The Effects of Natural Disasters and Economic Volatility on Fertility

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Preliminary—Comments Welcome

Abstract

This paper examines whether economic or environmental instability affects fertility. My identification strategy uses regional data to exploit the natural variation within each of the two countries I examine: one European country—Italy—and one Asian country—Japan. I use the variance of the detrended wage to measure economic volatility; the crude birth rate to measure demographic risk; and the number and magnitudes of natural disasters to measure environmental instability. According to my results, natural disasters have a significant negative effect on fertility in both countries, while mortality risk and economic volatility have significant negative effects in Italy but no effect in Japan. Thus, instability, particularly that arising from the natural environment, appears to cause a decrease in fertility.

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1 Introduction

The dynamic relationships between population and the economy have been of interest to economists at least since the time of Malthus' pioneering work in the late eighteenth century (see e.g. NBER, 1960; Lindahl-Kiessling & Landberg, 1994; and Schofield & Wrigley, 1985). Among the reasons for such sustained interest in dynamic demographic-economic relationships are their important implications for understanding past, current and future economic development.

Although the economic theory of population growth has focused primary on the extent to which wages and vital rates exert influence on each other, it is possible that economic and environmental instability would affect steady-state dynamic demographic-economic relationships as well. Individuals behave differently under conditions of risk and uncertainty than they do under conditions of perfect certitude. For example, ample empirical evidence suggests that household-level income volatility leads to lower investment in both physical and human capital at the micro level, and that country-level economic volatility leads to lower government spending and lower mean growth at the macro level (Blattman, Hwang & Williamson, 2004, & references therein). In a similar fashion, sources of instability are likely to affect fertility decisions as well. According to Cain (1983): "If people are motivated by a principle of safety-first, [their fertility behavior] may be influenced less by *average* mortality experience than by variance in that experience, and particularly the tail of the distribution that contains the worst records" (p. 698).

The purpose of this paper is to expand upon the existing literature on population and the economy by examining whether economic or environmental instability affects fertility. My identification strategy uses regional data to exploit the natural variation within each of the two countries I examine: one European country—Italy—and one Asian country—Japan. I use the variance of the detrended wage to measure economic volatility; the crude birth rate to measure demographic risk; and the number and magnitudes of natural disasters to measure environmental instability.

Studies of the effects of instability on population growth are important for several reasons. First, they may enable economists to better understand the sources of the global income inequality. For instance, Jones (1981) makes the bold claim that differences in Asian and European population growth and income prior to the Industrial Revolution were due to the fertility response to different risk profiles; because Asia experienced more natural disasters, its population growth rate was higher and, as a result, its income was lower. A second reason why research on the effects of environmental variability on population growth is important is that it may enable economists and environmentalists alike to better predict the potential effects of the elevated climatic instability that may result from global climate change. Third, if population size affects the living standard, then an understanding of all the factors influencing population growth, including environmental ones, is essential.

The research question I hope to answer is the following: *How do natural disasters and economic volatility affect fertility?*

According to my results, natural disasters have a significant negative effect on fertility in both Italy and Japan, while mortality risk and economic volatility have significant negative effects in Italy but no effect in Japan. Thus, instability, particularly that arising from the natural environment, appears to cause a decrease in fertility.

The balance of this paper is as follows. In Section 2, I survey the relevant literature. Section 3 describes the mechanism through which economic, demographic and environmental facts may affect fertility. I present my data set in Section 4. Section 5 analyzes the components of fertility. I describe my estimation methodology in Section 6 and present my results in Section 7. Section 8 concludes.

2 Previous Literature

2.1 Environmental effects on economic development

My research relates to several existing branches of literature. First, it draws upon the literature on the effects of the environment on economic development (see e.g. Diamond, 1997; Gallup, Sachs & Mellinger, 1999; and Sachs, 2001). In particular, my research is primarily motivated by Jones' (1981) provocative theory that preindustrial differences in income and population between Asia and Europe resulted from the fertility response to different risk profiles. According to Jones' theory, because Asians were faced with a more natural disaster-prone environment, they accumulated a population surplus as a form of demographic insurance against catastrophe; they therefore had a higher fertility rate, a higher marriage rate, and a lower age at marriage in steady-state than their European counterparts did. This strategy of family size maximization resulted in lower consumption levels, lower savings rate, less investment in human capital, and larger disparities in income in Asia than in Europe. Thus, according to Jones, preindustrial differences in environmental risk had dire consequences on social and economic inequality both within and between the two regions. Moreover, Jones claims, demographic choices were a result of the risk profile of the environment; if the risk profile were to change, then the choices would change as well.

To support his theory, Jones provides empirical evidence on the effects and incidence of preindustrial disasters. He finds that severe natural disasters, whether geophysical, climatic or biological, were more frequent in Asia than in Europe. As a consequence, Europe suffered smaller overall losses from natural disasters than Asia did. Moreover, while the shocks in Europe had a less destructive impact on capital than on labor, those in Asia destroyed capital and labor more equally.

My research addresses two main flaws in Jones' work. The first flaw is that he does not account for the endogeneity of natural disaster damage. The death toll from a disaster is a function not only of the magnitude of the disaster itself, but also of the number of people living in the area and of the nature and state of the area's capital stock: both of the latter factors are subject to human agency and therefore potentially endogenous. As Jones himself admits, the incidence and effects of a disaster are

> functions of the technological specifications in which they occur and the social and economic systems which play host to them. They are not, in truth, completely exogenous acts of God divorced from the choices made by man. For example, the density of human populations, their income level and social organisation [sic], the crops they grow and the animals they keep, all affect the degree of vulnerability to particular shocks, and the impact they will have (Jones, 1981, p. 22).

For example, owing to a larger population density, Asians did not economize on human life during war, and as, a consequence, lost more lives to warfare than did Europe (Jones, 1981, pp. 36-37). Similarly, the differential impact of social disasters on capital between Asia and Europe was due to the different forms of capital in the two regions. While Asian capital consisted of irrigation agriculture that required a large amount of organizational effort to restore, European capital goods were atomistic and could be recovered by local initiative (Jones, 1981, pp. 37-38). Because capital was thus more vulnerable to social disasters in Asia than in Europe, Asian capital suffered more from these disasters. On the other hand, because they adapted to their warm, wet climate, Asians may have been less vulnerable to diseases endemic in Asia than were Europeans (Jones, 1981, p. 7). Catastrophic risk therefore depends in part on social, technological and demographic factors, some of which may be endogenous to the risk itself.

The empirical evidence Jones presents on the effects and incidence of disasters does not provide a sufficient test of his theory that the higher fertility rates in preindustrial Asia were a response to a more disaster-prone environment. The data on the higher frequency and severity of geophysical, climatic and biological disasters in Asia that he presents in Chapter 2 of his book at best demonstrates a correlation between the risk of catastrophe and population growth, but not causality. In particular, fertility rates, which he claims were affected by environmental instability, may have in turn affected the incidence and effects of a disaster. There is thus an omitted variable, human agency, which affects both natural disaster damage and fertility. Thus, while Jones may have demonstrated that natural disaster damage was associated with higher fertility rates, he did not prove that it was their cause.

In contrast to Jones, who uses potentially endogenous measures of disaster risk, I use measures that are exogenous: the number and geophysical magnitude of disasters, neither of which are affected by fertility.

In addition to the endogeneity of disaster damage, the second major flaw with Jones' work is that he often uses figures from different centuries to compare Europe with Asia. For example, to support his claim that Asian society was more unequal, he merely compared the percent of non-producers in China in the 1880s with the percent of non-peasants in France, Germany and Britain in the fourteenth century (p. 4). Without an explanation of the trends in inequality in the intervening five hundred years, such data is insufficient evidence for his claim. Similarly, in comparing marriage rates, he uses European data from the 1750s but Indian data from the 1930s (p. 17). Data from different time periods are not comparable and thus provide misleading evidence for his claims. In contrast, my data set for Italy spans from 1771 to 1988, while that for Japan spans 1671 to 1965.[2]

2.2 Population homeostasis and Malthusian checks

In addition to Jones' work, a second line of literature that relates to my work is that on the economic theory of population growth. Classical economic theory predicts that in the long run, population size is determined by the demand for labor; population growth, in turn, depresses economic well-being. As a result, population is homeostatic: that is, it automatically tends toward some equilibrium (R. Lee, 1985; J. Lee & Wang, 1999). This economic theory of population growth suffers from several flaws, however. First, while it may describe trends in population and income over millennia, it is likely to do less well in explaining dynamics over shorter periods of time. In this paper I thus attempt to test this theory using a model at the time scale of decennia rather than

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[2] These dates refer to the earliest and latest observation collected for each country. Owing to limited data availability, most of my regressions are limited to a shorter time period. However, in contrast to Jones' data for Europe and Asia, which were centuries apart, the data used in my regressions still have several decades of overlap between Italy and Japan.

millennia.[3] Second, this theory does not account for the many other factors that could affect vital rates, including those that are political, social, climatic, medical, and ecological in nature (R. Lee, 1985). As a step toward this end, I examine the effects of an ecological factor—natural disasters—on fertility rates. Third, this theory ignores the potential role for variability, both economic and environmental, in the demographic-economic system. I attempt to address this problem by studying the effects not only of environmental instability but also income variability. It is possible that the instability of a region affects its steady-state demographic-economic relationship. A fourth flaw with this theory is that it is agnostic on the proper geographic scale of the system. Whether the theory applies to national or more local levels, or both, is unclear. In this study, I look at the determinants of fertility at both levels. Fifth, the theory of population homeostasis is more likely to apply to pre-industrial economies than post-industrial ones. In this study, I use both pre- and post-industrial data from Italy and Japan, in a step toward developing a theory that better integrates these two periods of economic and demographic development.

A sixth major flaw with the classical economic theory on population growth is that it does poorly in describing non-Western population dynamics. Malthusian theory posits two types of checks on population growth: a preventative check, in which fertility is controlled by customs and institutions preventing the birth of children; and a positive check, in which population size is regulated by mortality. According to Malthus, modern European societies were characterized by the former, while non-European or non-modern societies were dominated by the latter (J. Lee & Wang, 1999). The classical theory of population homeostasis thus applied to Europe, where fertility rates were responsive to economic conditions, but not to Asia, where fertility rates were high and uncontrolled.

The failure of the classical economic theory to describe Asian population growth may be due to reasons other than those proposed by Malthus, however: recent work has suggested that Malthus' depiction of Asia may have been wrong because it fails to account for forms of preventative check other than the delay of marriage that may occur in non-European societies. For example, the research of J. Lee and Wang (1999) on China has shown that while the age at marriage of women, the channel through which the preventative check operated in Europe, was indeed low and relatively unresponsive to economic conditions, the age at marriage of men was high owing to a gender-unbalanced marriage market. Moreover, although they did not restrict marriage as their European counterparts did, the Qing nobility did regulate fertility within marriage through "a combination of late starting, early stopping, and—most significantly—long spacing" (Wang, J. Lee & Campbell, 1995, p. 400). Thus,

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[3] Ideally, of course, I would have annual or decennial data over millennia; such data would enable me to test the theory at all time

differences in marriage behavior between men and women and restriction of fertility within marriage were two aspects of preventative checks that Malthus ignores. In my paper, I examine not only fertility but also its constituent components of marital fertility, non-marital fertility, and marital status.[4]

Although Malthus' depiction of Asia may have been inaccurate, he may still be correct in his assertion that the classical economic theory of population growth does not apply to non-Western societies. Rather than dismiss the entire non-Western world as an exception, or vice versa, economists need to develop a unified theory that better captures the experiences of all human societies. As a step toward this end, my research examines and compares both a European country and an Asian one.

2.3 Empirical models of demographic change

My research also draws upon the econometric model of demographic change developed by R. Lee (1973) and later modified by Stavins (1988). Lee (1973) designed his model to enable testing of three stylized theories of demographic change: (1) the constant equilibrium wage theory, in which fertility adjusts automatically to mortality so that population change is a function of the real wage; (2) the constant fertility theory, in which population change is due to mortality alone; and (3) his synthesis theory in which fertility responded to the wage but not to mortality. This general model is given by the following system of equations:

$$cbr = \mu + \alpha \ln(w) + \lambda \, cdr \tag{1}$$

$$w = \eta \, pop^{-\beta} \tag{2}$$

$$pop\_gr \equiv cbr - cdr , \tag{3}$$

where *cbr* is the crude birth rate, *w* is the real wage, *cdr* is the crude death rate, *pop* is the population level, and *pop_gr* is the population growth rate. Using 50-year averages of data on population levels, crude death rates and

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scales. Unfortunately, I have yet to find such data.

[4] A second flaw with Malthus' theory is that it fails to account for the possibility that, as with preventative checks, positive checks may be subject to human agency. According to Malthus, positive checks were such random and exogenous sources of mortality as war, famine and disease. However, as explained earlier, the effects of such shocks on mortality may be endogenous to human behavior. Moreover, not only can human agency affect the responses to exogenous shocks, but it can also create its own forms of positive checks as well. For example, excess female mortality, defined as the mortality of females due to gender equities in the access to survival-related resources and opportunities, exists in many countries in both Europe and Asia (Klasen, 2002). Because these gender equities arise from human agency, not from exogenous stochastic shocks, the excess female mortality that results from them are thus human-induced types of positive checks. At its most extreme form, this type of positive check is manifested in female infanticide, a practice that is prevalent in such countries as China (J. Lee, Feng & Campbell, 1994; Lee & Wang, 1999). Thus, Malthus fails to account both for different forms of preventative checks as well as for the role of human agency in positive checks.

real wages for England over the period 1250 to 1700, Lee rejects the constant equilibrium wage theory and the constant fertility theory and accepts his own synthesis theory.

Stavins (1988) expanded Lee's model to account for exogenous technological change and for endogenous migration in order to test a fourth composite theory in which fertility does not respond to either the wage or mortality, and in which technological change causes shifts in the labor demand function. His expanded model is given by the following system of equations:

$$cbr = \mu + \alpha \ln(w) + \pi \ln(w\_m1) + \lambda \, cdr \qquad (4)$$

$$net\_immig = - \ln(\gamma) - \rho \ln(w\_m1) \qquad (5)$$

$$w = \eta \, pop^{-\beta} e^{\delta \, urban} \qquad (6)$$

$$pop\_gr \equiv cbr - cdr + net\_immig \ . \qquad (7)$$

where w_m1 is the lagged real wage, net_immig is the net immigration rate, and $urban$ is the degree of urbanization, which he defines as the percentage of the English population residing in urban areas of population 10,000 or greater. Using 25-year averages of data on population levels, crude death rates, real wages, net out-migration, and urban portion for England over the period 1573 to 1873, Stavins finds that, of the four theories, his composite theory provides the best explanation of the observed pattern of English demographic change.

As the determinants of the crude birth rate appear to be a central focus of the Lee and Stavins models and the various theories they test, my work examines these determinants in more detail. In addition to the wage and the crude death rate, I include economic volatility and natural disasters as potential determinants of the crude birth rate. Second, to resolve the omitted variables bias problem that arises if both fertility and some of its determinants are trending over time, I include year as an additional regressor. Moreover, in addition to the crude birth rate, I examine some of the determinants of such components of fertility as marital fertility, non-marital fertility, and marital status.

Along with the detailed analysis of the crude birth rate equation presented in this paper, I also attempted to modify the structural models of Lee and Stavins to fit the experiences of Italy and of Japan. In my modified model, which I ran using both 2SLS and 3SLS, I added additional regressors such as time effects to the crude birth rate equation, the net immigration rate to the labor demand equation, and used a more credible set of instruments. I also corrected what appears to be an error in the equation they use to estimate labor demand.[5] However, as I was unable

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[5] The error in the labor demand equation used by both Lee and Stavins is as follows. Because their wage variables are centered half a time step behind population, wage w_t relates to the midpoint population size between lagged population from half a time

to identify the labor demand equation for either Italy or Japan, the results from the structural model are not reported here.

3 Determinants of Fertility

In this section, I describe the mechanisms through which economic, demographic and environmental factors may affect fertility.

The primary economic determinant I consider is income. There are several possible theories for how fertility may respond to wages. Malthusian theory predicts that wages should have a positive effect on fertility through its effect on increasing the marriage rate (Lee and Wang, 1999), perhaps because in Europe couples could not marry before they acquired an economic means of support (R. Lee, 1979). Another possible reason for a positive relationship between wages and fertility is the effect of nutrition on fecundity (R. Lee, 1985).

On the other hand, it is also possible for higher wages to have a negative effect on fertility. One reason why fertility may decrease with income is that higher wages diminish the need for children as a form of insurance. A second reason is that higher income levels may be associated with a stronger social custom against marriage. Third, when one's earnings in the labor market are high, then the opportunity cost of marriage and of raising children are high as well. Thus, economic theory does not make a definitive prediction on the sign of the effect of income on fertility. The net effect of income on fertility therefore becomes an empirical question best resolved with data.

In addition to income levels, a second economic factor that may affect fertility is economic volatility, as measured by the variance of the detrended wage. As with the level of the wage, economic theory does not make a

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step earlier $pop_{t-0.5}$ and the population size from half a time step later $pop_{t+0.5}$. Lee and later Stavins both suggest using the average of these two population sizes in the labor demand equation, which implies:

$$w_t = \eta\ [(pop_{t-0.5} + pop_{t+0.5})/2]^{-\beta}\ e^{\delta\ urban_t}.$$

Taking logs to enable linear estimation, one gets:

$$\ln(w_t) = \ln(\eta) - \beta \ln((pop_{t-0.5} + pop_{t+0.5})/2) + \delta\ urban_t$$

or

$$\ln(w_t) = \ln(\eta) - \beta\ [\ln(pop_{t-0.5} + pop_{t+0.5}) - \ln(2)] + \delta\ urban_t\ ,$$

but not the equation they use:

$$\ln(w_t) = \ln(\eta) - \beta/2 \ln(pop_{t-0.5} + pop_{t+0.5}) + \delta\ urban_t\ .$$

Moreover, aside from the confusion inherent in using wages and population levels centered on different years in estimating labor demand, the use of midpoint population size itself is potentially problematic. If the population growth rate is not constant within each time step—and, judging from their figures for population growth between time steps, population growth appears unlikely to be the constant—then the actual midpoint population is unlikely to be simply the average of the population definitive prediction about the direction of the effect of the variance of the wage on fertility,[6] and the issue can only be resolved with an empirical analysis.

The primary demographic factor I consider is the crude birth rate. There are three possible ways in which mortality can affect fertility. First, if couples desire to have a certain number of surviving children, then higher rates of infant and child mortality would induce higher levels of marital fertility, for parents would endeavor to replace the children they have lost. Second, in some pre-industrial populations, age at death of one's father would affect the timing of inheritance and therefore of one's marriage (Lee, 1973). Third, as with other forms of risk, mortality risk may affect individual behavior; for instance, parents may be more cautious about having a child if they do not believe they will live long enough to care for the child, or long enough to reap any potential old age insurance benefits from investing in children.

For environmental determinants of fertility, I use the number and magnitude of natural disasters. According to Jones (1981), who hypothesized that families living in a more natural disaster-prone environment would accumulate a population surplus as a form of demographic insurance against catastrophe, one would expect natural disasters to have a positive effect on fertility. However, it is also possible that environmental volatility may decrease fertility, perhaps because it makes individuals less willing to make the long-term investments required to raise a family. Thus, there are theories to support either sign of the effect of natural disasters on fertility, and which effect dominates therefore becomes an empirical matter.

Because one cannot appeal to economic theory alone to predict the direction of the net effects of the various determinants of fertility, one must conduct an empirical analysis in order to tease out the and quantify the net effect. I now turn towards describing the data I assembled to do just that.

4 Data Description and Summary Statistics

For this study, I use demographic, economic, and disaster data for Italy and Japan. Factors taken into consideration when choosing these two countries were the availability of data, the prevalence of natural disasters, and the need for a country each from Europe and Asia. The choice of natural disaster-prone Italy as my European

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levels at either end of the time step. To avoid these issues entirely, I used average wages centered at the same date of the population for each observation used in my estimation of the labor demand equation.

[6] Economic theory does have a definitive prediction about the effects of economic volatility on capital, however: it predicts that greater volatility will lower capital investment (Blattman et al., 2004).

country enables me to test Jones' (1981) theory that preindustrial Asian fertility behavior was a result of the natural environment, not of culture, and therefore that any other society subjected to the volatility of the Asian environment would have responded in a similar manner. Demographic data were compiled from various print sources (see Appendices A.1 to A.3) or extracted from the Princeton European Fertility Project online demographic data set (Treadway, 1980). These variables include such measures of fertility as crude birth rates, total marital fertility, mean household size, mean number of children per marriage,[7] the index of total fertility (*If*), the index of marital fertility (*Ig*), the index of non-marital fertility (*Ih*), the index of marital status (*Im*), and age at marriage.[8] They also include crude death rates.[9]

Annual real wage data were from Jeffrey Williamson: Italian wages were taken from Williamson (1995) while Japanese data were provided in digital form. This wage data was used to calculate variables for the variance of the detrended wage over the past 10 years (including the current year). The variance of the detrended wage was then divided by 1000 so that the magnitude of its coefficients in the various regressions would not be too small. I chose a decade as the time period over which to calculate variances because it seems reasonable to expect that individuals who are making choices about marriage and childbearing and their potential tradeoffs with their careers beginning in their early twenties[10] would be affected by the economic conditions they experienced in the recent decade. Whenever possible, all wage variables (including the variables calculated from the detrended wage) were averaged over the same years over which observations for the demographic dependent variable spanned in any given regression.[11] All averages were centered on the floor of the midpoint of the years covered in the average.

Daily natural disaster data on earthquakes, tsunamis and volcanos were taken from the National Geophysical Data Center web site (Dunbar, Lockridge & Whiteside, 1999; Lockridge, 1999; and Whiteside, 1999); data on other disasters were compiled from various print sources (see Appendices A.1 to A.3). From this raw data, I constructed variables for the number of each type of disaster over the past 20 years (including the current year) as well as for the sum of the geophysical magnitudes of all occurrences of earthquakes, tsunamis and volcanos over the

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[7] Though preliminary analyses were conducted using the mean household size and mean number of children per marriage to test whether families have a desired target number of children, their results are not presented in this paper.

[8] The fertility indices (If, Ig, Ih, Im) will be discussed in more detail in the next section.

[9] In a previous version of this paper, I also use data on other measures of mortality such as infant mortality rates and age-specific death rates.

[10] In my data set, the minimum mean age at marriage for females was 21.8 for Italy (Tables 1.1 and 1.2) and 22.9 for Japan (Table 1.3). For men in Italy, the minimum mean age at marriage is 27.1 (Table 1.1).

[11] Some of the original wage data for pre-industrial epochs has already been interpolated over several years.

past 20 years.[12] When multiple observations existed for any given disaster, an average of the magnitudes reported was taken. For a detailed description of all the data and their sources, see Appendices A.1 to A.3.

There are two main reasons why the time scales over which I calculate the variance of the detrended wage is different from that over which I sum the natural disaster data. The main reason was that the choice was governed by my prior expectations. I chose 20 years as the appropriate time scale for the natural disaster data because I wanted to approximate the risk environment experienced by an individual over the length of his or her conscious lifetime up to the time decisions about fertility are made; in contrast, the various functions of the detrended wage were calculated over 10 years because a decade approximates the *economic* lifetime of such an individual. Defined as the number of years to date that a given individual has lived during which he or she has been directly affected by wages and the labor market, an individual's economic lifetime is shorter than an individual's conscious lifetime because children are likely to become aware of any disasters such as earthquakes and volcanos they may experience before they are aware of wage levels and other labor market concerns. The second reason for these choices is data availability: while ample natural disaster data exists for at least several decades before any of my demographic data begins, the wage data does not extend that far back. Thus, requiring the use of wage data for the past twenty years would limit the number of observations available for my regressions.[13]

Table 1.1 presents summary statistics and trends for the national data for Italy. Both crude birth rates and crude death rates have downward trends that are significant at a 5% level;[14] in contrast, the population growth rate does not have any significant trend. The indices of total, marital, and non-marital fertility all have significant negative trends. Although the mean ages at first marriage for both males and females have significant upward trends, the index of marital status has no trend.

Regional data for Italy were compiled at the level of a region. There are 18 regions in Italy; following del Panta (1979), these regions can be grouped into 5 geographical areas: Northwest, Northeast, Center, South, and

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[12] The magnitudes reported for tsunamis and for volcano eruptions are incremented by 2 and 1, respectively, so that the minimum magnitude is 1, not -1 or 0. This enables 0 to denote no disaster. Since the minimum values for both the magnitude and the intensity of an earthquake are already larger than 0, no such adjustment is needed for them. For the earthquake data, while some records report both the earthquake magnitude and the earthquake intensity, others report only one. Whether I use earthquake magnitude or earthquake intensity as my measure of the severity of the earthquake depends on which variable has more observations for that country. When an earthquake occurs but either the magnitude or the intensity is not reported, then this value is coded as missing, not 0.

[13] A possible extension of this paper would investigate the effects of using data from the past 5, 10 and 20 years, respectively, for calculating these wage and disaster variables.

[14] Unless specified otherwise, "significant" will mean "significant at a 5% level" when used to describe trends and coefficients throughout this paper.

Islands.[15] I contract a panel using data from all 18 regions spanning the years 1771 to 1988. While measures of fertility were available at the region level, the measures of mortality I compiled were at the level of the geographical area.[16] Thus, for each geographical area, the area's values for the crude birth rates were used for all regions in the area. The same national Italian wage data, which reflects mainly the wage in Northern Italy, was applied to all regions. Volcano data were matched to the region in which the volcano was located. All other natural disaster data were matched to the region based on the location(s) named in the source, or, when I am unable to locate the location name in any region, on the latitudes and longitudes given. Disasters that occur in areas larger than a region are assumed to strike all regions in that area; disasters that occur in areas smaller than a region are assumed to affect the entire region.

Table 1.2 summaries the data and trends for the Italian regions. Trends are reported for the variables both before and after the geographical area-level and national-level variables were merged with the region-level data.[17] Trends are also reported for the post-merging variables after controlling for region effects; these trends are meant to assess whether omitted variables bias might be a concern if year is not added to regressions that already include region dummies. As with the national Italian data, the regional data for the crude birth rates and all the various indices of fertility except that for marital status have significant negative trends even after controlling for region effects.[18] Also consistent with national trends, the mean age at first marriage of females has a significant upward trend. Both the number and the sum of the magnitudes of earthquakes and volcanos have significant upward trends. There is no trend in the number of avalanches/landslides and in severe lightning storms, but there is a significant increase in the number of floods. For the geographical area-level variables, both the crude death rate and the infant mortality rate have significant downward trends even after adding region controls, as was the case with the national data.

Two types of regional data for Japan were compiled. The first were data from 13 *mura* (villages), one *shi* (city) and one *han* (domain), most of which were from preindustrial time periods. The second type of Japan regional

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[15] The regions can also be subdivided into 92 provinces of Italy. As a possible extension to my study, I could use repeat my analyses using provincial data.

[16] The few figures I did find for regional crude death rates covered only 7 regions with only 2 to 6 observations each (del Panta, 1979, p. 226). Moreover, periods of major crises were excluded from this data; such an exclusion would bias my results. Another alternative would be to calculate regional averages from the provincial crude death rates reported in Hoffman (1981). I chose not to do so for this present study because the provincial data covered fewer time intervals than the geographical data did (5 per province as opposed to 9 per geographical area). An extension of my paper would use this provincial data for analyses at both regional and provincial levels.

[17] These two trends are the same for all variables already at the region level.

data was that at the prefecture level. There are 47 prefectures in Japan;[19] following Taeuber (1958), these prefectures can be grouped into 11 regions. I have data for all prefectures for the period 1919-1955, with the exception of Okinawa, for which no data was available after 1945, when it came under United States occupation (Taeuber, 1958). Each of the villages and the city from the first regional data set can be matched to a prefecture; the one domain, Morioka, covers two prefectures (Iwate and Aomori), both of which are located in the same region. For lack of a better term, I call the level at which an observation applies—whether it be a village, city, domain, or prefecture—a "place". Regressions run on the first, non-prefecture, data set include place fixed effects. Since for the second data set a place is the same as a prefecture, regressions run using this data set include prefecture fixed effects.

The same national Japanese wage data were applied to all places; the data were constructed by Jeffrey Williamson from pre-1930 wage data for Kyoto and Kamikawarabayashi (near Osaka) and post-1930 wage data for Tokyo. Volcano data were matched to the prefecture in which the volcano was located. All other natural disaster data were matched to the prefecture based on the location(s) named in the source, or, when I am unable to locate the location name in any prefecture, on the latitudes and longitudes given. Disasters that occur in areas larger than a prefecture are assumed to strike all prefectures in that area; disasters that occur in areas smaller than a prefecture are assumed to affect the entire prefecture. All the places from the first regional data set are assumed to be affected by the disasters matched to the prefecture(s) in which they are located.

Table 1.3 presents the summary statistics and trends for the regional Japanese data. For the non-prefecture data, neither the crude birth rate nor the mean age at first marriage of females has a significant trend either with or without place controls. Although crude death rates have a significant positive trend, this trend is no longer significant once place fixed effects are included. Both the numbers and the sum of the magnitudes of earthquakes, tsunamis and volcano eruptions have significant upward trends; the number of cyclones or typhoons does not. Both the wage and the variance in the detrended wage have significant positive trends. For the prefecture-level data, crude birth rates and crude death rates both have significant negative trends. With the exception the number of cyclones and typhoons, which only has a significant trend when prefecture fixed effects are added, all the disaster

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[18] Unlike in the national data, the index of marital status (*Im*) has a significant negative trend when region effects are not controlled for.

[19] This includes the prefecture of Okinawa, which came under United States occupation in 1945 (Taeuber, 1958).

variables have significant upward trends both with and without prefecture controls. Wage and the variance in the detrended wage both have significant upward trends.

Having summarized my data, I now analyze the components of fertility in more detail.

5 Components of fertility

As alluded to above, the crude birth rate is affected by several different forms of fertility, including the age at marriage, marital fertility, non-marital fertility, and marital status. As measures of total fertility and its constituent components, demographers have developed indices of total fertility (If), marital fertility (Ig), non-marital (illegitimate) fertility (Ih), and marital status (Im). If is defined as the ratio of the number of births the women in a given population actually have to the number they would have if they were subject to a maximal well-recorded age-specific fertility schedule (that of the Hutterites). Ig is defined as the ratio of the number of births the married women in a given population actually have to the number they would have if they were subject to the maximal age-specific fertility schedule. Ih is the ratio of the number of births the unmarried women in a given population actually have to the number they would have if they were subject to the maximal age-specific fertility schedule. Im is the ratio of the number of births married women would experience if subject to the maximal age-specific fertility schedule to the number of births all women would experience if subject to that same maximal fertility schedule; it is an index of the extent to which the marital status distribution would contribute to the attainment of maximal fertility in a population in which all births were to married women.

The fertility indices have the following relationship:

$$If \equiv Im * Ig + (1 - Im) * Ih \tag{8}$$

(Treadway, 1980). Because the decomposition of total fertility If to its constituent components Ig, Ih and Im is an identity, it is possible to determine to what extent changes in total fertility can be attributed to changes in each of its constituent components.[20] In terms of growth rates, equation (11) can be rewritten as:

$$\begin{aligned} If\_gr = \; & (Im * Ig \;/ If) * Ig\_gr \; + \\ & ((1 - Im) * Ih / If) * Ih\_gr \; + \\ & (Im * (Ig - Ih) / If) * Im\_gr \, , \end{aligned} \tag{9}$$

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[20] I thank Dale Jorgenson for suggesting this growth rate decomposition to me.

where *If_gr*, *Ig_gr*, *Ih_gr*, and *Im_gr* are the growth rates in *If*, *Ig*, *Ih*, and *Im*, respectively. When each divided by *If_gr*, the three terms in the right-hand side of equation (12) are the fractions of growth in *If* due to the growth in *Ig*, in *Ih*, and in *Im*, respectively. Table 2 presents summary statistics and trends for these fractions for Italy at both the national and the regional level over the period 1871 to 1961.[21] At the national level, growth rates in both marital fertility and marital status have, on average, contributed negatively to the growth rate in total fertility during this period, while growth rates in non-marital fertility have, on average, contributed positively towards it. Growth rates in all three components of fertility have contributed both positively and negatively to the growth rate in overall fertility at one time or another over this period. The fraction of the growth rate in total fertility due to the growth rates in both marital and non-marital fertility have downward trends that are significant at a 5% level, while that due to the growth rate in marital status has a significant upward trend. In other words, while the contributions of growth in legitimate and illegitimate fertility to growth in overall fertility have declined, that of the proportion married has increased. Whether or not one is married has had an increasingly important effect on overall fertility. There is no trend in the growth rate of total fertility for the national data.

At the regional level, growth in marital fertility and in non-marital fertility have, on average, a negative and positive contribution, respectively, to the growth rate of total fertility; both results are consistent with those using at the national level. However, the growth rate in marital status has, on average, a positive contribution to the growth rate of the overall fertility at the regional level, which is the opposite of what occurs at the national level. Moreover, unlike at the national level, none of the trends the contributions are significant, either with or with region controls. Also unlike the national results, the trend in the growth rate of total fertility is significant and positive, both with and without controls.

Having examined how the level and growth rate of the index of total fertility is affected by those of the other indices of fertility, I will now analyze how well the index of total fertility measures crude birth rates. Table 3.1 presents various regressions of the crude birth rate on the index for total fertility using the national data. For almost all specifications, the coefficient on the index of total fertility is positive and significant at a 5% level. The one exception is the regression of a crude birth rate that spans 10 years on the index of total fertility, which spans 3

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[21] Regrettably, my data set does not include values for these indices for Japan, as the Princeton data set was for Europe. As a consequence, the results and discussion in this section will focus exclusively on Italy. However, Mosk (1983) uses data on these indices for Japan; as an extension to my work, I could acquire a copy of the data tape from him to repeat the analyses in this section on Japan.

years, lagged five years[22] and on year; this result is likely due to a combination of the lagging and of the addition of year to the regression.

To further analyze the regressions of the crude birth rate on the index for total fertility, I conduct several tests. To test for neglected nonlinearities, I conduct a version of the Ramsey RESET test on each specification. This version uses an F-test to test the null hypothesis that the coefficients on the 2nd to 4th powers of the explanatory variables in an augmented model are equal to zero (StataCorp, 1997; Wooldridge, 2002). Nonlinearities appear to be present in some, but not all, specifications, especially those involving logs. In addition to nonlinearities, I also tested for heteroskedasticity using a Cook-Weisberg test. This is a chi-squared test of the null hypothesis that the variance is not a function of the fitted values. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold (StataCorp, 1997). The null hypothesis of homoskedasticity could not be rejected at the 5% level for any of the specifications.

After analyzing how well the index of total fertility measures crude birth rates on a national level, I then repeat the analysis on the regional data. As presented in Table 3.2, the index of total fertility again has a significant positive coefficient even when year and region effects are included. Nonlinearities exist in all but one specification. The heteroskedasticity that exists in some specifications appears to be resolved by either logging the index or controlling for year and region effects. Taken together, the results from the national and regional regressions of the index of total fertility on crude birth rates affirm that the former is indeed a valid indicator for the latter.

In addition to marital fertility, non-marital fertility and marital status, one would expect that age at marriage would also have an effect on overall fertility. In order to test this hypothesis, I run regressions of crude birth rates on age at marriage of both men and women for both the national and regional Italian data.[23] The results are presented in Tables 4.1 and 4.2. At the national level, the age at marriage has a negative effect on crude birth rates that is significant at a 5% level in all but one specification. In contrast, age at marriage of women has no significant effects in all but one specification; in this case, its effect was also negative. Thus the delay of marriage by men appears to affect crude birth rates more than that by women. For the regional data, age at marriage was only available for women. As with the national data, age at marriage of females has a significant negative effect in only one specification. My results suggest that women tend to have the same number of children regardless of when they

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[22] The lagging was necessary because the two variables were centered five years apart.

[23] Owing to data limitations, these regressions could not be run for Japan.

marry, while men who marry later have fewer children, perhaps because those men that must delay marriage until they are economically secure are also those with fewer economic means to support a large family.

These tables also present the results of regressions of the index of marital status on age at marriage. At the national level, neither the marriage age of males nor that of females appear to have any significant effect. In contrast, the marriage age of females has a significant negative effect on marital status at the regional level, even after controlling for region effects.

In summary, at a national level for Italy, whether or not one is married has had an increasingly important effect on overall fertility and the delay of marriage by men appears to affect crude birth rates more than that by women. Moreover, the index of total fertility is a valid indicator for the crude birth rate. Having fully characterized the determinants of fertility, I now describe my econometric methodology for assessing the dependence of fertility on economic, demographic and environmental factors.

6 Methods

This section describes the econometric methods I use to analyze the effects of national disasters and economic volatility on fertility.

In order to analyze the effects of instability on fertility, I use regional data only, for several reasons. First, natural disasters are likely to have local, not national effects. Second, with panel data the regions that are not affected by a particular disaster can serve as controls for those that are. Thus, the use of regional data enables me to exploit the natural within-country variation for both Italy and for Japan in order to better identify my coefficients. Third, the regional data sets have a larger number of observations, yielding more degrees of freedom. A fourth advantage from using regional data is that the use of regional fixed effects may resolve some omitted variables problems that exist when only one place (i.e., the entire country) is used.

To test whether and how economic factors may affect fertility, I include the real wage as an explanatory variable. I choose to use the level of the wage rather than its log for several reasons. First, because the wage is a national real wage index rather than the wage of each particular individual, it is less likely to have the skewed distribution the resolution of which is a primary motivation for economists to use the log of the wage.[24] Second, because the real wage data I use are indexed to a given year for both countries, they are almost already in percentage terms. Thus, the use of logs to enable examination of percent changes does not seem quite so justified in this case.[25] Third, as demonstrated by preliminary analysis (not shown) and also by results presented later in this paper, whether or not a wage is logged does not seem to affect the sign or significance of the coefficients; it thus seems reasonable not to log the wage since none of the other variables are logged. Moreover, in preliminary analysis (not shown), the use of the non-logged wage often results in better t-statistics.

To determine the effects of instability on fertility, I use the variance of the detrended wage to measure economic volatility;[26] the crude birth rate to measure demographic risk; and the number and magnitudes of natural disasters to measure environmental instability.

I first run regressions on either the number or magnitude of the disasters with fixed effects but not time effects, and then with time effects but not fixed effects. Both time and the fixed effects are likely to be omitted variables in regressions that exclude them since disasters are correlated with time as well as such region unobservables as local culture or local attitudes toward risk or mortality. I then add in the crude death rate while controlling for time and fixed effects; since disasters are likely correlated with the death rate, and since the death rate can affect the birth rate, there may be omitted variables bias when the crude death rate is excluded. Finally, in the full model, I also include the wage and the variance in the wage. Although regional disasters and the national wage are unlikely to be correlated, economic variables may have to be added to any fertility model that includes the death rate since wages and death rates are potentially correlated. For all models, I test the joint significance of the natural disaster variables. In the full model that includes the wage and its variance, I test the joint significance of these economic variables as well.

All regressions are OLS. For the economic variables, I therefore assume that neither the real wage nor the variance of the wage is likely to be endogenous to the contemporaneous birth rate because babies are too young to

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[24] As a possible extension to this study, the distribution of the various variables could be examined.

[25] The crude birth rates and the crude death rates are already in percentage terms, so a desire to convert the variables to percentage terms is no longer a justification for logging any of these variables either. I do not log these rates in any of my regressions, except in my analysis of the effect of the index of total fertility on crude birth rates. In this latter case, I chose to use the logged crude birth rate in some of my specifications because I was testing for the proper functional form, not because I believed that the variable needed to be recast in percentage terms.

[26] Previous regressions also included the minimum and the maximum of the detrended wage over the past 10 years. However, because these variables did not turn out to be significant and because they had little effect on the coefficient estimates of the other variables, but merely served to depress the degrees of freedom, I excluded them in the analysis presented here.

have an effect on the labor market.[27] For environmental instability, I use measures that are exogenous: the number and geophysical magnitude of natural disasters, neither of which are affected by fertility.

For the crude death rate, one potential omitted variable that may cause the crude death rate to be endogenous to fertility is famine, which both elevates mortality and depresses fertility (Lee, 1985; Maharatna, 1996). Controlling for natural disasters addresses this problem at least in part, as natural disasters are often a cause of famine. Moreover, any endogeneity of mortality to fertility would operate through the number of births, not the birth rate.

Further details about the regressions are provided in Appendix B. Having described my regression models, I now present their results.

7 Results

In this section I present the results of the regressions of the effects of natural disasters and economic volatility on various measures of fertility in both Italy and Japan.

Table 5.1 presents the results for the crude birth rate in Italy. When the crude birth rate is regressed on the number of disasters, the death rate, the wage, and the variance in the detrended wage (model 9), the number of earthquakes, the death rate and the variance in the detrended wage all have significant negative effects on the birth rate. Moreover, all the disaster variables are jointly significant, as are the economic variables. When the magnitudes of the disasters are used instead of the number (model 10), the earthquake intensity, the crude death rate, and the variance all have significant negative coefficients. Once again, the disaster variables are jointly significant and the economic variables are jointly significant. This result appears to be consistent with the hypothesis that the risk profile of an environment affects fertility behavior. However, the effect is the opposite of what Jones (1981) predicted: the results suggest that individuals react to natural disasters, high mortality rates and volatile wages by decreasing, not increasing, their fertility.

Are the results for the crude birth rate robust to other measures of fertility in Italy? The significant negative coefficients in models 9 and 10 on either earthquake number or earthquake intensity, on crude death rates, and on the variance in the wage, as well the joint significance of the disaster and economic variables, respectively, also hold

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[27] It is possible that the birth rate may affect wages through, for example, the wages of pediatricians or of childcare professionals, but I assume for this present study that these effects are not first-order.

for both total fertility (Table 5.2) and marital fertility (Table 5.3) as well. However, for these same two models, only the number of earthquakes affects non-marital fertility (Table 5.4) and only the crude death rate affects marital status (Table 5.5). The mean age at marriage of females is not significantly affected by any of the variables in these two full models, although it is negatively affected by natural disasters in all the other models.

Taken together, the results using the regional data for Italy provide strong evidence that fertility behavior is negatively affected by environmental and economic volatility. The channel through which this occurs appears to be marital fertility: couples who experienced natural disasters over the past two decades and volatile wages over the past decade will tend to have fewer children.

The story is somewhat different for Japan. Table 6.1 presents the results for the regressions on the crude birth rates in the non-prefectures. In the full models (models 9 and 10) that include both demographic and economic variables, the number of tsunamis has a significant negative effect on the crude birth rate. Natural disasters have significant negative effects in several other models as well. Unlike for Italy, neither the crude death rate nor any of the wage variables has any effect in any of the models. For the crude birth rate in the prefectures (Table 6.2), most of the natural disaster variables have significant coefficients until the village crude death rate is added to the model. The wage has a significant negative effect. For the mean age at first marriage of females (Table 6.3), in the regressions that included the wage and its variance, both the number of earthquakes and the level of the wage have significant positive effects on the marriage age.[28] The presence of natural disasters causes women to delay marriage.

Thus, natural disasters have a significant negative effect on fertility in both Italy and Japan across many specifications. Other measures of risk and volatility such as the death rate and the variance in the wage have negative effects on fertility in Italy, but not in Japan.

8 Concluding remarks

The research in this paper presents a detailed investigation of the economic, demographic and environmental determinants of fertility and its components in both Italy and Japan. I use regional data to exploit the natural variation within each of these two countries in order to best identify the effects of instability on fertility.

Among the many interesting results generated, three in particular deserve special mention. First, both the number and magnitude of natural disasters appears to have a significant negative effect on fertility behavior in both countries, even after controlling for year, the death rate, the wage, and the variance in the wage. This result has important implications for understanding differences in income and population growth both within and between countries and both throughout the past and in the present. It also has implications for policies regarding disaster insurance, foreign aid, and the environment. In particular, the effects of increasing climatic volatility owing to global climate change may be even more profound than previously assumed, for it may affect not only agriculture and coastal property but also population growth and, as a consequence, the income level as well.

A second important result is that measures of risk and volatility other than natural disasters appear to have a significant effect on fertility behavior as well. Economic volatility, as proxied by the variance of the detrended wage has a significant negative effect in many models for Italy. In addition, mortality risk, as measured by the crude death rate has a significant negative effect on crude birth rates, total fertility and marital fertility and a significant positive effect on marital status in Italy, but no effect on crude birth rates in Japan. Taken together, the significant effects that environmental, economic and demographic risk have on fertility behavior have important implications for the development of models of behavior under uncertainty, and for the design of policies for risk-sharing.

The third important result of my paper is that while the fertility rates in Italy and Japan both respond negatively to natural disasters, there appear to be some systematic differences in the ways in which the fertility rates in these two countries respond to other variables. Mortaility has a negative effect on fertility in Italy, but an insignificant effect in Japan. Similarly, the variance in the detrended wage has a negative effect on the crude birth rate, total fertility and marital fertility in almost all specifications for Italy, but an insignificant effect on on the crude birth rate in Japan. One possible reason why the fertility choices of the Japanese respond less to economic volatility than do those of the Italians is that there may be some instititions in Japan, such as cultural norms, that already provide the Japanese with insurance against economic volatility. Another possible reason is that, as seen in the summary statistics in Tables 1.1-1.3, the Japanese wage appears less volatile than the Italian wage, and thus is too stable to have much of an effect of fertility.

My main results are therefore that natural disasters have a significant negative effect on fertility in both countries, while mortality risk and economic volatility have significant negative effects in Italy but no effect in Japan. Thus, instability, particularly that arising from the natural environment, appears to cause a decrease in fertility.

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[28] For these regressions, there were too few observations on the crude death rate to include this variable as well.

The results of my paper point to several possible avenues for future research. First, as perhaps the most intriguing part of my paper, my analyses of the effect of natural disasters can be extended to include other measures of environmental volatility such as variations in temperature and precipitation.[29] A second possible extension would be to examine the determinants of fertility in countries other than Italy and Japan. Unfortunately, while data appears to be available for several other countries in Europe, data for Asia is harder to find.[30] A third extension would be to test the theory of population homeostasis using co-integration, error correction and other time series methods often used in macroeconomics (see e.g. King, Plosser, Stock & Watson, 1991). One drawback with this method is that it requires ample data coverage over many centuries; very little such data appears to be available. Other possible extensions include those mentioned in various footnotes throughout this paper.

My analyses provide evidence that natural disaster risk and economic variability affect fertility behavior; these results should be of interest to economists, historians, environmentalists, and policymakers alike.

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[29] I have extracted data for monthly mean temperatures and precipitation from the National Climatic Data Center web site (NCDC, 1999a; NCDC, 1999b), but have yet to either see if the data has adequate coverage for the years required or devise a measure of climatic variability from this raw data.

[30] I initially considered using India as well, but could find very little pre-twentieth century data. Some recent population data for Asia is available on tape (Harm, 1976).

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Table 1.1: Summary statistics for Italy (national)

variable	**# obs**	**mean**	**s.d.**	**min**	**max**	**trend**
population	11	3.84 E7	9.26 E6	2.58 E7	5.38 E7	**2.48 E5** **(1.20 E4)**
crude birth rate per 1000						
10-year average	11	28.35	7.69	18	37.4	**-0.227** **(0.015)**
3-year average	10	28.72	6.98	18.48	36.84	**-0.228** **(0.018)**
fertility indices						
total fertility If	9	0.305	0.083	0.192	0.389	**-0.0025** **(0.0003)**
marital fertility Ig	9	0.53	0.133	0.338	0.648	**-0.0040** **(0.0005)**
non-marital fertility Ih	9	0.036	0.019	0.011	0.063	**-0.0006** **(0.0001)**
marital status Im	9	0.544	0.021	0.513	0.578	-0.0001 (0.0002)
mean age of women at 1st marriage						
3-year average	5	24.32	0.589	23.6	25	**0.0255** **(0.0078)**
5-year average	15	24.29	0.556	23.4	25.1	**0.0189** **(0.0045)**
mean age of men at 1st marriage, 5-year average	15	28.01	0.630	27.1	28.9	**0.0169** **(0.0063)**
crude death rate per 1000; 10-year average	11	19.63	7.60	9.6	30.3	**-0.227** **(0.011)**
real wage	118	205.67	162.51	39	636	**3.91** **(0.250)**
variance in real wage	117	0.842	1.457	0.007	6.148	**0.0229** **(0.0034)**

Notes: The trend is the coefficient on year when the variable is regressed on year and constant (standard error in parentheses). Trends that are significant at a 5% level are in bold.

Table 1.2: Summary statistics for Italy (regional)

variable	**# obs before merging**	**mean**	**s.d.**	**min**	**max**	**trend before merging**	**trend after merging**	**trend after merging, with region controls**
region-level variables								
crude birth rate	212	30.31	8.02	10.26	43.5	**-0.18** **(0.01)**	**-0.18** **(0.01)**	**-0.18** **(0.01)**
fertility indices								
total fertility If	184	0.31	0.09	0.105	0.444	**-0.002** **(0.000)**	**-0.002** **(0.000)**	**-0.002** **(0.000)**
marital fertility Ig	184	0.57	0.15	0.222	0.809	**-0.004** **(0.000)**	**-0.004** **(0.000)**	**-0.004** **(0.000)**
non-marital fertility Ih	184	0.03	0.02	0.004	0.124	**-0.0004** **(0.0000)**	**-0.0004** **(0.0000)**	**-0.0004** **(0.0000)**
marital status Im	184	0.52	0.04	0.39	0.634	**-0.0002** **(0.0001)**	**-0.0002** **(0.0001)**	-0.0001 (0.0001)
age of women at 1st marriage	312	24.48	1.01	21.8	27.3	**0.01** **(0.00)**	**0.01** **(0.00)**	**0.01** **(0.00)**
# earthquakes	3924	0.14	0.51	0	6	**0.001** **(0.000)**	**0.001** **(0.000)**	**0.001** **(0.000)**
earthquake intensity	3887	1.53	5.24	0	38	**0.01** **(0.00)**	**0.01** **(0.00)**	**0.01** **(0.00)**
# volcano eruptions	3924	0.03	0.22	0	3	**0.0002** **(0.0001)**	**0.0002** **(0.0001)**	**0.0002** **(0.0000)**
volcano magnitude	3924	0.10	0.64	0	9	**0.0005** **(0.0002)**	**0.0005** **(0.0002)**	**0.0006** **(0.0001)**
# avalanches and landslides	3924	0.0005	0.02	0	1	7.72 E-6 (5.73 E-6)	7.72 E-6 (5.73 E-6)	7.72 E-6 (5.71 E-6)
# severe lightning storms	3924	0.0003	0.02	0	1	5.12 E-6 (4.05 E-6)	5.12 E-6 (4.05 E-6)	5.12 E-6 (4.05 E-6)
# floods	3924	0.001	0.03	0	1	**0.00002** **(8.09 E-6)**	**0.00002** **(8.09 E-6)**	**0.00002** **(8.09 E-6)**
geographical area-level variables								
crude death rate per 1000	45	18.58	7.25	8.7	33	**-0.24** **(0.01)**	**-0.25** **(0.00)**	**-0.25** **(0.00)**
national-level variables								
real wage	118	205.67	162.51	39	636	**3.91** **(0.25)**	**3.91** **(0.06)**	**3.91** **(0.06)**
variance in real wage	117	0.842	1.457	0.007	6.148	**0.02** **(0.00)**	**0.02** **(0.00)**	**0.02** **(0.00)**

Notes: The trend is the coefficient on year when the variable is regressed on year and constant (standard error in parentheses). Trends that are significant at a 5% level are in bold. For variables that apply to areas larger than a region (i.e., to a geographical area or to the entire country), the trend before merging uses only one observation per area-year (instead of multiplying that observation by all the regions in that area). In contrast, the trend after merging uses observations from all regions, regardless of whether some regions may share the same values for some variables due to merging. Thus, for variables that apply to areas larger than a region, the number of observations used in the trends after merging will be larger than those before merging. The last column reports trends after merging when region fixed effects are added to the regression on year and a constant.

Table 1.3: Summary statistics for Japan (regional)

variable	# obs	mean	s.d.	min	max	trend	trend with place controls
non-prefecture variables							
crude birth rate per 1000	217	31.11	11.83	4	81.5	0.02 (0.02)	-0.01 (0.02)
crude death rate per 1000	165	24.87	7.72	7.3	57.2	**0.03** **(0.01)**	-0.00 (0.01)
age of women at 1st marriage	16	24.17	0.96	22.9	25.8	-0.00 (0.01)	0.00 (0.01)
# earthquakes	4425	0.05	0.23	0	3	**0.0004** **(0.0000)**	**0.0005** **(0.0000)**
earthquake intensity	4363	0.24	1.39	0	24.9	**0.003** **(0.000)**	**0.003** **(0.000)**
# tsunamis	4425	0.03	0.18	0	3	**0.0002** **(0.0000)**	**0.0002** **(0.0000)**
tsunami magnitude	4425	0.08	0.60	0	12	**0.0003** **(0.0001)**	**0.0004** **(0.0001)**
# volcano eruptions	4425	0.06	0.31	0	5	**0.0004** **(0.0001)**	**0.0004** **(0.0000)**
volcano magnitude	4425	0.17	0.88	0	11	**0.001** **(0.000)**	**0.001** **(0.000)**
# cyclones and typhoons	4425	0.00	0.02	0	1	0.00 (0.00)	0.00 (0.00)
national real wage	3180	55.72	16.28	25	118.6	**0.21** **(0.00)**	**0.21** **(0.00)**
variance in national real wage	3285	0.03	0.02	0.00	0.11	**0.0002** **(0.0000)**	**0.0002** **(0.0000)**
prefecture variables							
crude birth rate per 1000	234	31.29	5.75	27	44.8	**-0.48** **(0.02)**	**-0.48** **(0.01)**
crude death rate per 1000	141	18.17	2.57	12.7	24.9	**-0.32** **(0.04)**	**-0.32** **(0.03)**
# earthquakes	13865	0.04	0.22	0	4	**0.0004** **(0.0000)**	**0.0004** **(0.0000)**
earthquake magnitude	13724	0.23	1.41	0	32.7	**0.003** **(0.000)**	**0.003** **(0.000)**
# tsunamis	13865	0.04	0.22	0	4	**0.0002** **(0.0000)**	**0.0002** **(0.0000)**
tsunami magnitude	13865	0.12	0.69	0	12	**0.0003** **(0.0000)**	**0.0004** **(0.0000)**
# volcano eruptions	13865	0.02	0.18	0	4	**0.0001** **(0.0000)**	**0.0002** **(0.0000)**
volcano magnitude	13865	0.07	0.56	0	13	**0.0005** **(0.0001)**	**0.0005** **(0.0001)**
# cyclones and typhoons	13865	0.00	0.01	0	1	0.00 (0.00)	**2.5 E-6** **(1.2 E-6)**
national real wage	9964	55.72	16.28	25	188.6	**0.21** **(0.00)**	**0.21** **(0.00)**
variance in national real wage	10293	0.03	0.02	0.00	0.11	**0.0002** **(0.0000)**	**0.0002** **(0.0000)**

Notes: The trend is the coefficient on year when the variable is regressed on year and constant (standard error in parentheses). The trend with place controls is the coefficient on year when place or prefecture fixed effects are added to the regression on year and a constant for the non-prefecture and prefecture variables, respectively. Trends that are significant at a 5% level are in bold.

Table 2: Components of the growth rate of total fertility (If), 1871-1961

2.1 Italy: national

	# obs	**mean**	**s.d.**	**min**	**max**	**trend**
growth in total fertility If	5	-0.15	0.37	-0.64	0.41	0.01 (0.01)
fraction of If growth due to the growth of:	**# obs**	**mean**	**s.d.**	**min**	**max**	**trend**
marital fertility Ig	5	-15.87	19.44	-36.54	13.53	**-0.60** **(0.10)**
non-marital fertility Ih	5	4.62	4.64	-1.63	10.41	**-0.14** **(0.03)**
marital status Im	5	-6.78	19.11	-22.27	25.51	**0.60** **(0.06)**

Notes: The trend is the coefficient on year when the variable is regressed on year and constant (standard error in parentheses). The trend with region controls is the trend when region fixed effects are added to the regression on year and a constant. Trends that are significant at a 5% level are in bold.

2.2 Italy: regional

	# obs	**mean**	**s.d.**	**min**	**max**	**trend**	**trend with region controls**
growth in total fertility If	82	-0.12	0.70	-2.40	2.42	**0.010** **(0.003)**	**0.008** **(0.003)**
fraction of If growth due to the growth of:	**# obs**	**mean**	**s.d.**	**min**	**max**	**trend**	**trend with region controls**
marital fertility Ig	80	-0.67	4.39	-19.76	8.59	0.02 (0.02)	0.03 (0.02)
non-marital fertility Ih	80	0.27	1.43	-5.58	8.00	0.00 (0.01)	0.00 (0.01)
marital status Im	80	1.35	3.71	-5.82	17.37	-0.02 (0.01)	-0.03 (0.02)

Notes: The trend is the coefficient on year when the variable is regressed on year and constant (standard error in parentheses). The trend with region controls is the trend when region fixed effects are added to the regression on year and a constant. Trends that are significant at a 5% level are in bold.

Table 3.1: Relationship between crude birth rate and the index of total marital fertility: Italy, national

	Dependent variable is:									
	cbr3	cbr3	ln(cbr3)	ln(cbr3)	cbr10	cbr10	ln(cbr10)	ln(cbr10)	cbr3	cbr10
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
If	**88.59**		**3.32**							
	(3.64)		**(0.19)**							
ln(If)		**25.11**		**0.95**			**3.50**		**63.79**	
		(1.01)		**(0.04)**			**(0.27)**		**(11.21)**	
If_m5					**91.08**					21.48
					(9.62)					(24.89)
ln(If_m5)						**25.26**		**0.98**		
						(3.14)		**(0.09)**		
year									-0.07	**-0.19**
									(0.03)	**(0.06)**
constant	1.66	**59.41**	**2.31**	**4.48**	-0.23	**58.56**	**2.21**	**4.48**	138.33	**377.82**
	(1.15)	**(1.27)**	**(0.06)**	**(0.05)**	(3.11)	**(3.86)**	**(0.09)**	**(0.11)**	(59.74)	**(130.60)**
p-value (Prob > F)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
adj. R squared	0.99	0.99	0.98	0.99	0.93	0.92	0.97	0.95	0.99	0.97
# obs	9	9	9	9	8	8	8	8	9	8
	Results from Ramsey RESET test									
p-value	[0.07]	[0.19]	**[0.01]**	[0.09]	**[0.05]**	**[0.03]**	[0.11]	**[0.05]**	*	*
	Results from heteroskedasticity test									
p-value	[0.69]	[0.15]	[0.18]	[0.73]	[0.28]	[0.31]	[0.35]	[0.27]	[0.99]	[0.93]

Notes: Standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold. Prob>F is the p-value from F-tests on all the coefficients (excluding the constant). Results that are statistically significant at a 5% level are in bold. Crude birth rates (cbrX) span X years per observation. The index of total fertility (If) spans 3 years per observation. *var*_m*X* is the variable *var* lagged *X* years. All variables spanning multiple years are centered on year. The Ramsey RESET test uses an F-test to test the null hypothesis that the coefficients on the 2nd-4th powers of the explanatory variables in an augmented model are equal to zero. An (*) indicates that all the powers were dropped due to collinearity. To test for heteroskedasticity, a Cook-Weisberg test is used. This is a chi-squared test of the null hypothesis that the variance is not a function of the fitted values. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 3.2: Relationship between crude birth rate and the index of total marital fertility: Italy, regional

	Dependent variable is:				
	cbr (1)	cbr (2)	ln(cbr) (3)	ln(cbr) (4)	cbr (5)
If	**88.89**		**3.56**		**70.55**
	(1.18)		**(0.06)**		**(-0.05)**
ln(If)		**22.74**		**0.93**	
		(0.41)		**(0.01)**	
year effects	N	N	N	N	Y
region fixed effects	N	N	N	N	Y
constant	**1.55**	**56.93**	**2.21**	**0.93**	
	(0.38)	**(0.51)**	**(0.02)**	**(0.01)**	
p-value (Prob > F)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
adj. R squared	0.97	0.94	0.95	0.98	0.98
# obs	184	184	184	184	184
	Results from Ramsey RESET test				
p-value	[0.06]	**[0.00]**	**[0.00]**	**[0.03]**	**[0.00]**
	Results from heteroskedasticity test				
p-value	**[0.00]**	[0.59]	**[0.00]**	[0.69]	[0.07]

Notes: Standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold. Prob>F is the p-value from F-tests on all the coefficients (excluding the constant). Results that are statistically significant at a 5% level are in bold. Crude birth rates (cbr) span years per observation. The index of total fertility (If) spans 3 years per observation. All variables spanning multiple years are centered on year. The Ramsey RESET test uses an F-test to test the null hypothesis that the coefficients on the 2^{nd}-4^{th} powers of the explanatory variables in an augmented model are equal to zero. An (*) indicates that all the powers were dropped due to collinearity. To test for heteroskedasticity, a Cook-Weisberg test is used. This is a chi-squared test of the null hypothesis that the variance is not a function of the fitted values. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 4.1: The Effects of Age at Marriage on Fertility: Italy, national

	Dependent variable is:												
	cbr5	cbr10	cbr10	cbr3	cbr5	cbr10	cbr10	cbr5	cbr10	cbr10	Im	Im	Im
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
age_marm5	**-3.75**							**-3.48**					
	(0.96)							**(0.94)**					
age_marm10		**-2.75**	-3.09						**-2.66**	**-24.48**	0.02		0.09
		(0.69)	(1.43)						**(0.86)**	**(0.11)**	(0.02)		(0.06)
age_marf3				-1.05									
				(3.03)									
age_marf5					3.26			1.96					
					(2.63)			(1.53)					
age_marf10						-1.70	17.90		-0.25	**-133.01**		0.01	-0.22
						(1.53)	(10.06)		(1.03)	**(0.71)**		(0.02)	(0.08)
If3_m5			13.32				439.77			**-2479.21**			
			(27.58)				(183.94)			**(13.34)**			
year	**-0.23**	**-0.21**	-0.16	-0.27	**-0.35**	**-0.22**	0.52	**-0.27**	**-0.20**	**-5.21**			0.00
	(0.04)	**(0.02)**	(0.08)	(0.09)	**(0.08)**	**(0.03)**	(0.39)	**(0.05)**	**(0.02)**	**(0.03)**			(0.00)
constant	**564.77**	**498.52**	423.15	**575.98**	**614.53**	**489.07**	-1504.72	**597.53**	**496.37**	**14691.22**	0.06	0.28	-0.41
	(71.03)	**(21.97)**	(169.05)	**(109.43)**	**(127.04)**	**(42.58)**	(1048.01)	**(72.27)**	**(25.94)**	**(76.37)**	(0.49)	(0.53)	(1.11)
p-value (Prob > F)	**0.00**	**0.00**	**0.01**	**0.04**	**0.01**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	0.38	0.65	0.51
adj. R squared	0.90	0.99	0.98	0.93	0.71	0.95	0.97	0.91	0.98	1.00	-0.01	-0.18	0.05
# obs	9	8	6	5	9	8	6	9	8	6	6	6	6
	Results from Ramsey RESET test												
p-value	*	*	*	*	*	*	*	*	*	*	[0.66]	[0.41]	*
	Results from heteroskedasticity test												
p-value	[0.18]	[0.80]	[0.77]	[0.43]	[0.59]	[0.42]	[0.76]	[0.64]	[0.94]	[0.78]	[0.55]	[0.54]	[0.42]

Notes: Standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold. Prob>F is the p-value from F-tests on all the coefficients (excluding the constant). Results that are statistically significant at a 5% level are in bold. Crude birth rates (cbrX) span X years per observation. One observation of cbr5 spans only 4 years instead of 5. The indices of total marital fertility (If) and of marital status (Im) both span 3 years per observation. The mean age at marriage of males (age_marmX) and of females (age_marfX) span X years per observation. The values for age_marm10 and age_marf10 are 10-year averages of the values for age_marm5 and age_marf5. *var*_m*X* is the variable *var* lagged *X* years. All variables spanning multiple years are centered on year. The Ramsey RESET test uses an F-test to test the null hypothesis that the coefficients on the 2nd-4th powers of the explanatory variables in an augmented model are equal to zero. An (*) indicates that all the powers were dropped due to collinearity. To test for heteroskedasticity, a Cook-Weisberg test is used. This is a chi-squared test of the null hypothesis that the variance is not a function of the fitted values. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 4.2: The Effects of Age at Marriage on Fertility: Italy, regional

	Dependent variable is:					
	cbr (1)	cbr (2)	cbr (3)	cbr (4)	Im (5)	Im (6)
age_marf	**-3.10**	-0.78	-0.23	-0.49	**-0.03**	**-0.02**
	(0.57)	(0.66)	(0.21)	(0.38)	**(0.00)**	**(0.01)**
If			**79.10**	**64.87**		
			(3.00)	**(5.65)**		
year effects	Y	Y	Y	Y	Y	Y
region fixed effects	N	Y	N	Y	N	Y
p-value (Prob > F)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
adj. R squared	0.63	0.90	0.96	0.97	0.40	0.60
# obs	86	86	86	86	86	86
	Results from Ramsey RESET test					
p-value	[0.08]	**[0.00]**	[0.19]	[0.19]	**[0.03]**	**[0.00]**
	Results from heteroskedasticity test					
p-value	[0.52]	[0.46]	**[0.00]**	**[0.00]**	[0.42]	[0.64]

Notes: Standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold. Prob>F is the p-value from F-tests on all the coefficients (excluding the constant). Results that are statistically significant at a 5% level are in bold. Crude birth rates (cbr) span 3 years per observation. The indices of total marital fertility (If) and of marital status (Im) both span 3 years per observation. The mean age at marriage of females (age_marf) span 3 years per observation. All variables spanning multiple years are centered on year. The Ramsey RESET test uses an F-test to test the null hypothesis that the coefficients on the 2^{nd}-4^{th} powers of the explanatory variables in an augmented model are equal to zero. An (*) indicates that all the powers were dropped due to collinearity. To test for heteroskedasticity, a Cook-Weisberg test is used. This is a chi-squared test of the null hypothesis that the variance is not a function of the fitted values. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 5.1: The effects of natural disasters on crude birth rates: Italy

	Dependent variable is cbr									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
# earthquakes	**-0.47**		-0.05	-0.02			-0.04		**-0.23**	
	(0.09)		(0.07)	(0.05)			(0.05)		**(0.05)**	
# volcano eruptions	-0.89		**0.30**	-0.11			-0.16		0.11	
	(0.50)		**(0.14)**	(0.26)			(0.27)		(0.28)	
# avalanches and landslides	0.26		3.58	1.60			-0.71		-1.64	
	(5.34)		(3.23)	(2.73)			(2.93)		(2.43)	
# severe lightning storms	-14.22		-3.95	-3.88			0.02		-0.13	
	(7.01)		(4.68)	(3.62)			(3.02)		(2.47)	
# floods	**		**	**			**		**	
earthquake intensity		**-0.05**			**-0.011**	-0.00		-0.01		**-0.02**
		(0.01)			**(0.006)**	(0.00)		(0.00)		**(0.00)**
volcano magnitude		-0.26			**0.10**	-0.05		-0.06		0.05
		(0.18)			**(0.05)**	(0.09)		(0.09)		(0.10)
crude death rate							**-0.42**	**-0.42**	**-0.44**	**-0.45**
							(0.18)	**(0.17)**	**(0.16)**	**(0.15)**
real wage									0.04	0.04
									(0.02)	(0.02)
variance in real wage									**-3.04**	**-3.00**
									(0.48)	**(0.47)**
year effects	N	N	Y	Y	Y	Y	Y	Y	Y	Y
region effects	Y	Y	N	Y	N	Y	Y	Y	Y	Y
p-value (Prob>F)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
adj. R squared	0.30	0.31	0.67	0.82	0.67	0.82	0.89	0.90	0.93	0.93
# obs	212	212	212	212	212	212	136	136	120	120
Results from joint test of all natural disaster variables										
p-value	**[0.00]**	**[0.00]**	[0.15]	[0.78]	**[0.02]**	[0.50]	[0.84]	[0.32]	**[0.00]**	**[0.00]**
Results from joint test of all the economic variables										
p-value									**[0.00]**	**[0.00]**
Results from heteroskedasticity test										
p-value	[0.90]	[0.93]	**[0.00]**	[0.12]	**[0.00]**	[0.15]	[0.86]	[0.92]	[0.18]	[0.15]

Notes: Standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold. Prob>F is the p-value from F-tests on all the coefficients (including year and the region dummies, but excluding the constant). Variables that were dropped in a regression due to collinearity are indicated by (**). To test for heteroskedasticity, a Cook-Weisberg test is used. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 5.2: The effects of natural disasters on total fertility: Italy

	Dependent variable is total fertility lf									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
# earthquakes	**-0.47**		-0.13	-0.09			**-0.14**		**-0.43**	
	(0.11)		(0.08)	(0.06)			**(0.06)**		**(0.06)**	
# volcano eruptions	-0.93		**0.36**	-0.23			-0.21		0.17	
	(0.59)		**(0.16)**	(0.30)			(0.35)		(0.34)	
# avalanches and landslides	-0.47		3.32	0.60			-2.04		-2.82	
	(6.01)		(3.69)	(2.98)			(3.76)		(2.92)	
# severe lightning storms	-13.92		-3.40	-2.17			0.99		1.00	
	(7.82)		(5.35)	(3.91)			(3.87)		(2.98)	
# floods	**		**	**			**		**	
earthquake intensity		**-0.05**			**-0.02**	**-0.01**		**-0.015**		**-0.04**
		(0.01)			**(0.01)**	**(0.00)**		**(0.005)**		**(0.01)**
volcano magnitude		-0.27			**0.12**	-0.11		-0.08		0.09
		(0.21)			**(0.06)**	(0.10)		(0.11)		(0.11)
crude death rate							**-0.55**	**-0.54**	**-0.55**	**-0.54**
							(0.23)	**(0.22)**	**(0.19)**	**(0.18)**
real wage									0.02	0.02
									(0.03)	(0.03)
variance in real wage									**-4.25**	**-4.19**
									(0.58)	**(0.56)**
year effects	N	N	Y	Y	Y	Y	Y	Y	Y	Y
region effects	Y	Y	N	Y	N	Y	Y	Y	Y	Y
p-value (Prob>F)										
adj. R squared	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
# obs	0.29	0.31	0.64	0.83	0.66	0.83	0.86	0.86	0.91	0.92
	184	184	184	184	184	184	136	136	120	120
	Results from joint test of all natural disaster variables									
p-value	**[0.00]**	**[0.00]**	[0.07]	[0.53]	**[0.00]**	[0.06]	[0.14]	**[0.01]**	**[0.00]**	**[0.00]**
	Results from joint test of all the economic variables									
p-value									**[0.00]**	**[0.00]**
	Results from heteroskedasticity test									
p-value	[0.78]	[0.83]	**[0.00]**	[0.96]	**[0.00]**	[0.91]	[0.73]	[0.85]	[0.69]	[0.77]

Notes: standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold. Prob>F is the p-value from F-tests on all the coefficients (including year and the region dummies, but excluding the constant). Variables that were dropped in a regression due to collinearity are indicated by (**). To test for heteroskedasticity, a Cook-Weisberg test is used. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 5.3: The effects of natural disasters on marital fertility: Italy

	Dependent variable is marital fertility Ig									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
# earthquakes	**-0.70**		-0.18	-0.08			-0.21		**-0.90**	
	(0.19)		(0.15)	(0.13)			(0.13)		**(0.13)**	
# volcano eruptions	-1.48		0.46	-0.36			-0.41		0.68	
	(1.06)		(0.33)	(0.67)			(0.78)		(0.70)	
# avalanches and landslides	6.42		13.69	8.14			2.68		0.24	
	(10.78)		(7.38)	(6.76)			(8.29)		(6.00)	
# severe lightning storms	-27.06		-10.65	-8.16			0.85		1.68	
	(14.01)		(10.69)	(8.86)			(8.54)		(6.11)	
# floods	**		**	**			**		**	
earthquake intensity		**-0.07**	**-0.35**		**-0.03**	-0.01		**-0.02**		**-0.08**
		(0.02)	**(0.03)**		**(0.01)**	(0.01)		**(0.01)**		**(0.01)**
volcano magnitude		-0.49			0.14	-0.24		-0.19		0.25
		(0.38)			(0.12)	(0.24)		(0.25)		(0.23)
crude death rate							**-1.65**	**-1.68**	**-1.73**	**-1.76**
							(0.52)	**(0.12)**	**(0.39)**	**(0.37)**
real wage									0.01	0.00
									(0.06)	(0.06)
variance in real wage									**-9.55**	**-9.55**
									(1.19)	**(1.13)**
year effects	N	N	Y	Y	Y	Y	Y	Y	Y	Y
region effects	Y	Y	N	Y	N	Y	Y	Y	Y	Y
p-value (Prob>F)										
adj. R squared	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
# obs	0.25	0.26	0.53	0.70	0.53	0.71	0.77	0.78	0.89	0.90
	184	184	184	184	184	184	136	136	120	120
	Results from joint test of all natural disaster variables									
p-value	**[0.00]**	**[0.00]**	[0.12]	[0.59]	**[0.03]**	[0.31]	[0.58]	[0.10]	**[0.00]**	**[0.00]**
	Results from joint test of all the economic variables									
p-value									**[0.00]**	**[0.00]**
	Results from heteroskedasticity test									
p-value	[0.58]	[0.68]	**[0.00]**	[0.48]	**[0.00]**	[0.62]	**[0.02]**	**[0.03]**	[0.29]	[0.30]

Notes: standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold. Prob>F is the p-value from F-tests on all the coefficients (including year and the region dummies, but excluding the constant). Variables that were dropped in a regression due to collinearity are indicated by (**). To test for heteroskedasticity, a Cook-Weisberg test is used. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 5.4: The effects of natural disasters on non-marital fertility: Italy

	Dependent variable is non-marital fertility Ih									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
# earthquakes	**-0.10**		-0.01	-0.03			-0.03		**-0.06**	
	(0.03)		(0.02)	(0.02)			(0.02)		**(0.03)**	
# volcano eruptions	**-0.36**		-0.01	**-0.22**			-0.18		-0.12	
	(0.14)		(0.05)	**(0.10)**			(0.14)		(0.16)	
# avalanches and landslides	1.30		1.29	1.51			0.99		0.54	
	(1.46)		(1.18)	(1.04)			(1.45)		(1.42)	
# severe lightning storms	-1.44		-0.51	0.87			1.56		1.78	
	(1.89)		(1.71)	(1.36)			(1.49)		(1.44)	
# floods	**		**	**			**		**	
earthquake intensity		**-0.01**			-0.00	-0.00		-0.00		-0.00
		(0.00)			(0.00)	(0.00)		(0.00)		(0.00)
volcano magnitude		-0.10			-0.00	-0.07		-0.05		-0.03
		(0.05)			(0.01)	(0.04)		(0.04)		(0.06)
crude death rate							-0.11	-0.09	-0.13	-0.11
							(0.09)	(0.09)	(0.09)	(0.09)
real wage									-0.00	0.00
									(0.01)	(0.01)
variance in real wage									-0.41	-0.36
									(0.28)	(0.28)
year effects	N	N	Y	Y	Y	Y	Y	Y	Y	Y
region effects	Y	Y	N	Y	N	Y	Y	Y	Y	Y
p-value (Prob>F)										
adj. R squared	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
# obs	0.27	0.27	0.36	0.63	0.37	0.63	0.63	0.63	0.65	0.64
	184	184	184	184	184	184	136	136	120	120
	Results from joint test of all natural disaster variables									
p-value	**[0.00]**	**[0.00]**	[0.83]	[0.06]	[0.92]	[0.08]	[0.30]	[0.26]	[0.16]	[0.16]
	Results from joint test of all the economic variables									
p-value									[0.34]	[0.43]
	Results from heteroskedasticity test									
p-value	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**

Notes: standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold. Prob>F is the p-value from F-tests on all the coefficients (including year and the region dummies, but excluding the constant). Variables that were dropped in a regression due to collinearity are indicated by (**). To test for heteroskedasticity, a Cook-Weisberg test is used. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 5.5: The effects of natural disasters on marital status: Italy

	Dependent variable is marital status Im									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
# earthquakes	**-0.12**		-0.09	**-0.11**			-0.08		0.04	
	(0.05)		(0.06)	**(0.05)**			(0.06)		(0.07)	
# volcano eruptions	0.12		0.23	0.14			0.15		-0.20	
	(0.28)		(0.13)	(0.28)			(0.35)		(0.38)	
# avalanches and landslides	-7.55		**-7.66**	**-7.52**			-7.03		-6.13	
	(2.83)		**(2.96)**	**(2.83)**			(3.71)		(3.31)	
# severe lightning storms	4.85		6.21	5.24			0.11		-1.13	
	(3.68)		(4.29)	(3.71)			(3.82)		(3.37)	
# floods	**		**	**			**		**	
earthquake intensity		**-0.01**			-0.01	**-0.01**		-0.01		0.00
		(0.00)			(0.01)	**(0.00)**		(0.01)		(0.01)
volcano magnitude		0.09			0.08	0.10		0.08		-0.04
		(0.10)			(0.05)	(0.10)		(0.12)		(0.13)
crude death rate							**1.07**	**1.10**	**1.16**	**1.19**
							(0.23)	**(0.23)**	**(0.22)**	**(0.21)**
real wage									0.06	0.05
									(0.03)	(0.03)
variance in real wage									1.06	1.15
									(0.66)	(0.65)
year effects	N	N	Y	Y	Y	Y	Y	Y	Y	Y
region effects	Y	Y	N	Y	N	Y	Y	Y	Y	Y
p-value (Prob>F)										
adj. R squared	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
# obs	0.37	0.34	0.08	0.37	0.05	0.34	0.42	0.41	0.56	0.55
	184	184	184	184	184	184	136	136	120	120
	Results from joint test of all natural disaster variables									
p-value	**[0.00]**	**[0.03]**	**[0.00]**	**[0.00]**	**[0.04]**	[0.07]	[0.15]	[0.25]	[0.43]	[0.90]
	Results from joint test of all the economic variables									
p-value									**[0.05]**	**[0.05]**
	Results from heteroskedasticity test									
p-value	[0.24]	[0.13]	**[0.02]**	[0.14]	**[0.00]**	[0.07]	[0.75]	[1.00]	[0.22]	[0.32]

Notes: standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold. Prob>F is the p-value from F-tests on all the coefficients (including year and the region dummies, but excluding the constant). Variables that were dropped in a regression due to collinearity are indicated by (**). To test for heteroskedasticity, a Cook-Weisberg test is used. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 5.6 : The effects of natural disasters on mean age at marriage of females: Italy

	Dependent variable is mean age at marriage of females									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
# earthquakes	**-0.04**		**-0.03**	**-0.02**			**-0.04**		-0.02	
	(0.01)		**(0.01)**	**(0.01)**			**(0.01)**		(0.02)	
# volcano eruptions	0.03		**-0.08**	-0.01			-0.03		-0.03	
	(0.05)		**(0.02)**	(0.05)			(0.08)		(0.08)	
# avalanches and landslides	-0.05		0.13	-0.02			0.05		0.15	
	(0.33)		(0.36)	(0.32)			(0.50)		(0.49)	
# severe lightning storms	0.21		0.06	-0.11			0.27		0.27	
	(0.37)		(0.49)	(0.36)			(0.51)		(0.49)	
# floods	-0.51		-0.60	**-0.86**			**		**	
	(0.30)		(0.43)	**(0.30)**						
earthquake intensity		**-0.003**			-0.00	**-0.002**		**-0.003**		-0.00
		(0.001)			(0.00)	**(0.001)**		**(0.001)**		(0.00)
volcano magnitude		0.01			**-0.03**	0.00		-0.01		-0.01
		(0.02)			**(0.01)**	(0.02)		(0.02)		(0.02)
crude death rate							-0.04	-0.04	0.00	0.00
							(0.04)	(0.04)	(0.05)	(0.05)
real wage									0.01	0.02
									(0.08)	(0.08)
variance in real wage									0.35	0.38
									(0.46)	(0.47)
year effects	N	N	Y	Y	Y	Y	Y	Y	Y	Y
region effects	Y	Y	N	Y	N	Y	Y	Y	Y	Y
p-value (Prob>F)										
adj. R squared	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
# obs	0.59	0.59	0.10	0.62	0.09	0.61	0.84	0.85	0.85	0.86
	312	312	312	312	312	312	70	70	70	70
	Results from joint test of all natural disaster variables									
p-value	**[0.00]**	**[0.00]**	**[0.00]**	**[0.01]**	**[0.00]**	**[0.02]**	**[0.02]**	**[0.00]**	[0.87]	[0.73]
	Results from joint test of all the economic variables									
p-value									[0.09]	[0.10]
	Results from heteroskedasticity test									
p-value	[0.07]	[0.06]	[0.66]	[0.66]	[0.85]	[0.42]	[0.20]	[0.23]	[0.55]	[0.60]

Notes: standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold. Prob>F is the p-value from F-tests on all the coefficients (including year and the region dummies, but excluding the constant). Variables that were dropped in a regression due to collinearity are indicated by (**). To test for heteroskedasticity, a Cook-Weisberg test is used. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 6.1: The effects of natural disasters on crude birth rates: Japan, regional non-prefectures

	Dependent variable is cbr for non-prefectures									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
# earthquakes	-0.14		**-2.54**	0.25			0.58		0.86	
	(1.00)		**(1.24)**	(1.27)			(1.17)		(1.73)	
# tsunamis	-1.27		1.50	-1.23			**-3.00**		**-2.46**	
	(0.90)		(0.97)	(0.91)			**(1.01)**		**(1.21)**	
# volcano eruptions	0.08		-0.91	0.03			-0.09		0.90	
	(0.60)		(0.64)	(0.61)			(0.53)		(0.84)	
# cyclones and typhoons	**		**	**			**		**	
earthquake magnitude		**-0.41**			**-0.70**	-0.41		-0.27		-0.14
		(0.21)			**(0.23)**	(0.22)		(0.21)		(0.40)
tsunami magnitude		0.00			**-0.78**	0.00		-0.44		-0.48
		(0.27)			**(0.28)**	(0.27)		(0.29)		(0.38)
volcano magnitude		-0.07			-0.33	-0.07		-0.10		0.24
		(0.19)			(0.20)	(0.19)		(0.17)		(0.28)
crude death rate							0.07	0.06	-0.12	-0.01
							(0.09)	(0.09)	(0.10)	(0.10)
real wage									0.07	0.06
									(0.16)	(0.16)
variance in real wage									31.17	27.35
									(45.37)	(45.26)
year effects	N	N	Y	Y	Y	Y	Y	Y	Y	Y
place effects	Y	Y	N	Y	N	Y	Y	Y	Y	Y
p-value (Pr>F)	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
adj. R squared	0.42	0.43	0.05	0.42	0.07	0.43	0.48	0.48	0.50	0.50
# obs	217	217	217	217	217	217	165	165	146	146
	Results from joint test of all natural disaster variables									
p-value	[0.55]	[0.16]	**[0.01]**	[0.60]	**[0.00]**	[0.19]	**[0.03]**	**[0.02]**	[0.13]	[0.19]
	Results from joint test of all economic variables									
p-value									[0.78]	[0.82]
	Results from heteroskedasticity test									
p-value	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**

Notes: Standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold.. Prob>F is the p-value from F-tests on all the coefficients (including year and the place dummies, but excluding the constant). Variables that were dropped in a regression due to collinearity are indicated by (**). To test for heteroskedasticity, a Cook-Weisberg test is used. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 6.2: The effects of natural disasters on crude birth rates: Japan, prefectures

	Dependent variable is cbr for prefectures									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
# earthquakes	**-1.22**		**-0.30**	**-0.33**			-0.13		-0.08	
	(0.22)		**(0.13)**	**(0.06)**			(0.12)		(0.14)	
# tsunamis	**-2.27**		0.28	**-0.30**			0.06		0.24	
	(0.27)		(0.16)	**(0.08)**			(0.14)		(0.20)	
# volcano eruptions	**-1.60**		**0.17**	-0.13			-0.29		-0.46	
	(0.28)		**(0.06)**	(0.08)			(0.17)		(0.24)	
# cyclones and typhoons	-3.48		-2.68	0.49			1.15		-0.29	
	(3.91)		(2.28)	(1.08)			(0.98)		(2.13)	
earthquake magnitude		**-0.21**			**-0.05**	**-0.04**		-0.02		-0.02
		(0.03)			**(0.02)**	**(0.01)**		(0.02)		(0.02)
tsunami magnitude		**-0.87**			0.06	**-0.10**		0.02		0.08
		(0.14)			(0.07)	**(0.04)**		(0.06)		(0.08)
volcano magnitude		**-0.43**			**0.05**	-0.02		-0.10		-0.18
		(0.10)			**(0.02)**	(0.03)		(0.06)		(0.09)
crude death rate							-0.03	-0.03	0.06	0.06
							(0.06)	(0.06)	(0.05)	(0.05)
real wage									**-0.20**	**-0.20**
									(0.02)	**(0.02)**
variance in real wage									**	**
year effects	N	N	Y	Y	Y	Y	Y	Y	Y	Y
pref. effects	Y	Y	N	Y	N	Y	Y	Y	Y	Y
p-value (Pr>F)										
adj. R squared	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
# obs	0.62	0.59	0.74	0.97	0.74	0.97	0.96	0.96	0.98	0.98
	234	234	234	234	234	234	141	141	94	94
	Results from joint test of all natural disaster variables									
p-value	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	**[0.00]**	[0.30]	[0.37]	[0.26]	[0.13]
	Results from joint test of all economic variables									
p-value									**[0.00]**	**[0.00]**
	Results from heteroskedasticity test									
p-value	[0.19]	**[0.00]**	[0.31]	[0.13]	[0.27]	**[0.01]**	[0.74]	[0.86]	[0.40]	[0.31]

Notes: Standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold.. Prob>F is the p-value from F-tests on all the coefficients (including year and the place dummies, but excluding the constant). Variables that were dropped in a regression due to collinearity are indicated by (**). To test for heteroskedasticity, a Cook-Weisberg test is used. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Table 6.3: The effects of natural disasters on mean age at marriage of females: Japan, regional non-prefectures

	Dependent variable is mean age at marriage of females							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
# earthquakes	-0.92		-0.96	-1.26			**7.17**	
	(0.60)		(0.72)	(0.69)			**(2.22)**	
# tsunamis	-0.30		-0.29	-0.32			1.25	
	(0.41)		(0.43)	(0.41)			(0.54)	
# cyclones and typhoons		**			**	**		**
earthquake magnitude		-0.00			-0.02	-0.00		-0.10
		(0.13)			(0.14)	(0.14)		(0.12)
tsunami magnitude								
real wage							**0.35**	0.13
							(0.08)	(0.05)
variance in real wage							13.07	-12.11
							(14.54)	(18.84)
year effects	N	N	Y	Y	Y	Y	Y	Y
place effects	Y	Y	N	Y	N	Y	Y	Y
p-value(Pr>F)	0.29	0.42	0.52	0.33	0.76	0.61	**0.02**	0.12
adj. R squared	0.10	0.00	-0.04	0.10	-0.11	-0.09	0.76	0.43
# obs	16	16	16	16	16	16	14	14
Results from joint test of all natural disaster variables								
p-value	[0.34]	[0.98]	[0.43]	[0.24]	[0.90]	[1.00]	**[0.03]**	[0.43]
Results from joint test of all economic variables								
p-value							**[0.01]**	[0.08]
Results from heteroskedasticity test								
p-value	[0.91]	[0.44]	[0.58]	[0.65]	[0.82]	[0.39]	[0.87]	[0.74]

Notes: Standard errors are in parentheses. Coefficients that are statistically significant at a 5% level are in bold.. Prob>F is the p-value from F-tests on all the coefficients (including year and the place dummies, but excluding the constant). Variables that were dropped in a regression due to collinearity are indicated by (**). To test for heteroskedasticity, a Cook-Weisberg test is used. For all specification tests, results for which the null hypothesis should be rejected at a 5% level are in bold.

Appendix A.1: National data for Italy

Name	Description	# yrs per obs	Yrs covered	Source
pop	population size (1971 boundaries)	1	1861 to 1971	Livi-Bacci, 1977, p. 52 (also del Panta, 1979, p. 220)
cbr3	crude birth rate (per 1000)	3	1862 to 1962	Livi-Bacci, 1977, p. 62
cbr4o5	crude birth rate (per 1000)	5 (one is 4)	1872 to 1940	Cipolla, 1965, p. 580
cbr10	crude birth rate (per 1000)	10	1862 to 1971	Livi-Bacci, 1977, p. 53 (also del Panta, 1979, p.220)
cdr5	crude death rate (per 1000)	5	1872 to 1963	del Panta, 1979, p. 226; and Cipolla, 1965, p. 580
cdr10	crude death rate (per 1000)	10	1862 to 1971	Livi-Bacci, 1977, p. 53 (also del Panta, 1979, p.220)
If	index of total fertility	3	1871 to 1961	Treadway, 1980
Ig	index of marital fertility	3	1871 to 1961	Treadway, 1980
Ih	index of non-marital fertility	3	1871 to 1961	Treadway, 1980
Im	index of marital status	3	1871 to 1961	Treadway, 1980
age_marf3	Mean age of women at 1st marriage	3	1911 to 1961	Treadway, 1980
age_marf5	Mean age of women at 1st marriage	5	1896 to 1969	Livi-Bacci, 1977, p. 100 (also del Panta, 1979, p.220)
age_marm5	Mean age of men at 1st marriage	5	1896 to 1969	Livi-Bacci, 1977, p. 100 (also del Panta, 1979, p.220)
w	real wage	1	1871 to 1988	Williamson, 1995

Appendix A.2: Regional data for Italy

Name	Variable description	# yrs per interval	Yrs covered	Source
region-level data				
cbr	CBR (per 1000)	mostly 3	1822 to 1961	Livi-Bacci, 1977, p. 22-23 & 62
age_marf	Mean age of women at 1st marriage	3	1906 to 1968	Livi-Bacci, 1977, p. 107
If	index of total fertility	3	1871 to 1961	Treadway, 1980
Ig	index of marital fertility	3	1871 to 1961	Treadway, 1980
Ih	index of non-marital fertility	3	1871 to 1961	Treadway, 1980
Im	index of marital status	3	1871 to 1961	Treadway, 1980
eq	# earthquakes in past 20 yrs	1	1771 to 1988	Dunbar, Lockridge & Whiteside, 1999
eq_intens	Modified Mercalli Intensity of earthquake (sum over 20 yrs)	1	1771 to 1988	Dunbar, Lockridge & Whiteside, 1999
volc	# volcano eruptions in past 20 yrs	1	1771 to 1988	Whiteside, 1999
volc_mag	volcano explosivity index + 1 (sum over 20 yrs)	1	1771 to 1988	Whiteside, 1999
ava_lan	# avalanches and landslides in past 20 yrs	1	1771 to 1988	Newson, 1998
ltning	# severe lightning storms in past 20 yrs	1	1771 to 1988	Newson, 1998
flood	# floods in past 20 yrs	1	1771 to 1988	Newson, 1998
geographical area-level variables				
g_cdr	CDR (per 1000)	4 or 5	1870 to 1963	del Panta, 1979, p. 226

Appendix A.3: Regional data for Japan

Name	Variable description	# yrs per obs	Yrs covered	Source
non-prefecture variables				
cbr	CBR (per 1000)	1 to 41	1671 to 1960	Hanley & Yamamura, 1977, pp. 148, 211, 257, 297-299, 301-302, & 305; Morris & Smith, 1985, p.236; Smith, 1977, p. 40 Jannetta & Preston, 1998, p. 88
cdr	CDR (per 1000)	1 to 41	1671 to 1960	Hanley & Yamamura, 1977, p. 148, 211, 257, 297-299, 301, 302, 305; Morris & Smith, 1985, p. 236 Smith, 1977, p.40; Jannetta & Preston, 1998, p.88
age_marf	Mean age of women at 1st marriage	4 to 30	1696 to 1865	Hanley & Yamamura, 1977, p. 247
prefecture variables				
cbr	CBR (per 1000)	6	1920 to 1955	Taeuber, 1958, p. 242
cdr	CDR (per 1000) for mura ("villages")	1	1925 to 1935	Taeuber, 1958, p. 298
Natural disaster variables				
eq	# earthquakes in past 20 yrs	1	1671 to 1965	Dunbar, Lockridge & Whiteside, 1999
eq_mag	measure of seismic energy released by earthquake	1	1671 to 1965	Dunbar, Lockridge & Whiteside, 1999
tsu	# tsunamis in past 20 yrs	1	1671 to 1965	
tsu_mag	measure of height of runup, + 2	1	1671 to 1965	
volc	# volcano eruptions in past 20 yrs	1	1671 to 1965	Whiteside, 1999
volc_mag	volcano explosivity index + 1 (sum over 20 yrs)	1	1671 to 1965	Whiteside, 1999
cyc_typ	# cyclones and typhoons in past 20 yrs	1	1671 to 1965	Newson, 1998
national variables				
w	real wage	1	1727 to 1938	from Jeffrey Williamson

Appendix B: Regression notes

Regressions for Italy (Tables 5.1-5.6):

Dependent variables (cbr, If, etc.) span 3 years per observation. Consequently, the natural disaster variables, which represent the sum of either the number or intensity of natural disasters over the last 20 years, are averaged over 3 years. Similarly, the real wage and the variance of the detrended wage (which is divided by 1000) are averaged over 3 years as well. Geographical area-level crude death rates span 4-5 years per observation. All variables spanning multiple years are centered on year.

Regressions for crude birth rates in Japan, non-prefectures (Table 6.1):

Crude birth rates span 1-41 years per observation, with an average span of approximately 10 years. Consequently, the natural disaster variables, which represent the sum of either the number or intensity of natural disasters over the last 20 years, are averaged over 10 years. Similarly, the real wage and the variance of the detrended wage (which is divided by 1000) are averaged over 10 years as well. Crude death rates (cdr) span the same number of years as the crude birth rate for each observation. All variables spanning multiple years are centered on year.

Regressions for crude birth rates in Japan, prefectures (Table 6.2):

Crude birth rates span 6 years per observation. Consequently, the natural disaster variables, which represent the sum of either the number or intensity of natural disasters over the last 20 years, are averaged over 6 years. Similarly, the real wage and the variance of the detrended wage (which is divided by 1000) are averaged over 10 years as well. Village crude death rates span 1 year for each observation, and is for first year of the 6-year interval over which the crude birth rate spans. All variables spanning multiple years are centered on year.

Regressions for mean age at marriage in Japan, non-prefectures (Table 6.3):

Mean age at first marriage of females spans 4-30 years per observation, with an average span of approximately 10 years. Consequently, the natural disaster variables, which represent the sum of either the number or intensity of natural disasters over the last 20 years, are averaged over 10 years. Similarly, the real wage and the variance of the detrended wage (which is divided by 1000) are averaged over 10 years as well. All variables spanning multiple years are centered on year. There are too few observations for crude death rates to be included in the regressions as well.