

# LONG-RUN HEALTH IMPACTS OF INCOME SHOCKS: WINE AND PHYLLOXERA IN NINETEENTH-CENTURY FRANCE

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*Abstract*—Between 1863 and 1890, phylloxera destroyed 40% of French vineyards. Using the regional variation in the timing of this shock, we identify and examine the effects on adult height, health, and life expectancy of children born in the years and regions affected by the phylloxera. The shock decreased long-run height, but it did not affect other dimensions of health, including life expectancy. We find that those born in affected regions were about 1.8 millimeters shorter than others at age 20, a significant effect since average heights grew by only 2 centimeters in the entire nineteenth century.

## I. Introduction

POOR environmental conditions in utero and during early childhood have been shown to have adverse consequences on later life outcomes, including life expectancy, height, cognitive ability, and productivity (Barker, 1992).<sup>1</sup> Important influences include the disease environment (Almond, 2006), the public health infrastructure (Almond & Chay, 2005), food availability (see, e.g., Almond et al., 2006, and Meng & Qian, 2009, on the great Chinese famine, and Rosebloom et al., 2001, and Ravelli et al., 2001, on the Dutch famine of 1944–1945), and even the availability of certain seasonal nutrients (Doblhammer, 2003).

At the same time, evidence from developing countries suggests, not surprisingly, that young children's nutritional status is affected by family income (see, e.g., Jensen, 2000, and Duflo, 2003). Taken together, these two facts suggest that at least in poor countries, economic crises may have important long-term impacts on the welfare of the cohorts born during these periods.<sup>2</sup> Yet except for the few papers on famines mentioned above, very little evidence establishes a direct link between economic events at birth and adult outcomes. This is perhaps not surprising since such an analysis requires good data on adult outcomes, coupled with information on economic conditions faced during early childhood. Longitudinal data are often not available over such long time periods, especially in poor countries, except for dramatic events such as famines. As a result, the few existing studies tend to be limited to cohort analyses. For example, Van den Berg, Lindeboom, and Portrait (2006) show that among cohorts born between 1812 and 1912 in

the Netherlands, those born in slumps have lower life expectancy than those born in booms. However, a concern with using just time variation is that it might reflect other time-specific elements, such as the quality of public services, the relative price of different nutrients, or even conditions in adulthood. To fill this gap, this paper takes advantage of the phylloxera crisis in nineteenth-century France, which, we will argue, generated a negative large income shock that affected different departments (regional areas roughly similar in size to U.S. counties) in France in different years, combined with the rich data on height and health collected by the French military administration.

Phylloxera, an insect that attacks the roots of vines, destroyed a significant portion of French vineyards in the second half of the nineteenth century. Between 1863, when it first appeared in southern France, and 1890, when vineyards were replanted with hybrid vines (French stems were grafted onto phylloxera-resistant American roots), phylloxera destroyed 40% of the French vineyards. Just before the crisis, about one-sixth of the French agricultural income came from wine, mainly produced in a number of small, highly specialized wine-growing regions. For the inhabitants of these regions, the phylloxera crisis represented a major income shock. Although there are no systematic data on departmental income in the period (or even agricultural income on a year-to-year basis), we estimate that the loss in department agricultural income during the crisis probably ranged from between 16% and 22% in these regions, where 67% of the population was living in rural areas just before the crisis (and 57% was living directly from agriculture income). Because the insects spread slowly from the southern coast of France to the rest of the country, phylloxera affected different regions in different years. We exploit this regional variation in the timing of the shock to identify its effects, using a difference-in-differences strategy.

We examine the effect of this shock on the adult height, health, and life expectancy outcomes of children born in years when the phylloxera affected their region of birth, controlling for region and year-of-birth effects. The height and health data come from the military, which measured all conscripts (who were 20 years old at the time of reporting) and reported the number of young men falling into a number of height categories at the department level. The statistics also reported the number of young men who had to be exempted for health reasons and specified the grounds of exemption. These data are available for 83 departments, which are consistently defined over the period we consider.<sup>3</sup>

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<sup>1</sup> The idea that in utero conditions affect long-run health is most commonly referred to as the “fetal origin hypothesis” and associated with D. J. P. Barker (1992, 1994). For additional evidence, see, among others, Strauss and Thomas (1995), Case and Paxson (2006), and Behrman and Rosenzweig (2004).

<sup>2</sup> In rich countries this effect may be compensated by the fact that pollutants diminish during economic slumps (Chay & Greenstone, 2003).

<sup>3</sup> France lost Moselle, Bas-Rhin, and Haut-Rhin to Prussia in 1870, while retaining the Territoire de Belfort, a small part of Haut-Rhin. Moselle, Rhin-Bas, Haut-Rhin, and Belfort are excluded from the analysis.

In addition, we use data on female life expectancy at birth constructed from the censuses and reports of vital statistics.

In many ways, France in the late nineteenth century was a developing country. In 1876 female life expectancy was 43 years; infant mortality was 22%; and the average male height at the age of 20 was 1.65 meters, approximately the third percentile of the American population today. The phylloxera crisis therefore gives us the opportunity to study the impact of a large income shock to the family during childhood on long-term health outcomes in the context of a developing economy. In addition, the crisis had a number of features that make it easier to interpret the results. First, we show that it was not accompanied by important changes in migration patterns or an increase in infant mortality. We therefore do not need to worry about sample selection in those we observe in adulthood, unlike what seems to happen, for example, in the case of a famine. Second, the crisis did not result in a change in relative prices, which means that it did not spill over into areas that did not grow wine (even the price of wine did not increase very much, for reasons we will discuss below). As a result, we can identify regions that were completely unaffected. Finally, the progression of the epidemic was exogenous, as it was caused by the movement of the insects, which is something no one knew how to stop until the late 1880s.

We find that the phylloxera shock had a long-run impact on stature. We estimate that children born during a phylloxera year in wine-producing regions were 1.6 to 1.9 millimeters shorter than others. Our very rough estimates suggest that the fall in department income in wine-producing regions during these years may have ranged between 10% and 15%.<sup>4</sup> These estimates are thus in line with the secular growth in height over the nineteenth century: height increased by 2 centimeters, when GDP was multiplied by 3, which implies a gain of 1.8 millimeters for a 10% increase in income.<sup>5</sup> If we assume that only wine-growing families were directly affected (which, as we discuss below, may not be a very good assumption, since we may expect market equilibrium effects in the department), we calculate that this drop in height corresponds to a decline in height of 0.6 to 0.9 centimeters for children born in families involved in wine production (workers or farm owners) in years where their region was affected. We do not find that children born just before or just after the phylloxera crisis were affected by it, which supports the Barker hypothesis of the importance of in utero conditions for long-run physical development. However, we also do not find any long-term effect on other measures of health, including

<sup>4</sup> We detail how we arrive at these numbers below, but we note that they are very approximative. They are useful merely as an order of magnitude.

<sup>5</sup> We have no reliable estimate of the share of agriculture in department income at the time, but given that the share of the adult population working in agriculture was about 60% in these regions, it is reasonable to expect that the drop in department GDP was somewhere between 50% and two-thirds of the drop in agricultural income, so between 8% and 15%.

TABLE 1.—SUMMARY STATISTICS

	Mean	s.d.	Observations
	(1)	(2)	(3)
Superficie grown in wine (hectare)	28,205	33,549	2,165
Log wine yield (value per hectare)	2.55	0.83	2,153
Log (wine production) (value)	12.03	1.87	3,088
Log (wheat production) (value)	13.66	0.89	3,209
Share of wine in agricultural production (1863)	0.15	0.14	3,649
Share of population working in agriculture	0.58	0.15	3,526
Superficie grown in wine per habitant	0.07	0.09	3,769
Share of population in agriculture multiplied by share of wine in agricultural production	0.09	0.08	3,526
Number of live births	10,751	8,593	2,795
Share of males surviving until age 20	0.69	0.23	2,683
Share of males surviving until age 20 (conditional on surviving until age 1)	0.85	0.29	2,599
Share of stillbirths	0.04	0.01	2,795
Infant mortality (death before age 1/live birth)	0.17	0.04	2,486
Life expectancy (women)	44.34	4.55	630
Net outmigration of youth age 20–29	–0.02	0.05	690
Net outmigration (all)	–0.02	0.02	690
Military class size	3,567	2,708	3,526
ilitary class/census cohort aged 15–19	0.99	0.27	504
Proportion exempted for health reasons	0.24	0.07	3,354
Mean height of military class at 20	1.66	0.01	3,526
Fraction of military class shorter than 1.56 meters	0.05	0.02	3,526
Height of percentile 10	1.57	0.01	3,526
Height of percentile 20	1.59	0.01	3,526
Height of percentile 25	1.60	0.02	3,526
Height of percentile 50	1.65	0.01	3,526
Height of percentile 75	1.69	0.01	3,526
Height of percentile 80	1.70	0.01	3,526
Height of percentile 90	1.72	0.01	3,526

Note: Except when otherwise indicated, this table presents average by department of the variables used in this paper over the years 1852–1892 (corresponding to the military classes 1872–1912, and years of birth 1852–1892). Data sources are described in detail in the data appendix.

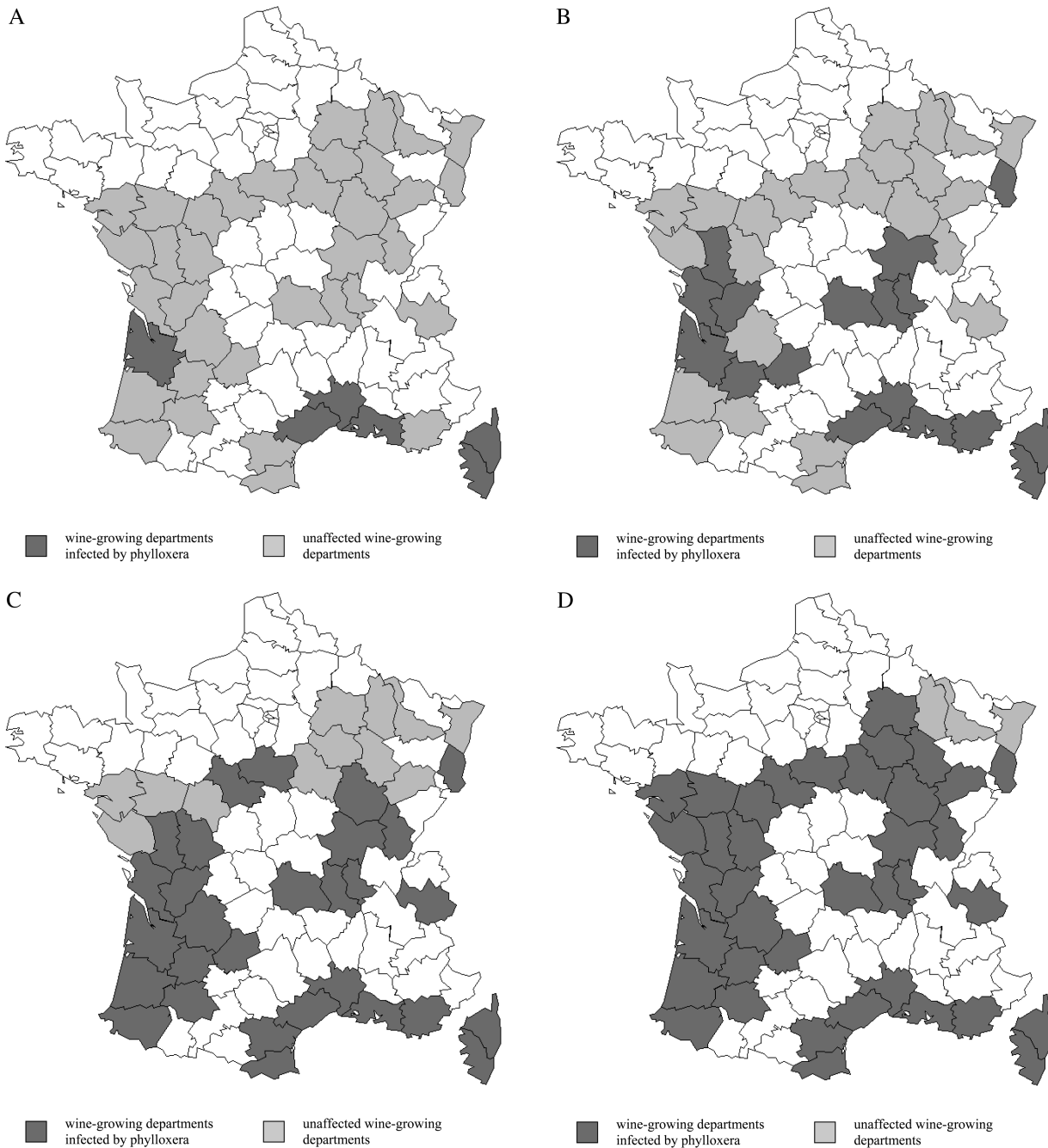
infant mortality, morbidity at the age of 20 (measured by the military as well), or life expectancy of women.

The remainder of this paper proceeds as follows. In the next section, we describe the historical context and the phylloxera crisis. In section III, we briefly describe our data sources (a data appendix, available online at [http://www.mitpressjournals.org/doi/suppl/10.1162/rest\\_a\\_00024](http://www.mitpressjournals.org/doi/suppl/10.1162/rest_a_00024), does so in more detail). In sections IV and V, we present the empirical strategy and the results. Section VI concludes.

## II. Wine Production and the Phylloxera Crisis

Wine represented an important share of agricultural production in nineteenth-century France. In 1863, the year phylloxera first reached France, wine production represented about one-sixth of the value of agricultural production in France, which made it the second most important product after wheat (table 1). Wine was produced in 79 of 89 departments, but represented more than 15% of agricultural production in only 40 of them. We refer to these 40 departments below as the wine-growing departments.

FIGURE 1.—SPREAD OF PHYLLOXERA

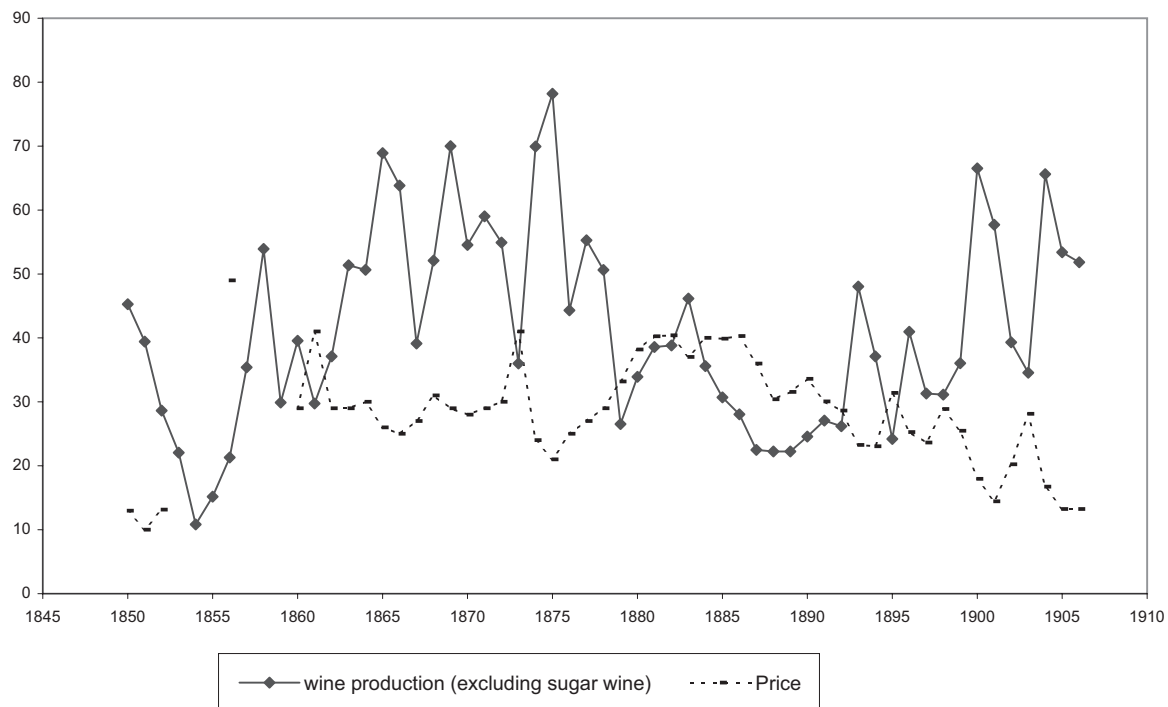


A: Phylloxera in 1870  
 B: Phylloxera in 1875  
 C: Phylloxera in 1880  
 D: Phylloxera in 1890

Phylloxera, an insect of the aphid family, attacks the roots of grape vines, causing dry leaves, a reduced yield of fruit, and the eventual death of the plant. Indigenous to America, the insects arrived in France in the early 1860s, apparently having traveled in the wood used for packaging (though it is possible that it was actually in a shipment of American vines). By the 1860s, the pest had established itself in two areas of France. In the departments on the southern coast,

near the mouth of the Rhône, wine growers first noticed the pest's effects in 1863, and there are many recorded reports of it in 1866 and 1867. In 1869 the pest also appeared on the west coast in the Bordeaux region. The maps in figures 1A to 1D show the progression of the invasion starting from these two points. From the south, the insects spread northward up the Rhône and outward along the coast. From the west, the insects moved southeast along the Dordogne and

FIGURE 2.—WINE PRODUCTION AND WINE PRICE, 1850–1908



Garonne rivers and north to the Loire valley. By 1878, phylloxera had invaded all of southern France and 25 of the departments where wine was an important agricultural production. It reached the suburbs of Paris around 1885.

During the first years of the crisis, no one understood why the vines were dying. As the phylloxera spread and the symptoms became well known, it became clear that the disease posed a serious threat to wine growers, and two of the southern departments, Bouches-du-Rhône and Vaucluse, formed a commission to investigate the crisis. The commission found phylloxera insects on the roots of infected vines in 1868 and identified the insects as the cause of the dead vines. After experimenting with various ineffective treatments (such as flooding or treatment with carbon bisulphide), they discovered the ultimate solution in the late 1880s: grafting European vines onto pest-resistant American roots. In 1888, a mission identified 431 types of American vines and the types of French soil they could grow in, paving the road to the recovery that started in the early 1890s. Eventually approximately four-fifths of the vineyards originally planted in European vines were replaced with grafted vines.

Figure 2 shows the time series of wine production in France from 1850 to 1908. The decline in the first years reflects the mildew crisis, which affected the vines before the phylloxera. After a rapid recovery between 1855 and 1859, the production grew until 1877, by which time more than half of wine-growing departments were touched by the phylloxera crisis. Note that aggregate wine production continued to increase until 1877 because it continued to increase quite rapidly in the unaffected region. Wine produc-

tion fell until 1890, when the progressive planting of the American vines started the recovery.

Table 2 shows the importance of the phylloxera crisis on wine production. Using data on wine production reported in Galet (1957), we construct an indicator for whether the region was affected by phylloxera. Galet indicates the year where the phylloxera aphids were first spotted in the regions. In most regions, however, for a few years after that, production continued to increase (or remained stable) until the aphid had spread. The number of years the aphid took to spread varies tremendously from one department to the next and cannot be captured by a single lag structure. Since we want to capture the fall in wine production due to the insect, we define pre-phylloxera year as the year before the aphids were first spotted, and the indicator “attained by phylloxera” is equal to 1 between the first year the production is below its preproduction level and 1890 (since the grafting solution had been found by then).<sup>6</sup>

We then run a regression of area planted in vines, the log of wine production, and yield for the years 1852 to 1892 on year dummies, department dummies, and an indicator for whether the region was touched by the phylloxera in that year. We run the following specification:

<sup>6</sup> We experimented with other ways of defining the phylloxera attack as well, with results that are qualitatively similar (although the point estimates clearly depend on how strong the fall in production has to be before a department is considered to be “affected”). In particular, the results are unaffected if we use an average of several years before the start of the epidemics to define the predisease situation rather than focusing on the last year.



TABLE 2.—IMPACT OF PHYLLOXERA ON WINE AREA AND WINE PRODUCTION

	Wine			Wheat		
	Log (Area) (1)	Log (Yield) (2)	Log (Production) (3)	Log (Area) (4)	Log (Yield) (5)	Log (Production) (6)
<b>A. Controls: Year Dummies, Department Dummies</b>						
Phylloxera	-0.069 (.061)	-0.287 (.06)	-0.264 (.101)	0.005 (.024)	-0.013 (.025)	-0.020 (.037)
Observations	2,165	2,153	3,088	1,020	1,020	3,172
<b>B. Controls: Year Dummies, Department Dummies, Department-Specific Trend</b>						
Phylloxera	-0.046 (.051)	-0.427 (.077)	-0.449 (.1)	0.005 (.017)	-0.027 (.024)	0.025 (.03)
Observations	2,165	2,153	3,088	1,020	1,020	3,172
<b>C. Sample Restricted to Wine-Producing Regions (with Department-Specific Trend)</b>						
Phylloxera	-0.016 (.049)	-0.480 (.092)	-0.448 (.119)	-0.008 (.016)	-0.008 (.031)	0.026 (.036)
Observations	1,058	1,051	1,519	456	456	1,433

Note: Each column and each panel present a separate regression. All regressions include department dummies and year dummies. Standard errors corrected for clustering and autocorrelation by clustering at the department level (in parentheses below the coefficient). The phylloxera dummy is 1 every year that production is lower than pre-phylloxera after the first year the aphid was seen in the region and before 1980. There are fewer data points in this regression than in the following tables, because the data on wine and wheat production are not available for every department in every year.

$$y_{ij} = aP_{ij} + k_i + d_j + u_{ij},$$

where  $y_{ij}$  is the outcome variable (vine-grown areas, wine yield, wine production, as well as wheat production) in department  $i$  in year  $j$ ,  $P_{ij}$  is an indicator for phylloxera,  $k_i$  and  $d_j$  are department and year fixed effects, and  $u_{ij}$  is an error term. The standard errors are corrected for autocorrelation by clustering at the department level. We also run the same specification after controlling for department-specific trends:

$$y_{ij} = aP_{ij} + k_i + t_{ij} + d_j + u_{ij},$$

where  $t_{ij}$  is a department-specific trend. The results are shown in table 2B. The yield and the production declined dramatically. According to the specification that controls for a department-specific trend, production was 32% lower and the yield was 35% lower during phylloxera years.

To make up for the shortage of French wine, both the rules for wine imports into France and the making of *piquette* (press cake—the solids remaining after pressing the grape grain to extract the liquids, which were then mixed with water and sugar) and raisin wines were relaxed. For example, while only 0.2 million hectoliters of wine were imported in 1860s, 10 million hectoliters were imported in the 1880s (for comparison, the production was 24 million hectoliters in 1879). Imports declined again in the late 1890s (Ordish, 1972). As can be seen in figure 2, this kept the price of wine from increasing at anywhere near the same rate as the decrease in production. Price movements thus did little to mitigate the importance of the output shock. Moreover, given the size of the crisis in the most affected regions, farmers could not systematically rely on credit to weather the crisis. In particular, Postel-Vinay (1989) describes in detail how the Languedoc region, the traditional system of credit collapsed during the phylloxera crisis (since both lenders and borrowers were often hurt by the crisis). All of

this suggests that phylloxera was a large shock to the incomes of people in the wine-growing regions, and the possibility for smoothing it away was at best limited.<sup>7</sup>

Unfortunately, yearly data on overall agricultural production or department income are not available except for a few departments (Auffret, Hau, & Lévy-Leboyer, 1981), so we cannot provide a quantitative estimate of the fall in department “GDP” due to the phylloxera. However, there are reasons to think that there was no substitution toward other activities, so that the decline in wine production led to a corresponding decline in income in the affected departments. Table 2 shows that the area planted with vines did not decline during the crisis, both because many parcels of land that had been planted with vines would have been ill suited to all other crops and also because most growers were expecting a recovery. As a result, the decrease in wine production was not compensated by a corresponding increase in other agricultural production: columns 3 to 5 in table 2 show the results of regressing the production of wheat and the area cultivated on wheat on the phylloxera indicator and show no increase of wheat production compensating for the decline in wine production. In the few departments in which the series on agricultural production have been constructed by Auffret et al. (1981), the fall in overall agricultural production appears to be proportional with the fall in wine production.

<sup>7</sup> One question that arises is whether the drop in the wine production was entirely compensated by the increase in export and *piquette* production. It appears that total wine or wine substitute availability was indeed lower during phylloxera years (Ordish, 1972). The reduction in wine consumption may have had a direct effect on health. However, this will be reflected in our estimation, which is based on a differences-in-differences strategy, only to the extent that wine consumption dropped differentially in wine-producing and non-wine-producing regions. If it did (there are unfortunately no data that can help us answer this question), and in particular if wine consumption dropped more in wine-producing regions than elsewhere, and if wine consumption during pregnancy is bad for child development, our estimates will be an underestimate of the true effect of income.

Given this evidence, we used the share of wine in agricultural production in 1862 and, using the total agricultural production as measured in the agricultural survey of 1862 (Statistique de la France, 1868) as the starting point, we computed two estimates of the drop in agricultural income in wine-producing regions during the phylloxera period. In one estimate, we assume that the production of other crops did not increase (or decrease) in response to the drop in wine production, which is consistent with the historical evidence. In the other, we assume that the surface area devoted to vine lost during the phylloxera was allocated to other crops during the crisis. With the first method, we estimate that the average loss in agricultural income in the wine-producing region during the phylloxera period was 22%. With the second method, we estimate that it was 16%.

The basis for computing the loss in total department income is even weaker. Before the crisis, 57% of the population was directly involved in agriculture in these regions (and 67% of the population was rural), with strong variation from department to department. For each department, we calculate an estimate of the regional income before the crisis, assuming the same relationship between the share of population in agriculture and the share of agriculture in the GDP as in the time series at the national level for the nineteenth century (Lévy-Leboyer & Bourguignon, 1990; Marchand & Thélot, 1997). We then compute what the GDP of the department would have been if nonagriculture was not affected by the crisis. With the two assumptions on how agricultural income evolved, we compute an estimate of the drop in income ranging from 10% to 15%. It is important to note that this is not a reliable estimate of the income loss. But it does help us scale the order of magnitude of the crisis, which will be useful to give a sense of the magnitude of our estimates.

### III. Data

In addition to the department-level wine production data, we use several other data sources in this paper (the data sets are described in more detail in the data appendix).

First, we assembled a complete department-level panel data set of height-reported by the military. Height is widely recognized to be a good measure of general health, and countless studies have shown that it is correlated with other adult outcomes. (See Case & Paxson, 2006, and Strauss & Thomas, 1995, for references to studies showing this in the context of the developing world and, among many others, Steckel, 1995, Steckel & Floud, 1997, and Fogel, 2004, for historical evidence on this issue from countries that are now considered developed.) France is a particularly good context to use military height data. Since the Loi Jourdan (compulsory conscription act) in 1798, young men had to report for military service in the year they turned 20 in the department where their father lived (all the young men reporting in one department in one year were called a *classe*, or military class). The military measured all members of each *classe*,

and, beginning in 1836, published the data on height yearly in the form of the number of young men who fell into particular height categories (the number of categories varied from year to year). These documents also included, for each department and each year, the number of young men exempted and the grounds for exemption (in particular, if they were exempted for disease, the nature of the disease). Using these data, we estimated both parametrically and nonparametrically the average height of the 20 year olds in each department in each year, as well as the fraction of youth who were shorter than 1.56 meters, the threshold for exemption from military duty (see the data appendix for the estimation methods).<sup>8</sup> We also computed the fraction of each military class exempted for health reasons and created a consistent classification of the disease justifying the exemptions.

The nation-level aggregate data on French military conscripts have been used previously (see Aron, Dumont, & Le Roy Ladurie, 1972; Van Meerten, 1990; Weir, 1993, 1997; and Heyberger, 2005). However, this paper is the first to assemble and exploit the data on mean height and proportion of those stunted for all departments and every year between 1872 and 1912.<sup>9</sup> The details of the data construction are presented in the appendix.

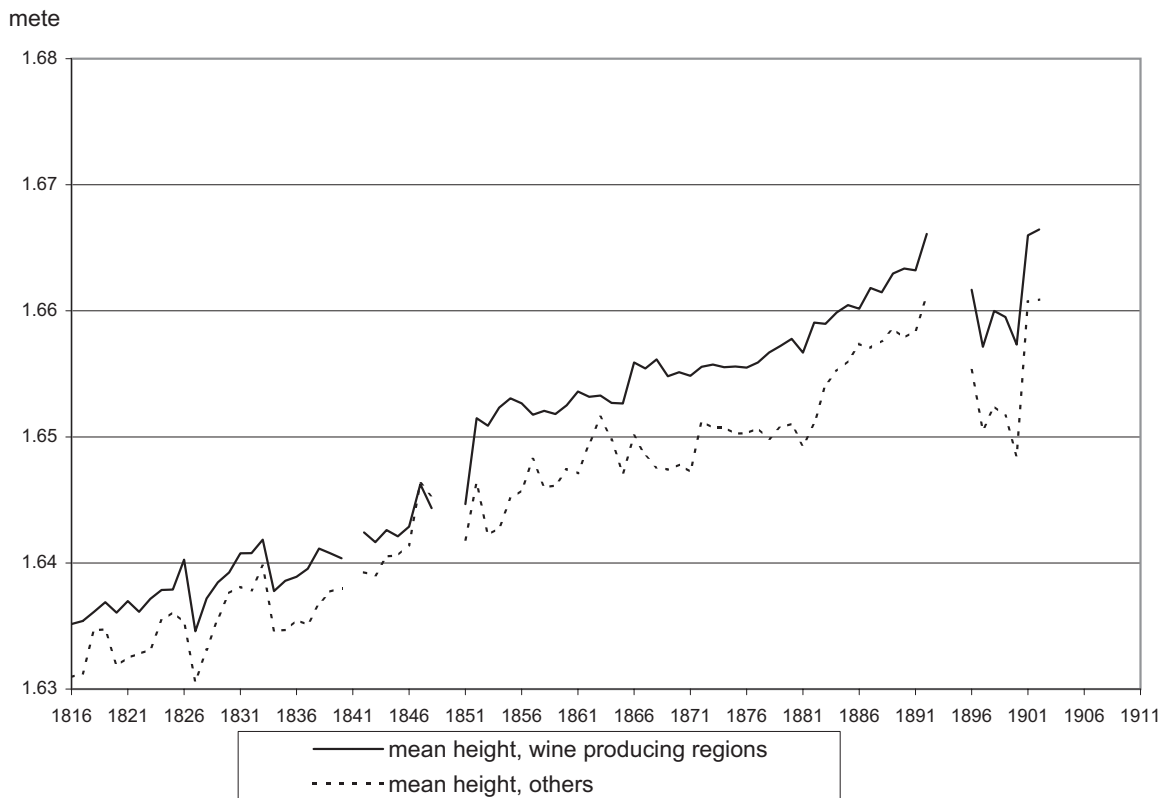
We also conducted original archival work in three departments to collect military data at the level of the canton (the smallest administrative unit after the *commune*, or village) in three wine-growing departments: Bouches du Rhône, Gard, and Vaucluse. The precise height data were not stored at this level, but the canton level data tell us three things: the fraction of people not inducted into the military for reason of height (which is available only until the cohort conscripted in 1901, since the military did not reject anyone based on height after that year), the fraction rejected for reasons of “weakness,” and the fraction put into an easier service for the same reason.

We use only the data for the years 1872 to 1912 in the analysis (corresponding to years of birth between 1852 and 1892), which span the phylloxera crisis, as well as the period before and during the recovery, since this is the period for which the military data are the most representative of the height in the population. Starting in 1872, every young man had to report for military service. Starting in 1886, every man’s height was published, even if he was subsequently exempted from military service. Therefore, the data are representative of the entire population of conscripts from 1886 on; from 1872 to 1885, we are missing the height data for those exempted for poor health (15%) or other reasons (25%). We discuss in the appendix what we assume about the height of those exempted to construct estimates that are

<sup>8</sup> Actually 1.56 meters was the highest threshold for exemption that was used. The threshold varied over time.

<sup>9</sup> With the exception of Postel-Vinay and Sahn (2006), which was written concurrently with this paper and exploits the same data set. Weir (1993) constructed a panel of departments over a longer time period but used only selected years.

FIGURE 3.—MEAN HEIGHT OVER TIME: WINE-PRODUCING REGIONS AND OTHERS



representative of the entire sample, and using a complete individual-level data set available for a subsample, we show that these assumptions appear to be valid. The data should therefore be representative of the entire population of young men who presented themselves to the military service examination in a given region.

This sample may be still endogenously selected if phylloxera led to changes in the composition of those who reported to the military conscription bureau in their region of birth because of death, migration, or avoidance of the military service. According to historians of the French military service (e.g., Woloch, 1994), the principle of universal military conscription was applied thoroughly in France during this period. A son had to report in the canton where his father lived (even if the son had subsequently migrated), and the father was legally responsible if he did not. Avoidance and migration by the son are therefore not likely to be big issues. As a check, we computed the ratio between the number of youths aged 15 to 19 in each department in each census year, and the sum of the sizes of the military cohorts in the four corresponding years—for example, a youth aged 19 (resp. 17) in 1856 was a member in the class of 1857 (resp. 1859). The average is 99%, and the standard deviation is low (table 1). Moreover, as we will show in table 8, this ratio does not appear to be affected by the phylloxera crisis.

The main potential sample selection problems that remain are therefore those of differential migration by the fathers

and mortality between birth and age 20. We will show in section VC that neither of these seems to have been affected by the phylloxera infestation.

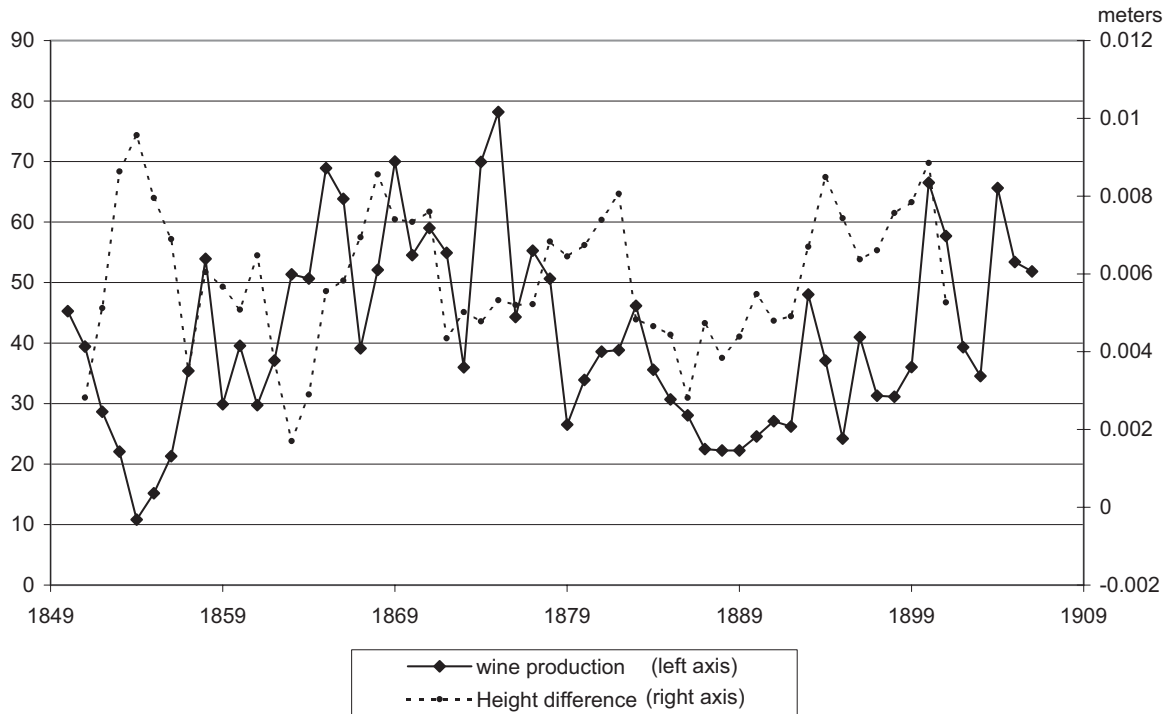
Finally, we use data on number of births and infant mortality (mortality before age 1) from the vital statistics data for each department and each year and two data series constructed by Bonneuil (1997) using various censuses and records of vital statistics. The first one gives the life expectancy of females born in every department every five years, from 1806 to 1901. The second gives the migration rates of females, for both the young (aged 20 to 29) and the entire population.

#### IV. Empirical Strategy

##### A. Department-Level Regressions

Figures 3 and 4 illustrate the spirit of our identification strategy. Figure 3 shows mean height in each cohort of birth for wine-producing regions (where wine represents at least 15% of the agricultural production) and other regions. Wine-growing regions tend to be richer and, for most of the period, the 20-year-old males are taller in those regions than in others. However, as figure 4 shows very clearly, the difference in average height between those born in wine-producing regions and those born in other regions fluctuates. The striking fact in this figure is how closely the general trend in the difference in mean height follows the general trend in wine production. Both grow until the end of the

FIGURE 4.—WINE PRODUCTION AND HEIGHT DIFFERENTIALS



1860s, decline in the next two decades when the phylloxera progressively invades France, and increase again in the 1890s when wine grafting allows production to rise again.

The basic idea of the identification strategy builds on this observation. It is a simple difference-in-differences approach where we ask whether children born in wine-producing departments in years where the wine production is lower due to the phylloxera, are shorter at age 20 than their counterparts born before or after, relative to those who are born in other regions in the same year. We also can ask whether they have worse health (which the military defines as, for example, lower life expectancy or lower long-term fertility). The difference-in-differences estimates are obtained by estimating

$$y_{ij} = aPL_{ij} + k_i + d_j + u_{ij}, \tag{1}$$

where  $y_{ij}$  is the outcome variable (for example, height at age 20, life expectancy) in department  $i$  in year  $j$ ,  $PL_{ij}$  is the production loss due to phylloxera in the wine-producing region, which is defined as the indicator that the region was affected by phylloxera (constructed as explained in section II), multiplied by the loss in production in a given year  $j$  ( $production_{ij}$ ) relative to the production in the latest pre-phylloxera year ( $preproduction_i$ ). Thus,

$$PL_{ij} = P_{ij} \times \left( \text{Max} \left( \frac{preproduction_i - production_{ij}}{preproduction_i}, 0 \right) \right)$$

for departments in producing regions and is set to 0 if the department was not a wine-producing department.<sup>10</sup>  $k_i$  and  $d_j$  are department and year fixed effects, and  $u_{ij}$  is an error term (following Bertrand, Duflo, & Mullainathan, 2004, the standard errors are corrected for autocorrelation by clustering at the department level).

We also run the same specification after controlling for department-specific trends. If there is no misspecification and no omitted time trend, the coefficient should be the same, but the standard errors should be tighter:

$$y_{ij} = aPL_{ij} + k_i + t_{ij} + d_j + u_{ij}. \tag{2}$$

We also define a binary instrument for whether a department is affected by the phylloxera in a given year. This is the interaction between the phylloxera dummy and an indicator for whether the loss in production was greater than 20% and run a similar specification.

Finally, we interact this dummy with two measures of the role of wine in a region's economy. The first one is the area of vineyard per capita before crisis (we use average area of vineyards over the years 1850 to 1869 taken from Galet as our precrisis measure). An alternative continuous measure is the fraction of wine in agricultural production before the

<sup>10</sup> Less than 15% of the agricultural income came from wine before the crisis.



crisis, multiplied by the fraction of the population deriving a living from agriculture.<sup>11</sup>

Finally, in some specifications, we restrict the sample to departments where wine represented at least 15% of the agricultural production before the crisis. All of these regions were affected by the phylloxera at one point or another, and in these specifications, we therefore exploit only the timing of the crisis, not the comparison among regions that may otherwise be different.

All of these regressions consider the year of birth as the year of exposure. But one could easily imagine that the phylloxera affects the long-run height (or other measures) even if children are exposed to it later in their lives. We thus run specifications where the shock variable is lagged by a number of years (so it captures children and adolescents during the crisis). For a specification check, we also estimate the effect of being born just after the crisis.

#### B. Canton-Level Regressions: Gard, Vaucluse, and Bouches-du-Rhône

With regressions run at the department level, one worry is that any relative decline of height during the phylloxera crisis is due to some other time-varying factor correlated with the infestation. This concern is in part alleviated by controlling for department-specific trends, but since we are considering a long time period, it is still conceivable that the trends have changed in ways that are different for regions and cohorts affected by phylloxera, but for reasons that have nothing to do with the disease. We therefore complement this analysis with an analysis performed at the level of the canton. We collected data on military conscripts at the canton level from the archives of three departments in southern France (Gard, Vaucluse, and Bouches du Rhône). Data on wine production are not available yearly at this fine a level, but the area of vineyards was collected for the 1866 agricultural inquiry and is also available at the canton level in the archives. We will combine this measure of the importance of vine production before the crisis with the indicator for the fact that the department as a whole was hit by the disease as a proxy for the impact of phylloxera on wine production.

The specification we use for these departments is as follows:

$$y_{ijk} = a(P_{ij} \times V_k) + m_k + d_{ji} + u_{ijk}, \quad (3)$$

where  $V_k$  is the hectares of vineyards in 1866 in canton  $k$ ,  $P_{ij}$  is a dummy indicating whether department  $i$  is affected by the phylloxera in year  $j$ ,  $d_{ji}$  is a department times year fixed effect and  $m_k$  is a canton fixed effect.<sup>12</sup> This specification compares cantons only within the same department,

and it fully controls for department times year effects. It thus asks whether young men born in cantons where wine was more important before the crisis suffered more due to the crisis than those born in cantons where it was less important.

## V. Results

### A. Height

Table 3 shows the basic results on height at age 20 at the department level. In table 3A, the independent variable is the fraction by which wine production dropped in the phylloxera period. The results are similar in magnitude with and without department trends, but more precise (and only significant) when we include department trends. The results that include trends indicate that at age 20, those born in a region that would have lost all of its production to phylloxera would be 3.2 millimeters shorter, or are 0.72 percentage points more likely to be short. Those born in years where production was less than 80% of what it was before the crisis are 1.9 millimeters smaller than others, on average. They are also 0.38 percentage points more likely to be shorter than 1.56 centimeters (table 3B). The last panel of table 2 shows that these two sets of numbers are consistent: 56% of the production was lost in the years during which the regions were most affected by phylloxera, and the coefficient of the binary indicator of phylloxera is 59% of the coefficient of the “lost production” variable.

While these numbers are small, they appear consistent with the time-series evidence and with other estimates of the impact of income on height over the period. Heights increased by 2 centimeters during the century, when GDP roughly tripled, which implies about a 1.8 millimeter gain per 10% of GDP. Using a time series of cross-sections of French departments over a period that includes ours, Weir (1993) finds an elasticity of height with respect to real wage of 1.5 millimeters per 10% of real wage. We argued above that the loss in agricultural income may have ranged between 16% and 22% in the wine-producing regions during the crisis. Under fairly strong assumptions, we estimate that this may have corresponded to a drop of 10% to 15% in the GDP in those regions during the crisis. Our estimates thus imply that a drop of 10% in a department’s income decreased height by 1.06 millimeters to 1.3 millimeters (with the 15% estimate) or 1.5 to 1.9 millimeters (with the 10% estimate). While our estimates of the income drop due to phylloxera are to be taken with considerable care, they suggest that our numbers are in the same general range.

In tables 3C and 3D, we multiply the dummy for exposure to the phylloxera with the intensity of wine production in the area (hectares of vineyards per capita), first in the entire sample and, in order to check that the results are not driven solely by the contrast between wine-producing and

<sup>11</sup> We will argue below that this appears to be a correct approximation of the fraction of people who lived in families involved in wine production.

<sup>12</sup> In the working paper version, we use instead the dummy for whether the department has lost at least 20% of its production, and the results are qualitatively similar. This changes the year for Bouches du Rhône, where the phylloxera was first spotted in 1863, but production did not signifi-

cantly decline until 1876. This way of defining the affected dummy turns it “on” in 1867, which had slightly lower production than 1862.

TABLE 3.—IMPACT OF PHYLLOXERA ON HEIGHT AT AGE 20

	Dependent Variables	
	Mean Height	Fraction Shorter Than 1.56 Meter
	(1)	(2)
<b>A.1. Ratio of Lost Production during Phylloxera Period: Year Dummies, Department Dummies</b>		
% production loss during phylloxera period	0.00216 (.0019)	-0.00538 (.00415)
Observations	3,403	3,403
Department trend	No	No
<b>A.2. Results of Lost Production during Phylloxera Period: Year Dummies, Department Dummies, Department Trend</b>		
% production loss during phylloxera period	0.00323 (.0019)	-0.00734 (.00329)
Observations	3,403	3,403
Department trend	Yes	Yes
<b>B. Binary Indicator for Phylloxera Year</b>		
Born in phylloxera year	-0.00188 (.00095)	0.00381 (.00173)
Observations	3,485	3,485
Department trend	Yes	Yes
<b>C. Hectare of Vine per Habitant</b>		
Born in phylloxera year × hectare vine per habitant	-0.00753 (.00389)	0.01928 (.01142)
Observations	3,485	3,485
Department trend	Yes	Yes
<b>D. Hectare of Vines per Habitant (Wine-Producing Region Only)</b>		
Born in phylloxera year × hectare vine per habitant	-0.01101 (.00422)	0.03074 (.01352)
Observations	1,558	1,558
Department trend	Yes	Yes
<b>E. Share of Population in Wine-Growing Families</b>		
Born in phylloxera × importance of wine	-0.00551 (.00392)	0.01198 (.00985)
Observations	3,485	3,485
Department trend	Yes	Yes
<b>F. Share of Population in Wine-Growing Families (Wine-Producing Regions)</b>		
Phylloxera × importance of wine	-0.00901 (.00459)	0.02257 (.01228)
Observations	1,558	1,558
Department trend	Yes	Yes

Note: Each column and each panel present a separate regression. The dependent variables are mean height (or proportion shorter than 1.56 meters among a military class in a department and year). "Born in phylloxera year" is a dummy equal to 1 if the department was affected by phylloxera in the year of birth of a military cohort (see text for the construction of this variable). All regressions include department dummies and year dummies. Standard errors are corrected for clustering and autocorrelation by clustering at the department level (in parentheses below the coefficient). The share of population in wine-growing families is estimated, as described in the text.

non-wine-producing regions, then in the sample of departments where wine is at least 15% of agricultural production. We find that in wine-producing regions, one more hectare of vineyard per capita increases the probability that a 20-year-old male born in years where production was at least 20% lower due to phylloxera is shorter by 3% and reduces his height by 1 centimeter. If, instead, we use data from all the regions, the effects are, respectively, 1.85% and 7 millimeters.

An interesting way to scale the effect of the phylloxera crisis would be to use the fraction of the population living in wine-producing households or in households servicing the wine industry (oak barrel producers, for example). Note, however, that this would likely be an overestimate of the impact on the families involved in wine production. To the extent that wine workers changed jobs in response to the crisis (moved to the local city or competed with other agricultural workers for other kinds of job), other families in the department may also be affected, violating the exclusion restriction that the only way a person may be affected is that they are a wine-growing family (or a family related to that business). In the other direction, non-wine-producing families could be positively affected by a drop in prices (through a reduction in demand from the wine-growing families hit by the crisis). For example, the price of wheat could decline if the demand of wheat dropped. However, the markets for grains and most commodities were well integrated at the time (Drame et al., 1991). Therefore, this effect is likely to be common to all departments (rather than local) and can therefore be differenced out by our difference-in-differences strategy.

In any case, there is, unfortunately, no data source on the fraction of families involved in wine production or wine-related goods and services. To proxy for it, we use the product of the share of wine in agricultural income before the crisis (in 1862) and the share of the population living in households whose main occupation is agriculture (workers or landowners). This would be an overestimate of the fraction of the population living in wine-producing households (or households involved in wine production, that is, workers on vineyards)<sup>13</sup> if the output per worker was higher for wine than for other agricultural products. On the other hand, it is an underestimate of the total number of families related to wine production since it does not take into account those involved in businesses related to wine. Estimates based on the cross-department variation in output per worker and share of wine in agricultural production suggest, however, that the output per worker in wine and nonwine production is similar, so that the coefficient of this variable can then be interpreted as the effect of the crisis on families involved in wine production (wine-growing households, or workers). We show this specification in table 3E (for all regions) and table 3F (for wine-producing regions only). The regressions indicate that a child born into a wine-producing family during the phylloxera crisis was 0.5 to 0.9 centimeters smaller by age 20 than he would otherwise have been. With all the caveats we discussed in mind, that is not a small effect, since heights in France grew by only 2 centimeters in the entire nineteenth century.

Table 4 shows the results of the specification at the canton level of the three wine-producing departments. The results can be directly compared to the results in table 2C and 2D

<sup>13</sup> This would lead to an underestimate of the effect of the phylloxera when we use this variable.

TABLE 4.—EFFECT OF PHYLLOXERA ON HEIGHT, WEAKNESS, AND EXCLUSION FOR OTHER REASONS: CANTON-LEVEL REGRESSION FOR THREE DEPARTMENTS

	Dependent Variable: Canton-Level Means				
	Fraction Rejected for Size		Fraction Rejected for Weakness		Class Size
	(1)	(2)	(3)	(4)	
Hectare of vine per habitant in canton × phylloxera was present in department in year of birth	0.01498 (.0074)	0.00033 (.0186)	0.01664 (.0081)	-64.38 (37.52)	
Observations	2,040	2,040	2,590	2,610	
Department × year fixed effect	Yes	Yes	Yes	Yes	
Canton fixed effects	Yes	Yes	Yes	Yes	
Sample	1852–1881	1852–1881	1852–1891	1852–1892	
Mean of dependent variable	0.019	0.090	0.10	147	
Standard deviation of dependent variable	0.019	0.056	0.06	291	

Note: Data source: Archival canton-level data collected by the authors for three departments affected by the phylloxera: Vaucluse, Gard, and Bouches du Rhône. The data set contains canton-level data for these three departments for the years 1852–1891. All the regressions include separate fixed effects for each year in each department and canton fixed effects. All standard errors (in parentheses below the coefficient) are clustered at the canton level.

since, as in that table, the explanatory variable is the number of hectares of vines divided by the population. One difference is that the data are available only for men born until 1881, and the other is that the threshold for being rejected is not 1.56 meters but 1.54 meters. This specification also suggests a significant impact of the phylloxera on height. We find that the probability of being rejected for military service because of height was 1.5% higher for each additional hectare of wine per capita. This is a somewhat smaller number than what we found in the department-level specification, but the two numbers are not statistically different and are of the same order of magnitude. The fact that this specification, which uses a much finer level of variation, provides results that are consistent with the department-level results is reassuring.

Table 5 investigates the effects of the phylloxera on various regions and cohorts. Columns 1 to 4 estimate the effect of the phylloxera on various cohorts. Column 1 is a specification check: we define a “born after phylloxera” dummy and confirm that those born immediately after the phylloxera epidemics are no shorter than those who were

born before. This is another element suggesting that the effect is probably not due to an omitted changing trend. Column 2 examines the effect on those who were young children (1 to 2 years old), or toddlers (2 to 5 years old) at the time of the epidemic. Interestingly, we find no long-run effects on them. Finally, column 3 looks at the effect on those who were teenagers during the crisis and again find no effect on them. It seems that the shock had no long-lasting effects if it was experienced later in childhood.

Column 4 presents another specification check. We run a specification similar to equation (2) (with the dummy set to 1 for regions where wine represents at least 15% of agricultural production), but we also include a phylloxera dummy for regions where wine production is less than 15% of agricultural production. Vineyards in those regions were also affected by the phylloxera (so that the phylloxera variable can be defined as for all regions), but we do not expect this to really affect average height, since wine did not affect most of the people in this region. Indeed, the coefficient of the phylloxera dummy in regions producing little wine is insignificant (and slightly positive).

TABLE 5.—WHO IS AFFECTED?

	Dependent Variables									
	Mean Height at 20					Fraction Shorter than 1.56 Meters at 20				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Born in phylloxera year	-0.00220 (.00119)	-0.00177 (.00093)	-0.00170 (.00091)	-0.00301 (.00121)	-0.00186 (.00084)	0.00550 (.00239)	0.00305 (.00181)	0.00349 (.00173)	0.00302 (.00229)	0.00221 (.0017)
Born 1 to 5 years after phylloxera	-0.00108 (.00171)					0.00563 (.00626)				
Born 1 to 2 years before phylloxera		0.00000 (.00091)					-0.00183 (.00127)			
Born 2 to 5 years before phylloxera		0.00079 (.00119)					-0.00384 (.0011)			
Born in phylloxera year, region affected early					-0.00009 (.00107)					0.00705 (.00218)
Born in phylloxera year, region producing little wine				0.00127 (.00081)					0.00088 (.00176)	
Teenager during phylloxera			0.00127 (.00083)					-0.00222 (.00104)		
Number of observations	3,485	3,485	3,485	3,485	3,485	3,485	3,485	3,485	3,485	3,485

Note: All regressions include year-of-birth dummies, department dummies, and department-specific trends. All standard errors (in parentheses below the coefficient) are accounting for clustering and autocorrelation by clustering at the department level.

TABLE 6.—IMPACT ON FERTILITY, MORTALITY, AND LIFE EXPECTANCY

	Life Expectancy (Women) (1)	Live Births (2)	Class Size/Live Births in Birth Year (3)	Class Size/Survivors at Age 1 (4)	Stillbirths/All Births (5)	Infant Mortality (before Age 1) (6)
Born in phylloxera year	0.5087 (.3604)	-39 (76)	-0.0025 (.0062)	-0.0082 (.0087)	-0.0004 (.0005)	-0.0033 (.0024)
Number of observations	622	2,763	2,651	2,568	2,763	2,461

Note: All regressions include year-of-birth dummies, department dummies, and department-specific trends. All standard errors (in parentheses below the coefficient) are accounting for clustering and autocorrelation by clustering at the department level. Data on life expectancy for women used in column 1 are from Bonneuil (1997). Data on live births, infant mortality, and stillbirths obtained from vital statistics. Data on class size obtained from military record. A class observed in year  $t$  was born in year  $t - 20$ .

Column 5 separates the regions that were affected early and those that were affected late (we code as “early” regions where the phylloxera was first spotted before 1876, the median year at which it reached the regions). Since the disease was progressing slowly from one region to the next, the regions affected later might have been able to anticipate the crisis, and thus avoid some of the negative impact. This is not what we find: the effect seems to be just as large in regions affected later. This is surprising, as one could imagine that these families would have undertaken measures to smooth the shock (savings, in particular).

B. Other Health Indicators

While height is an important indicator of long-run health, it is also important to estimate whether the phylloxera affected more acute indicators of health, in both the short run (infant mortality) and the longer run (morbidity, life expectancy).

*Mortality and Life Expectancy.* We start by looking at various measures of mortality. A first measure is given by our data. Since after 1872, all 20-year-old men were called for the military service, and since, as we will show below, it does not appear that there was selective migration out of the phylloxera departments, a proxy of survival by age 20 for males is given by the size of the military cohort (*classe*), divided by the number of births in that cohort (column 3). This measure also shows no effect of phylloxera. We also construct the ratio of the size of the *classe* and the number of children who survived to age 1 (column 4), and again see no effect. Finally, column 6 presents the results on infant mortality (mortality before 1). There again, we find no impact.

Our next measure of health is the life expectancy of those born during the phylloxera periods. To study this question, we take advantage of data constructed by Bonneuil (1997)

from censuses and corrected vital statistics. Bonneuil constructed life expectancy at birth for women born every five years from 1801 to 1901.<sup>14</sup> In column 1 of table 6, we use this variable as the dependent variable, still using the specification from equation (2). We find no impact on life expectancy. This is not surprising since we find no impact on child mortality, and life expectancy is in a large part driven by child mortality.

*Military Health Data.* To investigate the size of the impact of the phylloxera infestation on health, we exploit the data collected by the military on those exempted for health reasons and the reasons for which they were exempted. We use the same specification as before, with the total number of people exempted, and then the number of people exempted for various conditions, as dependent variables. We use the specification in equation (2) (with department-specific trends).

Column 1 of table 7 displays a surprising result: the number of young men exempted for health reasons is actually smaller for years and departments affected by the phylloxera outbreak. However, the following columns shed light on this surprising result: the incidences of all the precisely defined illnesses (such as, myopia, goiter, and epilepsy) are in fact unaffected. The only categories of health condition that are affected are that of *faiblesse de constitution* (or weakness) and hernia. Weakness was explicitly a residual category at the time. In her story of military conscription, Roynette (2000) quotes an 1886 treaty of military hygiene that describes this category as one that could cover “any other ailments which could not be more precisely identified due to lack of time or information”

<sup>14</sup> Focusing on women avoids biasing the results due to the massive mortality of men during World War I. The data are constructed with care but embody assumptions and corrections that are sometimes considered inadequate.

TABLE 7.—EFFECT ON HEALTH OUTCOMES, MILITARY DATA

	Exempt Due to Health (1)	Myopia (2)	Goiter (3)	Hernia (4)	Spinal Problem (5)	Epilepsy (6)	Low IQ (7)	Feeble (8)	Blind (9)	Deaf (10)
Born in phylloxera year	-0.0081 (.0044)	-0.00012 (.00014)	-0.00010 (.00014)	-0.00092 (.00032)	-0.00025 (.00028)	0.00001 (.00011)	0.00020 (.00023)	-0.00218 (.00077)	0.00008 (.00012)	0.00020 (.0001)
Number of observations	3,315	3,485	3,485	3,485	3,485	3,485	3,485	3,485	3,485	3,485

Note: All regressions include year of birth dummies, department dummies, and department-specific trends. All standard errors (in parentheses below the coefficient) are accounting for clustering and autocorrelation by clustering at the department level.



(Morache, 1886). A first reason that the number of rejections for weakness is lower is that there is a mechanical link between rejection for height and rejection for weakness: the height criterion was evaluated first so a “weak” person was necessarily not short. A second possibility is that, faced with the necessity of drafting a fixed number of people for the contingent, the military authorities were stricter with the application of the “weak” category at times where they were rejecting more people for reasons of height. The negative effect on hernia is more puzzling, but could be due to the fact that these cohorts performed less hard physical labor at young ages.

Overall there seems to be no clear evidence of a negative long-run impact of phylloxera on any health condition. Although it affects long-run height, it seemed not to cause any other physical problems. The conclusion is similar when using canton-level data (table 4) in the three wine-producing regions. In these data, we have the number of people exempted from military service because of weakness. If we consider the years until the year of birth 1881 (class of 1901), there is no impact of the phylloxera on exemption for weakness. After 1901, however, the military adopted a policy of not rejecting anyone because of height, and when we include the post-1901 period, we see an increase in the number of those exempted for weakness during the phylloxera period. This suggests that after 1901, some of those who would have been exempted based on their height were now exempted based on being labeled as weak, another indication of the permeability of those two categories.

### C. Robustness to Sample Selection

Table 5 presented a number of specification checks confirming the fact that those conscripted 20 years after the department where they reported was affected by phylloxera are shorter than others born in other years. However, as we have pointed out above, while a strength of the military data is that they cover a large sample of the male population, there are some reasons to worry about selection biases. The main source of potential selection bias comes from the composition of the military class (the cohort drafted in each department in each year), and whether it is representative of all the children born in the department or of all the children who would have been born in the department in the absence of the phylloxera.

Selection could arise at several levels. First, there could be fewer births during the phylloxera period due either to fewer conceptions or more stillbirths. The “marginal” (unborn) children could be different from the others; in particular, they could have been weaker had they lived. We regress the number of live births in a year, as well as the ratio of stillbirths to total births in the phylloxera years in table 6 (columns 2 and 5). There does not appear to be a significant effect on the number of births.

Second, there could be more infant mortality in the phylloxera years, thus selecting the “strongest” children. However, we have seen in table 6 that life expectancy and the ratio of the size of the class over the number of births, or the number of survivors by age 1, were not significantly affected.

While none of the estimates in table 6 is significant, it is useful to see whether they could induce a selection bias that may produce spurious results. We see an insignificant reduction in infant mortality, which could potentially bias our results upward. Suppose, for example, that there is no effect of phylloxera on height, but that it helps weak children to survive (perhaps because women do not drink wine during pregnancy). Suppose all the weak children are also below 1.56 meters. This would generate a coefficient equal to what we estimate in table 3. However, all the other coefficients go in the other direction: the number of births is slightly lower in the phylloxera area, which would introduce positive selection (if unborn children would have been weaker) and may be the reason for the negative effect on infant mortality. The class size is also slightly lower, again suggesting a positive selection. Thus, on balance, we do not think that the results can reasonably be caused by selective birth or survival.

Third, children born in phylloxera years may have been less likely to report for service where they were born. Since they have to report in the place where their parents live, this would be due to either avoidance by the child or migration of the child’s parents. Some people may have left the affected regions during those years. Table 6 shows some evidence that neither avoidance nor migration is likely to be biasing our results. To measure avoidance, we construct the ratio of the size of five subsequent military cohorts on the size of the census cohorts for people aged 15 to 19 (as discussed above, the mean of this ratio is 99%). As shown in column 3 of table 6, this is no different for children who were affected by the phylloxera, suggesting they were no more likely to avoid military service. Finally, columns 1 and 2 use data constructed by Bonneuil on the migration of women. We use the fraction of women aged 20 to 29 and 20 to 60 who migrated as dependent variables. There appears to be no effect of the phylloxera on migration out of the affected departments. This does not mean that people did not migrate at all. In the three departments for which we have canton-level data, we find that the classes born in phylloxera years are smaller in the cantons that relied more intensively on wine production (column 4, table 4). This, combined with the fact that we see no migration out of the departments, suggests that some of the families may have migrated out of the wine-producing cantons but remained in the department.<sup>15</sup>

<sup>15</sup> A regression of the urbanization rate on the phylloxera dummy (controlling as usual for department dummies, year dummies, and specific department trends) suggests indeed that urbanization progressed significantly faster in phylloxera years in the affected departments.

## VI. Conclusion

The large income shock of the phylloxera had a long-run impact on adult height, most likely due to nutritional deficits during childhood. We estimate that children born in affected regions during the years of the crisis were 0.5 to 0.9 centimeters shorter than their unaffected peers. This is a large effect, considering that height increased by only 2 centimeters over the period. Similar results are obtained when comparing departments with each other or when using data at a lower level of aggregation, the canton, which reinforces our confidence in their robustness. The effects are concentrated on those born during the crisis, and imply that they suffered substantial nutritional deprivation in utero and shortly after birth, and that had a long-term impact on the stature they could achieve.

However, this crisis did not seem to result in a corresponding decline in other dimensions of health, including mortality, even infant mortality. This suggests, as suggested by Cutler et al. (2006), that despite the shock to income and corresponding decline in nutrition, health status may have been protected by other factors, such as public health infrastructure (see Goubert, 1989, on the importance of clean water in the period).

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