Seasonality of Birth Rates in Agricultural Iceland

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Abstract

The seasonal pattern of birth rates in 19th century agricultural Iceland, peaking in late summer and early autumn, gradually disappeared when the population migrated to fishing villages in the last decades of the 19th century and the first three decades of the 20th century. We describe how this pattern is consistent with changes that have occurred in other countries and discuss some possible causes.

Keywords: Fertility, urbanization, seasonality.

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1. Introduction

We explore the seasonality of births in an agricultural society taking advantage of the rapid urbanization of Iceland in the late 19th century and early 20th centuries. Ours is primarily a descriptive exercise although we attempt to relate our results to explanations on the cyclicality of births that have been proposed by others. We will show that when agriculture was the dominant industry in Iceland, births peaked in late summer and early autumn, with the highest number of births in August. This pattern then disappeared when the population moved to urban areas in the 20th century.

The population of Iceland did not grow from the Age of Settlement (A.D 874-1000) to the end of the 19th century.[1] Icelanders did not share in the rise in living standards enjoyed by many European countries in the 18th and early 19th centuries while the economy was based on agriculture. Investment in modern fishing vessels was prevented by institutional barriers such as the absence of investment capital and the Danish trade monopoly hindered economic development by preventing Icelanders from trading with other countries such as Britain. The late 19th century brought free trade, foreign capital and foreign technologies that raised the marginal productivity of labour in the fishing sector. As a result, workers migrated from rural farms to fishing villages situated close to fertile fishing grounds. Between 1890 and 1940, the share of the population living in farming areas fell from 88.2% to 35.6%. We explore the relationship between this transition and changes in the seasonality of fertility and compare our results with those from other countries.

We start by reviewing the literature on the seasonality of births and the causes thereof before describing economic development and urbanization in Iceland. Thereafter we turn to the empirical analysis and finally summarize our results in concluding comments.

2. On the seasonality of births

A selective pressure to maximize the survival of offspring explains the well-known seasonal pattern of births in the animal kingdom. Turek *et al*. (1976) find that the administration of melatonin, which tends to increase with the length of the day, resulted in reduced testicular weight and suppressed spermatogenesis in golden hamsters and

[1] The population was around 40,000 between A.D. 900 and 1100; 55,000 from 1000-1300; 60,000 from 1300-1500; and 55,000 from 1500-1900. It started to grow in the 1890s, reaching 77,967 in 1900; 84,528 in 1910; 120,264 in 1940; 173,855 in 1960; 226,948 in 1980; and 279,049 in 2000. As of 2016, it is 332,529. Source: Gunnarsson (2000) and Statistics Iceland (www.statice.is).

grasshoppers but had no such effect on mice and rats. This they interpreted as suggesting that the level of melatonin plays a role in species that have seasonal fluctuations in births. Gerlach and Aurich (2000) study the interplay of the photoperiod, the production of melatonin and prolactin, and fertility in the stallion, ram and hamster. They show that this interplay creates differing seasonality patterns in the species, depending on whether they are long-day or short-day breeders.

The seasonality of births among humans is a widely observed phenomenon. Lam and Miron (1991, 1994) find that the pattern of seasonal variations differs dramatically between countries and time periods. They describe two main patterns. The first is the European pattern, which is characterized by a global peak in the spring and a local peak in September, followed by a trough in the fall and early winter. The U.S. pattern is markedly different, as it is characterized by a spring trough from April to May and a September peak. However, the two patterns are not complete polar opposites, as they do share a September peak and a similar trough in the fall and winter. These patterns have also been found in other parts of the world, and the September peak that is common to both patterns is found in many countries (Doblhammer, Rodgers, and Rau, 1999). Christmas holidays in modern societies may explain this September peak.

We are not the first to explore the seasonality of births in agricultural societies. Knodel and Wilson (1981) find strong seasonal patterns in births in 18th and 19th century German villages, which suggest reduced rates of conception during the harvest period from August through November. Levy (1986) studies birth seasonality in rural Egypt and finds evidence consistent with attempts to avoid births during the period of peak labour demand, with a maximum in December and minima in June and September. The authors interpret the evidence as showing that people avoid births in months when the opportunity cost of time is high. Mosher (1979) studies farming communities in Taiwan and finds that the annual cycle of production influences birth seasonality through the intervening variable of diet. Massey and Mulan (1984) study Mexican data where husbands spend part of the year in the United States, with predictable results. Spencer *et al*. (1976) study seasonal patterns in the birth rate in Belgium in the 17th and 18th centuries. They find that in both rural areas and in the cities (Liege and Ghent) there is a peak in February and March, with a secondary cluster around August and September, the latter indicating conception after the harvest. Interestingly, the agricultural areas have a much more pronounced August-September peak, a pattern similar to what we detect in

the Icelandic data in the empirical analysis below. There is no cyclical pattern in the urban parish in Ghent.

3. Possible causes of birth seasonality

We start by reviewing some of the possible biological causes and then mention one possible economic reason for the seasonality of births in human societies. The biological causes include the effect of net energy intake on ovarian activity; the effect of a high outdoor temperature on semen quality in hot climates; and the effect of the length of the day on the level of melatonin in the brain, which may affect fertility.[2] Economics could also help explain the pattern if people take into account the opportunity cost of childbirth when deciding when to have children, or conceive during times of leisure or vacations.

Ellison, Valeggia, and Sherry (2005) note that human reproduction is a highly energy-intensive process for females, which makes a positive net energy intake increase ovarian activity. The net energy intake could therefore be a possible predictor of the timing of conceptions. In subsistence agricultural economies there is large variation in both workload and the amount of available resources over the course of the year. The workload is high during the harvest season, and the food is less nutritious in spring and early summer. Once the harvesting is over, the workload falls and the food becomes more nutritious. Therefore, it is possible that conceptions occur more frequently in the weeks after the harvest. Bailey *et al.* (1992) find supporting evidence for this thesis. They find that rainfall is positively linked with food production in many countries and increases ovarian function and fertility. They find that reduced food availability has a negative effect on conception and find support for the hypothesis by comparing two groups of subsistence farmers, only one of which displays seasonality in food production.

Lam and Miron (1996) propose an alternative biological explanation. They find that high temperature has a depressing effect on conception. Since the temperature peak occurs in the summer months, this suggests a trough in births in the early spring, which is the U.S. pattern. Furthermore, they find that this effect increases with the average level of temperature: it is mild in Sweden, where the mean summer temperature barely exceeds 16°C but exerts a stronger effect in the southern part of the United States, where the mean summer temperature is 27°C. Thus Lam and Miron (1994) find a stronger cyclical pattern in the state of Georgia than in either California or New York, and a strong pattern

[2] For surveys of the literature, see Lam and Miron (1991).

in India and Israel. Although the heat effect is found in many parts of the world, Lam and Miron (1996) find no evidence that extremely low temperatures affect conception. Levine (1999) has suggested a reduction in semen quality during hot summer months as a potential cause. Lam and Miron find that the magnitude of the cyclicality has decreased in the southern U.S. states in recent decades, something that might be explained by the introduction of air conditioning.

Manfredini (2009) finds that the length of the photoperiod in Italy from 1993-2005 is positively associated with conception, with the longer days in summer months having a positive impact and the shorter winter months a depressing effect. According to Reiter (1998), the seasonal level of melatonin could be one reason. Therefore, if long summer days reduce the level of melatonin and lower melatonin levels increase the rate of conception, the effect may be to increase the likelihood of conception. Reiter shows how melatonin plays a role in the seasonal patterns of mammals, and because the secretion of melatonin is photosensitive in humans, the timing of births might be affected. However, a functional link between melatonin and reproduction has not been firmly established, as clinical trials have given inconclusive results.

One can also explain the seasonality using economics. Pitt and Siegel (1998) attribute the seasonality of births in Senegal to seasonality in the opportunity cost of childbirth. If the opportunity cost of birth varies over the year, parents might shift births to those months where the opportunity cost is low. In agricultural societies, this generally occurs after harvesting. Holidays may also play a role in modern societies. Summer holidays may be responsible for the spring peak in births in many European countries, and the Christmas holidays may be responsible for the September peak in the U.S. and the local September peak in Europe.

We will now briefly describe the evolution of the Icelandic economy in the 19th and the 20th centuries that resulted in increased urbanization before exploring the data on the seasonality of births since these changes may be due to urbanization.

4. The drivers of urbanization in Iceland

The level of technology in Iceland's 19th century agriculture was very primitive, as is described by Vasey (1996). Eggertsson (2009) notes that agricultural practices made agriculture very sensitive to cold spells and diseases. Jonsson (1993) notes that Icelandic agriculture enjoyed no significant technological improvements until the beginning of the

20th century. The farmers were restricted to owning small hayfields, which could only be used to grow vegetables and fodder (hay) for the winter. Poor farmers dominated farming, although fishing was an important secondary activity. While the milking of cows required a constant effort, the workload in sheep farming was very seasonal and continues to be so to this day. The sheep breed around Christmas, and lambing takes place in the spring and farmers then send the sheep to the mountains to graze over the summer months. In September, the farmers gather the sheep and bring them to collection points before slaughtering them. This occurs only once a year. Thereafter, the surviving sheep are kept in pastures and then indoors until the following summer. This cycle has repeated itself for centuries and may possibly affect the seasonality of fertility. During the harvest season, farmers required more labour, and extra workers came from the coastal areas in early July for 8-10 weeks. In the winter, around February and March, labour – mainly male workers – transitioned to the coastal areas for fishing and returned to farm work in May. Permanent migration from agriculture to the fisheries was discouraged through labour bondage. Anyone who did not own land had to work as a labourer for a landowner and could not marry and have a family.[3] This was society's method of population control.

The policies of the colonial masters in Copenhagen delayed urbanisation. The Danish king maintained a monopoly in trade with Iceland from 1602 until 1855, which made the price of fish artificially low – the price of fish was higher in Britain – and artificially raised the price of agricultural products. Instead, Denmark bought the fish caught from Iceland at below world market prices. Although the trade monopoly ended in 1787, Icelanders could not trade freely with other countries until 1855. Following trade liberalization, there was a substantial increase in fish exports to Britain, which led to an increase in the number of sailing ships, introduced for the first time in 1780. The growth of the fishing industry then created demand for capital, and in 1885 Parliament created the first state bank (Landsbanki). In 1905 came the first motorized fishing vessel, which marked an important step in the development of a specialized fishing industry in Iceland. Iceland exported fresh fish to Britain and salted cod to southern Europe, with Portugal an important export market. Fishing replaced agriculture as the country's main industry.

[3] The population was 71,981 in 1880. There were about seven sheep for every person alive; that is, 515,364 sheep on the island, 23,337 cows, and 41,342 horses. By 1990 the population had increased to 253,784, with around two sheep per person (548,707 sheep), while the number of cows had increased in proportion to the population, to 74,903 cows.

These developments set the stage for the urbanisation that was to follow in the 20th century. Accompanying this growth was a rapid expansion of the service sector around the beginning of the 20th century. The growth of the fishing and service industries created many jobs that attracted people from the countryside to the new fishing villages. At the end of the 19th century, the majority of Icelanders lived in rural areas, with only 16.6% living in villages in 1899 (Jonsson and Magnusson, 1997). The relaxation of labour bondage in 1894 preceded extremely rapid urbanization in Iceland, with only around 30% of the population living in villages in 1910, as opposed to 75% by 1950. This transition coincided with a drastically reduced ratio of people employed in agriculture. In 1880, 77% of the population worked in agriculture, but by 1930 that ratio was only 36% (Jonsson and Magnusson, 1997).

5. Empirical analysis

We start by exploring directly the seasonality of births in selected periods in Iceland.[4] Figure 1 shows the percentage difference between the month of highest and lowest fertility by year since 1853 and figure 2 shows the coefficient of variation for each time period. Both figures show a reduction in seasonality over the period. The percentage difference between the highest and lowest values falls from 5.69% in 1853-1900 to 3.57% from 1901 to 1948, 2.05% from 1949 to 1996, and only 2.01% in the modern era from 1997 to 2015. The standard deviation falls from 1.87% for the period 1853-1900 to around 0.6% for 1949-2015.[5]

[4] Our main data source is *Statistics Iceland* (www.statice.is). In 1990 the agency published *Icelandic Historical Statistics*, which includes annual data on the proportion of the Icelandic population living in urban nuclei from 1889 to 2014, the number of births by month from 1853 to 2015, and data on the share of labour employed in agriculture in the period 1801-1990.

[5] We also plotted the average absolute deviations of the monthly ratio of births from the annual average and the plot looked almost identical to the two plots shown in figure 1 and figure 2.

Figure 1. Difference (%) between month with highest and lowest frequency of births.

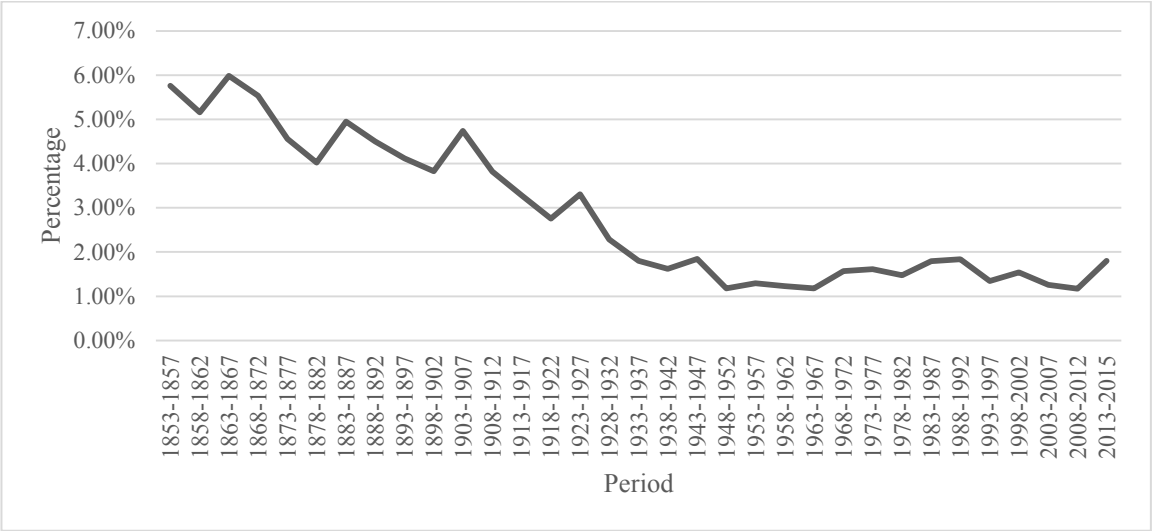
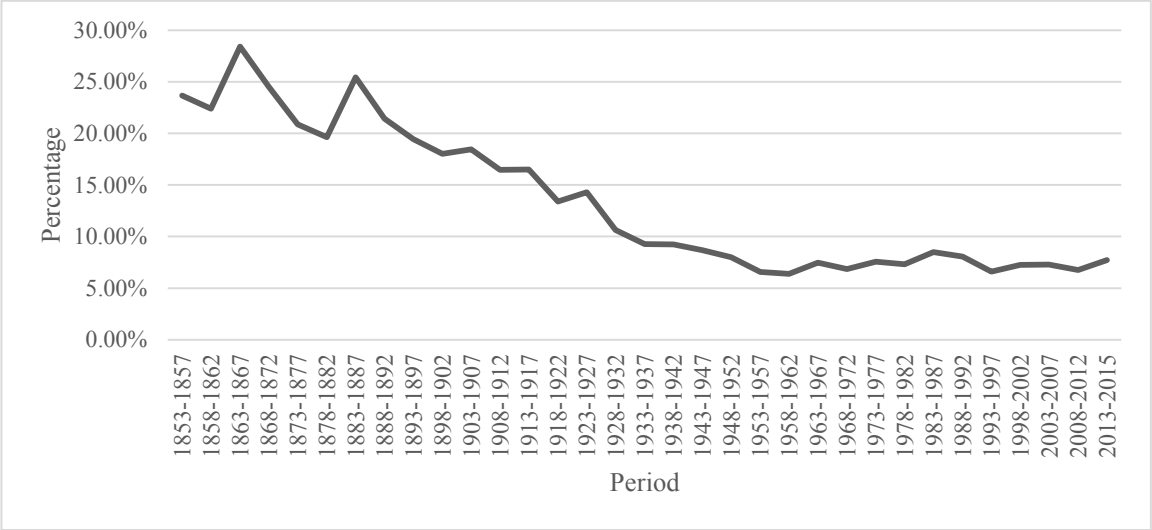


Figure 2. Coefficient of variation.



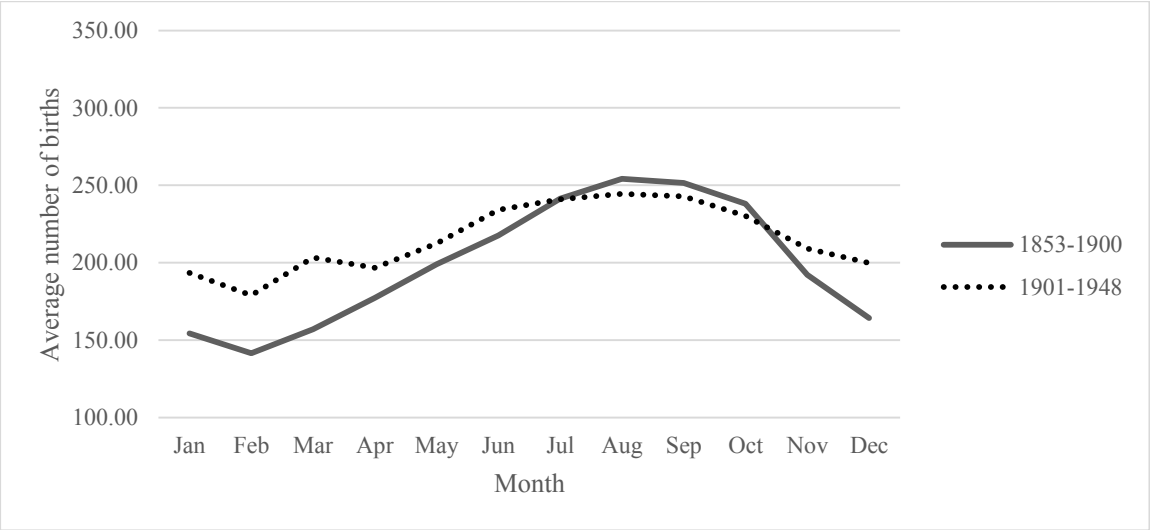
Source: *Statistics Iceland* (www.statice.is).

There were changes not only in the magnitude of seasonality over the period but also in the patterns. In the 19th century, a global peak in August characterized the pattern, followed by a trough in the fall and winter and a global minimum in February. The global February minimum was consistently observed throughout the period from 1853 to 2015. At the beginning of the 20th century, there is a dramatic reduction in seasonality and a change in the pattern of births. In 1901-1948, the August global peak was still present but

less pronounced, as was the winter trough. Additionally, a local peak in March emerged and remained present in all later periods.

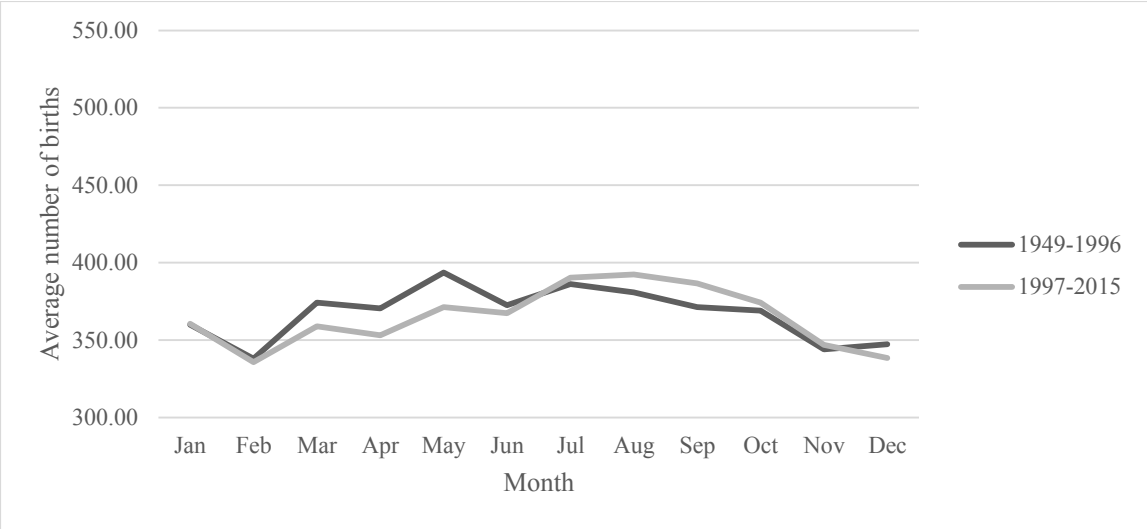
Figure 3 and figure 4 show the number of births per month for the same period.[6] The upper panel shows that the absolute number of births fell in the summer months and increased in the winter and spring between the second half of the 19th century and the first half of the 20th century. The bottom half shows that the absolute number of children born was much higher in the second half of the 20th century, most likely due to a larger population but possibly also changes in demographics.[7] Moreover, it shows that the absolute number of births fell somewhat in the spring months from 1949-1996 to 1997-2015 and increased in the late summer months. Comparing the lines from 1901-1948 in the upper panel and 1949-1996 in the lower panel we find that the number of children born in the first five months of the year increased continuously from 1853 to 1996. The number of late summer births fell between the second half of the 19th century and the first half of the 20th but then increased in the second half of the 20th due to a larger population and possibly changed demographics.

Figure 3. Average monthly values of births $B_{i,t}$, Iceland, 1853-1948.



[6] We do not have historical time series for the number of women per month nor for the number of women in each age group. Therefore it is not possible to calculate the fertility rate by month going back to 1853.

Figure 4. Average monthly values of births $B_{i,t}$, Iceland, 1997-2015.



Source: *Statistics Iceland* (www.statice.is).

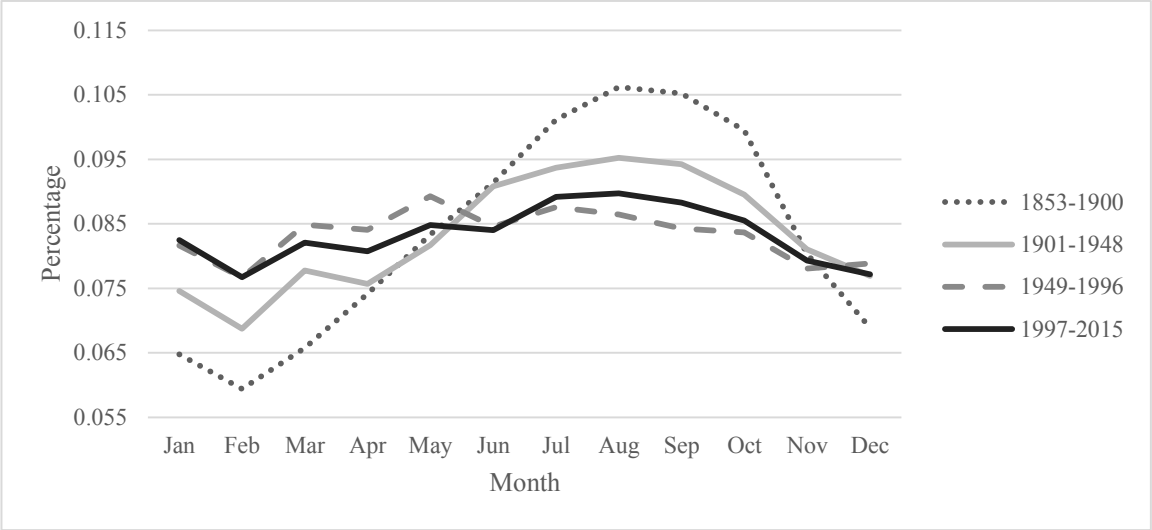
We next remove the time trend in the number of monthly births by taking the number of births each month in a particular year and dividing by the total number of births in the same year;

$$b_{i,t} = \frac{B_{i,t}}{\sum_{i=1}^{12} B_{i,t}}$$

where $B_{i,t}$ is the number of births in month i of year t. Figure 5 shows monthly values for $b_{i,t}$, with each series representing the average for each month over the relevant period.[8] It is clear that there was a dramatic decrease in the seasonality of births over the period from 1853 to 2015.[9]

[8] So, to take an example, the February number for 1901-1948 is the average of the February values of b over this period.
[9] A more detailed look at each period can be found in the Appendix.

Figure 5. Average monthly values of $b_{i,t}$, Iceland, 1853-2015.



Source: *Statistics Iceland* (www.statice.is).

A change occurred in the period from 1949 to 1996, when the frequency of births in winter and spring increased relative to births in summer and autumn. The result was that May was now a global peak month in births, while October was a mild local peak. This is broadly consistent with the widely observed European pattern of births. Thus the seasonality of births changed from having a peak in late summer and early autumn in agricultural Iceland to a less pronounced peak in the spring, as is observed in Europe.

In the period from 1997 to 2015, there was a noticeable increase in births from July to October and a decrease in births from March to June. This resulted in a pattern again resembling that in 1901-1948, although much less pronounced, with the main difference being the presence of a local peak in May in 1997-2015. It is not clear what caused this change.[10]

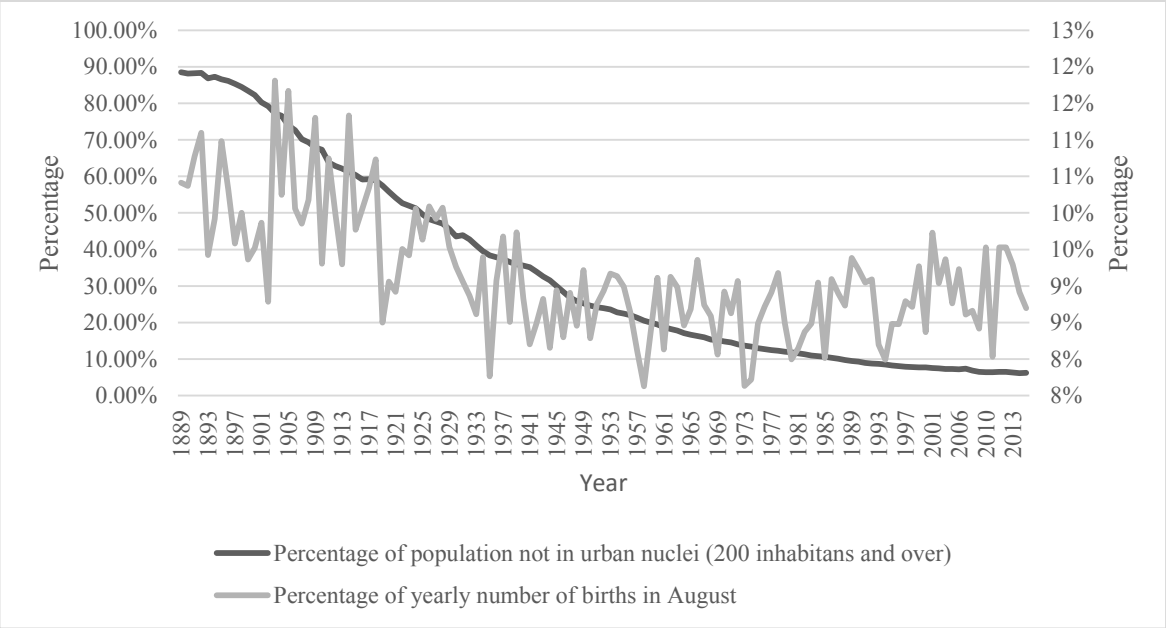
Thus the data show a peak in August in the earliest period, 1853-1900, with high values also in July, September, and October. A similar pattern emerges in 1901-1948, but it is much less pronounced. There is much less seasonality thereafter: the period 1949-1996 has a small spring peak, and 1997-2015 has a small peak from July to September.

We next use the value of b for August – August being the peak month in the agricultural society of the 19th century. Figure 6 shows the value of the August births juxtaposed with the share of the population living in rural areas. The positive correlation

[10] Similar changes have also occurred in recent years in Denmark, Finland, Germany and the Netherlands. Data provided by authors upon request.

between the two series indicates that increased urbanization goes together with a fall in the relative number of births in August. As is described above, during this period Iceland's economy transitioned very rapidly from agriculture to other industries, and with this went the dramatic seasonality of workload in the country. [11]

Figure 6. August (relative) births and the share of the rural population 1889-2014.

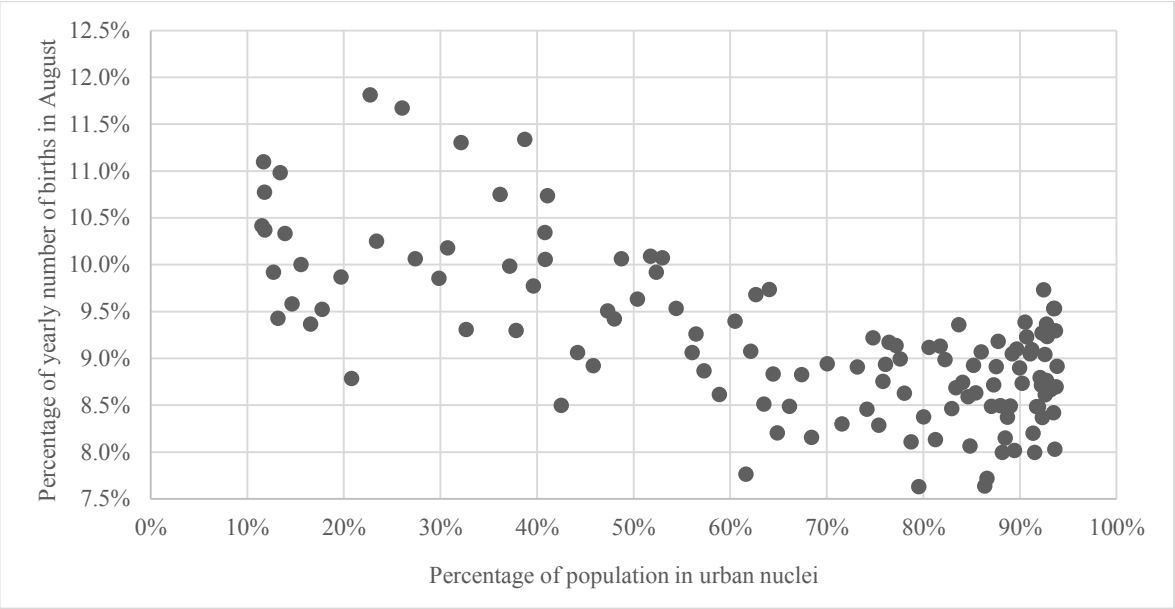


Sources: *Statistics Iceland* (www.statice.is) and the book *Icelandic Historical Statistics*.

Figure 7 shows the scatter plot between the two variables. The vertical axis has the relative number of births in August and the horizontal axis the share of the population living in non-farm villages. A clear negative relationship appears so that more urbanization goes together with a lower value of August births.[12]

Figure 7. Scatter plot of August and the share of the population in villages 1889-2014.

[11] A unit root test (augmented Dickey-Fuller test) that included both a constant and a trend term rejected the null hypothesis of a unit root for August births. (ADF = -4.86, where critical values were -4.03 for significance of 1% and -3.45% for significance at the 5% level). The hypothesis is also rejected when allowing for a constant and NOT a trend term for the urbanisation variable (ADF=-6.79 where -3.48 is the critical value at the 1% level and -2.88 is the critical value for the 5% level).
[12] Data on urbanisation do not exist before 1889.



Sources: *Statistics Iceland* (www.statice.is) and the book *Icelandic Historical Statistics*.

We then move on to estimate the relationship in Figure 7. To test for the effect of urbanization on August births (proportion of total), a series of multiple regression models for the period 1889-2014 were estimated using annual data. The dependent variable in all cases is the share of annual births that occur in August. In the first model shown in column (1) of Table 1, August births are regressed on the share of the population living in urban nuclei, denoted by U. A time trend t is added in the second model, shown in column (2). We then only estimate the equation for the period starting in 1970 in column (3). In models (4)-(6) we in addition include three lags of the dependent variable.

Table 1. Least square regression models, Iceland, 1889-2014.

Dependent variable: Share of annual births that occur in August

Variables	**Model (1)**	**Model (2)**	**Model (3)**	**Model (4)**	**Model (5)**	**Model (6)**
Constant	0.11 (71.99)***	0.11 (61.68)***	0.11 (1.09)	0.06 (4.45)***	0.08 (5.16)***	0.12 (1.12)
U	-0.02 (-10.37)***	-0.04 (-6.50)***	-0.05 (-0.37)	-0.01 (-3.36)***	-0.03 (-3.60)***	-0.05 (-0.39)
t		0.00 (3.47)***	0.00 (0.88)		0.00 (2.45)**	0.00 (0.88)
Share of annual births that occur in August $_{t-1}$				0.08 (0.87)	0.03 (0.28)	0.05 (0.30)
Share of annual births that occur in August $_{t-2}$				0.24 (2.64)***	0.19 (2.05)**	0.14 (0.89)
Share of annual births that occur in August $_{t-3}$				0.06 (0.68)	0.02 (0.26)	-0.24 (-1.51)
Observations	126	126	45	123	123	45
R^2	0.465	0.512	0.141	0.474	0.500	0.204
Adjusted R^2	0.460	0.504	0.100	0.456	0.478	0.101
Durbin-Watson	1.753	1.932	1.905	1.998	1.998	1.991
Shapiro-Wilk	0.991	0.988	0.988	0.990	0.988	0.994
Breusch-Pagan	6.44	15.02	0.00	11.52	17.84	0.11
White	6.11	19.86	4.25	19.78	31.15	29.62

*** 1% significance, ** 5% significance, * 10% significance

Source: *Icelandic Historical Statistics*. t-statistics in parentheses.

The results show that urbanization consistently has a negative and significant effect over the whole period 1889-2014 in Models (1)-(2) and (4)-(5). The numerical estimates in Model (2) suggest that a 10% increase in the share of the population living in urban areas reduces the proportion of births in August by 0.4%. Model (2) explains over half of the variation in the dependent variable over the whole period while the models that start in 1970, that is Models (3) and (6), explain very little and the coefficient of the urbanisation variable becomes statistically insignificant. This is confirmed in Figures 6 and 7 above where there is no relationship between the two series once the share of the population living in rural areas falls below roughly 30%.

The statistical tests reject the null of autocorrelation using the DW test as well as failing to reject the null of normality of residuals using the Shapiro-Wilk test. However, the Breusch-Pagan and White tests fail to reject heteroscedasticity (null hypothesis is homoscedasticity). In response, we estimated the equation using robust regressions, reported in an appendix, and the coefficient of urbanisation remains negative and statistically significant.

Models (4)-(6) show that adding three lags of the dependent variable does not change the results and only the second lag has a significant positive coefficient in Models (4) and (5).

6. Concluding remarks

A peak in late summer and early autumn births characterized the seasonal pattern in the agricultural society of the 19th century, with the highest number of births in the month of August and the trough in births in winter and fall. The pattern therefore highlights the importance of the autumn and early winter months for conception. This pattern disappeared when the population had migrated from the rural agricultural areas to coastal villages.

This seasonal pattern is similar to that which has been found in other countries. In Germany, Knodel and Wilson (1981) found strong seasonal patterns in births in 18th and 19th century German villages, which suggested reduced rates of conception during the harvest period from August through November. A similar pattern has also been found in Belgium where Spencer *et al.* (1976) studied seasonal patterns in the birth rate in the 17th and 18th centuries. They found that in both rural areas and in the cities there was a peak in February and March, with a secondary cluster around August and September. As in Iceland, the agricultural areas had a much more pronounced August-September peak while there was no cyclical pattern in the urban parish in Ghent.

This pattern does not prove any of the particular explanations given in the literature for the seasonality of births. However, they are consistent with the thesis of Ellison *et al.* (2005), that a positive net energy intake increases ovarian activity in women and the chances of conception. But, admittedly, we do not have any data on the net energy intake of women in 19th century Iceland. However, food was abundant and work was limited during these months. The pattern is also consistent with the idea that having more leisure hours, which was the case in Iceland in the autumn months, leads to more sexual activity.

Compliance with Ethical Standards: The authors declare that they have no conflict of interest.

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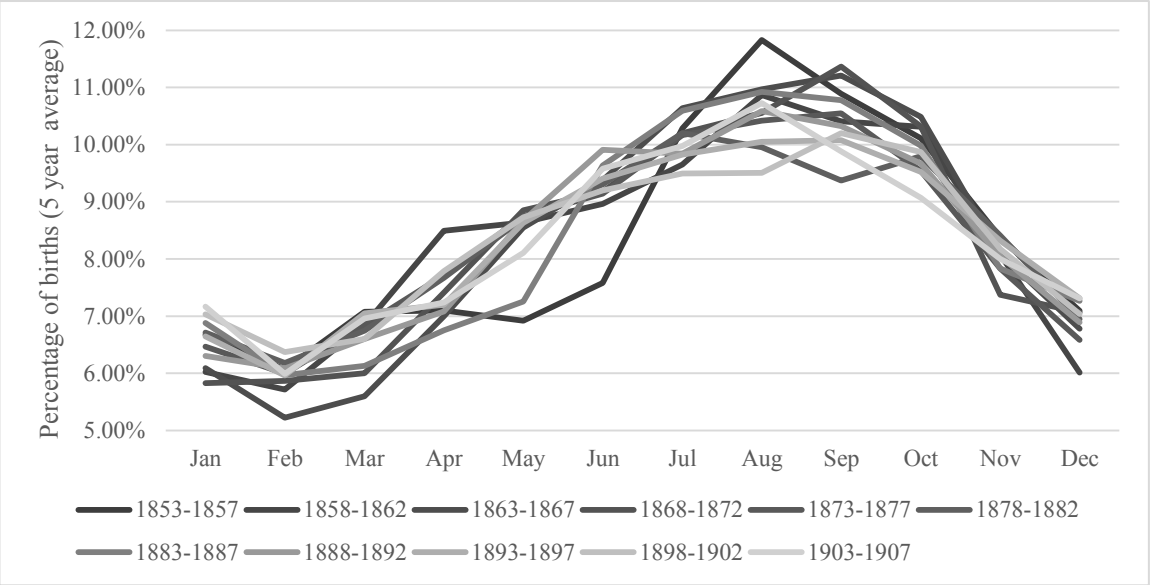
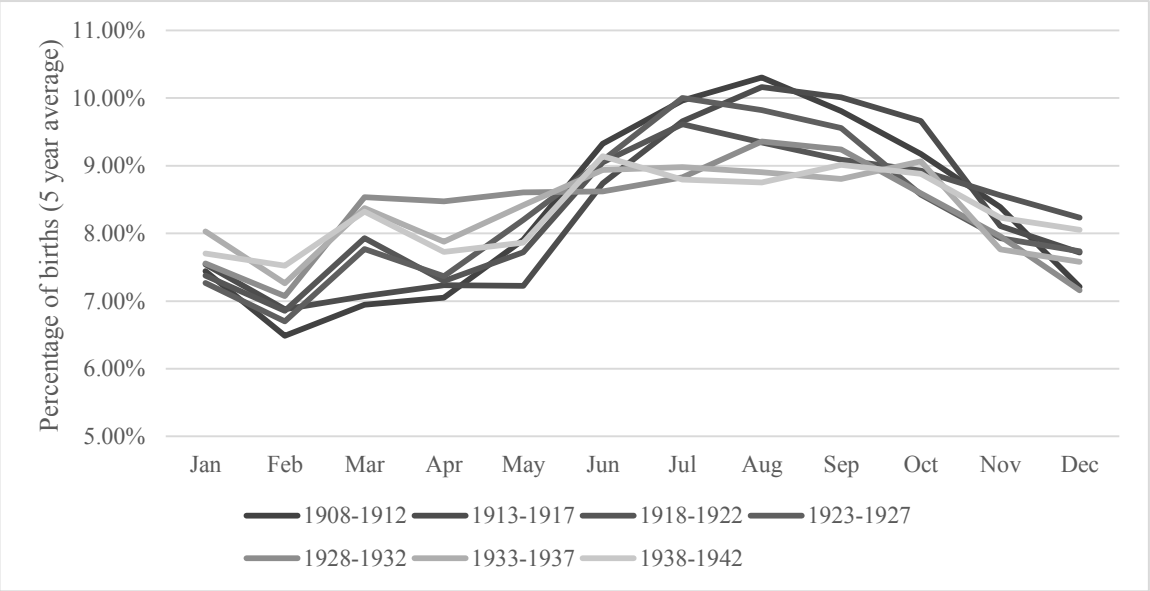
Appendix I

Seasonal patterns of births in Iceland, 1853-1907



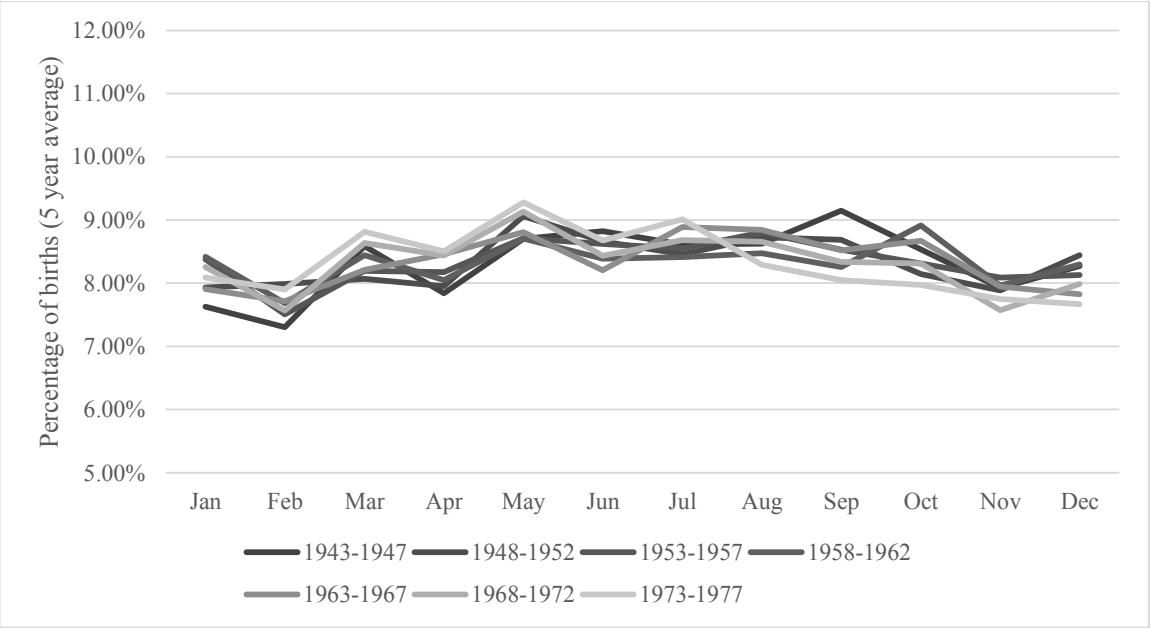
Appendix II

Seasonal patterns of births in Iceland, 1908-1942



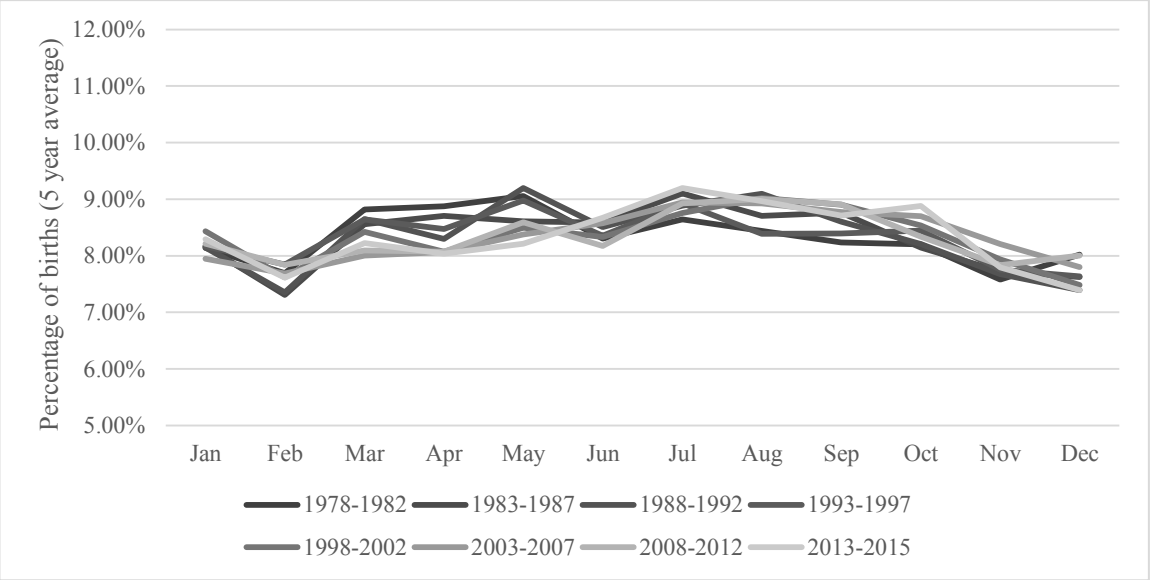
Appendix III

Seasonal patterns of births in Iceland, 1943-1977



Appendix IV

Seasonal patterns of births in Iceland, 1978-2015



Appendix V

Robust estimates of equations in Table 1

Dependent variable: Share of annual births that occur in August

Variables	**Model (1)**	**Model (2)**	**Model (3)**	**Model (4)**	**Model (5)**	**Model (6)**
Constant	0.11	0.11	0.11	0.06	0.08	0.12
	(60.92)***	(49.75)***	(1.18)	(4.44)***	(4.52)***	(1.13)
U	-0.02	-0.04	-0.05	-0.01	-0.03	-0.05
	(-9.46)***	(-6.64)***	(-0.40)	(-2.99)***	(-3.00)***	(-0.40)
t		0.00	0.00		0.00	0.00
		(3.90)***	(0.97)		(2.39)**	(0.89)
Share of annual births that occur in August $_{t-1}$				0.08	0.03	0.05
				(0.80)	(0.25)	(0.28)
Share of annual births that occur in August $_{t-2}$				0.24	0.19	0.14
				(2.48)**	(1.92)*	(0.89)
Share of annual births that occur in August $_{t-3}$				0.06	0.02	-0.24
				(0.67)	(0.25)	(-1.97)*
Observations	126	126	45	123	123	45
R^2	0.465	0.512	0.141	0.474	0.500	0.204
Adjusted R^2	0.460	0.504	0.100	0.456	0.478	0.101
Durbin-Watson	1.753	1.932	1.905	1.998	1.998	1.991
Shapiro-Wilk	0.991	0.988	0.988	0.990	0.988	0.994

*** 1% significance, ** 5% significance, * 10% significanc