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Coupling between death spikes and birth troughs. Part 1: Evidence

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HIGHLIGHTS

- Sudden death spikes are followed 9 months later by birth troughs.
- Six case-studies ranging from 1860 to 2011 provide closer insight.
- A crucial parameter is the number of collateral sufferers

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ABSTRACT

In the wake of the influenza pandemic of 1889–1890 Jacques Bertillon, a pioneer of medical statistics, noticed that after the massive death spike there was a dip in birth numbers around 9 months later which was significantly larger than that which could be explained by the population change as a result of excess deaths. In addition it can be noticed that this dip was followed by a birth rebound a few months later. However having made this observation, Bertillon did not explore it further. Since that time the phenomenon was not revisited in spite of the fact that in the meanwhile there have been several new cases of massive death spikes. The aim here is to analyze these new cases to get a better understanding of this death–birth coupling phenomenon. The largest death spikes occurred in the wake of more recent influenza pandemics in 1918 and 1920, others were triggered by the 1923 earthquakes in Tokyo and the Twin Tower attack on September 11, 2001. We shall see that the first of these events indeed produced an extra dip in births whereas the 9/11 event did not. This disparity highlights the pivotal role of collateral sufferers. In the last section it is shown how the present coupling leads to predictions; it can explain in a unified way effects which so far have been studied separately, as for instance the impact on birth rates of heat waves. Thus, it appears that behind the apparent randomness of birth rate fluctuations there are in fact hidden explanatory factors.

1. Introduction

This paper is about a remarkable case of birth and death fluctuations which, apart from its own interest, may give new insight in the more general problem of vital rate fluctuations. We begin with the following observation.

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1.1. Two alternative views of birth fluctuations

The number of births in a given time interval θ can be written: $b(t) = \lambda(t)P(t)$ where $\lambda(t)$ is the crude death rate at time t and $P(t)$ the size of the population.[1] Depending on whether θ is one day, one week, one month or one year, λ will be the daily, weekly, monthly or annual rate.

We can immediately distinguish two cases:

(1) The rate is fixed $\lambda(t) = \lambda$. In this case the changes of $b(t)$ reflect the changes of the population.

(2) The population is constant $P(t) = P$. In this case the fluctuations of $b(t)$ reflect the fluctuations of the birth rate $\lambda(t)$.

Conceptually, there is a great difference between these cases. For in the first there is nothing to explain whereas the second case raises many questions. What we mean by "nothing to explain" is that, as the population increases or decreases regularly the only question that one may possibly raise is why the birth rate is set at its given value λ.
However, fluctuations of the rate raise numerous questions in the sense that $\lambda(t)$ reflects the behavior of individuals and the conditions under which they live. In other words, for any major change in $\lambda(t)$ one is prompted to ask to what change in real life it is tied.

A quick comparison of the orders of magnitude of the two types of fluctuations can be made as follows.

• In the early 20th century European populations were increasing at an annual rate of around 1%. Under the assumption of a constant λ birth numbers will see the same annual change. Thus, for *monthly* changes the rate will be 12 times smaller, i.e. around 0.1%.

• In contrast, the monthly birth rate fluctuations of actual observed monthly birth numbers were about 4%.[2] This is 40 times larger than the fluctuations under constant birth rate.

However remarkable, the case considered in this paper is possibly just one of several similar processes leading to predictable birth rate changes. The topic of short-term fluctuations has so far attracted much less attention than the study of medium- or long-term changes. For instance the demographic transition in developed countries was brought about by changes of vital rates over a time interval of several decades.

The present study shares several important features with the research field that is concerned with the fluctuations of sex ratio at birth, see [1,2].

• Both researches rely crucially on comparative analysis, either in space across different countries or in time over past centuries.

• Both investigations focus on short-term effects, for instance the changes that occur in the months following an epidemic or a war, see [3] and [4].

• The respective key-variables, monthly birth rates on one hand and sex ratio fluctuations on the other, can be used as markers, in other words as measurement devices which give insight into abnormal situations. For instance, James [5] documents how offspring sex ratios can reveal endocrine disruptions; similarly mortality sex ratios can be used to explore anomalies of the immune system, see [6] and [7].

1.2. Are there "hidden variables"?

In any country the time series of monthly births display substantial fluctuations. There is usually a seasonal pattern which is country dependent; in addition for the same month (say October) in different years there are annual fluctuations of about the same magnitude. It is customary to say that these are random fluctuations but are they really random? In this respect one can observe that by saying that a phenomenon is random one gives up *ipso facto* all attempts to understand it. It is probably for this kind of reason that Albert Einstein supported the "hidden variable" interpretation of quantum physics. In 1935, i.e. some 10 years after quantum mechanics was introduced, Einstein et al. [8] suggested that the wave function description of quantum objects was incomplete in the sense that it did not include some hidden parameters.

1.3. The Bertillon discovery

In 1892 Jacques Bertillon, a pioneer of medical statistics and one of the designers of the "International Classification of Diseases", published an analysis of the influenza pandemic of November 1889–February 1990 in which he showed that approximately 9 months after the climax of the epidemic a temporary birth rate trough (of an amplitude of about 20%) was observed in all countries where the pandemic has had a substantial impact, particularly Austria, France, Germany or Italy. While writing his paper Bertillon did not know that some 28 years later there would be a massive influenza pandemic through which his discovery could be tested. We will show below that it was indeed confirmed in all countries where the pandemic has had an impact. Apparently, there has been no further studies of this phenomenon ever since. Actually, even in Bertillon's paper the effect is discussed fairly briefly. In particular its mechanism remains to be uncovered. This is the purpose of the present paper.

While in 1889–1990 and 1918–1919 the effect can be detected very clearly, is it not natural to assume that it exists also in less spectacular cases. This raises the following question. In most countries the death rate presents a winter peak in January

[1] The difference between θ and t is that θ is a time interval, whereas t is a specific time.

[2] The 4% estimate is for normal conditions; exceptional birth dips and rebounds can be much larger, for instance ±30% in the case of Fig. 1b.