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Intensity of Agricultural Workload and the Seasonality of Births in Italy

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Abstract

According to "the energy balance mechanism" theory, female ovarian function is strongly hindered by even a modest negative energy balance (the difference between calorie intake and calorie consumption). Agriculture-based economies were characterized by periods of extremely intense workload (especially in summer when grain was harvested) without sufficient nutrition. We analyze the role of the intensity of agricultural workload (proxied by marriage seasonality) on seasonal oscillations in births. Using data at the regional level, from Italian Unification to the eve of the World War I, we find some empirical support for the energy balance theory. In particular, we find the strength of the relationship between marriage seasonality and birth seasonality to be lower in the more developed Northern part of the Italian country, in which some signs of industrialization had already been present.

Keywords Seasonality of births · Seasonality of marriages · Energy balance · Economic development · Agricultural calendar

1 Introduction

The causes of seasonal fluctuations in human births are still not fully understood (Doblhammer et al. 1999). This represents a research problem in and on itself, but its comprehension may also prove useful in other demographic ambits. For instance, robust evidence in the literature shows that the particular month of birth was of crucial importance for determining the probability of the survival of newborns in the *ancien régime*, and this remains true in economically underdeveloped contemporary societies (Breschi and Livi-Bacci 1986, 1997; Dalla Zuanna and Rosina 2010; Dorélien 2015; Muñoz-Tudurì and Garcìa-Moro 2008). In addition, the analysis of birth seasonality can, we will suggest, offer indications about the role that economic activity might play in determining natural events. In particular, workload seasonality

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may affect the timing of both marriages and conceptions (see, among others, Bailey et al. 1992; Ellison et al. 2005; Pascual et al. 2002; Danubio et al. 2002; Gruppioni et al. 2005). Simplifying the argument proposed by Ellison et al. (2005), reproduction is, for every species, including humans, a high energy demanding process for mothers. Therefore, conceptions might be expected to be concentrated within a period where the energy balance is positive. For example, Ellison and colleagues report that modest changes in weight, in the range of two kg within a month, are associated with significant changes in the production of the principal ovarian hormones, estradiol and progesterone. In other words, this energy balance mechanism implies that in societies with an unequal distribution of resources through the year—such as in agriculture-based economies—conceptions tend to be concentrated during the months in which resources are more abundant and/or when energy consumption is lower. Therefore, according to the "energy balance" theory, we might expect, for example, that in the period of grain harvest, when the resources are not yet available and when concurrently the workload is intense, the energy balance of workers will be negative. This should induce a steady reduction in conceptions and consequently births months later. Against this, it could be argued that, according to both the biological literature and demographic literature, conceptions are negatively related to: temperature (Seiver 1985, 1989; Lam and Miron 1994, 1996; Lam et al. 1994); duration of the photoperiod (Roenneberg and Aschoff 1990; Manfredini 2009); and light intensity (Cummings 2002, 2007, 2010, 2012). Therefore, given that harvesting is generally a summer activity, the hottest and most light-abundant period of the year, these environmental factors, rather than workload intensity, appear to determine birth seasonality. As such, it is necessary to disentangle the effect of economic activity from that of climate (see also Doblhammer et al. 1999). However, this requires the analysis of accurate data on climatic variables that are frequently not available/reliable for historical periods.

Despite this problem, we adopt an indirect approach for testing the energy balance theory by only referring to data on monthly births and work intensity. Since the intensity of the workload in an agriculture-based economy was uneven across the year, as seen in the seasonal pattern of marriages, we expect its effect on birth seasonality to disappear during the shift from agriculture to industry.

If we are able to observe this temporal pattern in the relationship between these two variables, then it is difficult to sustain that the true determinants of the link between work intensity and birth seasonality are confounding environmental factors. Our research questions can, then, be formulated as follows: Does work intensity affect birth seasonality? Does this hypothesized relationship vanish as less of the workforce is employed in agriculture? To answer these questions, we employed the times series of monthly births in each Italian region for the period 1870–1914, as well as for Italy as a whole (1863–2014),[1] for a longer period. In order to better clarify our research questions, in the second section we will briefly discuss the main

[1] The datasets generated during and/or analyzed during the current study are available from the corresponding author on receipt of a reasonable request.

theories about the determinants of human birth seasonality and about the relationship between agricultural workload and marriage seasonality.

The methodology used for the analysis is described in the third section, which also presents preliminary results for Italy as a whole. The results at the regional level are presented in the fourth section, while the last section is devoted to conclusions.

2 Theoretical Background

2.1 The Three Main Explanations for Birth Seasonality

The theories proposed to explain the seasonal oscillation in human births may be categorized into three main strands: the bio-climatological explanation, which focuses on the effect of climatic variables on human fecundity; the sociocultural explanation, in which the forces underlying seasonality are traced to those social factors affecting the frequency of intercourse; and the energy balance theory, which focuses on how energetic factors affect female fecundity. Obviously, one explanation need not negate the others, but different theories tend to emphasize one of these factors.

Considering the bio-climatological strand, the main variables that have been said to explain human birth seasonality are: surface temperature; the duration of the photoperiod; the intensity of the light; and rainfall. Various empirical works (Seiver 1985, 1989; Lam and Miron 1994, 1996; Manfredini 2009) have highlighted the possible role of temperature on fecundity. In particular, Lam and Miron (1996) documented, for the USA, both the existences of a heterogeneous seasonal pattern in births in different states. For example, even though the maximum concentration of births in the nation was in September, the southern states had a marked trough in April and May (corresponding to a trough in July and August conceptions). Lam and Miron argue that the hot temperatures of July and August induced a steady reduction in the number of conceptions. There was less sperm mobility and spermatogenesis was negatively affected. A meta-analysis carried out by Levine (1994) seems to confirm that heat waves can reduce the quantity and mobility of sperm. The April and May trough in the birth rate, then, may be explained by reduced male fertility.

Seiver (1985, 1989), similarly, traced the reduction in the amplitude of seasonal fluctuation in US births to the diffusion of modern systems of air conditioning, beginning in the 1960s. Despite these encouraging results, Lam and Miron (1996) also found that the effect of temperature on monthly births turns out to be modest or statistically not significant in European countries and in Canada. They had thought that a country in the southern hemisphere would be characterized by a 6-month lagged model of seasonality (because of inversion in the climatic seasons), with respect to one localized at the same longitude but in the northern hemisphere. However, their analysis of birth seasonality in South Africa did not confirm these expectations.

Temperature may also increase the likelihood of observing a negative birth outcome in terms of miscarriages, stillbirths or low birth weight (see Grace 2017 for a brief discussion). One might argue that if the stillbirth rate increases in the summer months, then this will also influence the overall seasonal profile of live births. Therefore, the negative relationship between temperature and the number of births may be due not to a depressing effect on the probability of conception, but to the fact that the number of pregnancies carried to term, in these months, was lower. In "Appendix," we present, in Table 3, a seasonal indicator calculated for stillbirths in Italy from 1891 to 1935. According to our data, there is not a summer peak in the number of stillbirths: in fact, stillbirths are skewed toward the winter months. Furthermore, it should be noted that the stillbirth rate (calculated out of a thousand births) was in a range between 32.4‰ and 48.1‰, too low to produce a significant impact on the overall seasonal pattern of births. This possible confounding effect may, therefore, be excluded, at least, for Italy.[2]

Other climatic factors that have been analyzed in relation to birth seasonality are: the length of the photoperiod (Roenneberg and Aschoff 1990; Wehr 2001; Manfredini 2009); and the level of atmospheric brightness (Cummings 2002, 2007, 2010, 2012).

The secretion of melatonin is inhibited by light and, in turn, melatonin decreases libido in many species of mammals. There is, thus, a mechanism, developed through selective pressure, to signal the optimal period for reproduction from a biological point of view. However, according to Cummings (2012) rather than focusing on the role of the photoperiod, more attention should be directed toward the intensity of light. These variables are clearly closely linked. It is worth remembering, though, that the human species evolved in Eastern Africa, a region characterized by little photoperiod variation, though with periodic variation in brightness tied to seasonal monsoons. Therefore, it makes sense that this sort of a signaling mechanism would be triggered by light intensity rather than by sunshine duration.

Nevertheless, it might be argued that both the photoperiod and the light intensity hypotheses are not compatible with the typical European seasonal pattern: a global spring peak and a local September peak. After all, these maxima correspond to July and August conceptions, the months of maximum duration of the photoperiod and of light intensity. Furthermore, this explanation is based on the idea that there is an optimal period for human reproduction. As observed by Ellison et al. (2005), even if this idea is plausible, no evidence exists to support the claim. Furthermore, it is necessary to establish what we actually mean when we talk of an optimal period for human reproduction: Is it the period of gestation, the weaning period or simply the month of birth?

Finally, there is rainfall. Bronson (1995) argued that, especially in tropical subsistence societies, rain plays an important role in determining food availability and, thus, may influence birth seasonality through this channel (see also the more recent work carried out by Philibert et al. 2013).

[2] Data on miscarriages for the epoch are not available. For stillbirths, Breschi et al. (2012) noted that, especially in the South, the presence of biases in the registration of stillbirths was clear. However, it might be argued that if the public officials had misclassified stillbirths, they will have done this all the year around, so the absence of summer peaks in stillbirths cannot be attributed to their errors. See also Derosas (2009) for an interesting discussion about the combined effect of malnutrition in late gestation and cold temperatures on neonatal mortality.

Switching to the strand of the literature privileging social explanations, Bobak and Gjonca (2001) claim that human fecundability (but also the probability of fetal loss) follows a seasonal pattern which is influenced by climatic factors. However, the influence that these factors have on determining observed fertility depends on which historical period we consider. Consider societies that are far from the natural level of fertility, in which both efficient and effective contraceptive methods exist and are easily accessible for all the population, and in which all social classes have (more or less) the same protection against climatic factors. In these societies, it is more likely that the seasonality of births will depend on factors tied to parental choice. For example, Buckles and Hungerman (2013) found that in the USA the seasonality of births is driven by planned births, while seasonality was not traceable in unplanned births.

In addition to social preferences, which seem a rather implausible explanation for societies in which birth control was primitive, some authors have highlighted how major civil and religious festivals (e.g., Christmas and the New Year) and paid holidays are conducive to relaxation and so to increased sexual activity and, thus, conception (James 1971; Regneir-Loilier and Divinagracia 2010; Trovato and Odynak 1993). Crisafulli et al. (2000) attributed, instead, the December trough, which characterized the seasonal distribution of live births in Calabria (Italy) during the pre-transitional demographic regime, to the deterrent effects exerted on sexual activity by the Lenten period (i.e., the 44 days of penitence and spiritual preparation to Easter). Finally, other scholars (Matsuda and Kahyo 1994; Grech et al. 2003) found that the seasonal movement of marriage is related to the seasonal movement of first-order births. Trovato and Odynak (1993) acknowledge that it seems reasonable that the seasonal movement of marriages could influence the seasonality of first-order births 9 months later. But they point out that this does not explain why high parity births show similar pattern of seasonality, or in some cases an even more pronounced seasonal movement (see also Regneir-Loilier and Divinagracia 2010). A possible reply to this criticism could be made, at least for natural fertility societies, with reference to energy balance theory. In the following, we will summarize this theory; then, we will focus on the relationship between marriage timing and energy consumption patterns.

Pregnancy is a high energy process. By measuring energy requirements in terms of increase in the basal metabolic rate (BMR), Butte and King (2005) report, for instance, that in healthy, well-nourished women, the cumulative increases in the BMR over pre-pregnancy are 4.5, 10.8 and 24.0% for, respectively, the first, second and third trimesters. Obviously, under conditions of constrained energy availability, there is a biological mechanism that allows human females to reduce their own basal metabolic rates, thus abating their own energy needs in favor of their offspring. However, this happens at a cost in terms both of: the increased likelihood of needing a cesarean delivery (caused by cephalopelvic disproportion) and intrauterine growth restriction, which is a significant child mortality risk factor (see Black et al. 2008).

Therefore, it would be quite reasonable to surmise that natural selection should favor a signal mechanism that makes fecundability sensitive to the availability of energy.

In much the same way, the production of the main ovarian hormones (estradiol and progesterone) seems to be highly sensitive to negative energy balance (i.e., the net residual of energy intake minus energy expenditure). Furthermore, heavy agricultural work has been associated with suppressed ovarian steroid profiles, even when energy intake is increased to produce neutral energy balance (Jasienska and Ellison 1998). The same evidence has been shown for sport activities (Ellison and Lager 1986). This has induced Ellison (2003) to conclude that energy balances are expected to have monotonically positive relationships to the availability of energy for reproduction. He also argues that, under conditions of neutral energy balance (in other words, an energy intake which is equal to energy consumption), energy flux (i.e., the rate of energy turnover independently from the energy balance) has a curvilinear relationship to the availability of energy for reproduction. This is true of both low (typical of famine victims) and high energy fluxes (typical of those who practice an intense physical activity). This produces negative effects on the ovarian function and hence on fecundability in each menstrual cycle.[3]

However, it is difficult to test this energy theory, empirically, using historical data, for the simple reason that we lack precise information about energy intake and energy consumption. In the following section, we will try to convince the reader that marriage seasonality is a suitable proxy for capturing periodic oscillations in the agricultural workload.

2.2 Marriage Seasonality as a Proxy for Workload Intensity

In what follows, we will use marriage seasonality as a proxy for workload intensity. There can be little doubt that agricultural activity in pre-industrial societies was characterized by a marked seasonal pattern. There were months of very intense activity (e.g., the summer months in which the grain was harvested) and months characterized by less intense activity (e.g., the months when the crops grew, during which the small-scale exchange of handicraft products was the main source of income). In Table 4 in "Appendix," we report the agricultural calendar of the ten most cultivated crops in Italy and their relative importance (in terms of % of ha of soil used for each production on the total cultivated surface) for each Italian region. In general, from June to September, agricultural workers harvested. In the winter months, the economic activity of the typical rural family was limited to the exchange of handicraft products: men worked as bricklayers or carpenters, while women generally wove.

To give an idea of the magnitude of the difference in the workload in the various periods of the year, Dribe and Van de Putte (2012) report that, in pre-industrial Southern Sweden, the normal working day (corvée) of an agricultural day laborer was about fifteen hours in the summer and about eight to ten hours in the winter. Also, Domenech (2007) argues that "in agriculture, building construction sites

[3] With high temperatures, female work in summer may have led to more miscarriages and/or stillbirths. Unfortunately, we do not have statistics for miscarriages for the period under analysis. For stillbirths, the reader is referred to the comments in Table 3.

or quarries, working hours in the 1880s in Spain were determined by the daylight hours. Accordingly, shifts could vary by as much as 5 h between summer and winter." Similarly, Prentice and Cole (1994) reported that, for rural Gambian women, food intake reaches its minimum level in August before the availability of the first crop. This was caused primarily by the fact that, in most cases, their food reserves from the previous year had run out. The situation was further complicated because the women did not have time and/or were too tired to prepare more than one meal *per* day. This combination of factors produced a very negative energy balance resulting in fat loss.

Thinking now of Italy, the influence of seasonal agricultural workload on the celebration of marriages has been highlighted by several studies for various Italian territories (see among others, Chiassino and Di Comite 1972; Moroni et al. 1973; Navarra 1998; Sanna and Danubio 2008; Coppa et al. 2001; Lucchetti et al. 1996; Danubio and Amicone 2001; Ruiu and Gonano 2015; etc).

Thus, in an agricultural society, we have a marked seasonal workload pattern and, presumably a marked season change in the energy balance and in energy flux. The problem is to establish whether summer was a period of high energy flux for women, too. We do not have official data to quantify the intensity of female work: agrarian economists of the epoch focused on the male head of household. Nevertheless, it seems reasonable to affirm that women did much more than light domestic work. This, at least, is suggested by the qualitative evidence furnished by the so-called Inchiesta Jacini a Parliamentary Inquiry on the material conditions of farmers in different Italian regions, carried out in 1878. For instance, describing the conditions of Piedmontese agricultural workers, the commissioner Maggiorino (1883) reported that: "…[T]he peasant woman takes part in farm work, showing an uncommon strength and resistance. Responsible for the domestic affairs, she prepares meals for the family, she looks after the cattle, she takes care of her own children and also operates as a paid nurse for those [children] of others. At the same time she is helping her father, her husband or her brother; when she has completed the home affairs, she goes to offer her help in the fields carrying the cradle of her suckling child on her shoulders when necessary. She leads the beasts of burden for the transportation of the fertilizers or of the products. She goes to the market to sell surplus goods frequently carrying notable weights; she joins in the reaping of the wheat and the grape harvest, and in general she deals with many other jobs that do not require physical strength, but that are no less exhausting." (our translation, p. 98).

Interesting here, too, are the interviews carried out in 1980 by Papa (1985) among retired female agricultural workers (i.e., those who were at least 65 years old of age) from Umbria (Central Italy). Here we see that during wheat harvest, even though males were responsible for those activities requiring physical strength, females worked for longer hours without breaks. Papa argues that females were required to compensate for the fact that they were busy with activities that required less muscle strength. For instance, females were responsible for water distribution among the farm workers. This might seem a light physical activity. However, it meant carrying water in jars (weighing between fifteen and twenty kilograms) through the fields, on their heads. On this evidence, female work in Italian agricultural communities was not limited to light domestic tasks, and women saw a marked increase in energy turnover during the harvesting season. But how does the intensity of the workload influence the seasonal pattern of marriages? There is overwhelming evidence in historical demography showing that, in pre-industrial societies, marriages were avoided in periods of intense workload (among others Kussmaul 1985; Van Poppel 1995; Danubio and Amicone 2001; Sanna and Danubio 2008; Dribe and Van De Putte 2012). For instance, Dribe and van De Putte (2012) looked at the situation, after the advent of the "industrious" revolution in Southern Sweden, which had intensified the intensity of the agricultural work in all months of the year (thanks to land reclamation and the introduction of new crops). Here the seasonality of marriage changed dramatically. It shifted from a classic grain production pattern, with a marriage peak in late spring and a marriage trough at harvest time in summer, to a concentration of marriages in December, thanks to the low work intensity in the weeks around Christmas. As explained by Ruiu and Breschi (2015), one reason for this seasonal pattern is that the opportunity cost of marrying varied in function of the period of the working year. Since the summer months were those in which the likelihood of being employed was highest, this part of the year was also that in which the opportunity cost of marriage in terms of lost wages was highest. Jennings and Gray (2017) have convincingly shown that marriages were very responsive to variations in opportunity costs. Using data for Netherlands, 1871–1937, they show that when climatic conditions were so bad as to prevent work in the fields, the number of marriages increased because there was less agricultural labor demand.

Assuming, therefore, that marriage seasonality is a good proxy for the seasonal pattern of the workload, three problems arise. First, the seasonal profile of marriages may have some direct effects on the seasonal pattern of first-order births and on December births (because of Lenten effects). Lent dampened the number of marriages because the Catholic Church forbade the solemnization of marriages during this period.[4] Second, summer marriages were avoided because of the intense workload, but at the same time they were months characterized by heat and high light luminosity. Thus, we cannot be sure about which of these effects we are capturing. Third, there was also the seasonal migration of the labor force: migration, by separating couples, means a reduction in the frequency of sexual activity.

As far as the first problem is considered, it might be argued that, in a natural fertility society, high order births should dominate first-order births and, therefore, that they should be considered as the force behind the seasonal profile of overall births. It is, thus, difficult to argue that any relationship between the seasonal movements of overall births and marriages is mainly driven by first-order births. Regarding what might be called "the Lenten effect," if it is present, then, this may influence all parities, not only first-order births. One might, therefore, conclude that if we find some

[4] Another possible effect of religious beliefs on marriage seasonality comes in May. Given that this month was dedicated to the Virgin Mary, some scholars sustain that marriages were avoided in the Catholic World as an act of respect for the Holy Virgin. It should be noted that if religious considerations are at the basis of the decision to not marry in May, then it would be reasonable to expect a depressive effect on sexual activity. This should imply a reduction in births approximately in February of the subsequent year. As we will show in the section of results, this seems not to have been true for the Italian regions. February was in fact a month of maximum concentration for live births.

correlation between the two variables, this is produced by the Lenten effect. However, the objection is easily overcome on empirical grounds. We will clarify this point in the next section.

To exclude, meanwhile, the possibility that we are confounding the effect of climatic variables and the effect of seasonal patterns in the workload, it is crucial to date the moment in which the relationship between the seasonal movements of marriage and birth starts to weaken. If this timing is compatible with the start of industrialization in the Italian economy, then it is difficult to argue that our results are driven by the climatic explanation.

Finally, the third problem is more difficult to solve with our aggregated data. Indeed, we cannot distinguish in what social class the births took place. We do not know whether the parents were land owners, sharecroppers, daily laborers and so forth. In the demographic literature, it has been recognized that spousal separation due to temporary migration reduces the conception rate. The impact varies in function of the length of the separation, length of postpartum amenorrhea and fecundability (Bongaarts and Potter 1979; Menken 1979; Millman and Potter 1984). Quaranta (2011) reported that in Treppo Carnico, an Alpine village situated in northeastern Italy, the seasonal movement of workers concentrated births between October and November and meant a smaller number of births among migrants than among stayers. Interestingly, Millman and Potter found that a separation of 4–7 months reduces the odds of a birth in the subsequent year by 15%. Hence, it is possible that the reduction in conceptions in the summer months was down to both temporary separation and workload intensity. Even though, in a study of a single Alpine community, such as that carried out by Quaranta, the role of separation may prove crucial, in our analysis, we are aggregating data at the regional level. This should, thus, substantially reduce the influence of seasonal migration on aggregated seasonal patterns. Indeed, it should be noted that according to official Italian statistics, in 1936, about 300,000 (3–4% of the total of about eight million agricultural workers) were seasonal migrants (Istat 1940). In our opinion, this evidence makes it difficult to affirm that temporary migrations were the predominant force in determining the positive relationship between seasonal patterns of births and marriages.

Finally, as argued by Bell (1979) in his analysis of four Italian rural communities (Albareto, Nissoria, Castel San Giorgio, Rogliano) the reduction in sexual intercourse may also have played a role in the reduction in conception in the summer months: “Circumstances during months of fewer conceptions, July–November, were far less conducive to conception. Obviously an excess of conceptions in the spring in itself reduced the number of pregnancies that might begin in the following months. Moreover, the pace of work was much harder in the summer; threshing in July was followed by the crowded and public gatherings of August (when, it may be recalled, even the *villici* came to the village, usually with no place to stay) and the *vendemmia* of the fall. High mortality in the July–September trimester, undoubtedly accompanied by increased morbidity generally, can only have decreased the frequency of sexual intercourse and the probabilities of ovulation, fertilization, and implantation. The same may be said for the aftereffects of malnutrition in the preharvest months and the high temperatures of July and August. All in all, it was a kind of time in which fewer children were conceived.” (pp. 79–80).

3 Data and Preliminary Descriptive Analysis of the Evolution of Birth and Marriage Seasonality in Italy

Our data sources for the monthly number of births are the official statistics reported in the volumes *Movimenti della popolazione secondo gli atti dello stato civile*. Our analysis spans the period from 1863 to 1933 at the regional level (due to the problem of regional data availability from 1934 to 1950): while for Italy as a whole, the time series spans 1863–2014.

A detailed discussion of the quality of this data source can be found in Somogyi (1965), for nuptiality, and in Livi (1929), for fertility data.[5] To gain an idea of how seasonality has evolved over the past 150 years, we calculated an index of birth seasonality as follows:

$$I_{i,t} = \frac{N_{i,t}}{\sum_{i=1}^{i=12} N_{i,t}} * 1200 \tag{1}$$

where $N_{i,t}$ is number of births (excluding stillbirths) for month i in the decade t (t = 1863–1872, 1873–1882,…, 1993–2012). After having calculated this index for all the non-overlapping 10-year periods, we ran a hierarchical cluster analysis to see how these decades are grouped together on the basis of their similarity/dissimilarity: we used Ward's method as an agglomerative algorithm and the Euclidean distance as a dissimilarity index. Our analysis suggests two main models of birth seasonality: the first model characterizes the Italian seasonal pattern from national unification up to the years immediately following World War II; while the second model covers the decade 1963–1972 onward. The dendrogram associated with the cluster analysis is reported in Fig. 1, while Fig. 2 represents the associated model of seasonality. The numbers reported above each cluster in Fig. 1 are labeled p values and are calculated using a method proposed by Suzuki and Shimodaira (2006). The higher the p values, the stronger the cluster supported by data.

The model of seasonality for the period 1863–1962 is characterized by a peak in January and February, followed by a decline from June (the month with the minimum concentration of births), after which we see a slow recovery up to the relative maximum of September, which is followed by a steady decline in the number of births. The most recent pattern is characterized by two peaks in July and September and a December trough.

[5] The main problem highlighted by Somogyi was associated with the first decade of the marriage time series: the 1866 marriage law reform, which revoked the legal validity of religious marriages. This law entered force 1 January 1866 causing an overwhelming concentration of celebrations in December 1865 to avoid the application of the new law. As far as births are considered, Livi (1929) discussed the postponement of the registration of home births in the last days of December 1865. This custom was due to parents' attempts to delay compulsory military service for their sons. However, Crisafulli et al. (2000) observed that the number of births in January continued to be higher than those in December, even in the second part of the twentieth century when the hospitalization of births was common and when the postponement of registration was impossible.

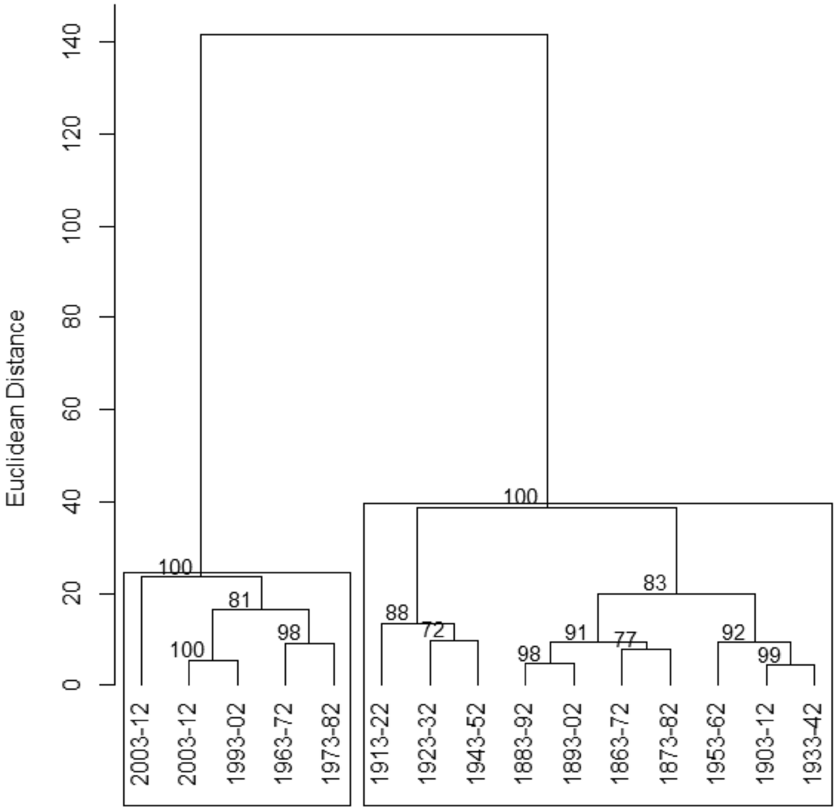

Fig. 1 Dendrogram associated with the cluster analysis of 10-year birth seasonal indicators. *Source*: Our elaborations on data from "Movimento dello stato Civile"

This first descriptive analysis appears to suggest that after the Italian economic miracle, in the 1950s, the timing of births was completely transformed. However, this change cannot automatically be attributed to changes in the distribution of the workforce within economic sectors. Indeed, Seiver (1985, 1989) argues that economic and technological changes that guarded against extreme climatic conditions changed US birth seasonality. Thus, one may confound the effect of climate with that of economic progress. To cope with this critique, it is crucial to understand when any structural change in the relation between workload intensity and birth seasonality occurred.

The most appropriate measure for workload intensity is likely the number of hours worked in a month weighted with the proportion of the workforce employed in the primary sector. However, in this case, we also need a time series and this is difficult to reconstruct without making arbitrary assumptions about their historical evolution. For this reason, we chose approximate workload intensity using marriage seasonality. As reported in the second section, a significant portion of the literature shows that agricultural work played a crucial role in determining marriage seasonality (see, among others, Dribe and Van De Putte 2012; Van

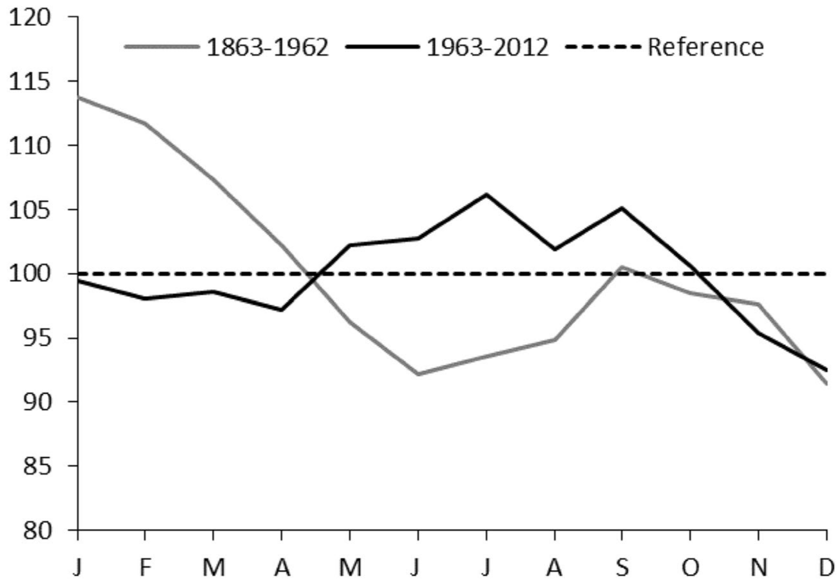

Fig. 2 Models of birth seasonality, Italy, 1863–2012. *Note*: These curves are those associated with the barycenter of each cluster. *Source*: Our elaborations

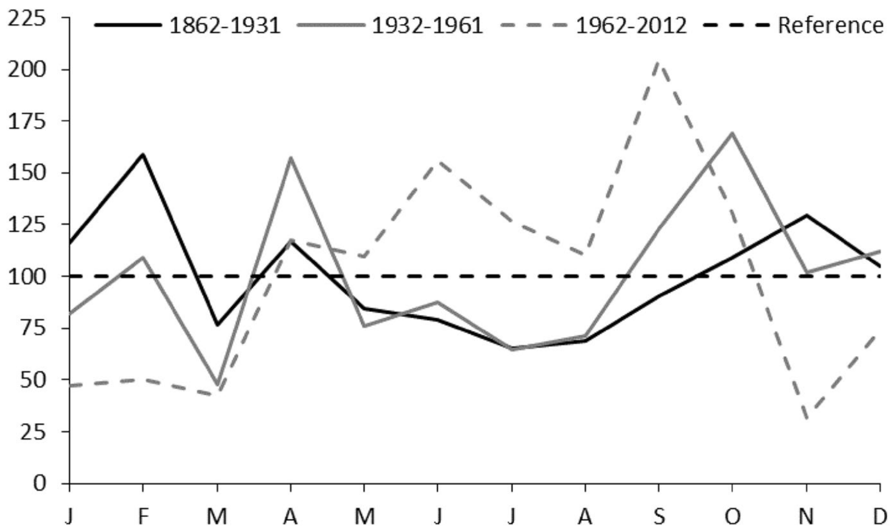

Fig. 3 Models of marriage seasonality, Italy, 1862–2012. *Source*: Our elaborations

Poppel 1995). Figure 3 highlights the models of marriage seasonality resulting from the implementation of the same cluster analysis described above for births.

From the 1960s, we have a reversal of the model of marriage seasonality, with the summer months becoming the preferred period of the year for getting married (formerly the least popular period), while weddings in autumn and particularly in winter (formerly the preferred season) become unusual events.

Therefore, we expect, at least for the period preceding World War II, a positive correlation between the oscillations of births and oscillations in the number of marriages 9 months earlier. After all, a higher value for the number of marriages should indicate a less burdensome workload. It might be argued that this correlation, especially in a Catholic country, is partly influenced by the relationship between first-order births and marriages. Matsuda and Kahyo (1994) argue that seasonal variations in marriage play some role in the seasonality of first births, while other features such as environmental factors may also be associated with the seasonal variations in subsequent births. However, we believe that, given the high level of fertility that has characterized Italy during the first years of Italian unification, the weight of first births on total births in month i should be negligible. In particular, according to Istat (1986), in 1930 first-order births still accounted for roughly 20% of total births, while the remaining 80% constituted births of an order greater than one. Thus, at least for the first years of our analysis, the seasonal pattern of births out of all births should reflect the seasonal pattern of births with an order greater than one. Using an *ad hoc* data extraction relative to the total legitimate births in Italy in 1958, Baroni (1964) showed that the seasonal distribution of higher-order births (which still accounted for the 70% of the total number of newborns) strictly reflected that associated with total births. In the following section, we present our empirical strategy for studying the relationship between marriages and births. We also present some results for Italy as a whole, in order to give a clear exemplification of the output of our estimation procedure.

3.1 Empirical Model and Results for Italy

Following Manfredini (2009), we firstly detrended both the monthly births and the monthly number of marriages by applying a twelve-term moving average:

$$y_t = Y_t \Big/ \sum_{m=t-6}^{m=t+5} Y_m$$

$$x_t = X_t \Big/ \sum_{m=t-6}^{m=t+5} X_m$$

where Y_t and X_t are, respectively, the number of births and the number of marriages in month t. Both Y_t and X_t are corrected to take into account the different lengths of months. We have normalized the number of days in each month to 30.

We then estimated the following regression:

$$\log\left(y_t\right) = c_{t+} \sum_{i=feb}^{i=dec} a_{it} d_{it} + b_t \log\left(x_{t-9}\right) + \varepsilon_t \tag{2}$$

The variables d_i are month dummies. The inclusion of these dummies is necessary should we want to avoid a spurious significant relation between marriages and births due to a similar underlying model of seasonality: for example, January and February were months with a high frequency both of births and marriages.[6] Note also that if Lent dampens the number of conceptions in March (the month which is the most affected by that period of religious sobriety), then the associated reduction in the number of births should be produced almost entirely in December. Therefore, including a dummy for this month should allow us to interpret the coefficient b_t as an effect that is cleansed from the depressing Lenten effect.

We are interested in establishing whether this relation changes over time. Therefore, we tested for the presence of multiple structural breaks with unknown dates in Eq. (2). We did so by applying an econometric technique suggested by Bai and Perron (1998, 2003a, b). Table 1 reports the results obtained: we allowed for both serial correlations in the errors and for possible changes in error distribution across the time periods individuated by the estimated breaks. The technique consists in finding the best combination of possible M breaks subjected to the constraint that distance between break intervals should be above some minimum threshold: 10% of the sample in our case. For "best combination" is understood the combination that allows us to minimize the minimum sum of squared residuals over all conceivable M-partitions.

Two break dates were identified by Bai and Perron's technique, the first occurring in 1905 and the second in 1961. For the sake of simplicity, we refer to the time interval before the first estimated structural break as "the old regime," while the period between the two breaks and the period after the last break will be indicated, respectively, as "the transitional regime" and "the new regime."

In support of our hypothesis, prior to the first break date, the relationship between the indicator of marriage seasonality and that of birth seasonality is positively signed and statistically significant at a 1% level. In terms of magnitude, our results indicate that prior to the first break, a 1% increase in the detrended number of marriages led to roughly an 0.10% increase in the detrended index of birth seasonality.

Following the first break date, a period of transition begins between the old regime and the new one, in which the relationship between the two variables becomes weaker, in terms of magnitude (a 1% increase in the index of marriages corresponds to roughly a 0.03% increase in birth seasonality), but not in terms of statistical significance. It should also be noted that the beginning of fertility transition in Italy as a whole, is dated by Delgado Perez and Livi-Bacci (1992) to 1913. Interestingly, Dalla Zuanna (2010) reported that, for instance, in Veneto, the level of fertility in 1912 was still high indicating a general absence of the use of parity-specific birth control within marriage. However, the fertility rate

[6] July, August and September were months of high workload in the agricultural economy, and we are estimating workload using a seasonal marriage index. At the same time, there are also other possible factors (for instance, hot temperatures) that might determine a trough in the conceptions and thus a depression in the number of births 9 months later. The inclusion of month dummies gives a partial control for this possible unobserved confounding effect.

Table 1 Changes in the relation between birth seasonality and marriage seasonality, Italy, 1870–2014

Dependent variable: Log (detrended birth)		OLS coefficients before the first estimated breakpoint 1870 Oct–1904 Dec	OLS coefficients between the two breakpoints 1905 Jan–1961 Dec	OLS coefficients after the second breakpoint 1962 Jan–2014 Jul
Variables	Approximated Month of conception			
log[detrended_marriage (−9)]		0.096 (0.020)***	0.028 (0.008)***	– 0.043 (0.006)***
Feb	May	0.061 (0.009)***	– 0.030 (0.0123)**	– 0.018 (0.007)**
Mar	June	0.053 (0.013)***	– 0.080 (0.014)***	0.000 (0.010)
Apr	July	0.025 (0.012)**	– 0.123 (0.015)***	– 0.021 (0.011)*
May	Aug	– 0.057 (0.009)***	– 0.181 (0.016)***	0.028 (0.011)**
Jun	Sep	– 0.146 (0.009)***	– 0.222 (0.020)***	0.057 (0.010)***
Jul	Oct	– 0.139 (0.010)***	– 0.220 (0.020)***	0.077 (0.012)***
Aug	Nov	– 0.135 (0.008)***	– 0.207 (0.016)***	– 0.024 (0.011)*
Sep	Dec	– 0.068 (0.010)***	– 0.140 (0.014)***	0.051 (0.009)***
Oct	Jan	– 0.114 (0.014)***	– 0.147 (0.011) ***	– 0.013 (0.010)
Nov	Feb	– 0.145 (0.009) ***	– 0.171 (0.019)***	– 0.065 (0.013)***
Dec	Mar	– 0.105 (0.031)***	– 0.237 (0.017)***	– 0.100 (0.007)***
Jan	Apr	Ref.	Ref.	Ref.
C		0.215 (0.007)***	0.178 (0.009)***	– 0.039 (0.006)***
Breakpoints estimated:	1905 Jan; 1961 Dec			
Adj R sq	0.706			
F (p value)	110.32 (0.000)			

Heteroskedatic and autocorrelation robust standard errors reported in parentheses. The correction procedure is that suggested by Newey and West (1994)

Significance levels: *0.10; **0.05; ***0.01

Note: We excluded the years prior to 1870, because in these years, the seasonal distribution of marriages was affected by the introduction of a change in the norms regarding the civil validity of religious marriages. Source: our elaborations on data from the "Movimento della popolazione secondo gli atti dello stato civile" dropped from about 5 children *per* woman to 2.5, from 1920 to 1950 without a particular change in marriage pattern, but with large differences between rural and urban industrialized areas: for instance, in rural areas the birth rate was still around 35–40 *per* thousands, while in Padua, the birth rate had sunk to around 10 *per* thousand in 1950. Analyzing the diocesan documents relative to this period, Dalla Zuanna reported that parishioners were increasingly resorting to *coitus interruptus* and that priests found it impossible to prevent this. This might be interpreted as the beginning of the securalization process, which is usually considered a necessary step in the decline of fertility (see for instance Lesthaeghe and Surkyn 1988; Lesthaeghe and Lopez-Gay 2013). Obviously, there were huge differences between northern Italy and southern Italy. For instance, Breschi et al. (2014) reported that in Sardinia, the fertility rate was still, in the 1950s, around four children *per* woman. Analyzing the situation of Alghero from 1866 to 1935, they also reported that signs of fertility control were detectable only among high status couples: there were no such signs in couples working in agriculture.

Therefore, the results as a whole seem to show two different Italys: an industrialized and in part secularized North and a less developed and less secularized South. In the next section, we will focus on regional differences.

After the second break date, we have a sign reversal in the relationship between marriages and birth. We believe this reversal was likely caused by the fact that, with the beginning of economic development, we were no longer able to capture the seasonal workload pattern using marriage seasonality. Indeed, as shown in Fig. 3, after World War II, couples preferred the summer months (particularly June and September). According to the literature, these months are also those in which the strongest depressive effects on conceptions were produced by light intensity and temperature. Therefore, the negative sign between the two variables likely reflects the above-mentioned confusion between the climatic determinants of birth seasonality and the seasonal pattern of marriages.

We also see, in the new regime, that first-order births increase their weight of total births; at the same time, however, the increasing possibility of birth control through contraceptives: "the pill" became legal in 1967, but only for women for whom conception would be dangerous; only in 1976 was "the pill" made more generally available. This also presumably cancels out the relationship between first-order births and marriages. See also Livi-Bacci (1990) for a detailed description of the diffusion of fertility control in the Italian Regions. In general, he found that while in some northern and central regions, fertility controls probably started to spread among high status families at the beginning of the twentieth century; in southern regions, the process started between 1936 (Campania) and 1961 (Sardinia).

Note also that the coefficients associated with month dummies appear to change radically between the first and third sub-periods of our analysis, in line with the descriptive evidence provided in Fig. 2. In Fig. 4, we represent the model of seasonality from the set month dummies in the first sub-period (1870–1905) and in the last sub-period (after 1961). Note that we have exponentiated the estimated coefficients reported in Table 1 and, for comparative purposes with Fig. 2, we multiplied them by 100.

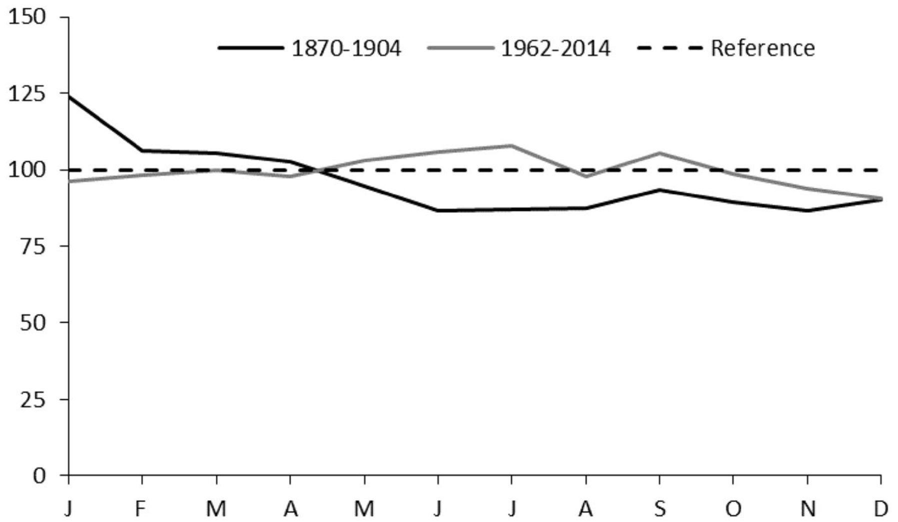

Fig. 4 Models of birth seasonality estimated for Italy. *Note*: these are the seasonal curves obtained from the estimations reported in Table 1

4 Evidence at the Regional Level

To provide a first description of the heterogeneous seasonal patterns among Italian regions, in Fig. 5, we plot the seasonal indicators of births calculated for each region for three non-overlapping periods, 1862–1885, 1886–1909 and 1910–1933.

There are two main models of seasonality:

- Model 1B: seasonality curves are characterized by peaks in one of the first 3 months of the year, followed by a stable decrease in the number of births from July or June (the months of minimum). After this trough, there is a moderate recovery in the number of births reaching a relative maximum in November. The regions characterized by this model are: Abruzzi, Apulia, Basilicata, Calabria, Campania, Sardinia, Sicily, Emilia Romagna, Latium, Marche, Tuscany and Umbria. These regions are part of central and southern Italy, save Emilia Romagna (northern Italy).
- Model 2B: this model of seasonality is characterized by less accentuated periodic oscillations. In Piedmont and Liguria, the peak is reached in the first months of the year, while in Lombardy and Veneto, it is reached in September. Apart from Liguria, in which the minimum point is in May, the other three regions have their minimum in December.

Comparing the first and third sub-periods into which we have split the analysis, the most accentuated change in the seasonal model is observed in Emilia Romagna, which, in the third period, may be included in model 2B (as defined above).

In general, the decline of live births after March is compatible with the hypothesis that fewer conceptions occur in the summer months, when marriages were also

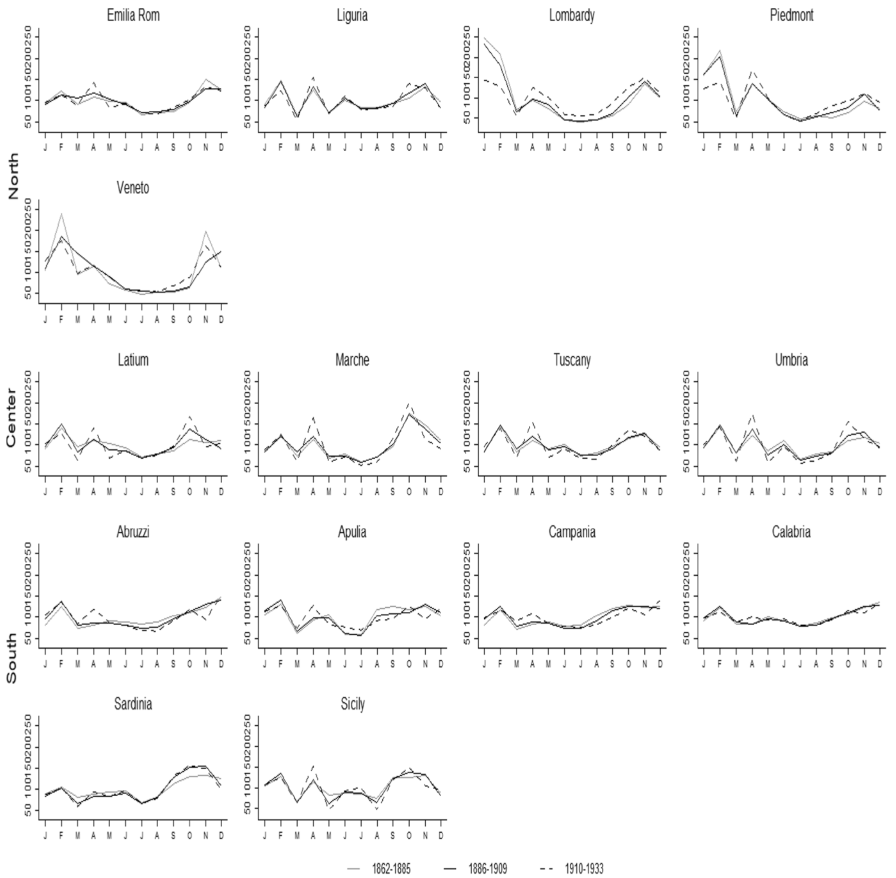

Fig. 5 Seasonal pattern of marriages in Italian Regions, 1862–1933. For Latium, data are from 1872 to 1933, because this region entered into the Italian Kingdom only after 1870

avoided because of the intense workload. However, as observed above, this may be a mere coincidence, owing to the fact that these are also the months in which the temperature is hottest and in which light luminosity is most intense.

To achieve a more formal test of our hypothesis of a relationship between workload and birth seasonality at the regional level, we present the results of the estimation of Eq. 2 for each region in Table 2. Having a shorter time interval and, therefore, fewer observations, the results associated with the years during and after World War I—for Italy the conflict lasted 1915–1918—will be marked by this traumatic event. Therefore, we decided to further limit the sample to the years from 1870 to 1914. We assumed a maximum number of two breaks during this time interval. Note that the beta coefficients reported in Table 2 are only those associated with our main variable of interest, i.e., the detrended monthly number of marriages.

We also allow the coefficients associated with month dummies to change, so that in some cases, we have time intervals—which have been identified by break dates

Table 2 Change in the relationship between the seasonality of births and seasonality of marriages. Italian regions, 1870–1914. [a]*Source*: Istat (2012) and our elaborations on the data from "Movimento della popolazione secondo gli atti dello stato civile"

Regions		% of the workforce employed in the secondary sector in 1871|1901|1931[a]	Start	First Break date	Beta before first break	*p* value	Beta after first break	*p* value	Second break date	Beta after second break	*p* value
North	Veneto	15.7| 19.2| 24	1870 Oct	1886 Oct	0.011	Not sign.	0.055	Not sign.	1895 Apr	0.046	0.019
	Liguria	20.5| 28.2| 33.4	1870 Oct	1886 Nov	0.064	0.006	0.047	0.014	1895 Sep	0.015	Not sign.
	Lombardy	23.1| 31.7| 42.9	1870 Oct	1886 Oct	0.062	0.01	0.016	Not sign.	1896 Jun	0.059	0.023
	Piedmont	14.2| 22.7| 33.4	1870 Oct	1879 Oct	0.043	Not sign.	0.043	0.038	1889 Feb	0.018	0.001
	Emilia Rom.	19.2| 19.9| 20	1870 Oct	1881 Jul	0.106	0.003	0.109	0.003	1904 Jun	0.064	0.001
Center	Tuscany	20.6| 25.4| 28	1870 Oct	1886 Oct	0.1	0.004	0.039	Not sign.	1896 Sep	0.054	0.003
	Umbria	11.4| 15.5| 18.6	1870 Oct	1886 Aug	0.08	0.022	0.089	0.09	1896 Jun	0.082	0.001
	Latium	13.3| 18.9| 22.3	1873 Apr	1886 Nov	0.025	Not sign.	0.052	0.033	1896 Nov	0.036	0.035
	Marche	17.3| 18| 18.1	1870 Oct	1887 Sep	0.056	0.026	0.047	Not sign.	1902 Oct	0.063	0.034
South	Abruzzi	16.9| 13.7| 14.3	1870 Oct	1886 May	0.156	0.001	0.067	0.028	1897 Nov	0.055	0.047
	Sardinia	12.6| 16.3| 19.1	1870 Oct	1879 Sep	0.003	Not sign.	0.105	0.01	1890 Sep	0.101	0.002
	Campania	22.7| 22.2| 23.8	1870 Oct	1887 Dec	0.095	0.001	0.132	0.006	1902 Sep	0.097	0.019
	Calabria	29.2| 26| 18.4	1870 Oct	1883 Jan	0.13	0.001	0.135	0.001	1898 Mar	0.081	0.001
	Sicily	21.4| 19.3| 20	1870 Oct	1886 Oct	0.072	0.001	0.12	0.001	1902 Oct	0.17	0.09
	Basilicata	19.9| 15.5| 14	1870 Oct	1879 Aug	0.074	0.001	0.055	0.048	1890 Sep	0.089	0.001
	Apulia	23.1| 21.7| 20.7	1870 Oct	1889 Dec	0.08	0.001	0.133	0.001	1900 Dec	0.085	0.001

that the coefficients associated with marriages are almost equal to that of the previous period, while the coefficients relative to month dummies change. To allow for the better readability of Table 2, we do not report the latter coefficients; however, they are available upon request. To give an idea of the different levels of industrialization for each region, we also report the percentage of the regional workforce employed in the secondary sector.

In general, we found that for almost all regions, a first break is identified during the 1880s. We possibly detected some disturbance in natural seasonal movement due to the first Italian colonial war in Eritrea (1885–1889).[7] It must be said, though, that the Italian military push was limited to about 20,000 troops (Beltrami 2011). Furthermore, the invasion reached this size only after the Italian defeat at Dogali in 1887. Thus, colonial efforts are unlikely to be the only reason. Another possible explanation is that these were the years of phylloxera, a phytophagous insect that destroys the roots of the *Vitis Vinifera*. In Italy, the first appearance of the insect came in Lombardy in 1879 (Bonardi 2014), about 10 years after phylloxera had arrived in France. The immediate consequence of the infestation in France had been an increase in the demand for Italian blending wine on the part of French producers. According to Bonardi (2014), the growth in demand led, especially in Southern Italy, to more land being given over to grape cultivation, at the expense of wheat.[8] This increased wine production reached its peak in 1887 and was abruptly interrupted by the end of the infestation in France and by the breaking of the commercial treaty between the two countries in 1888. Exports fell from 2.8 million hectoliters in 1887 to 23,000 hectoliters in 1890. At the same time, in the 1890s, phylloxera became more and more serious in Italy forcing a return to cereal cultivation and vineyards were, consequently, destroyed (see Lentini 2015).

These vicissitudes might have produced changes in the agricultural workload in the harvest months.

Thus, the second estimated break date is the most indicative of possible structural changes in the relationship between the seasonal movement of births and seasonal movements in marriages. Assuming that our interpretation is correct, one has to compare the beta coefficient associated with the ante colonial war/phylloxera crisis period (before 1886) and the coefficient estimated after the second break.

Confirming our expectations, more economically advanced regions (Lombardy, Piedmont and Liguria) are also those where the relationship between the two variables is weaker and where there is a further decrease following the second break date. Among the Southern regions, only in Abruzzi and in Calabria do we see a drop in the coefficient associated with detrended marriage after the second break date, while in the remaining regions it remains stable (save in the case of Sicily where it increases). In Table 2, we also report the percentage of the workforce employed in

[7] Ruiu and Breschi (2017) argued that during dramatic events like wars or epidemics, there is a huge decrease in fertility levels due to the dramatic increase of marriage dissolution caused in turn by rising mortality. Furthermore, even when the event is ended, only after several lags do, we observe a rebound in fertility to higher levels than pre-crisis times.

[8] In northern Italy, 1884 and the 1889 were also characterized by heavy production losses due to vine mildew (Matta and Alma 2010).

industry in each Italian region. The industrial divide, which according to Daniele and Malanima (2014) started in the 1880s, was certainly there in the first years of the twentieth century.[9] Among the central regions, in Tuscany and Latium the coefficient associated with marriage decreased after the second break, while in Marche and Umbria it remained stable. Note that for Tuscany, the magnitude of the coefficient is very similar to that estimated for Emilia Romagna, the most easily comparable region in terms of economic conditions and population size.

In the case of Latium, the estimation in first time interval identified by the Bai-Perron technique suggests that the relationship between birth seasonality and marriage seasonality was not significant. As Rome and the former territory of the Vatican State entered the Italian Kingdom only after September 1870 (i.e., during the initial phase of its constitution), the borders in this region were changed. However, with the data available to us, we are unable to take these border adjustments into account.

There is the same issue with Veneto, since during the period of our study, this region also included parts of what became Friuli.

5 Conclusions

The energy balance theory postulates that when women are subjected to prolonged period of negative energy balance or to high energy turnover, their organisms adopt a self-protection mechanism that reduces the possibility of successful conception.

The aim of this paper was to show that this theory is compatible with the evolution of live births seasonality in Italian regions immediately following Italian unification (1861) and in the years up to the Great War. In that period, save for the three Northern regions (Piedmont, Liguria and Lombardy) in which some signs of industrialization were already present, the economy of the remaining Italian regions was characterized by non-mechanized agriculture. It is well known that agricultural economies have marked workload seasonality, with a dramatic difference in work intensity between high season (summer months) and low season (winter months). Unfortunately, accurate data on the number of hours by season are not available for Italy. We used marriage seasonality as a proxy for workload intensity in order to study the relationship between workload intensity and the seasonality of births. Specifically, we conducted a multivariate regression in which the dependent variable is a seasonal indicator of live births and the explicative variables are the nine-month lagged seasonal indicators of marriages, in addition to month dummies. We believe that the inclusion of this set of dummies will capture the different climatic characteristics of each month, thus allowing for an interpretation of the coefficient associated with marriages as a partial effect, which is removed from the effect of environmental factors. Adopting the Bai -Perron technique, we also attempted to identify when the relationship between work intensity, as captured by marriage seasonality, and our

[9] The reader is referred to Daniele and Malanima (2014) for more details on the economic development of Italian regions from unification onwards.

dependent variable began to decline. In line with the energy balance theory, we have shown that a one-point percent increase in the seasonal indicator of marriages (and thus a decrease in the work intensity of the month) was associated with an increase of about 0.10% in the seasonal indicator of births from unification to the early 1900s. According to our estimated breakpoint, the relationship between the two variables became weaker around 1905 (some years before of the fertility decline), while after the 1960s (thus after the Italian economic miracle), it was completely reversed. Interestingly, at the regional level, and focusing on the period 1870–1914, the strength of the relationship between marriage seasonality and birth seasonality was weaker in the more developed North, in which some signs of industrialization (Lombardy, Piedmont and Liguria) and of fertility decline were already present. The timing of the reversal of the relationship between marriages and births as well as the regional heterogeneity in the strength of this link at the regional level seems to be compatible with the modernization of the Italian economy. As such these results give weight to the idea that agricultural workload calendar had played a role in shaping the seasonal curve of live births in the pre-industrial phase.

A limitation of this work is that we were unable to separate first-order births from subsequent births. This problem may have undermined our ability to pinpoint the relationship between agricultural cycles and births, if the observed correlation between the seasonality of marriages and the seasonality of births merely reflects the fact that in a not yet secularized society the timing of marriage and of first-order births are related. However, we believe that, at least for the first period (1870–1914), this criticism does not apply, since subsequent births should be preponderant in determining the overall seasonal pattern.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Human and animal rights This research has not involved human and animal participants.

Appendix

See Tables 3 and 4.

Table 3 Seasonality of stillbirths in Italy, 1891–1933 *Source*: Our elaborations on data from "Movimento della popolazione secondo gli atti dello stato civile"

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Stillbirth rate per 1000 total births
1891	122.1	109.1	114.7	99.4	95.7	87.3	91.1	91.8	90.5	93.3	99.5	105.3	37.7
1892	118.5	107.0	117.6	104.6	97.3	86.7	89.3	91.7	90.8	93.9	94.8	107.7	38.7
1893	123.4	104.8	108.9	100.7	102.3	88.0	88.8	92.0	88.4	97.9	98.2	106.4	39.4
1894	120.8	101.0	105.2	99.9	97.0	89.0	91.7	91.8	86.8	99.6	100.9	116.4	40.3
1895	124.1	118.8	115.7	99.0	98.2	87.4	87.0	90.0	86.8	95.5	92.7	104.7	40.3
1896	118.7	110.2	112.7	101.9	95.0	88.6	89.6	90.1	89.2	96.6	100.1	107.4	40.6
1897	112.9	106.5	110.4	101.1	99.4	90.4	91.8	90.9	81.9	96.5	105.5	112.8	40.6
1898	115.6	111.6	106.2	99.6	95.0	93.2	91.0	91.1	90.1	96.4	99.7	110.5	40.4
1899	109.8	96.8	108.1	99.8	95.6	88.7	93.2	96.5	94.9	100.2	103.0	113.3	40.5
1900	119.5	107.1	114.1	102.0	96.5	87.9	93.4	92.2	90.1	92.9	99.6	104.8	41.0
1901	121.8	112.1	109.6	97.8	97.5	89.9	91.6	88.9	91.5	94.5	99.5	105.3	41.9
1902	109.8	101.1	108.5	98.7	98.8	90.2	91.8	93.7	92.5	102.4	102.8	109.8	43.4
1903	121.7	106.2	109.8	104.1	94.7	87.3	89.8	89.0	88.3	99.5	99.9	109.7	42.9
1904	113.0	104.3	109.3	95.5	94.0	85.7	90.8	94.5	96.0	99.7	105.7	111.5	43.3
1905	125.7	110.9	108.6	95.6	93.9	88.0	91.0	92.8	90.5	98.2	95.2	109.5	43.6
1906	118.8	111.5	109.3	97.0	96.6	87.5	93.8	90.9	92.0	95.9	95.5	111.3	43.0
1907	125.5	115.8	111.7	99.6	94.1	87.0	89.9	91.8	88.0	93.6	96.9	106.1	43.3
1908	113.8	105.3	108.7	99.4	91.8	87.9	90.4	91.2	88.7	101.4	106.0	115.5	43.2
1909	121.9	116.2	117.5	98.1	96.9	89.5	90.7	86.0	89.1	94.0	95.4	104.7	43.2
1910	116.4	104.1	113.0	102.2	97.1	91.5	88.9	91.2	89.6	96.2	104.2	105.5	42.1
1911	127.9	113.6	110.6	103.6	97.9	88.4	91.5	90.4	88.0	89.3	91.2	107.5	41.6
1912	115.8	103.9	103.3	97.0	92.7	86.3	91.5	92.1	95.2	103.9	106.8	111.4	40.5
1913	120.8	111.4	111.8	98.3	94.2	87.2	89.8	90.0	91.6	96.9	97.4	110.8	40.1
1914	124.2	102.2	106.0	96.3	94.2	86.0	89.0	91.2	91.9	99.2	105.3	114.5	41.0
1915	127.9	114.1	119.4	104.5	97.4	87.3	90.2	87.6	81.4	91.2	97.9	101.0	40.9

Table 3 (continued)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Stillbirth rate per 1000 total births
1916	142.2	127.8	113.0	102.5	91.6	84.8	84.3	86.9	83.0	92.5	94.8	96.5	32.5
1917	128.6	116.7	112.3	99.4	90.1	89.6	89.9	93.1	87.2	90.8	93.7	108.7	41.4
1918	113.5	103.0	103.7	92.7	86.0	76.7	74.2	77.3	102.0	152.3	115.5	103.2	48.1
1919	98.5	86.9	83.6	75.4	73.3	66.2	76.0	91.0	104.1	139.2	138.5	167.2	45.2
1920	122.3	120.8	107.2	98.7	92.5	84.1	85.1	83.5	89.3	94.5	108.4	113.5	43.3
1921	116.1	103.5	102.5	93.8	90.2	86.5	91.7	89.5	93.9	104.6	110.2	117.5	45.9
1922	138.3	116.1	108.5	97.2	88.6	84.5	85.1	84.8	86.1	95.0	101.6	114.2	44.9
1923	130.5	111.1	114.8	98.3	87.7	84.3	86.3	87.1	87.6	96.8	100.2	115.2	43.8
1924	122.8	116.8	114.9	95.3	90.1	85.8	92.1	88.7	88.4	95.2	99.3	110.6	41.5
1925	122.5	107.6	114.0	98.5	95.0	88.8	88.7	89.6	89.3	94.4	97.2	114.5	41.6
1926	122.5	108.6	116.5	100.7	99.6	85.9	91.5	87.5	86.4	94.4	95.9	110.4	38.6
1927	117.2	108.3	107.8	101.8	94.6	85.4	90.0	89.1	91.1	98.8	102.0	113.8	36.9
1928	121.4	112.0	114.7	100.6	92.3	88.5	85.7	88.1	88.5	94.9	99.7	113.6	35.7
1929	123.6	118.0	110.9	95.1	91.9	86.7	89.0	89.5	89.2	98.3	94.9	112.8	35.5
1930	113.3	107.8	110.7	102.5	99.4	84.9	90.0	91.6	90.1	101.7	98.9	109.0	35.2
1931	122.1	112.6	112.2	100.7	100.2	83.2	88.6	86.7	91.6	97.6	95.1	109.3	34.3
1932	114.5	113.2	113.2	97.5	99.9	89.6	91.5	92.1	89.2	97.1	97.3	105.1	34.0
1933	116.2	103.9	111.1	96.7	102.4	91.4	86.1	83.5	91.7	96.3	104.1	116.5	34.2
1934	122.3	111.4	111.6	103.7	93.4	84.8	87.1	88.6	87.7	94.4	104.2	110.8	33.5
1935	123.3	107.2	108.4	102.0	93.9	93.7	87.3	87.2	91.4	96.2	97.1	112.2	32.8

Table 4 Agricultural calendar in Italian regions in 1939. *Source*: Istat (1948)

Type of crop	Planting/harvest season	% of agrarian surface occupied by the crop (1939–1942 average)[a]															
	Start (End) (DD/MM)	Pie	Lom	Lig	Ven	Emi	Tus	Mar	Umb	Lat	Abr	Apu	Bas	Cal	Cam	Sar	Sic
Wheat	01/09–15/01(20/05–31/08)	45.8	42.0	48.9	35.8	68.8	61.5	72.4	63.3	59.0	49.9	61.3	59.6	57.8	46.3	70.0	68.9
Rye	01/09–31/01(02/06–31/08)	6.4	2.5	0.6	0.5	0.3	1.1	0.0	0.2	0.2	0.2	0.0	0.1	2.5	0.7	0.0	0.1
Barley	01/09–31/01(10/05–31/08)	0.3	0.1	0.2	0.2	1.3	1.6	2.0	2.0	0.8	0.7	5.3	3.2	3.0	1.3	8.2	4.7
Oat	01/09–31/12(01/05–10/09)	2.3	2.3	0.7	1.0	0.9	6.2	0.7	3.8	5.0	2.2	16.5	16.8	8.8	5.0	5.8	2.7
Spring maize	01/03–31/05(10/07–10/11)	18.9	31.1	17.8	29.0	10.8	0.0	16.6	9.7	18.1	17.5	0.0	6.9	10.9	17.0	1.8	0.3
Summer maize	10/04–31/08(15/08–30/11)	2.8	5.3	1.5	9.3	0.5	11.4	0.1	0.1	0.2	0.2	3.6	0.1	1.1	3.1	0.0	0.1
Rice	28/03–31/05(25/08–10/11)	11.6	9.0	–	0.8	1.7	1.1	–	–	0.0	–	0.0	–	0.0	–	0.0	0.0
Sugar beets	15/02–20/05(20/07–31/10)	0.3	1.2	0.1	7.1	8.9	7.4	0.3	0.6	0.8	0.5	11.3	–	0.2	0.3	–	–
Potato	01/12–31/05(01/05–30/11)	5.3	3.1	26.1	2.0	1.8	4.4	3.5	5.9	3.6	14.0	0.6	2.5	4.9	8.4	1.0	0.3
Fava bean	01/09–31/05(01/05–30/09)	0.6	0.1	0.7	0.0	0.7	3.9	3.2	5.5	5.5	5.4	1.4	10.2	7.1	5.0	12.5	22.6
Bean	15/02–31/08(10/05–30/11)	5.8	3.5	3.5	14.4	4.3	1.4	1.2	9.6	6.9	9.4	0.0	0.7	3.6	12.9	0.7	0.3

[a]The total agrarian surface is calculated as the sum of the surface (measure in ha) of the 10 ten most diffused agricultural crops

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