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Spreading Uncertainty, Shrinking Birth Rates: A Natural Experiment for Italy

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Abstract

Many previous studies have documented the procyclicality of fertility to business cycles or labour market indicators in Western countries. However, part of the recent fertility decline witnessed since the Great Recession has been left unexplained by traditional measures. The present study advances the notion that birth postponement might have accelerated in response to rising uncertainty, which fuelled negative expectations and declining levels of confidence about the future. To provide empirical support for the causal effect of perceived uncertainty on birth rates, we focus on Italy's sovereign debt crisis of 2011–2012 as a natural experiment. Perceived uncertainty is measured using Google trends for the term 'spread'—which acted as somewhat of a barometer for the crisis both in the media and everyday conversations—to capture the general public's degree of concern about the stability of Italian public finances. A regression discontinuity in time identifies the effect of perceived uncertainty on birth rates in Italy as a drop between 1.5% and 5%, depending on model specification.

Introduction

The business cycle's procyclicality of fertility rates—increasing throughout periods of economic growth and decreasing during recessions—has been extensively investigated since the onset of the Great Recession (Goldstein *et al.*, 2013; Lanzieri, 2013). In advanced economies, rising unemployment rates are strongly and robustly correlated to total fertility drops not only during the most recent financial crisis but also in every major economic downturn of the last centuries (Sobotka, Skirbekk and Philipov, 2011). However, the widespread and prolonged decline in European birth rates in the aftermath of the Great Recession remains an unsolved puzzle. First, analyses that simultaneously include numerous indicators, such as unemployment rates, the economic policy uncertainty index, public debt, and the consumer confidence index do not *entirely* explain the decline in birth rates in Europe and the United States during 2008–2013 (Comolli, 2017). Second, since 2010, a persistent drop in fertility has been registered in Nordic and other European countries where the Great Recession was comparatively mild; there, the birth rate decline is not explained by traditional macroeconomic indicators (Comolli, 2018; Comolli *et al.*, 2020). Finland and Norway, for instance, reached their historically lowest levels of fertility with 1.35 and 1.53 children per woman, respectively, in 2019 (Syse et al., 2018; Statistics Finland 2019). Crucially, these declines are no less radical than that seen in Greece after its economic collapse. A recent study by Matysiak, Sobotka and

Vignoli (2020) illustrated that the negative effects of GDP decline and rising levels of unemployment were more pronounced during the recession period in 2008–2014 than before. This did not result from the fact that Europeans more strongly adjusted their fertility according to the worsening, rather than improving, economic conditions (as has been found for the United States). All in all, these studies indicate that the driving factor behind contemporary European fertility decline has, as yet, been unexplained by traditional economic and labour market indicators. Part of this unexplained fertility decline in the aftermath of the Great Recession can be, we propose, explained by the rise of uncertainty—a condition in which the future cannot be deduced by present information (Dequech 2000).

In family demography, economic uncertainty is usually interpreted as an individual risk factor, mainly related to the labour market—for example, unemployment or short-term contracts (Mills and Blossfeld, 2003; Kreyenfeld, Andersson and Pailhé, 2012; Alderotti *et al.*, 2021). However, fertility postponement may have accelerated irrespective of person-specific economic circumstances (Vignoli et al., 2020b). The current paper regards economic uncertainty as a macro-level phenomenon, reflecting the uncertainty felt by people in times of economic discontinuities(Sobotka, Skirbekk and Philipov, 2011). Most information necessary for evaluating uncertainty is directly associated with either the job in question or the individual/employee's own characteristics. For example, a temporary labour contract usually implies higher job insecurity than a permanent one (Kreyenfeld, Andersson and Pailhé, 2012; Vignoli, Drefahl, and De Santis 2012). However, much information is unavailable to the individual in everyday life (Garz, 2012). For a majority of citizens, the media—which also evaluates, filters, and simplifies information—is an essential source of complex, economic information (Boomgaarden *et al.*, 2011). The perception of economic uncertainty is thus strongly rooted in public images produced by the media and other powerful opinion-formers, such as journalists and politicians (Vignoli *et al.*, 2020b). For instance, the media played a pivotal role in shaping the public's perception of the Eurozone crisis and, by extension, the European Union's institutional elite and its (in)ability to cope with the crisis (Joris et al., 2018a,b). During the Great Recession, the news contributed to the emergence of a European public sphere predominantly (and pessimistically) characterized as a stagnant, underperforming continent (Cross and Ma, 2013). The Great Recession became 'pop'—meaning popularized by a tsunami of news that favoured a simplified narrative in which the economic crisis was presented as the 'evil' of contemporary European societies (Cepernich, 2012). One of the pillars of the spectacularization and simplification process is the use of a language so reliant on buzzwords that technical terms, such as *spread*, become popular in everyday use (Cepernich, 2012).

To first provide empirical support for the causal effect of perceived uncertainty on birth rates, we focus on Italy's sovereign debt crisis of 2011–2012. As a marker of the uncertainty produced by the crisis, and filtered by media narrative, we refer to the notion of *spread*—the interest rate differential between the Italian (risky) and German (solid) long-term bond yields. The sovereign debt crisis is particularly suitable for distinguishing between the effects of perceived economic uncertainty and underlying macroeconomic trends. Indeed, within the media narrative, the spread became the measure of the country's loss of credibility in the financial markets—not only as a technical financial indicator but also as a crucial measure of how the wide public perceived this uncertainty (Ansa, 2011). We expect that the popularization of the term 'spread' in the media narrative produced a rise in the public's concern, thereby prompting people to search for additional information online. Based on this assumption, we used Google searches for the term 'spread' as a proxy for when interest in the topic peaked, and then isolated the uncertainty spike to assess its impact on Italian birth rates.

Overall, since the Great Recession's assault on advanced economies, economic uncertainty has often been cited as an explanation for the recent fertility rate decline in Europe and the United States. Nonetheless, previous studies suffer from two main limitations. First, the operationalization of economic uncertainty is in most cases limited to traditional indicators that fail to capture the potential connection between the broader climate of uncertainty and fertility. Second, the causal nexus between these latter elements is usually left unaddressed (with only a few notable exceptions, such as Hofmann and Hohmeyer, 2013; Prifti and Vuri, 2013; Hofmann et al., 2017; Clark and Lepinteur, 2020). Through examining the 2011 sovereign debt crisis in Italy, this study demonstrates that part of the drop in Italy's birth rate has been causally generated by the perceived uncertainty channelled by the media.

Persistently low fertility levels have long characterized Italy's demography. Since 2010, Italian fertility has seen a steady decline, reaching a total fertility level of 1.29 in 2019. A glance at age-specific births rates in Italy during the Great Recession suggests that the largest fertility drop was concentrated among young women and first births, suggesting that the negative fertility

response to the recession in Italy is essentially attributable to birth postponement (Caltabiano *et al.*, 2017). On the one hand, previous studies show that young adults are more negatively affected by economic uncertainty than older individuals, and that earlier-order parities are more negatively affected by recessions than higher-order ones (Matysiak, Sobotka and Vignoli, 2020). On the other hand, it is widely accepted that young adults tend to use the internet more than their older counterparts, which is likely the case for the Google search data we have collected (Greenwood et al., 2016). We assume here that Google searches (and in fact only the date of their peak, which is even less dependent than real searches on whom actually conducts the search) proxy for the time of the general concern for the crisis. While some strata of the population manifest this concern by searching for information online, others might exhibit this concern by, for instance, buying newspapers or watching television.

What is Uncertainty?

Uncertainty represents a pervasive component of individual identities and social structures (Keynes, 1921; Giddens, 1991; Halpern, 2017). In globalized societies, deregulation, internationalization, and delocalization processes generate intrinsic components of uncertainty (Blossfeld and Hofmeister 2006; Mills, Blossfeld and Bernardi, 2006). Besides, uncertainty tends to spike when sudden shocks, such as economic crises, conflicts, natural disasters, or social unrest, produce unpredictability. The Great Recession, which began to plague advanced economies in 2008, represents a recent example of a surge in uncertainty affecting markets, institutions, and private individuals alike. In the aftermath of the crisis, the notion of uncertainty—and economic uncertainty in particular—has become central to social science literature, from economics and sociology to family demography.

The American economist, Knight (1921), coined the current definition of uncertainty as the condition(s) under which, instead of taking decisions linked to a set of possible outcomes—each of which is associated with a known probability (or, risk)—actors are unable to assign a probability distribution to future outcomes. The main distinction between risk and uncertainty is that the former is quantifiable while the latter is not. This does not mean, however, that the two concepts are not theoretically linked (Friedman *et al.*, 1994; Dequech, 2000; Zinn, 2006) or empirically separable (Bloom, 2014). Several sociology studies have questioned the rigid distinction between uncertainty and risk (Giddens, 1991; Beck, 1992; Dequech, 1999, 2000, 2003; Trinitapoli and Yeatman, 2011). Different definitions of uncertainty feature various degrees of the actor's ignorance in the decision-making process—where failure is always a possibility, but the odds of such are known to the actors to different degrees (Vignoli et al., 2020a).

Uncertainty and the Media

For the majority of citizens, the media is the primary source of information regarding the economic sphere (Joris et al., 2018a,b). Through its coverage, the media tends to create images of society that strongly influence the public consciousness. Not only does the media select the topics it reports on it but also defines its coverage respect to angles and tone (Bounegru and Forceville, 2011; Esager, 2011; Horner, 2011). A review of Italian news, for instance, illustrates that the more common narratives associated with the Great Recession are those juxtaposing the absolute categories of the 'good' (before the crisis) and the 'evil' (during the crisis) (Cepernich, 2012).

Studies connecting the media's economic coverage and fertility are rather few. Sobotka, Skirbekk and Philipov (2011) suggest that individuals' observations of the broader economic climate, including media coverage of the economy, might increase uncertainty and affect fertility. Schneider (2015) meanwhile suggests that press coverage comes closer to measuring the economic sentiments shaping economic uncertainty than the measures of unemployment and foreclosure. While these studies certainly advance novel perspectives on uncertainty and fertility, they fail to establish a direct link between media coverage and the individuals' receptivity to the media message. How do we know that the particular media framing of an event is known (and actually internalized)? If so, does this influence the behaviour of the general public? The present study seeks to address these questions.

In an era of uncertainty, individuals take decisions while exposed to persistent, media-channelled messages on the economic climate (Vignoli *et al.*, 2020b). During recessions, high news coverage of the economy tends to be more concentrated (Doms and Morin, 2004) and people seek out information with more determination than usual (Coombs and Holladay, 2004). Additionally, the fraction of people who update economic information increases in times of greater news coverage, because the cost for information procurement decreases (Carroll, 2003; Doms and Morin, 2004). Moreover, negative news tends to have a stronger impact on perceptions than positive reports (Alsem *et al.*, 2008; Dräger, 2015).

Online searches of critical recession-related information might thus represent a crucial marker of the fact that such general perceptions of uncertainty also permeated into private life.

Economic Uncertainty and Fertility

Due to the irreversibility of childbearing decisions, and the possibility of postponing pregnancy, uncertainty may generate re-evaluations of preferences, risk, and opportunities that produce either a permanent decline, or a temporary postponement, of childbearing (Ranjan, 1999). Caldwell (2006) argues that the future uncertainty caused by social upheaval can accelerate fertility declines during demographic transitions. The effect of uncertainty on childbearing has also been demonstrated in relation to major economic discontinuities. Examples of this would include the drop in birth rates following the Great Depression (Ryder, 1980), or the same in Eastern Europe after the collapse of the Soviet Union and the transition to a free-market economy (Ranjan, 1999; Billingsley, 2011). Several authors have connected the rise in economic uncertainty with childbearing postponements in the aftermath of the Great Recession based on country-specific (Pailhé and Régnier-Loiler, 2015; Cazzola *et al.*, 2016; Tragaki and Bagavos, 2019) or comparative studies (Goldstein et al., 2013; Bellido and Marcén, 2016; Comolli, 2017; Matysiak, Sobotka and Vignoli, 2020).

Recently, the effects of uncertainty on private behaviours have received renewed scholarly interest (see Lugilde, Bande and Riveiro, 2018 for a review and test of multiple sources of uncertainty on private consumption). Regarding fertility research, most studies measure the effects of economic uncertainty on fertility by using labour market indicators—such as job loss or unemployment (Ahn and Mira, 2001; Adsera, 2005, 2011; Barbieri et al., 2015, De La Rica and Iza, 2005; Da Rocha and Fuster, 2006), precarious or temporary contracts (Vignoli, Drefahl and De Santis, 2012; Vignoli, Tocchioni and Mattei, 2019), or indexes of persistent joblessness (Busetta, Mendola and Vignoli, 2019). For the United States, Schneider and Hastings (2015) suggest that economic concerns were connected to fertility behaviours for socioeconomically disadvantaged groups during the Great Recession. For Europe, a study of the Nordic countries by Comolli *et al.* (2020) illustrate a relatively homogeneous negative fertility response to the Great Recession across countries and education groups. Ayllón (2019) , combining individual-level data with regional indicators of unemployment, precarious employment, and subjective indicators of job uncertainty, show that objective indicators are more strongly linked to fertility than subjective indicators. More exogenous measures of uncertainty include concerns generated by labour market reforms (Hofmann and Hohmeyer, 2013; Clark and Lepinteur, 2020), mass layoffs (Ananat, Gassman-Pines and Gibson-Davis, 2013; Hofmann *et al.*, 2017), and measures related to industry composition (Schaller, 2016). There is also mounting evidence to suggest that, on top of the actual economic outlook or objective insecurity, the perception—or anticipation—of future downturns inhibits childbearing (Bernardi *et al.*, 2008; Kreyenfeld, 2009; Trinitapoli and Yeatman, 2011; Kreyenfeld, Andersson and Pailhé, 2012; Hanappi et al., 2017; Vignoli, Mencarini and Alderotti, 2020c).

Uncertainty and the Italian Sovereign Debt Crisis of 2011

The Italian sovereign debt crisis of 2011–2012 provides us with the unique opportunity to examine the first empirical example of the causal effect of media narratives of economic uncertainty on birth rates. The crisis emerged due to the costs of the Great Recession weighing heavily on public expenditure, which in turn boosted government debts. Financial markets started doubting Italy's capability to ever repay its significant and increasing debt and asked for larger premiums to buy Italian bonds. The interest rate differential between Italy (risky Bot) and Germany (solid Bund), also known as the 'spread', represents—in our view—a marker of the uncertainty produced by the sovereign debt crisis. The record-high Bot/Bund spread level of 575 points in November 2011 elicited mass political instability in the country, culminating in Silvio Berlusconi's resignation as Prime Minister (12 November). In the media narrative, the term 'spread' acted as the historic barometer for the crisis. Many television programmes interviewed both and politicians and members of the public in the streets to ask about the definition of 'spread' (Ansa, 2011). We used Google searches for the term 'spread' to grasp the uncertainty spike and establish its impact on birth rates in Italy.

Figure 1 (top panel) shows the trend in the spread between the Italian and German bonds between 2005–2018 (solid line) and Italian birth rates—both deseasonalized (dash-dotted line) and not (dotted line). The graph shows that until early 2008, the differential between the cost of public debt in Italy and Germany was almost zero. The spread began a slow increase at the end of 2008, but only truly escalated in mid-2011, with the spread peaking first at the end of that year to a 5% differential and again in mid-2012 (although to a lower value).

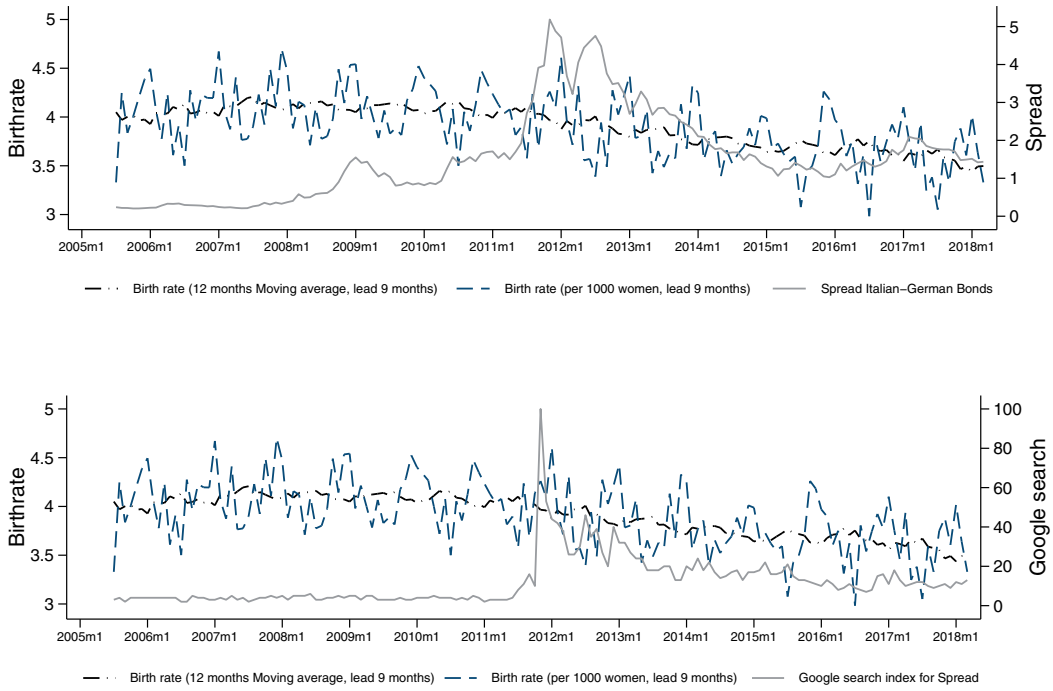

Figure 1:. Birth rates, spread, and Google queries for the term 'spread'. *Source*: Elaboration based on Eurostat, OECD, and Google data (2020).

This increase represents a crucial step in understanding the evolution of media representations of the crisis. Indeed, it was at this point that the spread became the major journalistic theme of the time—invading the daily media arena, regardless of press and television information and infotainment (Cepernich, 2012). The term 'spread' became the main media buzzword. Although birth rates appear to have begun their decline before the sovereign debt crisis' peak at the end of 2011, the downturn accelerated after this point.

Google Searches and Issue Salience

A small, but expanding, body of research has been exploring the socioeconomic and demographic implications of the growing diffusion and use of the internet. Part of this literature has investigated the meaning of web searches and their implications for individuals' decision-making processes. The main mechanism linking the two is information gathering: broadband availability and web searches reduce the cost of seeking information with respect to the more decentralized offline information markets (Guldi and Herbst, 2017). Between 2007 and 2017, Italian print newspaper readership declined from 67% to 35.8%. In the same period, households' expenses on print newspapers and books declined by 37% (CENSIS, 2018). In 2014, the share of Italians reading online newspapers and news-related websites stood at 20.8% and 34.3%, respectively (CENSIS, 2018).

The Google Trends (GT) tool was introduced by Google in the summer of 2008 to provide a public view into relative internet search volumes. GT provides a time-series index of the volume of queries entered into Google in a specific geographic area (Choi and Varian, 2012). The advantage of Google search activity data is that they visualize the demand for a wide range of information. They allow one to investigate combinations of space, time, and context related to many facets of human behaviour. Finally, the data are high in frequency and available in almost real-time. The drawbacks of these data are that they are available only in aggregate

form, and the methodology of collecting, sampling, and reporting it is largely untransparent. Moreover, the geographical distribution of the searches is not always precisely estimated since the IPs cannot always be properly located, and the meanings of certain terms may change over time and place (Askitas, 2015).

The use of search behaviour was popularized by Ginsberg *et al.* (2009) in their Google Flu article. GTs are mostly recognized as useful for measuring a topic's issue salience among the general public (Mellon, 2013, 2014) and for their 'tracking of real-life quantities' (Ojala et al., 2017). GTs have been used to track economic indicators, such as 'job searches' for unemployment in various countries, including Germany, Italy, and Spain (Choi and Varian, 2012; see Simionescu and Zimmermann, 2017 for a review). Mellon (2013) showed that, for Spain, despite low internet penetration rates, GT searches generate search data that closely match survey measures, especially for economic terms (Mellon, 2013: p. 289). Italy has a similar internet household coverage to Spain: in 2019, 84% of households in Italy and 91% in Spain had broadband access (Eurostat, 2020). Regarding fertility, searches for the term 'maternity' have proven useful in forecasting fertility, tracking temporal and spatial variation in fertility, and depicting the different contextual meanings of fertility (Ojala *et al.*, 2017; Billari *et al.*, 2019). As to the consequences of the Great Recession, Google queries for 'malaise' and 'symptoms' have been used to track the effects on health (Askitas and Zimmermann, 2015), and searches for 'hardship letter' in the United States have served as an indicator of mortgage delinquency to track the crisis' impacts on the housing market (Askitas and Zimmermann, 2011).

Figure 1 (bottom panel) shows that Google searches for the term 'spread'[1] peaked in Italy in November 2011. Before that time, searches for the term were approximately zero (a figure to which they have gradually returned to nowadays). The date of the maximum number of searches can identify when the Italian sovereign debt crisis was perceived to be most salient among the population. The latter can be used to investigate the effects of the media narrative of uncertainty on birth rates by investigating what happened in the nine months after the peak.

Data and Measures

We calculated national and regional crude birth rates for 2005–2018 from the Italian National Institute of Statistics (ISTAT) as the ratio between live births per month and the number of women aged 15–44 residing in Italy on 1st January of each year. We derived monthly data from complete national vital statistics on births. At the regional level ($N = 20$), monthly live births were divided by the number of women aged 15–44 resident in the region on 1st January every year. Birth rates (per 1,000 women) were de-seasonalized using a centred 12-month moving average (each point in time is the average of the preceding, and following, 6 months). In this way, the expected birth rate captures long-term trends rather than seasonal noise,[2] without imposing a specific shape of the seasonal pattern across calendar months (Seiver, 1985; Bernal *et al.*, 2017). Our robustness checks (Supplementary Appendix SB) show the results obtained using an alternative smoothing method (X12ARIMA)[3]. Finally, birth rates are led by 9 months.

GT data (for a description of how data are collected and released, see Askitas, 2015) represent the searches for the word 'spread' in www.google.it. The values represent search interest *relative* to the highest point in a given region and time $\left[\frac{Searches}{Maximum} * 100\right]$. A value of 100 is the peak popularity for the term, 50 means that the term is half as popular, and a score of 0 means that there was insufficient data for this term. To roughly assess the *absolute* magnitude of the searches, we considered the change in popularity of the term 'spread' over 2006–2016 in Italy relative to searches for highly common terms used in Italy to inquire about football: '*Serie A*' (A League), '*Campionato*' (Championship), and '*UEFA Champions League*'. Until 2010, the queries for 'spread' were null compared to any of the above three terms. In 2012, the queries for 'spread' became almost 100 times greater than queries for '*UEFA Champions League*', 60 times greater than '*Campionato*', and 15 times greater than '*Serie A*'—though it should be noted that these queries gradually declined in subsequent years.

The system eliminates repeated queries from a single user over a short time period, so that the level of interest is not artificially affected by these types of searches (e.g. typographical errors). Complements—namely searches for the term 'spread' in non-related words (e.g. 'Spread Eagle', US band; 'Spreadsheet', Excel; 'Spread Shirt', clothes printing online shop)—have been removed. The national-level GTs used in this analysis are robust to related search categories, including 'All Categories', 'Finance', and 'People and Society'; meanwhile, as expected, the trend values differed in non-related categories (e.g. 'Food and Drinks'). Our estimates are also robust depending on whether the search was conducted in either a web or news search. A related event to the burst of the Italian sovereign debt crisis was the resignation of Prime Minister Berlusconi, which also occurred in

November 2011. Predictably, searches for the term '*dimissioni Berlusconi*' (Berlusconi resignation) peaked at the same time in the Google's 'News' category search. However, the query was not so prevalent as that of 'spread' when we consider the general category. The top 25 related searches to 'spread' suggest that the queries were not dominated by individuals looking for the definition of the term, but rather mostly seeking to read about its trend. The search for '*significato spread*' (spread meaning) came only in 21st place in the related searches, while the most common were '*spread btp*' (BTP refers to *Buoni del Tesoro Poliennali*, the Italian sovereign bonds), '*oggi spread*' (spread today), and searches linked to the term '*borsa*' (Italian stock exchange) or German bonds ('*spread bund btp*').

Geo-localization allows us to identify the exact popularity of the query for 'spread' in more specific locations during the specified time frame. As in the case of country-level data, a higher GT value means a higher proportion of all queries, not a higher absolute query count. A key limitation with GT at a regional level is data sparsity—which is to say that, in a location where there are few data for queries on this term, GTs are zeros. When modelling temporal variations at the regional level, GT fails to provide any data in 788/3,060 (25.75%) of cases due to there being insufficient queries in those region/month combinations (reported as missing data in the GT variable). For this reason, both national and regional estimates are presented here.

The treatment variable is a dummy for the months after the peak in searches (1 after GT = 100). It is worth noting that, although the treatment dummy in the model was allowed to differ by region, for the period from July 2005 to March 2018, the peak in GT was registered in November 2011 in almost all regions. The only three exceptions were Molise, where the peak in GT queries for 'spread' took place in December 2011, and Val d'Aosta and Basilicata, which registered the peak in March and September 2012, respectively. These are the three least populated regions in Italy and also the regions registering the lowest absolute count of queries. For these regions, in 85, 90, and 110 out of 153 time points per region, the values of the GT queries were missing in Basilicata, Molise, and Val d'Aosta, respectively. Given this large measurement error, we decided to drop these three regions from our main analysis (their inclusion, however, does not alter the main findings).

Research Design

Non-experimental data pose many challenges to distinguishing between correlation and causation (Angrist and Krueger, 2000). Regression discontinuity (RD) is one strategy with which to identify the causal effect of a treatment using observational data. The treatment is based on being either above or below a certain threshold of a 'forcing' variable, such as a location, birthdate, or time. The identifying assumption is that units just above or below the threshold for treatment assignment do not systematically differ in their unobservable characteristics, thereby offering a valuable counterfactual comparison between the control and treatment groups (Calonico *et al.*, 2017).

When, as in the present case, time is the forcing variable, the design represents a particular case of RD, called a Regression Discontinuity in Time (RDiT). One advantage of using RDiT in contrast to event studies (Bernal *et al.*, 2017) is that it is not necessary to assume that there are no unobservable variables correlated with time; it is enough to assume—with the caveats expressed below—that the latter do not change discontinuously at the threshold (Davis, 2008; Hausman and Rapson, 2018). The cross-sectional vs time-series nature of the data represents the first difference between RD and RDiT. In a cross-sectional RD, one needs a large enough sample (N) in the neighbourhood of the cut-off. In an RDiT, however, there is little or no cross-sectional variation. This could be problematic in light of bias or precision trade-off, as the sample size increases away from the cut-off by increasing T instead of N. Researchers rely on observations away from the threshold in order to obtain the sufficient power with which to precisely estimate the coefficient which 'represents a substantial conceptual departure from the identifying assumption used [in] a cross-sectional RD' (Hausman and Rapson, 2018: 535). Therefore, if unobservable confounders or time-series properties are not correctly addressed, estimates could be biased. Assuming continuity of unobservables at the threshold that are normally enough to ensure identification in standard RD is insufficient in RDiT. With the latter, three additional issues arise anticipation close to the threshold, time-series auto-regression, and short- vs. long-term effects of the treatment. While the last two issues are addressed later, regarding anticipation, Figure 2 shows that, from July 2011, the GT for 'spread' slowly increased (albeit with a blip in October 2011), just before the jump in November. Searches, however, remained between 1/10th and 1/5th of the

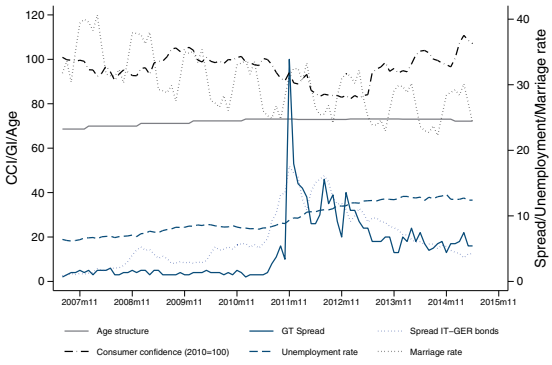

Figure 2:. Trends in potential confounders around the treatment date (GT Spread peak). *Source*: Elaboration based on Google Trends, OECD, Eurostat, and Istat data (2020).

November peak, thereby suggesting that the anticipation would not affect the estimates.

The identification assumption at the core of this article is that births which occurred approximately 9 months after the peak did not differ in terms of parents' unobservable characteristics, and the only unsmooth change at the cut-off was due to the sudden surge in the spread salience, namely in uncertainty. Figure 2 shows that, on the treatment date in November 2011, the jump was observed in the treatment only while other determinants of fertility—marriage rates, women's age structure, unemployment rates, and the consumer confidence index—were smooth on the threshold.

As mentioned above, RDiT is affected by a trade-off between precision and bias. The researcher typically aims to stay as close as possible to the cut-off but also seeks sufficient data points with which to obtain precise estimates. The assumed functional form of the relation also determines how close one can stay to the cut-off. If the underlying regression function of Y is fairly linear, the bandwidth can be enlarged to obtain more precise estimates without loss in terms of bias; however, if it is non-linear, the bandwidth should be restricted to obtain unbiased estimates. Since there is no prior knowledge for assuming that the functional form of the birth rates might be linear (local linear regression, Equation 1) rather than a polynomial of any degree (global polynomial estimation, Equation 2), we estimated the underlying regression function using both approaches[4], and varying the bandwidth between 3 years and 3 months around the cut-off ({-h, h} in Equation 1).

$$MA(Birth\ rate_{i,t+9}) = \gamma_0 + \gamma_1 D_t + \gamma_2 t + \gamma_3 D_t{*}t + X_t + u_i + \varepsilon_{it}\ \text{with} -h < t + h \text{and} i = 1, \ldots, N \quad (1)$$

$$MA(\ Birth\ rate_{i,t+9}) = \gamma_0 + \gamma_1 D_t + \gamma_2 t + \gamma_3 D_t{*}t + \sum_{k=2}^{P} \delta_k t^k + \sum_{k=2}^{P} \beta_k D_t{*}t^k + X_t + u_i + \varepsilon_{it}\ \text{with}\ i = 1, \ldots, N. \quad (2)$$

On the left-hand side, we have the 12-month moving average birth rate at time t (led by 9 months) for either Italy or each separate region i and, on the right-hand side, we have the continuous-time variable t *(year-month)*, centred around the cut-off date (0 in November 2011). D_t is the treatment dummy variable, for after November 2011 ($D = 1$ if $t \geq$ November 2011 and $D = 0$ if $t <$ November 2011), indicating the eventual departure from the trend occurring after the peak in GT 'spread'. Parameters are allowed to differ on the left (γ_2) and right (γ_3) of the cut-off. Otherwise, we would be using data on the right-hand side of the cut-off (treated units) to estimate the effect, which is inconsistent with the nature of RD. The main coefficient of interest, the jump at the cut-off, is γ_1. The polynomial time term in Equation 2 was added for the global polynomial estimation, conducted on the whole sample between July 2005 and March 2018 (with birth rates between April 2006 and December 2018)—a symmetrical period around the cut-off of November 2011. Finally, control variables were included in the term X_t, and the errors in both Equations (1) and (2) reflect the panel data structure of the regional data: u_i represent the region, i the unobserved time-invariant fixed effect, and ε_{it} the error term. To account for the autoregressive dependence in the residuals, standard errors were clustered for years in the national models, and in regional models they have been shown to be robust[5,6].

Results

Supplementary Table SA.1 in Appendix SA reports summary statistics of the variables used in the analyses before and after the cut-off at the national and regional level. After November 2011, Italy's demographic and economic outlook worsened: the average crude birth and marriage rates declined, and the spread on Italian bonds and the unemployment rate significantly increased. Figure 3 illustrates the RDiT plot of the

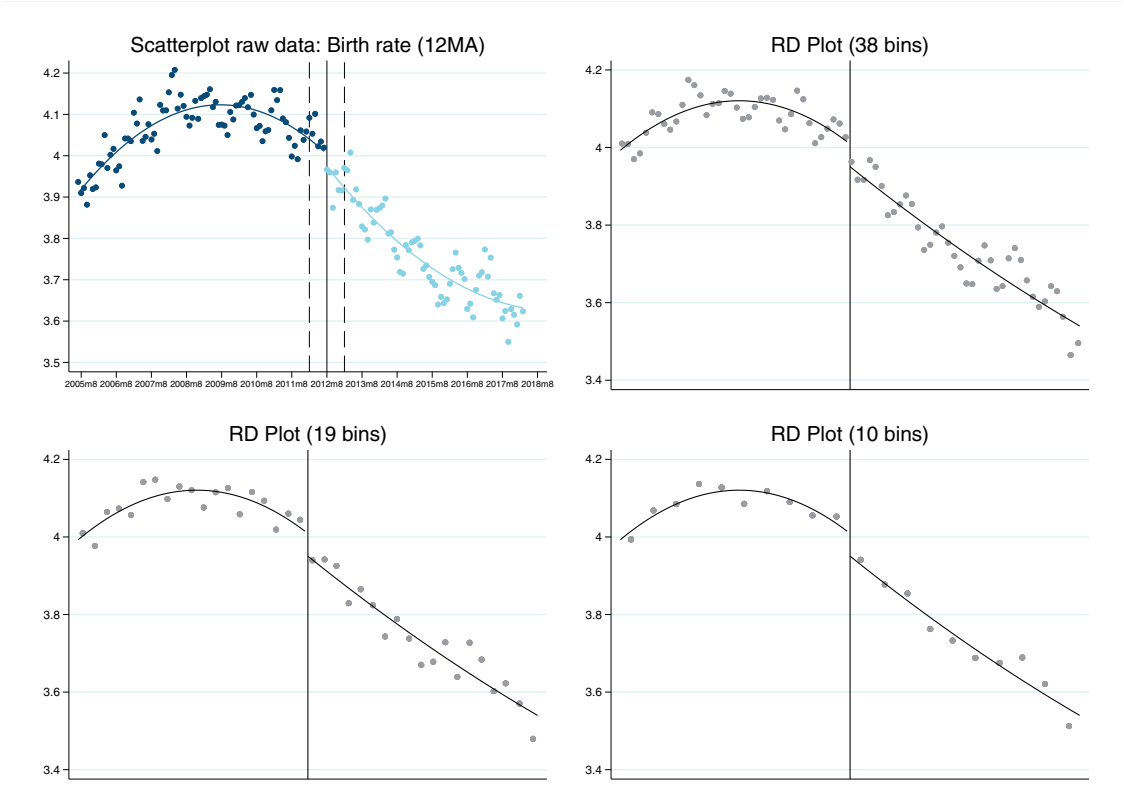

Figure 3:. RDiT plot of monthly birth rates varying the number of bins (national-level data). *Source*: Elaboration based on Istat data (2020).

monthly (moving average of) birth rates for Italy (national estimates). The top-left panel shows the scatterplot of the raw data where each dot represents the birth rate of 1 month ($N = 153$). The cut-off point (led by 9 months) is in August 2012, and the vertical dotted line indicates an example of a 6-month bandwidth. The other three panels depict the same plot, varying the width in which each bin is calculated and averaging the birth rate over a given number of months (two in the top-right, four in the bottom-left, and eight in the bottom-right panel). The figure illustrates the trade-off between the precision and unbiased nature of the estimate of the jump at the threshold. The more data we use, the more precise our estimates are, but the less evident the jump at the threshold is.

Figure 4 depicts the results of national (top panels) and regional (bottom panels) fixed effects estimates (results from cross-sectional models are qualitatively identical and available upon request) for the local linear (left panels) and global polynomial (right panels) RDiT of the effect of the GT spread peak on birth rates. All models control for the actual spread between Italian and German sovereign bonds[7] (models without controls, available upon request, present very similar estimates). The full models' estimates can be found in Supplementary Tables SA.2-5 in Appendix SA. For the local linear category, different estimates are reported by varying the bandwidth—through using either the whole symmetric sample or a bandwidth between 3 years and 3 months around the cut-off. For the global polynomial, different estimates are presented varying the degree of the polynomial between the linear and an eighth-order polynomial. Estimates range between −0.20 and −0.05, with more precise estimates resulting from the regional data models, as more observations (one for each region) are available at each point in time[8]. We clearly noted a robust negative effect of the uncertainty peak on birth rates. The Bayesian Information Criterion (BIC) suggests that the most useful models are the global linear or fourth-order global polynomial models for the national sample, and the three months bandwidth or second-order global polynomial models for the regional sample,

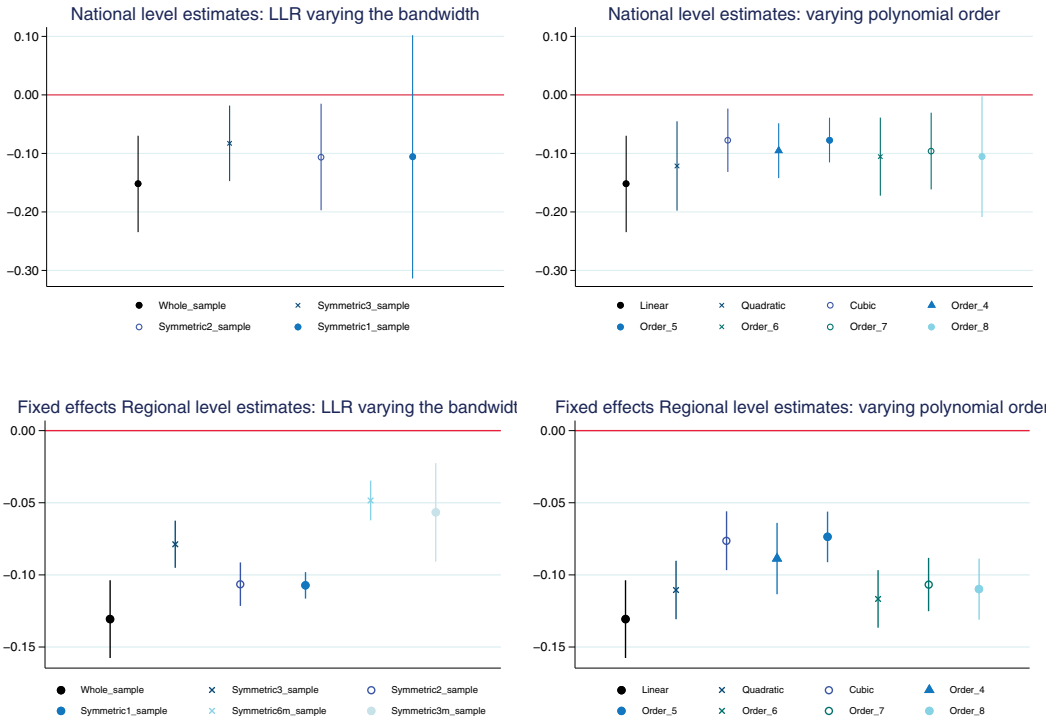

Figure 4:. GT spread peak effect on birth rates. National and regional data. Local linear regression and varying order global polynomial. *Source*: Elaboration based on Google Trends, OECD, and Istat data (2020). Note: Whole sample covers births between April 2006 and December 2018; Symmetric 3 year sample covers births between August 2009 and August 2015; Symmetric 2 year sample covers births between August 2010 and August 2014; Symmetric 1 year sample covers births between August 2011 and August 2013; Symmetric 6 months sample covers births between February 2012–February 2013; Symmetric 3 months sample covers births between May 2012 and November 2012. Global Polynomial models were run on the whole sample. Blank estimates have been omitted for collinearity. Standard errors were clustered by years in national models and robust in regional models. ***$P <$ 0.01, ** $P < 0.05$, * $P < 0.1$.

which indicate effects between −0.06 and −0.15. For instance, given an average rate of 4 monthly births per 1,000 women aged between 15 and 44 before the uncertainty increased, a drop between −0.06 and −0.15 in birth rate 9 months after the peak in GT for spread translates into a drop of between 1.5% and 3.75% in births due to the sovereign debt crisis.

Together with replicating results from GT resampled data (in March 2018, and June and October 2020), using both national and regional data levels, and RD alternative specifications (varying the bandwidth, and using both local linear and global polynomial estimates with various polynomial orders), we performed several extensive robustness checks (see Supplementary Appendix SB)—all of which corroborated our results. First, we re-estimated the models using an alternative smoothing method (X12-ARIMA) for the dependent variable, birth rates (Supplementary Tables SB.1–2). Second, we re-estimated the models including several additional control variables beyond the actual spread between Italian and German sovereign bonds used in the main analyses (Supplementary Tables SB.3–4): unemployment rate and consumer confidence index, women's age structure index, and GT index. To account for the diversity in internet access across Italy, we added a correction factor to the GT variable that weights the queries on the basis of a household's internet access by region. Finally, we performed two placebo tests using monthly marriage rates and changing the date of treatment. First, while marriage rates are likely to be negatively influenced by economic uncertainty, there is in fact no reason to expect a negative effect 9 months after

the shock, as is the case for childbearing (Supplementary Figure SB.1). Second, we did not find a period effect in dates when the uncertainty did not peak (Supplementary Figure SB.2). Indeed, our results are strongly supported by these placebo tests.

Concluding Discussion

The emergence of new forms of risk is a consequence of the rising levels of complexity in contemporary industrial societies (Beck, 1992). With globalization, liberalization, and labour market deregulation, the probability of experiencing recessions or negative outcomes—such as income drops, financial losses, unemployment or job precariousness, and downward mobility—have increased. As these new forms of risk have emerged in contemporary societies, some authors have argued that the risk framework is no longer sufficient for pinpointing the degree of unpredictability of events in contemporary society (Vignoli *et al.*, 2020a). The concept of uncertainty, as distinct from risk, highlights the condition of ignorance in which actors cannot predict the likelihood of their actions' outcomes (Knight, 1921). In this article, we have posited that the rising perception of uncertainty, also promulgated by the media's framing of the economic crisis (Vignoli *et al.*, 2020b), might have contributed to Europe's unexpected birth rate decline.

To provide evidence for the causal nexus between perceived economic uncertainty and birth rates, we have focused on Italy in the aftermath of its 2011 sovereign debt crisis. In a later phase of the Great Recession, some countries, such as Italy, suffered a loss of credibility in the financial market due to their skyrocketing public debts. Speculation on the country's inability to repay its debt, as well as the subsequent rise in the cost of the Italian debt, was so brutal that the financial crisis rapidly escalated into a political crisis so profound that the very permanence of Italy within the EU came into question. The spread between the cost of (risky) Italian and (safe) German bonds became a barometer of the country's financial uncertainty in the media narrative and everyday conversations (Ansa, 2011; Cepernich, 2012). The widespread use of the term 'spread' in the media's discourse expanded public concern about Italy's situation within the global crisis and raised general interest in the definition of 'spread' and its consequences. From positions of ignorance, people tend to more regularly seek out information (from wherever possible) concerning causes and effects (Coombs and Holladay, 2004). Indeed, the search queries for the term 'spread' suddenly spiked in November 2011 when, we argue, the salience of the crisis and the perceived uncertainty also reached its peak. We used this discontinuity to assess the consequences on birth rates in Italy 9 months after the peak.

Using national and regional monthly birth data from the ISTAT, we have demonstrated a drop in crude births rates of between 1.5% and 3.75% 9 months after the uncertainty shock in November 2011. In size, this is similar to the associational evidence found between unemployment rates and total fertility rates (−3%). Moreover, it is higher than the association between the decline in consumer confidence and total fertility rates (−1%) for both Europe and the United States (Comolli, 2017). This result comes from the most apt BIC selected models, but considering the average monthly rate of 4 births per 1,000 women aged 15–44 before the uncertainty peaked, some point estimates suggest a drop of approximately −0.2, which roughly translates into a 5% drop in births due to the sovereign debt crisis. We corroborated our results by robustness checks, such as with placebos on other dates and on marriage rates nine months after the shock, which, as expected, were unaffected by the uncertainty spike.

The present study is not without its limitations. First, as with many research designs seeking to identify the causal effect of events, RDiT favours internal validity at the expense of external validity. The question here is to what extent is the identified effect limited to the specific case of the Italian sovereign debt crisis. While we certainly believe (as supported by aforementioned past research) that the decline in fertility in other European countries is similarly associated to rising economic uncertainty, it would be difficult to apply this model to other contexts—not even in other Southern European countries, like Spain—where there has not been such an example of crucial media and public attention to a given issue, as in Italy with the spread. Moreover, other European countries that appear as natural counterpoints to Italy, such as Germany, witnessed (during the same period) highly different contextual factors that confound the relationship between social climate and childbearing behaviour—for instance, migration profiles and family policy changes. Second, as modelled in our specification, we assumed the treatment effect to be constant during the post-treatment period, meaning that the short- (9 months after the uncertainty peak) and long-term (7 years later) effects were equal. While we have no a priori reason to assume otherwise, this assumption cannot be tested and, if wrong, the global polynomial estimates would suffer from overfitting and bias (Hausman and Rapson, 2018). As such, we chose not to expand our coverage period to the more recent years available (2019–2020). The robustness of our results to different polynomial orders and local linear bandwidths,

however, makes us confident about the reliability of our estimates. The estimates of a 1.5–3.75% drop in birth rates represent a short-term impact (approximately) 9 months after the shock. What we observed is thus a postponement of childbearing. Whether this postponement produced long-term or even permanent effects remains to be seen. A third limitation concerns the separation between the strictly monetary component of debt and its value as an indicator of perceived uncertainty. A decline in the share of public debt owned by private Italian citizens was indeed registered in the aftermath of the crisis (21% in 2011 and 6% in 2018). However, previous studies have shown that the meaning of debt transcends its monetary aspect, with an excess of debt being both problematic and stressful to individuals and societies (Nau, Dwyer and Hodson, 2015). A final concern is that, despite mounting evidence as to the usefulness of internet search data and the considerable number of studies confident in their reliability—at least in predicting macroeconomic indicators—their use as a measure of media-promoted economic uncertainty is a novelty, and further research along this line is needed.

Despite these limitations, the current study proposes an innovative framework with which to investigate the link between perceived economic uncertainty and childbearing. Prior research has hinted at a causal nexus but has often failed to provide direct evidence for this causation. We have been able to show that the general public responds to the media's framing of uncertainty by, in our case, suddenly searching on Google.it for information regarding the media-identified source(s) of economic uncertainty. The Italian sovereign debt crisis in Italy served as a natural experiment that provided us with the first evidence that this general concern produced a reduction in births.

Our study offers implications for future research. First, methodologically, we integrated traditional and unconventional sources of data within a solid methodological framework so as to study fertility behaviour and 'improve the predictive power of demographic models' (Billari and Zagheni, 2017: 7–8). Second, we have advanced the importance of uncertainty perceptions for future research into fertility. The level of economic uncertainty narrated in the press and social media is likely correlated with underlying levels of unemployment and foreclosures within a particular region, but it is distinct in terms of drawing attention to said economic indicators. In order to advance our understanding of the topic, it would be crucial to analyse whether public discourses on crises affect childbearing plans above and beyond the effects of more objective measures, such as GDP or unemployment rates (Vignoli *et al.*, 2020b). It will also be interesting to consider whether there exist any links between indicators of media-channelled uncertainty and macroeconomic trends. This perspective might shed new light on Europe's contemporary 'great fertility recession'.

Supplementary Data

Supplementary data are available at *ESR* online.

Endnotes

1 The term 'spread' is typically untranslated by Italian media.

2 The strong seasonal variation could confound the period effect of the sovereign debt crisis when comparing changes in birth rates across different months and functional forms.

3 Our reasons for using the 12 months moving average in our main analyses are twofold. First, methods like X12ARIMA for seasonal adjustment are predominantly adopted to smooth time series with more available observations. Second, we wanted to ensure the comparability of our findings with existing studies, and most of the sociology, demography, and epidemiology studies on the determinants of fertility rates use the 12 months moving average. A discussion of the different time series smoothing techniques goes beyond the scope of this paper, however, interested readers can refer to Rodgers, John Coleman (2005: 683) for a list of references on the topic.

4 Lee and Lemieux (2010) mention polynomial functions as a simple way of relaxing the linearity assumption. However, others recommend avoiding third or higher order polynomials in regression discontinuity. Gelman and Imbens (2018) argue that higher order polynomials lead to noisy estimates sensitive to the degree of the polynomial and poor confidence intervals, and that local linear, or local quadratic estimates, should be preferred (Gelman and Imbens, 2018: 448).

5 We conducted additional checks using an AR(1) process.

6 A rectangular kernel—where observations are not weighted depending on their distance from the cut-off—is typically preferred to a triangular kernel function as the latter approach is more arbitrary regarding the choice of the weights (Lee and Lemieux, 2010).

7 The rise in the spread is not smooth at the threshold (Figure 2); moreover, the spread is the underling variable explaining the increase in searches and,

contrary to the GT index itself, displays enough variation across time and has fewer missing values.

8 Additional results simultaneously varying the order of the polynomial and reducing the bandwidth display similar coefficients, and are available upon request.

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