Late height growth from historical individual-level panel data*

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Abstract

The combination of height information in two sources from French conscription yields a quasi-exhaustive individual-level panel of men in their 21st year. The *tableau de recrutement cantonal* applies to men when they are to be selected for military service. The *fiches matricules* pertain to selected men from 6 to 22 months later. An illustration on the 2,923 men born in 1887 in Corrèze shows an average annual growth between 0.29 and 0.39 cm. Most men reach maturity at age 21/22, but the shortest men continue to grow until 26/27 years.

JEL classification numbers: N33, O15, J11.

Keywords: Height, growth, rural development, historical demography, military data, norm of reaction.

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1 Introduction

In the absence of reliable data on income or wealth, anthropometric variables, in particular the height of the man, are common proxies for well-being and economic development. Indeed height, as a key criterion of military aptitude, is often easily available from the archives of the military administration. Louis-René Villermé [56] was probably the first scholar to identify from such a source a correlation between the height of French conscripts at the beginning of the nineteenth century and the 'degree of prosperity or poverty' of the region where they live. This correlation has been largely confirmed by subsequent studies and there exists now a vast literature relying on the average height of different cohorts of individuals to assess local economic development over the last centuries.[1]

We still know very little, however, about individual height growth for periods preceding World War II. This is mostly due to data limitations, as large individual-level panel data sets were only developed after 1945 to provide national child growth standards to pediatricians (see Michel Sempé and al. [51] for France).[2] So far human auxology has therefore mostly relied on cross-sectional cohort analysis, rather than longitudinal individual-level panel data, to recover historical height-for-age growth charts by computing for each age the average height of different individuals.[3] This averaging procedure is not without shortcomings; in particular, it may obscure sudden breaks in the individual growth patterns (James Tanner [53]) and yields biased estimates as soon as there is some differential selection of individuals into the sample (Eric Schneider [50]). The innovation of this article is to show that one can combine two military data sources from France to build a quasi-exhaustive longitudinal individual-level panel of young men measured twice when they are about 20. For il-

[1] See Angus Deaton [15], Robert Fogel [22], Fogel et al. [23], Roderick Floud and Richard Steckel [20], John Komlos [35] or Steckel [52] for classical synthesis of this literature. Recent evidence from event studies can be found in Abhijit Banerjee et al. [4] and Denis Cogneau and Lionel Kesztenbaum [12]. This correlation is exploited by, *e.g.*, David Weir [57], Laurent Heyberger [30] or Floud et al. [21]. Seminal studies on France are Marie-Claude Chamla [11] and Jean-Paul Aron et al. [2]. For a focus on children, see Floud et al. [19] or Komlos [36].

[2] See Anne Case and Christina Paxson [10] for a panel study on British children born in 1958. Early longitudinal data on healthy children in the United States are available from the Brush Foundation Study of Child Growth and Development starting in 1931, and on children born in Berkeley in 1928-29 from the Berkeley Guidance Studies of the Institute of Human Development. Both are used in, *e.g.*, James Sanders et al. [49].

[3] See Noël Cameron [9], Simon Rosenbaum [48], Stephen Nicholas and Richard Steckel [41], Bernard Harris [27], Tim Cole [13] or Brian A'Hearn et al. [1]. Jacques Houdaille [31] uses a cross-sectional strategy to study growth of adolescents from 15 to 19 in the early nineteenth century in France.

lustrative purposes the panel is used to measure individual height growth of the men born in 1887 in the department of Corrèze, an economically disadvantaged rural area of France.

There are two main sources on height for the nineteenth century in France. The first source is the recruitment table (*tableau de recrutement cantonal*). The table reports height at the moment when men are examined by the review board (*conseil de révision*), a committee set up under an imperial decree of 1804 to select draftees. The second source comes from individual soldiers' registration forms (*fiches matricule*), which are considered as an avatar of vetting of troops' records becoming more generally used from 1716 to avoid multiple enlistments and keep track of deserters; see André Corvisier [17] for a detailed history of these forms.

These two sources are widely used and they are often thought of as interchangeable, providing similar information on height. It is known that they display slight differences in their scopes. The recruitment table cannot include information on men who do not appear before the review board, and there is no registration form created for the men deemed unfit by the review board. These possibly negligible differences should however draw our attention to a crucial point: the two sources pertain to two different points in time. The recruitment table reports the height of young men before enlistment, when they are to be selected by the review board. Instead the registration forms are used as internal soldiers' ID documents by the military administration and so refer to some post-enlistment period.

So far this observation has not been exploited. Indeed there exists no systematic individual-by-individual comparison of the height information contained in these two sources.[4] This article shows that the information differs. It makes use of the body of the legal military texts to reconstitute the main steps of the enlistment process and identify the (approximate) moment at which the height in the registration form was recorded. It appears that the time between the height measurements available in the two sources in general is either between 6 and 10 months or between 18 and 22 months.

Combining the recruitment table and the registration forms yields a longitudinal individual-level panel on young men after having reached age 20. The panel can be made quasi-exhaustive for cohorts born in the late nineteenth century as most

[4]Insights from the influential landmark study by Jules Maurin [40] on two departments of France, Hérault and Lozère, actually suggest that for these two departments the height information contained in the registration form may be a transcript of the height taken during the examination by the review board, recorded in the recruitment table. See Chapter 1, Sections A3 and B1. This possibly contributes to explaining why so far the two sources have been considered as about equivalent in the literature.

men from these cohorts were exceptionally reexamined in the course of military recall procedures implemented during World War I. The French Army then being much less attentive to previously demanding military aptitude criteria, many men exempted from military service before the war were eventually sent to the front lines, and were thereby subject to a late registration form. However one cannot achieve a fully exhaustive sample since the height of the (small number of) men absent from the review board is definitively lost.

Given the system of compulsory universal conscription in use in France, one may argue that the panel is almost immune to sample selection issues for cohorts of 20-year-old males subject to military recall. Still the measurement of height growth is not immune to endogeneity issues. Indeed the time elapsed between the two height measurements on the same man depends on the evaluation made by the review board about his individual aptitude. The legal recommendation was to postpone the decision on men in poor health to the next meeting of the review board in the following year. This is why we observe in the data a concentration on 6 to 10 and 18 to 22 months for the time between the height measurements. The (no longer observable) health status and height growth potential are very likely correlated: the data suggest that those with the weakest growth potentials end up measured over a longer period of time.

One can deal with endogeneity of the time elapsed between the two height measurements by appealing to an instrumental variable strategy in the case of the specific cohort of men born in 1887 in Corrèze. When these men were examined in 1908, the chairman of the review board was the Prefect (*préfet*) Georges Calmès, a short man previously exempted from military service. If temporarily absent from some session of the review board, the Prefect was replaced by the Secretary (*secrétaire général*) of the Prefecture Charles Filhoulaud. It appears that Calmès was much more willing to postpone decisions than Filhoulaud.

Relying on the actual chairman of the review board as a relevant instrument, I first find that the men born in 1887 in Corrèze are still growing after age 20. The average height gain is between 0.29 and 0.39 cm over one year. Late growth was commonplace at the turn of the nineteenth century: some have even proposed a delayed enlistment to reduce the volume of exemptions (based on the difficulties encountered by short men to handle long rifles) arguing that many men did not reach adult maturity at age 20 (Rampal [45]).

A second result from this illustration is that growth mostly concerns the shortest men. It is the more physically and possibly economically disadvantaged who show the greatest growth at 20 and so catch up slightly to their more well-off peers. The predicted growth pattern following the examination by the review board suggests

that the recovery process may be very slow as many men reach adult maturity only six years later.

The scarcity of individual-level panel data before World War II makes the literature that characterizes historical height growth of men very narrow.[5] A classic reference is the work of Adolphe Quételet [43] building in 1835 a growth chart giving height for most ages until adult maturity from a small sample of children selected in schools, boarding schools and orphanages in Brussels. In his 1870 revised chart, he reports a total growth of 1.3 cm from 20 to 25 years old. The first modern insights on historical height growth have been recently obtained by Pei Gao and Eric Schneider [25] using longitudinal individual-level panel data on repeated samples of selected destitute boys assigned to the training ship Indefatigable over a long period from the 1860s to the 1990s. The boys were between 10 and 18 years old, thus encompassing the period of adolescence, but stopping two years before men were concerned by conscription in France. There are two studies on men in their late growth stage. Erik Beekink and Jan Kok [5] and Kristina Thompson, Björn Quanjer and Mayra Murkens [55] exploit subsamples of self-selected Dutch conscripts measured twice, first at 19 and then at 25 when they decide to apply to the civil guard of Woerden and Maastricht, respectively. Both find evidence of prolonged late growth and catch-up.

The present article is organized as follows. I first provide in Sections 2 and 3 evidence that one indeed faces two different height measurements in the data. Section 2 describes the data sources that I combine, the recruitment table and the registration forms. Section 3 shows that height information contained in these two sources differ and discusses legal evidence on the time at which the height recorded in the registration forms was taken. The reader willing to accept that the difference in the height reported in the two sources reflects growth of the man can pass directly on to Section 4 for descriptive statistics on height level and height growth of the $2,923$ men born in Corrèze in 1887. Sections 5 and 6 give OLS and IV height growth estimates from various fixed effects models. They describe how growth varies with initial height, reconstitute the last part of the growth chart for different categories of men, and they consider an augmented sample including the men born in the two previous years (1885 and 1886) in Corrèze to assess the existence of cohort effects. Section 7 concludes.

[5] A recent important research effort is devoted to building historical panel data. For instance Roy Bailey, Timothy Hatton and Kris Inwood [3] and Gregori Galofré-Vilà [24] combine military data with census records to analyze how soldiers' height relates to childhood circumstances. The census does not contain height information which prevents an analysis of height growth episodes. See Beekink and Kok [5] for other references.

2 Two different data sources

2.1 Military draft under the 1905 Berteaux Law

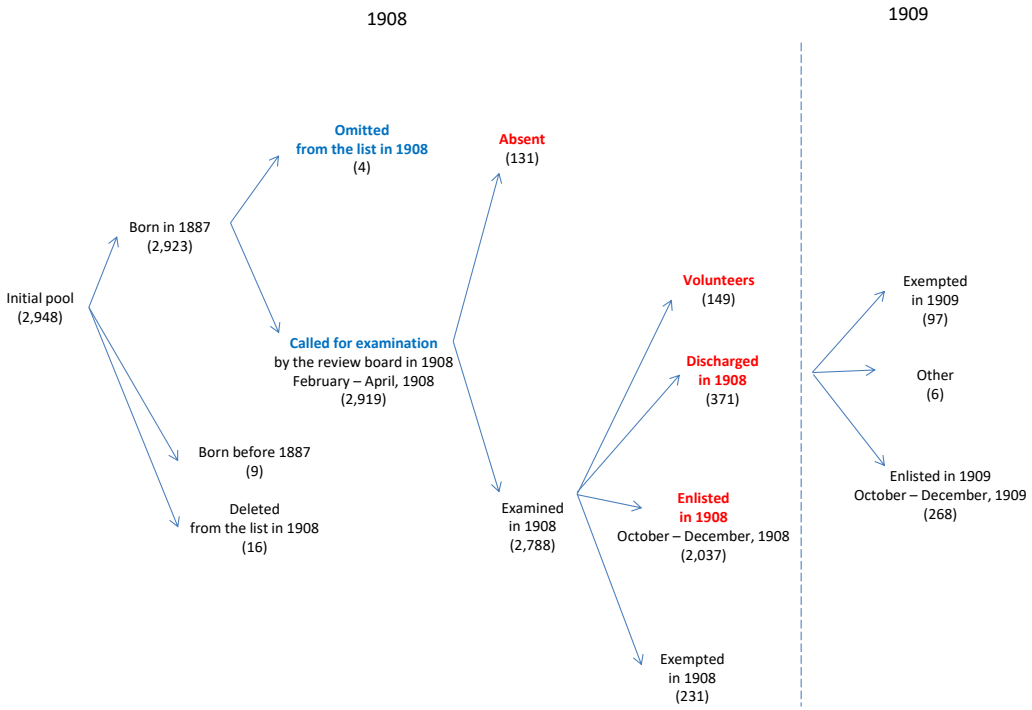
Following the Maurice Berteaux Law [39] of 21 March 1905, a comprehensive census of all French men born in $t-20$ must be conducted in each municipality at the end of every year t. The men from the municipalities of the same county are called to be examined within the same session by the review board early in year $t+1$, usually between February and April.[6] The purpose of this examination is to select men fit for military service. Some men can be allowed an examination by the review board operating where they live, but the final enlistment decision always remains with the review board operating in their county of birth. The review board thus rules on every man born in the county, irrespective of his actual place of residence.

Men deemed fit for service by the review board are enlisted (*incorporés*) during the fall of $t+1$, usually between October and December, so about 2 quarters after the examination by the review board.

The others are either exempted (*exemptés*) from service or discharged (*ajournés*). In principle, exemption implies that the man will never enter the Army; however men exempted before the Great War were reexamined in the course of several waves of exceptional military recall procedures throughout the hostilities, and many were eventually enlisted during the war.

A discharged man in year $t+1$ is provisionally exempted pending re-examination in $t+2$. In the case of discharge, the review board thus merely postpones its decision to the next year, when the men born in $t-19$ in the county will in turn be subject to examination. If a man deferred for re-examination in $t+1$ is deemed fit by the review board in $t+2$, then he is enlisted during the fall $t+2$, about 6 quarters after the examination by the review board in year $t+1$. Otherwise the Law states that he must be definitively granted exemption, but this is once again subject to the same caveat involving exceptional military recall procedures. The whole sequence of events is summarized in Figure 1.

[6] The French territory is subdivided into departments (*départements*), each of them being itself subdivided into *arrondissements* and then into counties (*cantons*). The *préfecture* is the capital city of a department. It is headed by an appointed government representative Prefect (*préfet*). The *préfecture* also designates the office and residence of the Prefect. At the beginning of the 20th century, the department of Corrèze consists of three *arrondissements* (Brive, Tulle and Ussel) and 29 counties (10 (resp., 12 and 7) in the *arrondissement* of Brive (resp., Tulle and Ussel). The *préfecture* of Corrèze is Tulle. The military territorial division does not exactly match the civilian one. The relevant military subdivision in the present article is the recruiting office (*bureau de recrutement*). There are two such offices in Corrèze, Brive and Tulle.



The men measured during the examination by the review board (with a height reported in the recruitment table) appear in bold blue. Those who should theoretically be subject to a registration form appear in bold red. The number of men concerned by conscription in Corrèze in 1908 are in brackets. For instance there were 2,919 men born in Corrèze in 1887 called for an examination by the review board in 1908. They all appear in the recruitment table, including 131 men who did not respond to the summons. In principle, a registration form exists for each of these men, except 231 men exempted from military service in 1908. In fact, the data contains registration forms for some exemptees (see Table 1).

Figure 1: Enlistment timeline

2.2 Recruitment table and registration forms

There exist two main individual-level data sources on the same men. Both are well-known among scholars and have been widely used separately. The first source comes from the height recorded during the examination by the review board. It is reported in the recruitment table (*tableau de recrutement cantonal*) which completes the initial census made by the municipalities of the county with the information collected during the examination.[7] The date on which the review board is held was publicly widely advertised. Nowadays it can be found at the front of the recruitment table, as well as in several other sources, *e.g.,* local newspapers or the *Bulletin des Actes Administratifs* official publication.

The second source originates from individual registration forms (*fiches matricule*). They were created for every man enlisted or discharged by the review board, and used by the military administration to keep track of the military career of the man over the whole 25-year-period of military service (with only the first two years of active duty until 1913).

Both sources contain basic civil status information, an occupation and some literacy indicator. They also give an anthropometric description indicating the color of hair, eyebrows and eyes; the shape of forehead, nose, mouth and chin, followed by a general statement about the shape of the whole face of the man. The description in the recruitment table includes the height and sometimes the weight of the man. The registration form has two items for the height and a corrected height (*taille rectifiée*).

While nowadays the recruitment table can only be found from archival work, it is very easy to access the registration forms. Indeed a scanned sample of all the forms was prepared as part of the *Mémoire des Hommes* national project to celebrate the hundredth anniversary of World War I. It is freely available for each department of France from the *Archives départementales* websites.[8] The project sometimes includes

[7]The municipality censuses made at the end of every year t are compiled at the county level in the *tableau de recensement cantonal*. These compilations list all the men born in $t-20$ in the county. They also provide civil status, occupation, and some anthropometric information. See footnote 16 for the treatment of height, if available at this early stage. Other designations of the same data source as the recruitment table for periods before the Berteaux Law of 1905 include *liste du contingent départemental*, *liste générale de recrutement*, and often *liste du tirage au sort* during the Third Republic.

[8]In Corrèze the recruitment tables of the counties within the same (civilian) department subdivision (*arrondissement*) are collated in a single register. The comprehensive collection is made up of three volumes, corresponding to the subdivisions of Brive, Tulle and Ussel. Access to the scanned version of the registration forms from the *Archives départementales de la Corrèze* website follows the link `http://www.archinoe.fr/cg19/recrutement.php`. Each individual form is fully identified by the (military) recruiting office (Brive or Tulle) in charge of the man and his unique

digitized individual registration form information about civil status, occupation and literacy. The *Archives départementales de la Corrèze* provided me with the digitized file of all men born in Corrèze between 1863 and 1901. I completed this file with information from the recruitment table on men born in Corrèze in 1887 and exempted by the review board in 1908. For every observation in the resulting exhaustive sample of all the men born in Corrèze in 1887 and reaching 20 years old in 1907, I entered additional (handwritten) information from the recruitment table: the height, the review board that actually examined the man, and the exemption/discharge/enlistment decisions made by the review board in 1908 and 1909. In addition, for every man with a registration form, I entered his (handwritten) enlistment date, his height and, if available, his corrected height.

2.3 Height completion in the two data sources

Figure 1 reports in brackets the numbers of men born in Corrèze in 1887 involved in the various steps of the enlistment process in 1908 and 1909. The initial 2,948 pool includes a few men born before 1887 but omitted from the census in the previous years, as well as some men who do not fall within the competence of the review board of Corrèze. Hereafter the analysis starts with the 2,923 men born in 1887 and falling within the competence of the review board of Corrèze. Most of them were examined in 1908 (only 4 were omitted from the census made at the end of 1907 and examined later). They all appear in the recruitment table. The blue bold writing in Figure 1 delineates the scope of men concerned by the 1908 review board.

In principle, an individual registration form must be created for each of the 2,919 men called for an examination by the review board in 1908, except 231 men who are exempted from military service in 1908. The theoretical scope of the registration forms is marked in bold red in Figure 1. It applies to the regular case of men enlisted in the fall of 1908, and to those discharged in 1908, regardless of the outcome of the examination by the review board in 1909 is. It also covers 149 volunteers, who decided to enlist before being called, and 131 men absent from the review board of 1908 (absentees are considered as suitable to serve). Again this theoretical scope is subject to the proviso that many men exempted in 1908 were actually reexamined throughout the war: men from Corrèze were involved in three consecutive waves of recall occurring in 1914, 1915 and 1917. Thus some men exempted in 1908 eventually entered the army, and in this way they were subject to a late registration form.

Table 1 adds to the timeline of Figure 1 some information about the number of

registration number. Entering these two pieces of information on the `archinoe` website is enough to allow the reader to access every form used in this article.

Table 1: Height completion

	Number of men	Number of men with a missing height in the recruitment table	Number of men with a missing height in the registration form	Number of men with a height entered in both sources
Initial sample	2,948	141	238	2,623
Men removed from the list	16	14	15	1
Men born before 1887	9	1	3	6
Men born in 1887	2,923	126	220	2,616
Men omitted from the list in 1908	4	0	0	4
Men called in 1908	2,919	126	220	2,612
Absentees in 1908	131	124	42	3
Examined by the review board in 1908	2,788	2	178	2,609
Volunteers	149	0	2	147
Enlisted in 1908	2,037	0	12	2,025
Exempted in 1908	231	1	142	89
Discharged in 1908	371	1	22	348
Enlisted in 1909	268	1	9	258
Exempted in 1909	97	0	13	84
Other	6	0	0	6

Reading: There are 2,025 out of 2,037 men enlisted in 1908 with a height completed in both the recruitment table and the registration form. The height of each of the 2,037 men is always completed in the recruitment table (filled out during the review board). It is missing for 12 men in the registration forms.

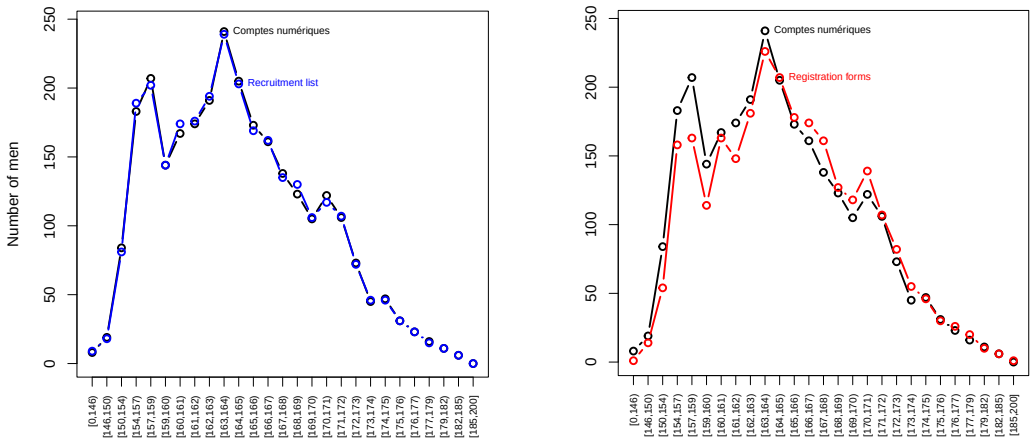
completed/missing individual heights in the recruitment table and the registration forms. Height may be missing either because the man does not appear in the source or because his height is left blank. Table 1 shows that there are two cases where height information is more likely to be missing. First, height is obviously missing in the recruitment table for men who are listed in the municipality census but did not obey the review board summons. Second, men exempted in 1908 and never recalled during the Great War do not appear in the registration forms (many of them actually died before the war). Table 1 highlights the impact of recall procedures, as height is known in $231 - 142 = 89$ men exempted in 1908.

3 The height growth hypothesis

3.1 Evidence from height distributions

Figure 2 refers to the height distribution in the summary statistics published every year for each department of France since the beginning of the nineteenth century in the *Comptes Numériques et Sommaires du Recrutement de l'Armée.* It plots the number of men (in the vertical axis) in every height class considered in the *Comptes Numériques* [16] for men born in Corrèze in 1887. The large 4 cm intervals used at the bottom of the distribution in the *Comptes Numériques* yield excess masses of short men that will soften when considering the exact height available in the data.

It is clear that the distribution in the *Comptes Numériques* (in black) originates in the height information from the review board recorded in the recruitment table (in blue). Instead, the right panel shows a significant discrepancy between the height distribution in the *Comptes Numériques* and the distribution coming from registration forms (in red). There is a huge deficit of short men in the registration forms for every height below the peak at 163 cm. This goes with an excess number of men taller than 163 cm in the registration forms.

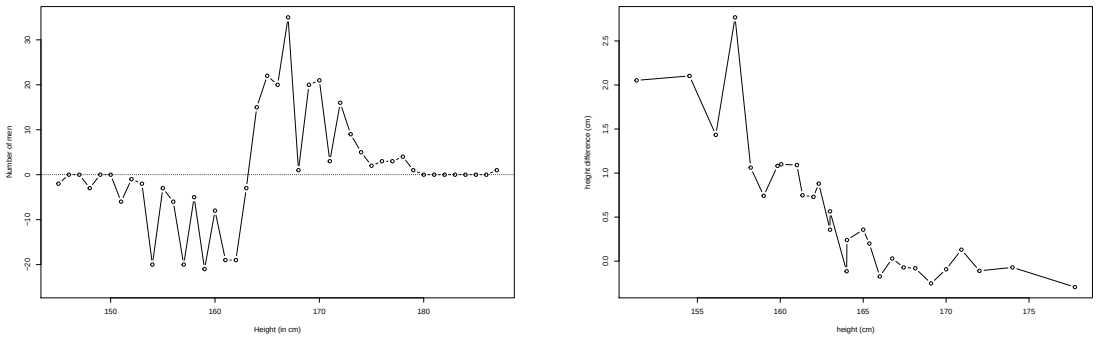


The Figure considers three height distributions giving the number of men born in Corrèze in 1887 per height class. The black distribution, which corresponds to the summary statistics in the *Comptes numériques*, is used as a reference in the two panels. The blue distribution in the left panel (resp., red in the right panel) counts the number of men (in the vertical axis) in each height class (in the horizontal axis) in the recruitment table (resp., the registration forms). There are 144 men whose height is between 159 (excluded) and 160 cm in both the *Comptes numériques* (black) and the recruitment table (blue); in the registration forms (red) there are only 114 men with a height in this same class $(159, 160]$. Note the larger height intervals used in the *Comptes numériques* yielding anomalous masses of men at the bottom of the height distributions.

Figure 2: Comparing height distributions

The left panel of Figure 3 zooms in on the spread between the number of men in the registration forms and the recruitment table shown in Figure 2. The vertical axis now refers to the exact height available in the original data, instead of the height classes considered in the *Comptes numériques*. The deficit of short men in the registration forms is widening as one approaches the peak of 163 cm in Figure 2 while the excess of tall men in the registration forms is lower as one moves away

from this peak.[9]



Excess number of men Average height difference

One-centimeter height intervals are used in the horizontal axis of both panels. The left panel reports for each height the difference between the number of men in the registration forms and the recruitment table. There are 21 men measuring 160 cm (with height in the $(159, 160]$ interval) less in the registration forms than in the recruitment table; there are 35 men measuring 168 cm more in the registration forms than in the recruitment table.

In the right panel men are first ranked in the order of increasing height in the recruitment table. For every 100 men, I compute the average height in the recruitment table (it is reported in the horizontal axis) and the average difference between the height in the registration forms and the height in the recruitment table. The average height of the 100 shortest men in the recruitment table in 151.34 cm and the average height difference for these men is 2.05 cm. The point corresponding to the next 100 shortest men is a height of 154.52 cm in the horizontal axis and a 2.10 cm height difference in the vertical axis.

Figure 3: Men and height spreads

Some discrepancy is to be expected as the scopes of the recruitment table and the registration forms differ. Short men exempted from military service together with tall absentees before the review board indeed contribute to the observed shape of the spread between the two distributions. But this is not enough to account for

[9]The saw-tooth patterns may result from rounding height during the examination by the review board. Also the existence of height thresholds to enter specific military units may yield slight bunching in the registration forms: the Law of 2 April 1901 [38] abolished selection to enter the Army based on some minimum height requirement, which was previously set at 154 cm, but height was still used as a selection criterion within the Army (see, *e.g.*, Appendix 1 of the military Instruction [33] of April 16, 1910). For instance, minimal height thresholds of 159 cm and 170 cm were relevant to enter the cavalry.

the whole discrepancies.[10] The explanation for the discrepancies between the two distributions that I will put forward is that short men during the examination by the review board (their height at this moment appears in the recruitment table) still continue to grow after the examination. The height recorded in their registration form in fact is a height they reach after this first examination. As they reach or possibly exceed the peak of 163 cm, there is a deficit of short men in the registration forms. They now fall in a class of taller men, which translates into an excess of tall men in the registration forms.

The right panel of Figure 3 provides a first graphical assessment of the height growth hypothesis. It plots the difference between the height in the registration form and the height in the recruitment table (in the vertical axis) against the height recorded in the recruitment table (in the horizontal axis). The nice decreasing shape makes it difficult to reconcile with pure measurement errors. If, instead, the height difference in the vertical axis is interpreted as an individual height change from the height level reported in the horizontal axis, the relation is consistent with a smooth late height catch-up: short men continue to grow after the examination by the review board, but not the tallest ones (the height difference reaches 0 for high levels of height in the recruitment table).

3.2 Procedural evidence: departure and enlistment examinations

The timeline in Figure 1 shows that the registration forms concern men at a stage (in bold red) of the enlistment process coming after the review board (in bold blue), which leaves open the possibility that the height recorded in the registration form indeed is retaken after the review board. This Section gives procedural evidence that the height discrepancies between the two data sources likely reflect a height growth process.

Preliminary insights on a second height measurement come from the particular case of absentees in Table 1. Their height is missing in the recruitment table but it is available in the registration forms, so that it must be that the Army sometimes completes height in the registration forms after the review board.[11]

[10] The total deficit in the registration forms amounts to 138 observations, while there are 181 observations in excess in the recruitment table. Instead, Table 1 shows that there are $230-142=88$ heights of exemptees (to be compared to 138) that appear in the registration forms but not in the recruitment table. There are also $131-42=89$ absentees with a height filled out in the registration forms, and the height of only 3 among them is completed in the recruitment table, so that one finds a net deficit of only $89-3=86$ absentees in the recruitment table (to be compared to 181).

[11] Men absent from the review board are considered as deemed fit for armed duty (Art. 30 of the Law [39] of 21 March 1905). Antoine Escalier was absent from the review board in 1908 and

The body of military laws enables us to identify the moment at which the second height measurement, recorded in the registration forms, was taken. The military *Instruction* legal text published at the head of the register compiling the registration forms specifies that the 'register (. . .) is (. . .) held by the commander of the recruiting office'. However, unlike the recruitment table completed by the review board, neither this *Instruction* nor, to the best of my knowledge, any other reference statutory text gives the exact moment when the registration form is created. The *Instruction* only states that the 'recruiting office commanders must start the register as soon as possible' after the selection of draftees by the review board.

Anecdotal evidence suggests that the Army had reservations against the decisions regarding aptitude made by the review board, which also includes civilian authorities represented by the *Préfecture* of the department and the mayors of the municipalities of the county. In practice the military administration was actually allowed to reconsider the pool of men selected by the review board.[12]

Following the review board, the enlistment process includes two additional examinations conducted under the sole auspices of the Army. Every man selected by the review board as fit for military service is first subject to the departure examination (*visite de départ*) organized within the recruiting office to allocate men into the various military units. Those men who fail to pass this inspection are rejected (*réformés*) from the Army. The remaining ones must join within a few days their unit where they undergo a new examination, the enlistment examination (*visite d'incorporation*). Only those who pass this last examination end up being actually drafted for military service. The others are rejected from the Army.[13]

A crucial legal text for this sequence of two examinations is the *Instruction* [6] of 22 October 1905, on Physical Aptitude to Military Service. Particularly insightful is the fact that the text insists on the importance of recording height, though at this

enlisted into the 44th Infantry Regiment in October 1908. His registration form (numbered 501 of the recruiting office of Tulle) contains a complete anthropometric description including a height of 162 cm. Similar examples are François Michelou (registration number 790 from the recruiting office of Tulle) or François Vaux (registration number 831 from the recruiting office of Tulle).

[12]The Berteaux Law of 1905 was enacted in a context of tense relations between the *Préfectures* of the various departments of France and the military high command following the *affaire des fiches* revealed by Guyot de Villeneuve in 1904. The *Préfecture* filled out secret files used to promote Republican officers at the expense of Conservatives and Catholics. The mayor of Tulle Jean-Baptiste Tavé was much involved in Corrèze, and the qualifiers 'reactionary', 'anti-Semite' or 'clerical' frequently occurred in the individual files published in the local newspaper *Le Corrézien* in 1906.

[13]Cf. Colin [14], page 316; Rasmussen [46]; or Bertschy [7], page 208. Based on the *Statistiques Médicales de l'Armée*, Bertschy [7] computes a volume of men 'excluded before being actually enlisted' of 30 per 1000 every year until the year 1901.

moment the Army is already aware of the height of the man when examined by the review board:

> 'Young men deemed fit [by the review board] are allocated by recruiting office commanders to the different military units according to their physical and professional abilities (...). The main physical requirements are: height, ability to walk, horse riding abilities and capacities to handle heavy loads.[14] The first of these requirements (...) can be assessed using a graduation measuring rod; the determination of others is more complex and falls within the specific competence and sphere of responsibility of the military physician'.

The same text goes on with a statement on the physician's field of intervention: 'the physician gives his opinion on the physical aptitude at the review board and at recruiting offices, before enlistment. He also gives his opinion after the enlistment in the presence of the commanding officer or during the regional commissions ruling military unit mutations.' This provides us with a clear summary of the sequence of the three examinations that men have to undergo: first at the review board, then within the recruiting office, and finally in their regiment once enlisted.[15]

In a nutshell, height is first taken when the man is examined by the review board, and this height is recorded in the recruitment table.[16] After the examination

[14]The quoted requirements were actually ranked in a previous version of this same text published in 1891: 'first height and then ability to walk' (see Section V page 76 of the *Instruction* [32] of 1891).

[15]The examination by the review board is documented in Pauline Hervois [28] with an emphasis on the role of the physicians in the assessment of individual disability. The departure and enlistment examinations are particular instances of the general recommendation that every man should be examined when allocated to a new unit (see art. 38 of the 25 November 1889 Decree [18]). We have little information about the actual operational process of the departure examination (see however Chapter 4 of Odile Roynette [47]). The enlistment examination is better documented as a recent strand of research exploits the listed military aptitude criteria to discuss the emergence of military body hygiene (see, *e.g.*, Rasmussen [46]). A colorful description of the examination is given in a Louis Auguste Picard [42] novel: the men, on their arrival at the barracks, just receive a cap; they immediately undergo the 'control of constitution' where 'every man who enters is examined from head to toes. Measured and weighed, it is the order of the minister' (page 38).

[16]Height information also appears in the initial municipality census available in the *tableau de recensement des jeunes gens* held by the *Archives communales* in Corrèze. Some are recorded in the recruitment table before the examination by the review board, and corrected during the examination if the information proves to be inaccurate. In practice most of these heights are corrected, as small villages often do not hold official graduation rods and rely on self-reporting or a rough visual estimate made by the mayor. For instance, the initial height of 165 cm of Jean Miginiac (number 54 in the recruitment table of the county of Corrèze) is corrected to 162 cm by the review board.

Table 2: Height differences between the two sources

	Number of men with height completed in the two sources	identical in the two sources	different in the two sources
Initial sample	2,623	2,125	498
Men removed from the list	1	1	0
Men born before 1887	6	6	0
Men born in 1887	2,616	2,118	498
Men omitted from the list	4	2	2
Men called in 1908	2,612	2,116	496
Absentees	3	1	2
Examined by the review board	2,609	2,115	494
Volunteers	147	104	43
Enlisted in 1908	2,025	1,714	311
Exempted in 1908	89	41	48
Discharged in 1908	348	256	92
Enlisted in 1909	258	183	75
Exempted in 1909	84	69	15
Other	6	4	2

Reading: Out of $2,025$ men enlisted in 1908 with a height completed in both the recruitment table and the registration form, height differs in the two sources for 311 men (so $2,025 - 311 = 1,714$ display equal height in the two sources).

by the review board, the Army retakes twice the height of men deemed fit by the review board for both selection and allocation purposes. These two new height measurements are made during the departure and the enlistment examinations.

3.3 The status of height in the registration form

If the height reported in the registration form is not a simple transcript of the height of the man when examined by the review board, then the constraint that the registration form should be created 'as soon as possible' after the review board by the recruiting office commander points toward a height recorded during the departure examination within the recruiting office.

Table 2 confirms that the difference between height in the registration form and height in the recruitment table does not merely reflect the difference in the populations covered in the two sources, with tall absentees alongside short exempted yielding the spread pattern in Figure 2. It restricts attention to men with a filled height in the recruitment table and the registration form. This $2,623$ observation

The height of Louis Pierre Florentin (number 55 of the same county) is also revised downward from 161 to 159 cm. An exhaustive compilation of these sources scattered throughout municipalities, if stored in the archives, seems unfeasible in Corrèze.

subsample thus excludes absentees and exempted men with only one height measurement. It is clear that a significant proportion of men still exhibit different heights in the two sources. In the sample of 2,616 men born in 1887, 498 men, *i.e.*, nearly 20 per cent of these men, display different heights in the two sources. Height is more likely to differ in the two sources if there is a long time period elapsed between the selection by the review board in 1908 and the departure examination within the recruiting office: there are 30 per cent (75/257) of men enlisted in 1909 who display a different height in the two sources, against 15 per cent (311/2,025) among those enlisted in 1908.

I build on this evidence to set the height in the registration form as taken after the review board, during the departure examination. The data provides no information on the date of this examination, but it is known that it comes a few days before enlistment,[17] the date of which is reported on the registration form. From now on, the date of the departure examination will be proxied by the date of the enlistment.[18] For most men the age difference between the two height measurements is the time between enlistment and examination by the review board; Appendix B gives an exhaustive classification for the time of the second height measurement including more marginal populations, *e.g.*, men discharged in 1908 and exempted in 1909.

4 Descriptive statistics

I complement the initial 2,923 observation sample on men born in 1887 with the 104 completed corrected heights to get a consolidated 3,027 observation sample. In this sample the enlistment date is only known for 2,857 observations in the registration form. The height is completed in both the recruitment table and the registration form for 2,707 observations.[19]

Summary statistics about this 2,707 observation sample are given in Table 3. The men deemed fit in 1908 are about 4 cm taller than the others. Those discharged in 1908 and enlisted in 1909 were also measured during the 1908 review board taller than the men exempted in 1909. A reverse pattern holds for height growth: the difference between the height at enlistment (recorded in the registration form) and the height

[17] Roynette [47], page 211.

[18] Information collected during the enlistment examination, which can be found in the *Registres Médicaux d'Incorporation*, is not exploited in the present study.

[19] The 2,707 observation sample size corresponds to the 2,612 men called in 1908 reported in Tables 1 and 2 with a height recorded in the two data sources, plus 104 observations involving a corrected height, minus 9 observations where the date of the height measurement in the registration form remains unknown.

Table 3: Summary statistics – 1887 cohort

	Number of observations	Review board height (cm)	Age difference (year)	Height growth (cm)
Military status				
Enlisted in 1908	2037	164.39	0.56	0.35
Exempted in 1908	231	160.29	7.79	1.99
Enlisted in 1909	268	161.10	1.57	0.56
exempted in 1909	97	160.18	7.20	0.76
Subdivision (*arrondissement*) of birth				
Brive	971	163.78	1.03	0.48
Tulle	1200	163.75	1.38	0.60
Ussel	539	163.53	0.94	0.80
Urban versus rural birthplace				
Village	747	163.87	1.11	0.61
Small-sized town	589	163.59	1.20	0.69
Medium-sized town	625	163.12	1.47	0.53
City	589	163.96	0.88	0.56
Education				
Can neither read nor write	242	162.02	1.67	0.43
Can only read	56	163.29	1.36	0.02
Can read and write	667	163.30	1.22	0.44
Primary education	1497	164.29	0.98	0.53
Intermediate education	48	163.21	0.41	2.56
Bachelor	53	164.11	0.97	2.60
Occupation				
Farmer	1482	163.64	1.33	0.41
Employee	541	163.90	0.99	0.71
Worker	347	163.16	0.92	0.65
Merchant	202	164.60	1.13	0.52
Soldier	52	165.94	0.89	0.13
Student	51	162.76	0.71	2.37
Senior executive	32	162.51	0.66	4.74

Note: The review board height is the one reported in the recruitment table.
The age difference is the time from the review board to the enlistment.
Height growth is the difference between height in the registration form and height in the recruitment table.

Reading: In the 2,707 observation sample there are 56 observations of men who can only read. They are 163.29 cm tall in the recruitment table, *i.e.*, when examined by the review board with the men of their county of birth. On average they grow 0.02 cm in height over 1.36 year from the review board.

taken during the review board in 1908 (recorded in the recruitment table) is lower for men enlisted in 1908 while the highest growth applies to exempted men. Section 6.2 explores whether the pattern in Figure 3 could merely follow from the heterogeneity in the time elapsed between both examinations. Men exempted in 1908 or 1909 are first measured in 1908 and then during the Great War, which yields an age difference of more than 7 years, while men deemed fit in 1908 are enlisted around 6 months after their examination by the review board. It shows that individual heterogeneity matters for height growth on top of age difference heterogeneity.

Table 4: Height and age descriptive statistics

	Mean	St. Dev.	Minimum	First quartile	Third quartile	Maximum
Age at the review board (year)	20.71	0.29	20.14	20.46	20.95	21.28
Age at enlistment (year)	21.80	2.02	16.02	21.04	21.69	30.60
Age difference (year)	1.01	2.01	−4.91	0.53	0.63	9.65
Height at the review board (cm)	163.71	5.70	145	160	168	184
Height at enlistment (cm)	164.31	5.67	145	161	168	188
Height growth (cm)	0.60	2.70	−11	0	0	23

Number of observations: 2,707

Table 4 reports detailed information on age and height. The height measurements on the same man are on average spaced by about a year. The review board examined the men born in Corrèze in 1887 in February, March and April 1908 when they were 20 or 21 years old. The enlistment was usually occurring between October and December every year. This yields a period of time of approximately 6 months between the review board and the enlistment in 1908, and 18 months if enlistment happens in 1909, hence the average age difference of 1.1 year. More marginal cases are volunteers, who decide to enlist before the call (from the age of 16 in the navy and 18 otherwise), which gives rise to a negative age difference, and men recalled during the war. Figure 6 in Appendix A depicts the whole age difference distribution.

The average individual growth over 1.1 year is 0.60 cm. We observe implausible extreme values of height growth at −11 cm and +23 cm. Some negative height growth episodes involve volunteers: since they enlist before the call, their height in their registration form is often smaller than their height when examined by the review board (a negative height growth associated with a negative difference between the age at enlistment and the date of their examination by the review board reflects a positive growth experience).

However in many cases such figures are measurement errors. Excess masses of men observed at levels of height thresholds required to enter specific military units

are consistent with marginal height manipulations made during the departure examination within the recruiting offices for allocation purposes. The large discrepancies between the two height measurements are probably due to errors made when height is measured during the review board and/or recorded in the recruitment table. These errors are more likely to occur if the man is examined outside Corrèze since then his height has to be transmitted to the review board of Corrèze. The review boards operating in the biggest cities were examining a very large number of men in a short period of time. Roynette [47] computes an average individual examination lasting 38 seconds in the densely populated Seine department (which included Paris). Indeed, in the subsample of the 2.5 per cent lowest and 2.5 per cent highest reported height growth, we only find half of the men examined in Corrèze, and another third consists of men recalled during the war.[20]

5 An assessment of individual height growth

In order to estimate the individual height gain of men during the year following the examination by the review board, I first consider a standard fixed effects model where height h_{it} (in cm) of man i at time t (after his 20th birthday) is

$$h_{it} = \beta a_{it} + \gamma_i + \varepsilon_{it} \tag{1}$$

where a_{it} represents age of the man at time t, and γ_i captures individual fixed characteristics of the man, *e.g.*, some given genetic factors, chronic illness, frailness or disability, family traditions or family wealth.[21] The variable t is a time dummy that takes value 0 when the man is examined by the review board in 1908 and value 1 at the moment of his last measurement, which is at enlistment for most men. The linear restriction in (1) is plausible as a first-order approximation over a short time window, but it seems less realistic over a longer period. It will be relaxed in Sections 6.1 and 6.2.

By time-differencing (1) we get

$$\Delta h_i = \beta \Delta a_i + u_i, \tag{2}$$

[20]Philippe Teulade and Jean-François Vialat, both with a negative growth of −11 cm, were respectively examined in Melun and Versailles, two cities near Paris. Léon Vernéjoux, with a growth of 23 cm, was examined in Paris. All three were enlisted in 1908, *i.e.*, a few months after they appeared before the review board.

[21]See, *e.g.*, Deaton [15] for studying the relationship between height, health, and income, and Seema Jayachandran and Rohini Pande [34] for an exploration into the role played by family values in height differentials.

where $\Delta h_i = h_{i1} - h_{i0}$ is growth of individual i (in cm) over the period $\Delta a_i = a_{i1} - a_{i0}$ (in years). The β coefficient gives the individual height growth (in cm) over the one-year period following the review board held in 1908.

5.1 OLS growth estimates

Various OLS estimates of the β coefficient are given in Table 5. In Column (1), which refers to the initial 2,707 observation panel, height growth of the man in the year following the review board is 0.31 cm. The high magnitude of +23 cm growth observations at the top of the height growth distribution in Table 4 makes that this is an over-estimate of individual growth. The OLS estimate falls to 0.24 cm in the 2,596 observation subsample in Columns (2) and (3) that excludes the 2.5 per cent observations at bottom and top of the height growth distribution.

Since all the men born in the same county are examined in a single session of the review board, robust standard errors are clustered at the county of birth level in Column (3). The lower precision of the estimates shows that height growth dispersion is lower when assessed from a wide time window, which suggests less individual heterogeneity within volunteers and within first exempted and then recalled men than within men enlisted in 1908 or 1909.

Table 5: HEIGHT GROWTH – OLS ESTIMATES

	Height growth (cm)				
			Robust county-clustered standard error		
	(1)	(2)	(3)	(4)	(5)
	Initial sample	95% subsample[a]		Enlisted in 1908	Enlisted in 1909 in the 95% subsample
Age difference (years)	0.306***	0.237***	0.237***	0.454***	0.291***
	(0.022)	(0.013)	(0.019)	(0.062)	(0.067)
Number of observations	2,707	2,596	2,596	1,965	293
r^2	0.064	0.11	0.11	0.034	0.083
F statistic	185.7	319.7	161.2	54.185	18.628

Notes: ***Significant at the 1 per cent level; ** 5 per cent level; * 10 per cent level.

a. The 2,596 observation subsample excludes the top and bottom 2.5% of the height growth distribution.

Reading: In the 2,596 observation sample, the OLS estimate of yearly individual growth is 0.237 cm.

A possible concern in the results obtained from the samples used in Columns (1) to (3) in Table 5 relates to the treatment of the more marginal populations of men from the 1887 cohort. Estimates in Columns (4) and (5) apply to the more standard subgroups of men enlisted in 1908 or 1909, thus excluding most volunteers and all recalled men. Men enlisted a few months after their examination by the review board in 1908 are assessed with a growth of 0.45 cm over one year, while those first discharged in 1908 and enlisted in 1909 experience a lower growth of 0.29 cm. Both estimates stand above the growth of 0.24 cm obtained in the presence of volunteers and recalled men, implying a weaker growth in these two marginal groups.

5.2 IV growth estimates

The legally-based discharge decision made by the review board in 1908 relies on individual characteristics of men whose physical condition is assessed as fragile but potentially able to recover within a year. Although some of these characteristics are sometimes reported in the recruitment table, it is likely that most of them are not observed by the econometrician. The heterogeneity in the growth estimates across subgroups in Columns (4) and (5) of Table 5 suggests that they may be associated with a lower growth potential: a delayed enlistment applies to men who registered a lower growth than the average man over the same time window. That is, the men actually enlisted in 1908, in the fictitious situation where they would have been enlisted older in 1909 or later, would have registered a greater growth than those discharged/exempted in 1908 and actually measured in 1909 or later. In this case the endogenous enlistment/discharge/exemption decision made by the board, which determines the individual age difference in (2), makes the OLS an under-estimate of the true growth.

The date of the session of the review board can be considered as exogenous. The order in which counties are visited must be chosen to minimize the review board travel costs. In 1908, the municipalities of Corrèze are grouped into 29 counties. The sequence of examinations started in the county of Ayen on 18 February 1908, and ended with the examination of men born in the county of Eygurande on 13 April. The travel cost constraints may have been especially sharp in this region cut into deep gorges, with underdeveloped rail links (Michel Genty [26]) and a poor state of roads and paths making them difficult to pass during late winter. Endogeneity of the age difference thus mostly comes from the enlistment date, *i.e.*, the date of the last rather than the first measurement taken during the examination by the review board.

To deal with this issue I rely on the person chairing the review board in 1908.

Article 16 of the Berteaux Law of 21 March 1905 provides that the Chairperson must be the Prefect (*préfet*) of the department. If the Prefect is unable to attend, priority is given to the Secretary (*secrétaire général*) of the Prefecture of the department.

The personal file of Georges Calmès, the Prefect of Corrèze in 1908, suggests a possibly complex relationship with the Army.[22] His mother was from a great military family, the names of some members stood out etched into a pillar of the Napoleonic *Arc de Triomphe* in Paris. Following the defeat of France in the war with Prussia in 1871, in a context of strong revanchism, the young Calmès succeeds in entering in 1872 the high-level military school of Saint-Cyr training future officers for the armed forces. But he decides to resign, which seems to be a quite rare occurrence. Later he is exempted from military service; he is described as a short man, and during 30 years every internal administrative document emphasizes his poor health status as a strong constraint on the place where he can be employed.

Table 6: Review board chair and delayed enlistment

	Age difference[a] (year)				Review board height[b] (cm)	Review board time[c] (year)
	(1)	(2)	(3)	(4)	(5)	(6)
	Initial sample	95% subsample	Enlisted in 1908 in the 95% subsample	Enlisted in 1909 in the 95% subsample	95% subsample	
Absent Prefect[d]	−0.290***	−0.278***	−0.020	0.021	0.348	0.019
	(0.081)	(0.084)	(0.018)	(0.030)	(0.425)	(0.018)
Constant	1.371***	1.363***	0.566***	1.483***	163.729***	0.195***
	(0.064)	(0.065)	(0.010)	(0.020)	(0.218)	(0.011)
Number of observations	2,707	2,596	1,965	293	2,596	2,596
r^2	0.004	0.004	0.019	0.002	0.001	0.033
F statistic	11.1	11.1	1.3	0.5	0.674	1.032

Notes: *** significant at the 1 per cent level; ** 5 per cent level; * 10 per cent level.
All robust standard errors (into brackets) are clustered at the county level.
a. The explained variable is the time between the examination by the review board and enlistment.
b. The explained variable is the height taken during the review board.
c. The explained variable is the time between 1 January 1908 and the examination by the review board.
d. The head of the review board is the Secretary Charles Filhoulaud rather than the Prefect Georges Calmès.
Reading: In the 2,707 observation sample, the time between the review board of 1908 and the enlistment decreases by 0.29 year if the review board is chaired by Charles Filhoulaud.

Columns (1) and (2) in Table 6 report correlations between the age difference and the identity of the chairperson of the review board, either the Prefect Georges

[22] *Archives nationales*, reference F/1bI/450.

Calmès or the Secretary Charles Filhoulaud. In 1908 Filhoulaud replaces Calmès in 9 counties, out of a total of 29 counties. The Prefect clearly appears much more willing to postpone the enlistment than the Secretary.

Columns (3) and (4) indicate that the correlation vanishes when one restricts attention to the separate subsamples of men enlisted in 1908 or those enlisted in 1909. This shows that the impact of the chairperson goes through the binary enlistment/discharge decision made in 1908 rather than the precise moment at which men are enlisted within a year. That should come as no surprise since the time when the man is enlisted actually depends on the management of human resources policy of the recruiting office.

The last two columns in Table 6 serve as robustness checks for the validity of the chairperson instrument. Column (5) shows that the presence of the Prefect is not based on the height taken during the review board, *e.g.*, because the Prefect would choose to be present in poor counties where men are short and more likely to be discharged. Column (6) serves as a test for the mechanical effect that the Prefect would have been present during the first sessions of the review board only, implying a longer period of time elapsed between the review board and the enlistment. Here the explained variable is the duration (in year) between January 1, 1908 and the date of the session of the review board. This duration is not correlated with the presence/absence of the Prefect. Additional tests will be performed in Table 8 below.

The estimation results of the two-step regression with an age difference instrumented by the identity of the chairperson of the review board in 1908, either Calmès or Filhoulaud, are reported in Table 7. Height growth over the year starting from the examination by the review board is revised upward from 0.24 cm to 0.34 cm (with a $[0.29, 0.39]$ confidence interval) in the sample that discards outliers in the bottom and top 2.5 per cent of the height growth distribution. As expected, this is consistent with an OLS bias such that men enlisted after 1908 display physical weaknesses associated with a growth weaker than the growth of the men enlisted in 1908.

Column (3) of Table 7 is based on the consolidated subsample of all the men born in 1887 and enlisted in 1908 or 1909; recall that the presence of the Prefect is not a valid instrument in the subsample of men enlisted in 1908 or in the subsample of men enlisted in 1909 considered separately. The higher growth estimate in this population tends to confirm the lower growth potential of exempted men called up for World War I, but the difference between the estimates in Columns (2) and (3) is only weakly significant.

Table 7: Height growth – Absent Prefect IV estimates

	Height growth (cm)		
	(1)	(2)	(3)
	Initial sample	95% subsample	Enlisted in 1908 or 1909 in the 95% subsample
Age difference (year)	0.464***	0.340***	0.428***
	(0.052)	(0.027)	(0.047)
Instrument	Absent Prefect	Absent Prefect	Absent Prefect
Weak instrument test (p-value)	< 2.2e-16	< 2.2e-16	< 2.2e-16
Hausman test p-value	1.3e-06	1.15e-07	0.002
Number of observations	2,707	2,596	2,258

Notes: ***Significant at the 1 per cent level; ** 5 per cent level; * 10 per cent level.

Robust standard errors (into brackets) are clustered at the county level.

Reading: In the 2,707 observation sample, individual height growth over 1 year is 0.464 cm, once the time between the review board and the enlistment is instrumented by the identity of the head of the review board, Calmès *vs* Filhoulaud.

6 Heterogeneity in the growth patterns

6.1 Late catching-up

Life history theories deal with the role of environment on stature referring to the concept of norms of reaction. The compilation of cross-countries data made by McIntyre and Kacerosky [37] emphasizes the existence of two different regimes. In the first regime, a later age at maturity is associated with a shorter adult height. It mostly concerns traditional small-scale societies. The second regime, which applies to industrialized societies, instead entails both an early maturity and a taller final height.

Sections 6.1 and 6.2 assess the existence of a similar pattern within the cohort of men born in Corrèze in 1887, *i.e.*, whether poor men are subject to a slower tempo of growth and experience shorter final height than the rich. I first reproduce the analysis made in Section 5.2 disaggregated at the level of clusters of men with the same height when subject to the first measurement. The fixed effects model (2) now becomes

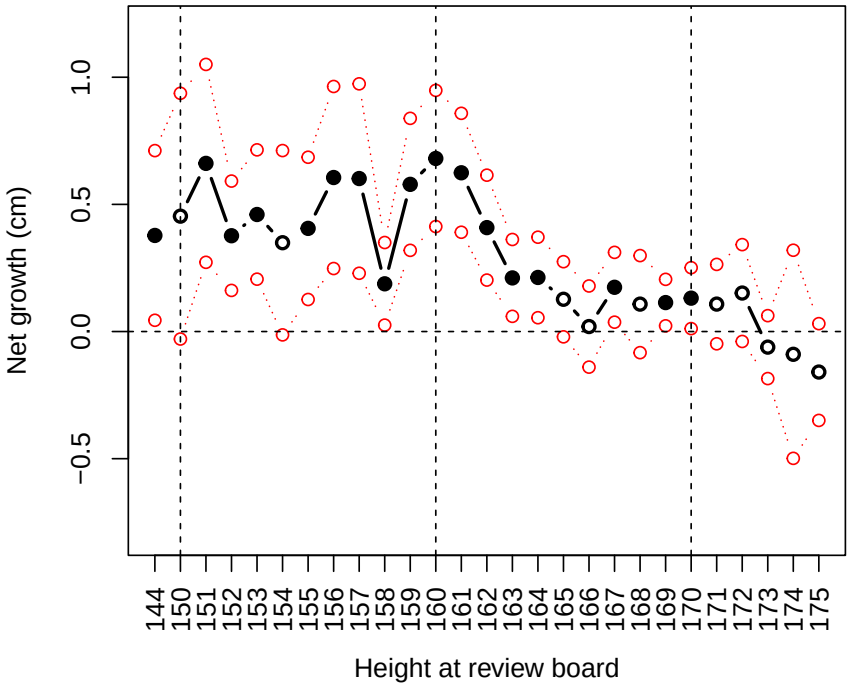
$$\Delta h_i = \sum_d \beta_d \, \Delta a_i \times \mathbf{1}_i^d + u_i \tag{3}$$

where $\mathbf{1}_i^d$ equals 1 if the height of conscript i is equal to d in the recruitment table, and 0 otherwise. Thus the parameter β_d gives the annual average height growth (in cm) of men who were d cm tall when examined by the review board in 1908.

The IV estimation results, using the chairperson as an instrument for the age difference, are given in Appendix C. They are summarized in Figure 4, with bold plain dots standing for growth estimates significant at the 5 per cent level (the 95 per cent confidence interval is in red). The pattern closely resembles the right panel of Figure 3. Late height growth appears decreasing with the height taken during the examination by the review board, thus implying a catch-up of the shortest men after age 20 that contributes to reducing adult height inequality.

Tall men may have already reached adult maturity at 21 years old. But otherwise growth concerns a large proportion of the cohort: there were only 15 per cent of men whose height was over 170 cm at the review board; most zero-growth observations in the data would therefore correspond to some sequence from a non-completed growth process. Zero-growth observations mainly concern men enlisted in 1908 (see Table 2) for whom both measurements were taken over the 6-month short span of time, which plausibly makes it difficult to measure the (small) growth accurately.

There is a lot of empirical evidence of late catch-up in modern populations. For instance, in the post World War II populations covered in the longitudinal British



Black dots have in the vertical axis the estimated height growth over one year of the men whose height taken during the examination by the review board of 1908 is reported in the horizontal axis. Height growth estimates are given in Table 12 in Appendix C. They rely on IV estimation, with the age difference (the time between the examination by the review board and the enlistment) instrumented by the identity of the head of the review board. Plain black dots apply to estimates significant at the 5 per cent level; black circles correspond to estimates not significant at this level. The red dots are the upper and lower bounds of the 95 per cent confidence intervals.

Figure 4: Within-cohort norm of reaction

standard Tanner-Whitehouse and the American National Center for Health Statistics data, late maturer boys (those boys who experience late peak load velocity) continue to grow after age 18 while the average boy then has reached adult maturity (Tanner [53]). Some catch-up is also detected by Beeking and Kok [5], Gao and Schneider [25], and Thomson, Quanjer and Murkens [55] in the various historical (selected) populations they consider. The late growth pattern in Figure 4 is thus much in line with these findings. The picture of short men from Table 3 as being farmers from sparsely populated areas, with at most primary education, points to the most economically disadvantaged groups in Corrèze, which gives rise to a within-cohort pattern echoing the cross-country norms of reaction.

6.2 Late growth deceleration

It is not clear whether late growth of the shortest men is the last phase of a prolonged growth trajectory, or a slow tempo of growth followed by a rapid catching-up. The existing literature tends to take the first of these two options, and this first option may indeed be easier to reconcile with the volume of men concerned by positive predicted late growth in Figure 4. This Section however shows that the late growth pattern of the less well-off part of the population involves significant nonlinearities, with slow growth followed by a rapid catching-up.

The analysis carried out so far is based on the assumption of a maintained growth of β or β_d cm every year. This is of course not a relevant assumption over a long period as this does not account for the deceleration where growth gradually slows down to zero after peak load velocity during puberty. This linearity may contribute to explaining why men observed over a short span of time from the examination by the review board were found to display a higher growth: the OLS growth estimate is greater for 1908 than for 1909 enlistees in Columns 4 and 5 of Table 5; and the IV estimates in Columns 2 and 3 of Table 7 also show a higher growth among conscripts for whom growth is measured over a short span of time than in the full sample including those recalled later during the war.

A standard strategy to account for growth deceleration is to introduce the age-squared in model (2), which becomes

$$\Delta h_i = \beta_1 \Delta a_i + \beta_2 \Delta a_i^2 + u_i \tag{4}$$

with $\Delta a_i^2 = a_{i1}^2 - a_{i0}^2$. A negative coefficient β_2 now captures a dampening of growth.

The model (4) gives rise to a difficulty: the single dummy instrument based on the presence/absence of the Prefect can no longer be exploited to deal with the endogeneity of the time of the last height measurement taken during the departure

examination, as it is now passed on to both the age and the square-age. To keep with a single-instrument set-up, I complement (4) with a preliminary Heckman selection stage, using the actual chairperson z_i (either Calmès or Filhoulaud) of the review board examining man i as explanatory variable for the discharge/enlistment decision. Man i is exempted or discharged in 1908 if the realization of the latent variable

$$y_i^* = \alpha + \delta z_i + \varepsilon_i^{\text{sel}} \tag{5}$$

is positive. He is otherwise enlisted in 1908. The pair of coefficients (β_1, β_2) in (4) is allowed to differ across selection outcomes, with (β_1, β_2) equal to $(\beta_1^{\text{dis}}, \beta_2^{\text{dis}})$ in the case of an exemption/discharge in 1908, and $(\beta_1^{\text{enl}}, \beta_2^{\text{enl}})$ in the case of an enlistment in 1908. The model thus accommodates for two different growth patterns, one for men enlisted in 1908 and the other for those discarded by the review board in 1908, and each of these two patterns accounts for late growth deceleration.

The model (4) and (5) is estimated by maximum likelihood assuming trivariate Gaussian errors. The results on the enlistment versus discharge or exemption decision made by the review board in 1908 are reported in Table 8. The estimated growth patterns are in Table 9. The positive estimates of β_1^{enl} and β_1^{dis} in Table 9 point to a prolonged growth for the two groups of men after the 1908 review board is held. The negative values of the square-age coefficients show that the linearity assumption in models (2) and (3) is indeed overly restrictive to capture late growth properly. Echoing the norms of reaction views, the slowdown in height growth after peak velocity appears more pronounced for men enlisted in 1908, who are 4 cm taller than discharged men (see Table 3).

The specification used in Column (1) mirrors the instrumental variable set-up used to estimate the model (2). It abstracts from time fixed effects as well as time-varying explanatory variables other than the individual age, and it sticks to the most parsimonious modeling of selection relying on absence/presence of the Prefect explanatory variable only.

Column (2) introduces individual time invariant characteristics into the selection equation. A delayed enlistment applies to short and/or young men when examined by the review board. A preferential treatment is provided by the Law of 1905 in form of postponed enlistment for the few men involved in higher education; as a result the few highly skilled men often are discharged.

The specifications in Columns (3) to (5) focus on the impact of time varying explanatory variables on individual growth. Column (3) accounts for a time dummy variable that takes value 0 (resp., 1) at the time when the first (resp., second) measurement is taken. Time fixed effects translate into constant terms in the outcome

equations (4) in Table 9. The conditions of the examinations are about similar for men discarded by the review board in 1908. Instead men enlisted in 1908 are (weakly) found to face a different growth-promoting environment over the short time window between the two examinations. Norms reactions views suggest a context of deteriorated economic situation.

One can approach some potential drivers for the change in the environment faced by 1908 enlistees by referring to county economic well-being indicators. Before 1914 the main *quatre vieilles* direct taxes were all related to land. They are available for every county seat in the *Matrices Générales des Contributions Directes* held in the *Archives de la Corrèze*. Given this common tax base reference, the changes in the different categories of tax between 1908 and 1909 are highly correlated. I keep the change in the *contribution foncière* property tax on land.[23] If viewed as a reasonable proxy for the change in county wealth, the results in Column (4) show no link between some global wealthy environment and late growth in Corrèze. Things are different in Column (5): Time fixed effects no longer matter when one accounts of the change in the county bovine population, which is a plausible proxy for the change in county income (as related to the annual calf sale). This suggests that the environmental contribution to late height growth relates to contemporaneous income changes: a lower county income is associated with a higher height growth after 20.

The results in Table 8 can also serve as additional tests for the instrumental variable estimation in Section 5.2. They show that the absence/presence of the Prefect as chairman of the review board is still a good predictor of the enlistment/discharge decision once additional individual time-invariant characteristics, as well as time-varying county wealth and income proxies are controlled for. They point toward the role played by the idiosyncratic psychology of the Prefect Calmès in postponing the enlistment decision, a feature that is further explored in Section 6.3.

In every specification the correlation coefficients show that OLS estimates suffer from an omitted variable bias. The negative correlation between the error in the selection equation and the errors in the two outcome equations (4) may be caused by some temporary illness, malnutrition and/or deprivation that increase the probability of exemption or discharge and hinder growth. As recommended by the Law of 1905 the review board exempts from military service or postpones the examination of the

[23]Different taxes apply to developed (*bâti*) and undeveloped (*non-bâti*) properties. The tax on undeveloped properties and the three remaining taxes (*taxe personnelle mobilière, taxe sur les portes et fenêtres* and the *patente* are highly correlated as all determined following a similar rule based on an administrative (notional) evaluation of land value. The calculation of the tax on developed land instead refers to a given share of the actual rents collected from buildings (following a 1891 tax reform). Tables 8 and 9 refer to the *principal* of the tax, which corresponds to the part collected by the Central State.

Table 8: Growth deceleration: Probit selection equation

	(1)	(2)	(3)	(4)	(5)
Absent Prefect (δ)	-0.1254***	-0.1184**	-0.1239**	-0.1228**	-0.1175**
	(0.0477)	(0.0507)	(0.0505)	(0.0523)	(0.0532)
Height at review board examination		-0.0406***	-0.0410***	-0.0409***	-0.0408***
		(0.0042)	(0.0042)	(0.0042)	(0.0042)
Age at review board examination		-0.1547**	-0.1264*	-0.0127*	-0.1351*
		(0.0751)	(0.0761)	(0.0762)	(0.0766)
Education (reference: no education)					
Can only read		-0.1914	-0.1937	-0.1926	-0.1905
		(0.1544)	(0.1545)	(0.1547)	(0.1541)
Can read and write and/or count		-0.1939***	-0.1993***	-0.2001***	-0.2009***
		(0.0537)	(0.0535)	(0.0536)	(0.0537)
Higher education		-0.0683	-0.0806	-0.0811	-0.0779
		(0.1530)	(0.1534)	(0.1539)	(0.1536)
Occupation (reference: Merchant)					
Farmer		0.0830	0.0783	0.0758	0.0808
		(0.0898)	(0.0892)	(0.0893)	(0.0897)
Soldier		0.0481	0.0341	0.0346	0.0407
		(0.1722)	(0.1697)	(0.1700)	(0.1703)
Employee/Worker		-0.0378	-0.0407	-0.0432	-0.0393
		(0.0944)	(0.0935)	(0.0935)	(0.0938)
Student/Senior executive		0.2917*	0.2818	0.2777	0.2837*
		(0.1714)	(0.1714)	(0.1718)	(0.1722)
Wealth/income proxies					
Tax on developed property[a]				0.0006	0.0006
				(0.0059)	(0.0061)
Tax on undeveloped property[a]				-0.0001	-0.0010
				(0.0019)	(0.0021)
Bovine population[b]					0.0020
					(0.0016)
Constant (α)	-0.5809***	9.3164***	8.7903***	8.806***	8.9511***
	(0.0278)	(1.7098)	(1.729)	(1.7344)	
Number of observations	2,596[a]	2,596	2,596	2,596	2,596
Log-likelihood	-5,726	-5,657	-5,655	-5,655	-5,651

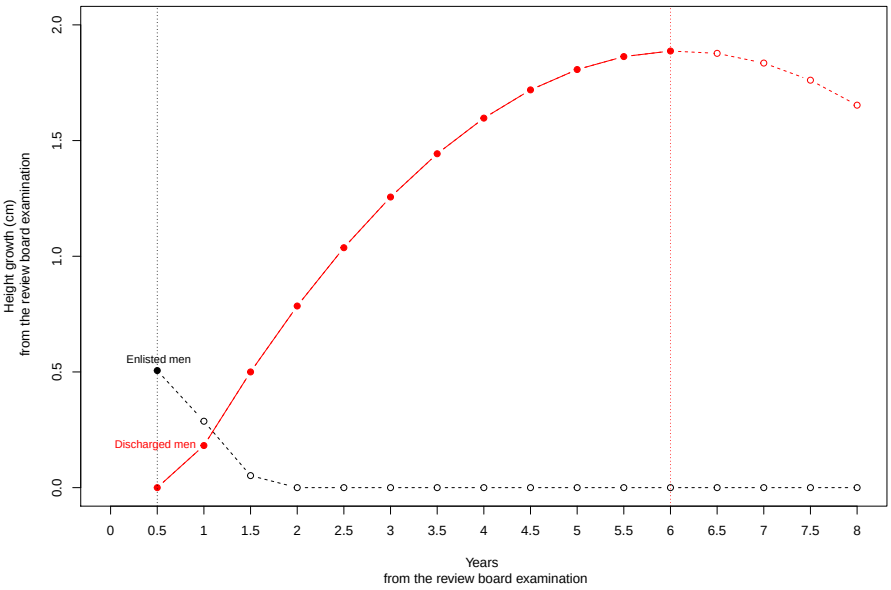
Notes: ***Significant at the 1 per cent level; ** 5 per cent level; * 10 per cent level.
The model in estimated on the 2,596 observation subsample that excludes the top and bottom 2.5% of the height growth distribution. The set of enlisted men consists of 2,090 observations on men enlisted before 1908. The 506 remaining observations apply to discharged or exempted men in 1908.
a. Change in per cent of the *principal* part of property tax revenues collected in the county seat between 1908 and 1909, in: *Matrices Générales des Contributions Directes*, *Archives de la Corrèze*, reference 2P6.
b. Change in per cent of the county bovine population between 1905 and 1911 or 1913 where information is missing for 1911. Source: *Statistique agricole annuelle, tableaux récapitulatifs cantonaux*, *Archives de la Corrèze*, reference 6M634-38.

Table 9: Growth deceleration: outcome equations

	(1)	(2)	(3)	(4)	(5)
Outcome equation 1: Men enlisted in 1908[a]					
Age difference ($\hat{\beta}_1^{\text{enl}}$)	4.3292***	3.0841***	5.6129***	5.5511***	5.2812***
	(0.9883)	(0.9589)	(1.6788)	(1.6825)	(1.6805)
Age squared difference ($\hat{\beta}_2^{\text{enl}}$)	-0.1111***	-0.0805***	-0.1447***	-0.1431***	-0.1364***
	(0.0245)	(0.0237)	(0.0422)	(0.0423)	(0.0422)
Income proxies					
Tax on developed property				-0.0010	0.0018
				(0.0070)	(0.0071)
Tax on undeveloped property				-0.0012	0.0013
				(0.0024)	(0.0026)
Bovine population					-0.0053***
					(0.0019)
Constant			0.1220*	0.1303*	0.0872
			(0.0638)	(0.0775)	(0.0791)
Outcome equation 2: Men exempted or discharged in 1908[a]					
Age difference ($\hat{\beta}_1^{\text{dis}}$)	3.5018***	3.7641***	3.5330***	3.5601***	3.5569***
	(0.7647)	(0.7073)	(0.8270)	(0.8279)	(0.8277)
Age squared difference ($\hat{\beta}_2^{\text{dis}}$)	-0.0653***	-0.0704***	-0.0659***	-0.0664***	-0.0663***
	(0.0150)	(0.0139)	(0.0162)	(0.0162)	(0.0162)
Wealth/income proxies					
Tax on developed property				-0.0079	-0.0090
				(0.0199)	(0.0203)
Tax on undeveloped property				0.0048	0.0041
				(0.0068)	(0.0073)
Bovine population					0.0012
					(0.0054)
Constant			0.2501	0.2724	0.2644
			(0.4197)	(0.4552)	(0.4542)
Error terms					
σ^{enl}	1.6073***	1.5814***	1.5745***	1.5744***	1.5724***
	(0.0272)	(0.0265)	(0.0266)	(0.0266)	(0.0266)
σ^{dis}	1.9905***	2.0024***	2.0347***	2.0325***	2.0296***
	(0.0686)	(0.0700)	(0.0955)	(0.0962)	(0.0955)
ρ^{enl}	-0.9267***	-0.9240***	-0.9232***	-0.9234***	-0.9235***
	(0.0053)	(0.0062)	(0.0064)	(0.0064)	(0.0064)
ρ^{dis}	- 0.2263**	-0.2811***	-0.3430***	-0.3416***	-0.3371***
	(0.0896)	(0.0824)	(0.1263)	(0.1286)	(0.1294)
Number of observations	2,596[a]	2,596	2,596	2,596	2,596
Log-likelihood	-5,726	-5,657	-5,655	-5,655	-5,651

Notes: ***Significant at the 1 per cent level; ** 5 per cent level; * 10 per cent level.
a. The model in estimated on the 2,596 observation subsample that excludes the top and bottom 2.5% of the height growth distribution. See the notes at the bottom of Table 8.

men who are assessed as in a fragile condition. The negative correlation ρ^{enl} reveals a hampered growth for many men enlisted in 1908, though the penalties were largely ignored by the review board that opts for an early enlistment in the fall season.



Dots have in the vertical axis the predicted average height growth over the number of 6-month periods (half a year) since the examination by the review board reported in the horizontal axis. The review board examination is held at 0 in the horizontal axis. Black (resp., red) dots apply to men enlisted (resp. discharged) in 1908. For instance, the height of discharged men has increased by 1.88 cm over 6 years starting from the review board examination in 1908. Estimates obtain from the endogenous switching regression model defined by Equations (4) and (5). Plain dots correspond to situations where growth has increased since the previous half-year; circles correspond to situations where growth has instead decreased.

Figure 5: Late growth pattern

The growth patterns predicted by the selection model can now be used to assess whether the lower growth performance of discharged men in Tables 5 and 7 merely reflects a measurement taken over a long period of decelerating growth. I refer to the most parsimonious specification used in Column (1). The prediction is computed by replacing the actual age at the last measurement with a fictitious age equal to the age of the man at the review board plus a certain number of periods of 6 months. The quadratic specification implies a negative predicted growth for high enough fictitious age. The time when the prediction becomes negative is interpreted as a signal of individual adult maturity; negative predictions are accordingly set to 0.

The predicted growth is depicted in Figure 5 (the exact predictions are in Table 13 in Appendix D). The growth pattern of men enlisted before 1908 is in black. These men gain 0.51 cm over the first 6 months from the examination by the review board. The average predicted growth falls after the first semester, which shows that they reach adult maturity within a year, *i.e.*, when they are between 21 and 22 years old. This corresponds to a linear annual height growth between 0.51 and 1.02 cm before they reach maturity.

The growth pattern (in red in Figure 5) is very different for men deferred for later examination. No growth is detected over the first semester, but from then they start to catch up with their well-off peers. They gain 0.18 cm over the first year and eventually reach adult maturity six years after the review board, when they are 26 or 27 years old. Overall they gain 1.89 cm, which corresponds to a linear trend of 0.31 cm height gain every year. Their growth prospect thus stands below the 0.51 cm lower bound found for 1908 enlistees.

The 160.75 cm average height of exempted or discharged men in spring 1908 is associated with an average final height of 162.64 cm achieved several years later. This fits the observation in Hauspie et al. (1996) of a male adult height reached at about 26 years of age in the 1910s in western countries. However, the main part of the cohort would have stopped growing much earlier. Appendix F suggests that the growth estimates may be revised upward when one accounts of absentees, which the two growth patterns delineated in this Section make consistent with a profile of the absentees as of the men that the board would have decided to draft in 1908.

6.3 Cohort-specific growth

The Berteaux Law of 21 March 1905 is implemented in France from the cohort of men born in 1885 and examined by the review board in 1906. Georges Calmès became Prefect of Corrèze in March 1905, and left the position three years later, in November 1908, when appointed Prefect of Hérault. Charles Filhoulaud remained Secretary in Corrèze from 1900 until his retirement in 1923. Hence they shared the chair of the boards reviewing the three cohorts of men born between 1885 and 1887 only.

I recorded the minimal amount of information needed to produce growth estimates for the 1885 and 1886 cohorts: the height of every man in the recruitment table, his height in the registration form and his enlistment date.

The sample of men born in 1886 (examined in 1907) differs in two respects from the other cohorts. First, nearly half of the observations are missing as the recruitment table has not been preserved by the *Archives* for the whole twelve-county subdivision (*arrondissement*) of Tulle. In addition, the review of the seven counties in the

subdivision of Ussel was carried out exceptionally late in May 1907, implying a very short period of time between the two height measurements for men enlisted in the fall of 1907.

The full sample of the three cohorts contains 6,573 observations with completed age difference and height growth episodes. As before, I discard the bottom and top 2.5 per cent of the (three-cohort) height growth distribution to deal with outliers. This yields a 6,182 observation sample.

An important point for the instrumental methodology concerns the replacement of Calmès as chairman of the review board. In 1908 the Prefect is on the way out and Filhoulaud replaces him in one-third of the counties (9 out of 29 counties). In the two previous years, however, the newly arrived Prefect was replaced far less often: Filhoulaud rules the selection of men from the 1885 and 1886 cohorts in only four counties out of a total of $2 \times 29 = 58$ counties. Column (1) of Table 10 shows that the lower variability in the presence/absence of the Prefect in the three-cohort sample makes this instrument no longer suitable for dealing with the endogenous individual age difference between the two height measurements.

The presence/absence of the Prefect instrument can nevertheless be strengthened by exploiting small provisions on the timing of the review board in a context of high transportation costs.

The impressive archival mass of preparatory documents for scheduling the examinations in the different counties is a clear indication of the difficulty of this task and the administrative effort involved. The schedules reproduced in Appendix E show that at most one meeting per day was held and that the examination of all the men from any given county was programmed on-site within a half-day. Two sessions set up on two consecutive days often concern neighboring counties, while breaks with at least one day off may entail counties located far apart from each other. The minimization of transportation costs rationale for the schedule of the review board, combined with the observation of sequences of consecutive examinations of neighboring counties, suggests that it is expected from the members of the committee that they spend the night within the reviewed counties. In particular, the fact that a star-shaped network designed around the Prefecture in Tulle was considered as too costly presumably indicates that the chosen schedule makes a return to Tulle difficult between an afternoon session followed by a session in the next morning.

Recall that Georges Calmès is portrayed in the personal file held by the *Archives nationales* as a frail man throughout his career as a senior civil servant. He was nearly 60 years old when reviewing these three cohorts in Corrèze, and had just married on 6 September 1905 Victorine Bédache, a widow born in Paris in 1857. Suppose then that Calmès, who lives in the city center of Tulle, prefers not to spend the night away

from home. An examination late in the afternoon following a day with no session enables him to leave Tulle in the morning on the day of examination: he should therefore prefer this option to an examination early in the morning. Symmetrically, an early examination in the morning allows him to return to Tulle in the evening if no session is scheduled the following day, which should suit him better than an examination scheduled in the afternoon.

Column (2) of Table 10 accounts for a new Night in Tulle dummy variable. The dummy takes value 1 if the session of the review board is consistent with a night spent in Tulle before or after the examination. Namely, it is 1 if the examination either starts after 1:30 p.m. if no session is scheduled the day before, or before 10:00 a.m. if no session is scheduled the day after. Otherwise the variable takes value 0. The results in Column (2) show that the enlistment/discharge decision of Calmès and Filhoulaud are similar if the schedule makes it difficult to depart from or return to Tulle the day of the examination (the Night in Tulle dummy is 0). The Prefect is much more willing to discharge or exempt men than the Secretary in the case where he does not have to spend the night in the countryside away from Tulle (the Night in Tulle dummy is 1).

Column (3) of Table 10 builds on this preference of the Prefect to strengthen the presence/absence of the Prefect explanatory power. It uses as instrument for the age difference a dummy that takes value 1 if Calmès chairs a session starting either after 1:30 p.m. if no session is scheduled the day before, or before 10:00 a.m. if no session is scheduled the day after. In every other alternative, *i.e.*, either Calmès chairs a session while Night In Tulle is 0 or Filhoulaud replaces Calmès, the variable takes value 0. Nearly a quarter of men ($1,367$ over $6,182$) are associated with a dummy of 1.

This refined binary Night in Tulle $\times$ Calmès instrument is strong enough to deal with the endogenous age difference. It is even more powerful in Column (4) that excludes the incomplete cohort of men born in 1886. Table 15 in Appendix E reproduces the same robustness tests as in Table 6. The Night in Tulle $\times$ Calmès instrument is neither correlated with age at the moment of the examination by the review board nor the individual height taken during this examination. There is no specific pattern in the schedule where, say, the instrument would mostly take value 1 at the beginning or the end of the whole set of sessions, thus implying a mechanical spurious impact on the age difference.

Table 11 reports IV estimation results on height growth using the Night in Tulle $\times$ Calmès instrument for the age difference. Column (1) shows that the average growth over one year from the review board equals 0.43 cm in the three-cohort sample, a figure that does not significantly differ from the one found for the men born in 1887

Table 10: A night in Tulle

	Age difference (cm)			
	(1)	(2)	(3)	(4)
	Sample of men born in 1885, 1886 or 1887			Sample of men born in 1885 or 1887
Reference: Calmès chairs the board				
Absent Prefect (Filhoulaud chairs the board)	−0.126			
	(0.080)			
Reference: Calmès chairs the board × Night in Tulle				
Calmès chairs the board × Night in Tulle		0.373***		
		(0.118)		
Filhoulaud chairs the board × Night away from Tulle		0.022		
		(0.085)		
Filhoulaud chairs the board × Night in Tulle		−0.080		
		(0.098)		
Reference: Calmès chairs the board × Night in Tulle[a]				
Either (Filhoulaud chairs the board)			−0.378***	−0.489***
or (Calmès chairs the board × Night away from Tulle)			(0.115)	(0.104)
Constant	0.899***	0.800***	1.172***	1.341***
	(0.053)	(0.049)	(0.108)	(0.094)
Number of observations	6,182	6,182	6,182	4,909
r^2	0.001	0.01	0.009	0.013
F statistic	2.5	4	10.8	22.08

Notes: ***Significant at the 1 per cent level. ** 5 per cent level; ∗ 10 percent level.
Robust standard errors clustered by county and year of birth.

a. Calmès chairs the board and he can spend the night before and/or after in Tulle.

using the single absence/presence of the Prefect as instrument. Column (2) shows that height growth of the different cohorts do not differ either, which may be viewed as a further indication of the validity of the approach. The point estimate of growth in the incomplete sample of men born in 1886 is slightly lower, possibly following the short period of time elapsed between the two measurements for many of these men. Column (3) restricts to the subsample excluding the men born in 1886 and reports an unaffected growth of the two remaining cohorts.

Table 11: Quantifying height growth – Night in Tulle IV estimates

	Height growth (cm)		
	(1)	(2)	(3)
	Sample of men[a] born in 1885, 1886 or 1887		Sample of men[a] born in 1885 or 1887
Age difference (year)	0.433***		
	(0.040)		
Age difference (year) × born in 1885		0.543***	0.543***
		(0.110)	(0.110)
Age difference (year) × born in 1886		0.253***	
		(0.059)	
Age difference (year) × born in 1887		0.411***	0.411***
		(0.032)	(0.032)
Instrument[b]	Night in Tulle × Calmès	Night in Tulle × Calmès × Birth year	Night in Tulle × Calmès × Birth year
Weak instrument test (p-value)	0	0	< 2.2e-16
Hausman test p-value	< 2.2e-16	< 2.2e-16	< 2.2e-16
Number of observations	6,182	6,182	4,909

Notes: ***Significant at the 1 percent level; ** at the 5 percent level; * at the 10 percent level. Robust standard errors clustered by county and year of birth.

Reading: The average height growth in the three-cohort sample is 0.433 cm over one year following the examination of the review board.

a. This excludes the bottom and top 2.5 percentiles of the three-cohort height growth distribution.

b. Night in Tulle × Calmès is 1 if Calmès chairs a session of the review board scheduled so that he can spend the night in Tulle before and/or after the session. It is 0 otherwise. The variable is interacted with the year of birth in the case where cohort-specific growth rates are estimated.

7 Concluding comments

This article is the first to document individual statural growth at the end of physical adolescence from quasi-exhaustive historical longitudinal individual-level panel data. The panel is obtained from the combination of two widely used anthropometric data sources from conscription in France. The result of this combination is illustrated on the cohort of men born in 1887 in the department of Corrèze. A majority of men reach adult maturity before age 21/22 but the less well-off initiate a late catch-up and continue to grow until age 26/27.

In principle, the analysis can be extended to France as a whole over the nineteenth century. The multiple-cohort analysis in Section 6.3 however highlights two features which must be taken into account in view of a more general treatment: the cohorts under scrutiny in this article all consist of men born within a short period of time before the Great War, and the selection of conscripts by the review board was chaired by a Prefect showing a special propensity to postpone enlistment. The first feature yields quasi-exhaustiveness of the sample relying on the waves of recall implemented during the war. The specific nature of the Prefect is exploited to deal with endogeneity of the time difference between the two height measurements.

In a climate of war preparation, France decided to extend the duration of military service from 2 to 3 years in 1913. This implied a one-year anticipated call of men born in 1893, during the year following their 19th rather than 20th birthday. The same timing was applied to the cohort of men born in 1894, while the war called for an even earlier enlistment of the subsequent cohorts during the year following their 18th birthday. Exploiting the younger age of the last cohorts when examined by the review board should allow us to sketch a final growth episode, and possibly identify the precise age of adult maturity of the tallest men.[24]

There are two other possible, and more speculative, directions for further research relying on both height level and height growth. A first line participates in the widespread effort to quantify the relative importance of the environment and genetic factors on human development; a standard rule of thumb imputes 80 per cent of adult height to genetic factors and 20 to the environment (Barry Bogin, 2020). If individuals with the same adult height share similar enough height-related genetic capital, so that one such individual who continues to grow after 20 has a genetic capital similar to that of a taller individual whose growth is completed at 20, a prolonged growth episode of the former suggests he was penalized by an unfavorable economic environment.

[24]The strategy cannot be implemented on Corrèze, however, as the height taken during the review board is rarely recorded in the recruitment table for this department during the war.

Height growth of the man, used on top of the height level, may also provide additional information in the assessment of long-run economic performance. In line with the analysis of β-convergence, the heterogeneity in per capita income growth rates is often exploited to get insights on the long run of economies with similar current per capita income levels: a higher growth rate signals that the economy still stands far from its long-run steady-state equilibrium. The present analysis thus suggests a way to go beyond the correlation between the height level and the actual state of the economy, with a higher height growth rate proxying long-run economic possibilities.

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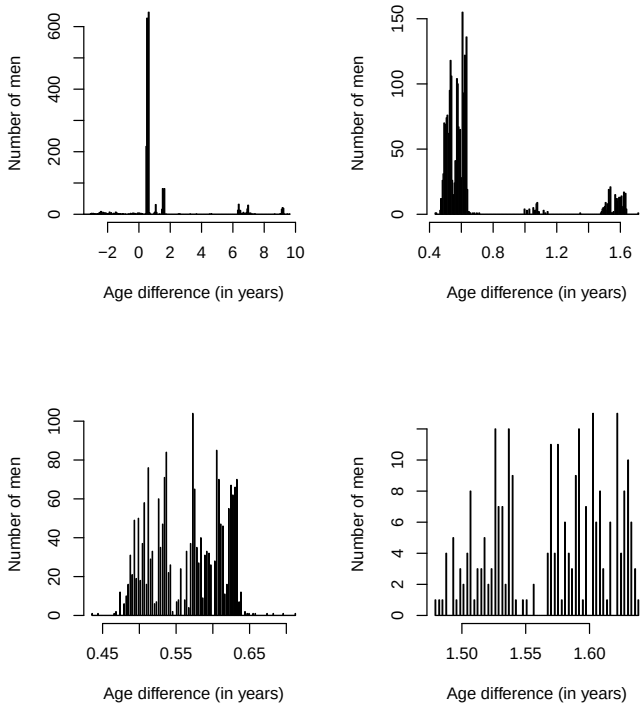
A Age difference sample distribution



The horizontal axis gives the age difference, *i.e.*, the time between the examination by the review board and the enlistment. The vertical axis gives the number of observations for every age difference. The top-left panel accounts for every age difference observed in the data. The top-right panel restricts to age differences of men concerned by an enlistment in 1908 and 1909. The bottom-left panel (resp., bottom-right) focuses on men enlisted in 1908 (resp., 1909). There are 71 observations with a age difference equal to 0.5342 year, *i.e.*, approximately 192 days.

Figure 6: Age difference distribution

This Appendix complements the information on the height growth and age difference distributions given in Table 4. Figure 6 depicts the distribution of age difference. It shows that the age difference heterogeneity comes from both the time of the examination by the review board (identical to all men born in the same county) and the individual-specific time of enlistment. The whole distribution is represented in the top-left panel. The top-right panel focuses on the two main categories of men,

formed by the men enlisted in 1908 or 1909. The two bottom panels of Figure 6 are zooms on each of these two categories.

Figure 7 gives the height growth distribution in the $2,596$ observation panel that discards the bottom and top 2.5 percentile of the height growth distribution; the right panel restricts to non-zero growth observations.

B Height in the registration forms

The height in the registration form is classified as follows:

1. The height of enlisted men is their height at enlistment.

   This covers men enlisted in 1908, men discharged in 1908 and deemed fit in 1909, as well as the men exempted in 1908 or 1909 but enlisted following recall waves during World War I.

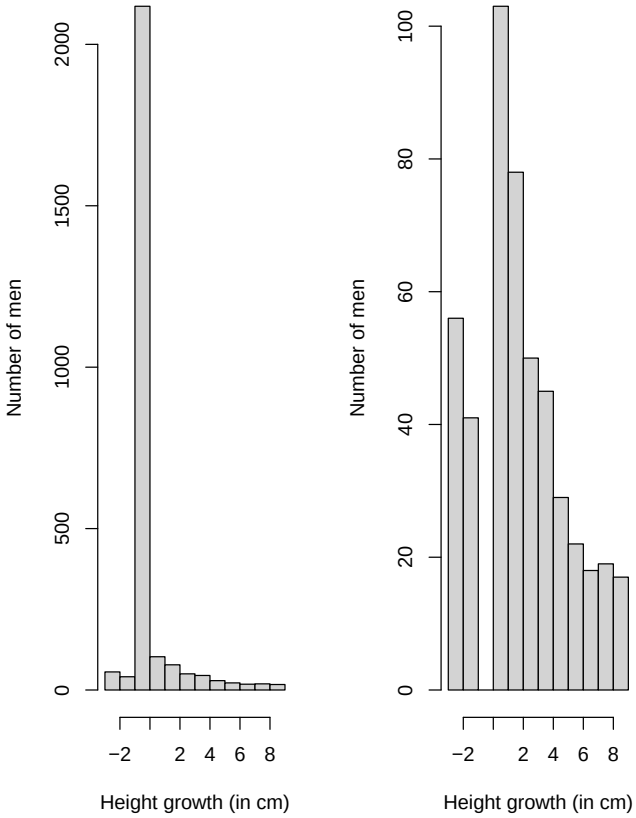
   Pierre Gautherie was 161cm tall during the review board. He is discharged in 1908 because of eczema. A form is created in 1908 following the discharge decision, with registration number 1049 from the recruiting office of Brive. He is not subject to the departure examination in 1908. He is exempted in 1909 and so he is neither subject to the departure examination in 1909. He is reexamined by the Army in the course of the first recall wave occurring in December 1914 and eventually enlisted. The height of 163 cm reported in his registration form is set as taken in 1914.

Item 1 covers the most common cases as men born in 1887 typically end up enlisted in 1908, 1909 or during the Great War. More specific situations are considered in the following Items.

2. The height of men discharged in 1908 and exempted in 1909 is taken during the 1909 examination by the review board.

   A registration form is created following a discharge decision in 1908. The man is not subject to the departure and enlistment examinations in 1908. The last measurement is assumed to be taken during the examination by the review board in 1909. If recalled during the war, see Item 4 below.

   François Dupuy (registration number 17 from the recruiting office of Tulle) is discharged in 1908 and exempted in 1909 for 'overall weakness.' The height of 163 cm reported in his registration form is set as taken on 26 April, 1909 when the review board examines the men born in 1888 in the county of Argentat. The observation corresponding to this man associates a height of 163 cm taken



The horizontal axis gives the difference between the height in the registration form and the height in the recruitment table, which is set as accounting of height growth. The horizontal axis reports the number of observations for every height growth. The height is identical in the two sources for most men, which yields a mass of 0 height observations in the left panel. The right panel excludes 0 growth observations to highlight the empirical height growth distribution. Negative height growth applie to volunteers (who enlist before the examination by the review board) and measurement errors.

Figure 7: Height growth distribution

during the review board on 14 March 1908 (the initial date of 6 March 1908 that appears in the *Bulletin* was modified after the publication) with the same height of 163 cm taken in 1909.

3. The height of men exempted in 1908 or 1909 and once again exempted at the outcome of all recall waves is their height measured during the first recall in December 1914.

   There are 47 registration forms on men exempted in 1908 and rejected at the outcome of recall waves; see, *e.g.*, Antoine Bouilhac (registration number 134 from the recruiting office of Brive). I set that the form is created following the first wave of recall in 1914. This should be seen as a conservative choice since the height coincides in the recruitment table and the registration forms for 45 men, *i.e.*, this amounts to setting no individual height growth over a long period of time.

4. Corrected height is the height of the man at the moment of his last enlistment.

   Men may be measured several times following enlistment, *e.g.*, when assigned to a new military unit or following a novel enlistment during the Great War several years after the 1908/1909 examinations. The Army then needs to update the height reported in the registration form according to item 1 or 2. This is done using the corrected height field of the form. The data only includes 104 corrected heights.

   René Aupetit (registration number 1633 from the recruiting office of Tulle) is discharged in 1908 with a short height of 154 cm and a low weight of 48 kg, but deemed fit by the review board in 1909 and enlisted on 7 October 1909. His height in the registration form, taken in 1909, is still equal to 154 cm. He is nevertheless rejected for 'insufficient weight' as of 12 October 1909, presumably at the outcome of the sequence of departure and enlistment examinations. When reexamined during the 1914 recall wave, he is considered as able and enlisted. The corrected height field is filled out in his registration form, with a height of 158 cm.

   Antoine Nauche (registration number 208 from the recruiting office of Tulle) is discharged in 1908 (with height 150 cm in the recruitment table) and absent from the examination by the review board in 1909, but enlisted in October 1909. His height set according to Item 1 as taken when enlisted in 1909 is still 150 cm. He is re-examined and enlisted in August 1914 (the corrected height field reports a height of 152 cm). There are two observations for this man in the sample, one with a height pair $(150, 150)$ associated with an age

difference of about 1 year (from 1908 to 1909), and another observation with a pair $(150, 152)$ associated with an age difference of about 6 years (from 1908 to 1914).

C Norms of reaction

Table 12: Assessing norms of reaction – IV estimates

	Height growth (cm)	Standard error	Number of men
(144,150]	0.378**	0.17	27
(150,151]	0.454*	0.246	13
(151,152]	0.661***	0.198	14
(152,153]	0.377***	0.11	23
(153,154]	0.46***	0.13	52
(154,155]	0.349*	0.185	52
(155,156]	0.406***	0.143	68
(156,157]	0.606***	0.183	76
(157,158]	0.602***	0.19	100
(158,159]	0.188**	0.083	119
(159,160]	0.579***	0.132	166
(160,161]	0.681***	0.137	164
(161,162]	0.624***	0.119	196
(162,163]	0.409***	0.105	225
(163,164]	0.211***	0.077	187
(164,165]	0.213***	0.081	160
(165,166]	0.127*	0.075	155
(166,167]	0.02	0.081	130
(167,168]	0.174**	0.07	122
(168,169]	0.108	0.097	100
(169,170]	0.114**	0.047	111
(170,171]	0.131**	0.061	107
(171,172]	0.108	0.08	66
(172,173]	0.151	0.097	44
(173,174]	-0.061	0.063	41
(174,175]	-0.089	0.209	27
(175,184]	-0.159	0.097	51
Instrument	Absent Prefect		
Observations	2,596		
r^2	0.084		

Notes: ***Significant at the 1 per cent level; ** 5 per cent level; * 10 per cent level. All robust standard errors are clustered at the county level.

D Predicted growth from the selection model

Table 13: Predicted growth

Year	Mean	1st Quartile	Median	3rd Quartile	Top decile
	(in cm)				
Men enlisted in 1908 or before (2,090 observations)					
0.5	0.506	0.476	0.511	0.552	0.574
1.0	0.287	0.230	0.287	0.351	0.394
Men discharged or exempted in 1908 (506 observations)					
0.5	0.000	0.000	0.000	0.000	0.000
1.0	0.182	0.149	0.189	0.214	0.238
1.5	0.500	0.451	0.508	0.546	0.579
2.0	0.785[1]	0.721	0.796	0.846	0.887[2]
2.5	1.037	0.958	1.049	1.114	1.162
3.0	1.256	1.162	1.273	1.348	1.408
3.5	1.443	1.333	1.461	1.552	1.618
4.0	1.597	1.470	1.618	1.725	1.797
4.5	1.719	1.574	1.742	1.864	1.942
5.0	1.807	1.646	1.833	1.968	2.056
5.5	1.863	1.686	1.891	2.041	2.136
6.0	1.887	1.696	1.915	2.079	2.183
6.5	1.877	1.672	1.909	2.085	2.198

Reading:
1. The average growth of men discharged or exempted in 1908 is 0.785 cm in two years after the 1908 review board.
2. The 10 per cent of men discharged or exempted in 1908 who register the greatest growth in two years after the 1908 review board gain 0.887 cm in average.

E Night in Tulle instrument

The sequence of examinations in 1906, 1907 and 1908 is given in Table 14.[25] The minimization of transportation costs which explains the trajectories of the review board implies that adjacent counties within the same subdivision are typically examined on consecutive days.

The dates of examinations in the missing counties in the Tulle subdivision in 1907 are not reported. In 1907 the examination starts with the subdivision of Brive, which ends in Beynat on 28 March, 1907. The subdivision of Tulle is reviewed from 16 April, so that Beynat is followed by a day without examination. It ends in Uzerche on Saturday, the 4th of May. Ussel is the first county examined in the Ussel subdivision, on Tuesday, the 7th of May. It follows that there was no examination scheduled the day before the review of men born in Ussel county.

Table 15 reports robustness checks for the absence of correlation between the unobserved height growth potential and the fact that Georges Calmès chairs the review board when Night in Tulle takes value 1 (an afternoon session if there was no session scheduled the day before, or a morning session if there was no session scheduled the day after). The binary instrument is linked with neither the height recorded during the examination by the review board nor the age of the men reviewed. In Column (3) the explained variable is the time elapsed from the 1st of January of the year when the examination takes place. It shows no special pattern in the schedule where, *e.g.*, non-working days would occur more frequently at the beginning of the session, making more likely that Night in Tulle is 1 early in the sequence, yielding a longer period of time until enlistment.

[25] It is taken from the *Procès Verbal du conseil de révision* for years 1906 (reference R1055 in the *Archives de la Corrèze*) and 1908 (reference R1057), and from the *Recueil des Actes Administratifs* (RAA) for year 1907 (reference 3K49). The RAA does not report the schedule in 1906. In 1908, the schedule published in the RAA was subject to several last-minute adjustments.

Table 14: Annual schedules of the review board

County	Men born in 1885	Men born in 1886	Men born in 1887
Argentat	1906-03-15, Thursday, 10:00		1908-03-14, Saturday, 10:00
Ayen	1906-03-01, Thursday, 9:30	1907-03-11, Monday, 9:30	1908-02-18, Tuesday, 10:00
Beaulieu	1906-03-13, Tuesday, 13:45	1907-03-22, Friday, 13:45	1908-02-26, Wednedsay, 13:45
Beynat	1906-03-14, Wednedsay, 10:30	1907-03-28, Thursday, 10:30	1908-02-28, Friday, 10:30
Bort	1906-04-10, Tuesday, 13:15	1907-05-16, Thursday, 10:15	1908-04-02, Thursday, 13:15
Brive	1906-03-07, Wednedsay, 13:00	1907-03-26, Tuesday, 13:00	1908-02-29, Saturday, 13:00
Bugeat	1906-04-04, Wednedsay, 10:15	1907-05-13, Monday, 10:15	1908-04-09, Thursday, 10:15
Correze	1906-03-29, Thursday, 13:30		1908-03-10, Tuesday, 13:30
Donzenac	1906-03-02, Friday, 13:45	1907-03-12, Tuesday, 13:45	1908-02-21, Friday, 13:45
Egletons	1906-03-19, Monday, 13:15		1908-03-24, Tuesday, 10:45
Eygurande	1906-04-06, Friday, 10:15	1907-05-10, Friday, 10:15	1908-04-13, Monday, 10:15
Juillac	1906-03-06, Tuesday, 9:15	1907-03-15, Friday, 9:15	1908-02-20, Thursday, 9:15
Lapleau	1906-03-20, Tuesday, 9:30		1908-03-09, Monday, 9:30
Larche	1906-03-12, Monday, 13:15	1907-03-23, Saturday, 13:15	1908-02-27, Thursday, 13:15
La Roche Canillac	1906-03-21, Wednedsay, 10:00		1908-03-25, Wednedsay, 10:00
Lubersac	1906-03-03, Saturday, 9:00	1907-03-18, Monday, 9:00	1908-02-22, Saturday, 9:00
Mercoeur	1906-03-17, Saturday, 10:00		1908-03-07, Saturday, 10:00
Meymac	1906-04-09, Monday, 9:00	1907-05-11, Saturday, 9:00	1908-04-04, Saturday, 13:00
Meyssac	1906-03-08, Thursday, 9:30	1907-03-25, Monday, 9:30	1908-03-04, Wednedsay, 9:30
Neuvic	1906-04-07, Saturday, 10:15	1907-05-14, Tuesday, 10:15	1908-04-11, Saturday, 10:15
Saint-Privat	1906-03-16, Friday, 14:00		1908-03-06, Friday, 11:15
Seilhac	1906-03-24, Saturday, 13:30		1908-03-12, Thursday, 13:30
Sornac	1906-04-03, Tuesday, 9:30	1907-05-08, Wednedsay, 9:15	1908-04-07, Tuesday, 9:30
Treignac	1906-03-28, Wednedsay, 9:30		1908-03-28, Saturday, 9:30
Tulle-Nord	1906-03-26, Monday, 9:00		1908-03-26, Thursday, 9:00
Tulle-Sud	1906-03-23, Friday, 9:00		1908-03-13, Friday, 9:00
Ussel	1906-04-02, Monday, 9:15	1907-05-07, Tuesday, 9:15	1908-04-06, Monday, 9:15
Uzerche	1906-03-27, Tuesday, 13:00		1908-03-30, Monday, 14:00
Vigeois	1906-03-05, Monday, 14:00	1907-03-14, Thursday, 14:00	1908-02-19, Wednedsay, 14:00

Table 15: Robustness for Night in Tulle × Calmès instrument

	Height in the recruitment table	Age	Time from January, 1st to the review board
	(1)	(2)	(3)
Reference: Calmès chairs the board × Night in Tulle			
Either (Filhoulaud chairs the board)	0.376	0.024	0.014
or (Calmès chairs the board × Night away from Tulle)	(0.317)	(0.021)	(0.016)
Constant	163.601***	20.716***	0.210***
	(0.291)	(0.019)	(0.014)
Number of observations	6,182	6,182	6,182
r^2	0.001	0.001	0.011
F statistic	1.4	1.3	0.7

Notes: ***Significant at the 1 percent level; ** at the 5 percent level; * at the 10 percent level.
All robust standard errors (into brackets) are clustered by county and year of birth.

F Accounting for growth of absentees

There were 131 men absent from the examination by the review board in 1908. They are not included into our final data set since their initial height is missing and definitively lost. Many absentees were eventually retrieved by the Army and enlisted, often in 1908: Table 1 shows that the registration forms report the height of 89 absentees. Their average height is 164 cm in the registration forms. It stands below the height of the men present at the review board (see Table 4). The norm of reaction pattern in Section 6.1 suggests that our assessment of the height growth of the man could consequently be under-estimated. To get a quantitative evaluation of the possible bias due to these men, I have matched each of them with the man present at the review board with the nearest propensity score. The score is computed referring to the age of the man when examined by the review board in 1908, his height at enlistment and his county of birth. Absent men then are imputed the height at the review board of their nearest neighbor.

The imputed height of absentees is 163.11 cm, with half of absentees' heights between 160 and 165 cm. Reintroducing the absentees with their imputed height into the sample, one gets an augmented initial sample of $2,785$ observations with a filled height in the two sources (rather than $2,707$ in the main text).

Table 16 reports estimation results from the model (2) on this augmented sample. It shows that the small number of absentees does not have much of an effect on estimated growth. Growth tends to be magnified if one discards extreme height growth observations in the tails of the distribution, yielding an additional height gain of 0.1 cm. In view of their short imputed height and the fact that many absentees were enlisted in 1908, the height gain is even more pronounced when restricting to the standard case where enlistment occurs in 1908 or 1909, reaching 0.2 cm.

Table 16: Height growth of absentees– Absent Prefect IV estimates

	Height growth (cm)		
	(1)	(2)	(3)
	Augmented initial sample	95% subsample	Enlisted in 1908 or 1909 in the 95% subsample
Age difference (year)	0.487***	0.434***	0.608***
	(0.058)	(0.033)	(0.063)
Number of observations	2,785	2,667	2,325
Instrument	Absent Prefect	Absent Prefect	Absent Prefect
Weak instrument test (p-value)	< 2.2e-16	< 2.2e-16	< 2.2e-16
Hausman test p-value	5.59e-07	8.7e-14	1.1e-4

Notes: ***Significant at the 1 per cent level; ** 5 per cent level; * 10 per cent level.
All robust standard errors (into brackets) are clustered at the county level.