WHEN SMALLER FAMILIES SEEM CONTAGIOUS

A SPATIAL LOOK AT THE FRENCH FERTILITY DECLINE USING AN AGENT-BASED SIMULATION MODEL

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Extended Abstract

Despite some disagreements about specific timing, it is now widely accepted that France was the first country in Europe to undergo a fertility decline. Available data suggests that birth rates there began to fall more or less systematically somewhere after the Revolution, whereas other regions in the continent had to wait no less than another fifty years to do so. But at least two other features –not necessarily unconnected with the first or with each other- make the French experience noteworthy: how long it took and how internal heterogeneity remained. Throughout the nineteenth century this uneven development took place in a quite distinctive geographical pattern: at least two clear areas of low fertility appeared to spread their influence (the Seine valley and the Aquitaine region) while two 'islands' of high fertility kept shrinking (Bretagne and the Massif Central) until they more or less disappeared in the early 1900s. Standard econometric studies can shed some light into the factors driving this apparent diffusion, but to better understand the mechanisms underlying its dynamics we need tools that look closer at the interaction of individuals and incorporate somehow a spatial dimension. In this paper we exploit an agent-based simulation model to address that issue.

Even to the naked eye a sequence of maps plotting fertility rates per *département* in France along the nineteenth century would suggest that a (slow) diffusion from the Parisian and Aquitaine basins towards these 'islands' of high fertility was taking place. As in other diffusion stories, from a fairly homogenous population a particular region gains a new 'status' that is transferred to the surrounding areas which, in turn, will transfer it to their surrounding areas, and so on, spreading like a disease and showing the typical S-shaped evolution of dispersion. Indeed, *variation* in the average levels of fertility among *départements* increased until it reached a peak in the last third of that century and then decreased systematically afterwards. Despite the substantial evidence suggesting that there was some sort of diffusion going on, the fact that many of the explanations relying on the adoption of new behaviour and consequent diffusion insinuate little or no clear economic force actually driving the decline have made some economist reluctant to accept them [e.g. Brown and Guinnane, 2007]. Many of those diffusion stories seem indeed rather naive. Some suggest that new contraceptive techniques were suddenly available or re-discovered which does not seem to be plausible according to the evidence. Others implicitly assume some degree of non-maximising behaviour on the side of potential parents in the pre-transition period. Partly, the simplicity of these arguments has to do with the problems of modelling a system able to generate this kind of pattern. Arguably, analysis has been held back in that area due to difficulties in modelling complex systems involving many simultaneous maximisations problems and the interaction of agents in a particular geographical space, but now a growing literature on social networks and diffusion has changed that [Rosero-Bixby and Casterline, 1993; Montgomery and Casterline, 1993, 1996; Montgomery et al., 2001; Kohler, 2001].

Timing of the downfall is also suggestive. There is some disagreement on how to accurately date the beginning of the fall and –consequently- to be sure on when it actually takes places, but even using different measures of fertility it seems clear that a new trend begins shortly after the French Revolution. Many scholars [e.g. Flandrin, 1979] have suggested in the past that there is indeed some connection between this momentous event and the fertility decline. David Weir, a scholar that has devoted a considerable part of his agenda to understand French fertility decline, saw the Revolution playing a role through the reallocation of property rights in land and labour. Others have referred to vaguer cultural or religious arguments, which are certainly difficult to assess but not necessarily less plausible. Interestingly enough, a series of recent papers have pointed out several examples of fertility declines that are related to social upheavals of some sort, not necessarily of democratic or secular nature, where they include the French case as yet another one [Binion, 2001; Caldwell, 2004; Bailey, 2006]. Nevertheless, causal links are certainly not obvious and potential mechanisms remain obscure.

We believe that with the help of agent-based simulation we can overcome some of the difficulties to incorporate these facts in a theoretical framework that helps us to understand these particularities of the fertility decline in France. Until recently, mostly due to technological limitations, agent-based models were rarely present in the toolkit of social science scholar. But the increase in computer power and simplification of programming languages have facilitated the accessibility of these techniques and now their use is becoming increasingly more common among researchers in certain areas of economics, sociology, demography, and political science [Arthur, 2005; Axelrod, 1997, 2005; Tesfatsion, 2005; Gilbert and Troitzsch, 2005], though they are still largely absent in economic history. This paper attempts to fill that gap. By using this technique, and profiting from the above mentioned developments in the research on fertility behaviour that incorporates the potential roles of social networks and social upheavals, we attempt to generate a model capable of replicate the particular geographical diffusion of the French fertility decline.

Using NetLogo we constructed an artificial society that mimics the spatial characteristics of French *départements* and we populated it with a certain number of agents following the proportions and age distributions suggested by historical data. These agents were then given some behavioural rules they follow according to their characteristics and the behaviour of the agents in their neighbourhood, and are 'killed' randomly according to the real mortality rates also suggested by historical records. In the end, this agent-based model incorporates both data on population characteristics and spatial information on the geography of France, to assess how different behavioural assumptions and social network topologies cause variations in diffusion patterns. In addition to these endogenous forces, we use quantitative data on the Ecclesiastical Oath of loyalty to the Revolution of 1791 to proxy for the institutional impact the Revolution –exogenous to the model- might have had on the population dynamics of different *départements*. As it has been emphasised extensively by Timothy Tackett, probably the outmost authority on the history of the oath, reasons behind the heterogeneity of the oath are hard to figure out [Tackett, 1986: 287-300, and 2006: 545-546]. But there are indeed reasons to believe the pattern of oath-taking could be correlated with some variables relevant to our analysis, an interpretation that is not really forced if we follow Tackett when he points out that the reasons behind the oath-swearing are rather complex and "almost everywhere laypeople exerted pressure on the clergy to accept or reject the oath, with the oath ceremony providing the occasion for a *de facto* referendum on the general religious and secular policies of the Revolution" [Tackett, 2006: 546].

We then assess how the actual heterogeneity of these factors could have affected the emergence of the distinctive geographical patterns. In this way, this paper looks at two components of the potential mechanisms driving fertility behaviour. On the one hand, we introduce the effect of the revolution as a heterogeneous shock to the population. Individuals in more 'progressive' departments are more likely to be affected by a shock that makes them want to have fewer children. On the other hand, we introduce an effect of social diffusion. Individuals want to have fewer children, but they do not want to be the only ones in the neighbourhood. In its simplicity the model takes as exogenous the maximisation process carried out by individuals, which is understandably crucial in many respects (which further research could incorporate). But it nevertheless allows studying several factors normally neglected because they are difficult to model in standard models, such as geographical diffusion. The statistical analysis of several simulations shows that a combination of both endogenous and exogenous factors help to explain the way in which the diffusion process took place during the evolution of the French fertility decline and suggest some of the mechanisms through which this was materialised.

Keywords Economic history, demographic history (Europe pre-1913), France, demographic economics, fertility, simulation models, spatial diffusion.

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