and April. The correlations are: −0.30, −0.42, −0.89 respectively with corresponds to an average of $\bar{r} = -0.54$. As the vertical scale is the same on the three graphs one sees that the slopes of the regression lines are nearly identical. The average of the slopes is $\bar{a} = -11 \pm 13$. This means that when the month/Ramadan intersection decreases from 1 to 0.5 or from 0.5 to 0 there are 5 additional suicides. The error bar is high because we required a standard confidence level of 95% and because for each of the months there are only few data points.

Note that the levels of the regression lines are quite different which suggests that it would not be a good idea to collect all points on the same graph.

The analysis of the period 2000–2013 (the data for 1998 and 1999 are missing) leads basically to the same results. The average correlation is $\bar{r} = -0.56$ and at $\bar{a} = -14 \pm 9.3$ the average slope is somewhat higher than for 1989–1997 in line with an overall increase in the number of suicides whose average climbs from 130 to 225.

For the two time intervals together the global average of the slope is: $\bar{a} = -12.5 \pm 8.0$.

4. Conclusion

First we have studied the impact of Lent on marriage rates. This was fairly easy because there is a very strong connection. It is somewhat stronger in Orthodox countries than in Western countries but is clearly visible in both cases.

The effect of Lent on conceptions was more difficult to study but it was also more interesting. Why?
Whether we consider religious or civil marriages, they will be subject to the scrutiny of the social group in which they take place. In other words, they are an indicator of social consensus and conformity. Religious consensus can also be measured through other indicators. One can mention the following French statistics. [9]

(1) *Proportion of baptized person by age group.* In 2015 in France 33% of newborns were baptized, down from 61% in 1990.

(2) *Proportion of religious marriages.* In 2015 in France, the percentage of Catholic marriages was 24%, down from 51% in 1990.

(3) *Proportion of priests and nuns in the population.* In 2012 in France priests and nuns represented 0.74 per million population, down from 1.30 in 2000.
It can be noted that the rates of decline of all these indicators are roughly the same: about 50% in 25 years, i.e. 2% per year.

[9] The data are from Statistiques de l'Eglise catholique en France [14]. On the same topic see also Requena [5].

With respect to the previous indicators, the incidence of religion on conceptions is of a different kind in the sense that it is independent of any form of social control. Therefore one is not surprised that in terms of percentage the reduction is about ten times smaller than the incidence on marriages.

In the future it will be possible to extend this exploration to the incidence of mobile religious time periods on other vital rates. There are mobile time intervals similar to Lent and Ramadan in other religions, e.g. the "Ten Days of Repentance" (from Rosh Hashanah to Yom Kippur in September–October) in Judaism. Thanks to the methodology introduced in the present paper, such issues can be investigated by using monthly instead of daily data. In contrast to daily data which are publicly available only in a few countries, monthly data are commonly available.

Appendix A. Effect of marriages on births 9 months later

In what follows it will be shown that in Orthodox countries the marriage effect represents less than 2% of the total birth effect.

Two methods will be used. (i) Firstly, we study the correlation between marriage and birth fluctuations in a general way. (ii) Secondly, we consider more closely the specific effect of the Lent reduction in marriages.

A.1. General effect of marriages on birth rates

We consider the series of monthly marriages, $M(t)$, and births, $B(t)$, between the years t_1 and t_2. Then, we move $B(t)$ 9 months to the left which gives a series that we denote $B'(t)$. As this operation brings births into coincidence with conceptions the level of the correlation $\big(M(t), B'(t)\big)$ will tell us to what extent new marriages and conceptions are connected. This test will be done for three countries: Bulgaria, Sweden and France.

A.1.1. Bulgaria

Here we take $t_1 = 1930, t_2 = 1936$ which gives 84 monthly data points. The correlation between $M(t)$ and $B'(t)$ is found equal to 0.023 which means no significant correlation.

A.1.2. Sweden

The time interval is the same and leads to a correlation of 0.30; the confidence interval with probability 0.95 is $(0.07, 0.49)$ which means a low and barely significant correlation.

A.1.3. France

Here we take $t_1 = 1925, t_2 = 1936$. The correlation is found equal to 0.49 with a confidence interval $(0.34, 0.60)$ which indicates a low but significant correlation.

In short, in Bulgaria we found no correlation whereas in France and Sweden we found a low correlation. How can one explain these results?

A.2. Newly married women versus annual births

The previous result must be in relation with the share of the conceptions occurring shortly after marriage in the total of all conceptions. The latter includes also births which are not first births as well as first births which do not follow marriage closely. In a country where fertility is high, many women will have 2nd, 3rd or 4th children. In such countries the proportion of first births will be a smaller proportion of total births than in countries where the women have only one or two children. Naturally, the same conclusion will hold for the proportion of first births conceived shortly after marriage.

In short, we need to know the proportion of first births in total births.

We consider the case of Sweden.

In the 1930s there were on average every month about 4,000 marriages (Flora et al. 1987, p. 73) which means 4,000 women joining the pool of the women able to have children. [10] On an average year there were about 100,000 births. Thus, even if we assume that all newly married couples will conceive a child, these births represent only 4% of all births. As already explained, this percentage will be even smaller in a country like Bulgaria where the fertility rate is higher. In 1930 in Sweden there were 56 births per year and per 1,000 women in the age interval $15-49$ whereas there were 120 in Bulgaria [11] (p. 78–79). In other words, it is not surprising that we found no correlation in Bulgaria.

In the case of France which has the highest correlation we can compute the regression. When each series is expressed in percentage with respect to its average one gets: births=0.16$\times$marriages.

[10] For the sake of simplicity we ignore illegitimate births.

A.3. Effect on births of the fall of marriages during Lent

The argument given in the previous subsection makes clear that in a general way one should not expect a significant correlation between monthly marriages and monthly births. However, in Orthodox countries the fall of marriages during Lent is so massive that we must examine more closely what will be its effect on births.

We consider the case of Bulgaria.

A graph of monthly births from January to December reveals a clear dip toward the end of the year (Fig. 4a). More specifically, for the seven years 1930–1936 the average fall in births between October and December was 6,180. We wish to compare this number to the reduction expected as a consequence of the fall in marriages in March. For the same seven year interval there were on average 13,100 marriages in February (i.e. prior to Lent) compared with only 1,900 in March (i.e. during Lent). Thus, the reduction in the number of newly married women was: $13,000 - 1,900 = 11,200$. As already mentioned above, there were 120 births per year and per 1,000 women which means $120/12 = 10$ births per month and per 1,000 women. Thus, the deficit of 11,200 marriages in March is expected to produce a deficit of $11.2 \times 10 = 112$ births in December. This represents a share of $112/6180 = 1.8\%$ of the fall of births seen in December. In other words, this very small effect means that in Bulgaria in the 1930s the bulk of the fall in conceptions during Lent comes from a reduction in 2nd, 3rd, ... conceptions or in first conceptions which however do not follow marriage closely.

The same calculation performed for France (also over 1930–1936) leads to the following results.

- Annual reduction in births between October and November [11]: 2,470.
- Annual reduction in marriages between February and March: 7,860.
- Number of births per year for 1,000 women: 68.2, thus $68.2/12 = 5.6$ per month and per 1,000 women.
- Expected reduction in births due to the fall in marriages: $7.86 \times 5.6 = 45$.
- Ratio of expected to observed reduction in births: $45/2470 = 1.8\%$

In conclusion we now know that the fall in marriages accounts for not more than 2% of the observed decrease in birth numbers. The rest is due to a change in sexual behavior.

Appendix B. Monthly turkish suicide data

The data for 1989–1997 had to be ordered and bought. The data of 1998, 1999 are not available. Although the data for 2000–2013 are available on Internet they were not easy to find. Here the data are made accessible for readers who wish to use them for further tests.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1989	091	093	105	112	123	112	118	109	090	075	061	083
1990	096	094	125	123	120	117	141	125	113	108	102	093
1991	086	098	094	118	121	126	131	117	098	078	089	072
1992	068	079	084	114	108	110	122	127	104	085	082	084
1993	101	079	112	131	100	112	112	102	110	092	085	093
1994	133	109	118	177	157	129	160	142	121	103	095	092
1995	110	082	125	131	147	130	141	130	128	116	108	112
1996	147	139	168	157	184	161	185	126	135	145	134	134
1997	143	143	191	169	204	173	203	179	132	152	157	144

Year	1	2	3	4	5	6	7	8	9	10	11	12
2000	149	163	167	158	163	168	178	149	146	147	105	109
2001	202	192	242	249	207	252	260	206	204	232	163	175
2002	205	181	207	206	223	232	213	193	191	166	133	151
2003	207	191	229	251	252	258	259	231	225	223	174	205
2004	189	215	236	257	243	270	240	257	229	204	171	196
2005	226	188	235	261	258	232	264	235	238	191	174	201
2006	195	207	249	262	284	278	245	284	226	213	203	183
2007	274	204	245	244	247	268	283	241	212	192	199	184
2008	183	227	252	231	270	280	262	257	188	248	208	220
2009	225	230	230	250	283	264	282	267	204	252	206	205
2010	255	207	291	274	234	285	279	274	220	206	188	220
2011	222	229	254	228	255	248	288	186	201	205	168	193
2012	253	220	247	308	308	321	295	271	269	237	249	247
2013	276	253	297	283	300	288	286	259	285	236	219	207

[11] We took the difference Oct–Nov instead of Oct–Dec as previously because from Nov to Dec there is an increase; this difference is probably related to the fact that on average western Lent starts about 2 weeks before Orthodox Lent.

References

[1] C. Herteliu, B.V. Ileanu, M. Ausloos, G. Rotundo, Effect of religious rules on time of conception in Romania from 1905 to 2001, Hum. Reprod. 30 (9) (2015) 2202–2214.
[2] P. Kadhel, N. Costet, T. Toto, E. Janky, L. Multigner, The annual carnival in Guadeloupe (French West Indies) is associated with an increase in the number of conceptions and subsequent births nine months later: 2000–2011, PLoS One 12 (3) (2017) e0173102.
[3] R.J. Lesthaeghe, On the social control of human reproduction, Popul. Dev. Rev. 6 (1980) 527–548.
[4] K. McQuillan, When does religion influence fertility? Popul. Dev. Rev. 30 (2004) 25–56.
[5] M. Requena, The secularization of Spanish society: change in religious practice, South Eur. Soc. Politics 10 (2005) 369–390.
[6] A. Adserá, Marital fertility and religion in Spain, 1985 and 1999, Popul. Stud. 2 (2006) 205–221.
[7] M. Friger, I. Shoham-Vardi, K. Abu-Saad, Trends and seasonality in birth frequency: a comparison of Muslim and Jewish populations in southern Israel: daily time series analysis of 200,009 births, 1988–2005, Hum. Reprod. 24 (2009) 1492–1500.
[8] G. Ruiu, M. Breschi, For the times they are a changin': The respect for religious precepts through the analysis of the seasonality of marriages. Italy, Demogr. Res. 33 (2015) 179–210.
[9] J. Lledó, C.X. Simó-Noguera, J.M. Pavia, Abstención sexual durante la Cuaresma en Andalucía a lo largo del siglo XX y su impacto en la estacionalidad de los nacimientos. [sexual abstention during lent in andalusia throughout the twentieth century and its impact on the seasonality of births.], Rev. Int. Sociol. 76 (2018) e107.
[10] C. Herteliu, P. Richmond, B.M. Roehner, Deciphering the fluctuations of high frequency birth rates, Physica A 509 (2018) 1046–1061, arXiv:1802.08966.
[11] H. Bunle, Le mouvement naturel de la population dans le monde de 1906 à 1936. [Vital statistics of many countries worldwide from 1906 to 1936.] Editions de l'Institut d'Etudes Démographiques, Paris, 1954.
[12] ScienceDaily-Oxford University Press, Length of human pregnancies can vary naturally by as much as five weeks, ScienceDaily (2013) 6 August 2013.
[13] R.A. Bhat, P. Kushtagi, A re-look at the duration of human pregnancy, Singapore Med. J. 47 (12) (2006) 1044–1048.
[14] Statistiques de l'Eglise catholique en France, (available on Internet).