Height Growth from Exhaustive Historical Panel Data*

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Abstract

This article shows that two widely used data sources from the French military administration pertain to two different enlistment stages and combines these sources to build a quasi-exhaustive panel of young men around their 20s. The panel is applied to measure height growth of men born at the end of the 19th century in an economically backward small rural area of France. The one-year growth is 0.39cm and only concerns the shortest men; the tallest men already reached adult maturity. Industrial pollution imposes a growth penalty that overcomes the enhancing impact of industrial development.

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1 Introduction

We know very little about economic growth when a significant fraction of the production does not transit through markets. This especially concerns early stages of development where agricultural activities are predominant and farmers' production is mostly used for on-farm consumption. 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 was probably the first scholar to exploit military data to exhibit a correlation between the height of French conscripts at the beginning of the 19th century and the "degree of ease or misery" of the region where they live, and this correlation has been largely confirmed by subsequent studies.[1] The significant academic interest in France is mainly due to its early adoption of universal conscription, provided by the Jourdan-Delbrel law of 1798 according to which "every Frenchman is a soldier and owes himself to the defense of the fatherland." Implementation of such a system of conscription requires an administration strong enough to conduct exhaustive enlistment censuses, thus making affordable today rich information on entire cohorts of French young men.[2]

This article combines several military data sources from France to build a quasi-exhaustive panel of French young men born at the end of the 19th century and uses it to quantify height growth in an economically backward

[1] David Weir (1993) shows that it holds over the two-century period $1780 - 1960$ in France, and Robert Fogel (1989) considers the case of major European countries (see Fogel (1994), John Komlos (1994), Roderick Floud and Richard Steckel (1997) and Angus Deaton and Raksha Arora (2009) for classical synthesis of this literature). There is also evidence from event studies, e.g., the negative income shock from the phylloxera crisis in France studied by Abhijit Banerjee et al. (2010), that adult height is responsive to early childhood income.

[2] The French conscription system alleviates sample selection issues prevalent in the presence of voluntary enlistment. Bodenhorn, Guinnane, and Mroz (2017) and Zimran (2019) are recent studies dealing with the U.S. case. Carson (2020) uses data from U.S. prisons and surveys other data sources used in the literature, e.g., passport applications, cadets of West Point military academy, or New York legislators, all of which are selected samples. Still French data are concerned by a different type of endogeneity issues (see section 6.2 for a discussion).

small rural area of France.

There exist two main sources on height for the 19th century in France. The first is the recruitment list ("tableau de recrutement cantonal") that reports the height measured at the moment where young men are examined by the review board ("conseil de révision"), a committee set up under an imperial decree of 1804 to select draftees in each county of France. The second source comes from individual soldiers' registration forms ("fiches matricule"), which are considered as an avatar of vetting of troops records appearing during the 17th century and becoming more generally used from 1716 to avoid multiple enlistments and keep track of deserters; see Jacques Houdaille (1975) or Lionel Kesztenbaum (2013) for a history.

Information from the review board is the most frequently used by researchers. This partly follows the considerable efforts provided by the French administration to release detailed summary statistics in the "Comptes Numériques et Sommaires du Recrutement de l'Armée" reports published every year since the beginning of the 19th century. Emmanuel Le Roy Ladurie and his colleagues have heavily exploited the height distributions of men around their 20s for each department of France contained in these reports to draw a picture of the evolution of height during the early 19th century (see, e.g., Aron, Dumont and Le Roy Ladurie (1972)). From the original recruitment lists Michel Alexander Van Meerten (1990) computes a median height of French men of approximately 163cm over the first half of the 19th century, and Laurent Heyberger (2007) extents the analysis to the whole 19th century for four regions of France. Weir (1993) instead bears on the registration forms and obtains a French conscripts' average height around 163cm at the beginning of the 19th century; a sharp height recession during the last years of the First Empire is followed by a rapid catching-up that leads to a height above 164cm since the 1820s.

Our knowledge on individual height growth, rather than its level, is much more limited for periods preceding World War II, as large panel data sets were only developed after 1945 to provide child growth national standards to paediatricians (see Sempé and al. (1979) for France).[3] The seminal work of Adolphe Quételet is a noticeable exception: from a small sample of children selected in schools, boarding schools and orphanages in Brussels, he was

[3]See Case and Paxson (2008) for a reference panel study on an exhaustive sample of British children born in 1958.

able to build as early as 1835 a growth chart giving height for most ages until adult maturity. In his 1870 revised chart, he reports a total growth of 1.3cm from 20 to 25, i.e., an average growth of 0.26cm per year. The first modern insights on historical height growth have been recently obtained by Gao and Schneider (2020) using panel data on repeated samples of selected destitute boys assigned to the training ship Indefatigable, a ship that could accommodate 200 boys at most, over a long period from the 1860s to the 1990s. Height growth of the boys born in 1900 is found between 3 and 5cm over one year, a figure much higher than the growth of older cohorts obtained by Quetelet (1870).[4]

In the absence of exhaustive panel data the standard strategy to quantify individual height growth from military data is to rely on the mean or median height of consecutive cohorts of soldiers. The result may sometimes look plausible at an aggregate level, but often cohort effects make it very disappointing when applied to small regional subsamples.[5] This is true whether as building on the recruitment lists or the registration forms. In fact these two sources are usually thought as providing about similar information on height, though they display slight differences in their scope: the review board report cannot include information on missing men, and there is no registration form for the men deemed unfit by the review board. These possibly negligible scope discrepancies should however draw our attention to a crucial point: these two sources pertain to two different points in time. The first source 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. There exists no systematic

[4]See also the recent studies exploiting small size subsamples of the conscripts measured twice, first at 19 and then at 25 when recruited in the civil guard of Woerden (Beekink and Kok (2017)) and Maastricht (Thompson et al. (2020)) in the Netherlands. The Woerden subsample includes 602 over $2,215$ recruits.

[5]The strong cohort effects often yield a time-contracting height that obviously cannot occur at the individual level. In general historians rely on moving average indicators to mitigate short-run cohort height fluctuations. Following Nicholas and Steckel (1991) an alternative strategy is to compute for each age the average height of different individuals. See also Cameron (1979), Cole (2003) or A'Hearn et al. (2009) for relying on cross-sectional age profiles. Cautionary remarks on this methodology can be found in Gao and Schneider (2020).

individual-by-individual comparison of the height information contained in these two sources. This article shows on the example of the French department of Corrèze that the information differs. It makes use of the body of the legal military texts to reconstitute the enlistment process and identify the (approximate) moment at which the height in the registration form was recorded. It appears that the time spent between the height measurements available in the two sources in general is either between 6 and 10 months or between 18 and 22 months.

Combing the recruitment list and the registration forms yields a quasi-exhaustive panel of young men born in Corrèze in 1887. Quasi-exhaustivity exploits the fact that cohorts born in the late 19th century were exceptionally re-examined 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 so subject to a late registration form. Although military recall yields a significant enrichment of the panel, one cannot achieve a fully exhaustive sample since the height of the men absent from the review board is definitively lost. The average height of men born in Corrèze in 1887 was 163.71cm during the first semester of 1908, when examined by the review board. The combination of these two sources shows that they still registered a gain of 0.39cm over the year following the review board.[6]

While improving anatomical stature may be good news when relying on cross-sectional age profiles, here late individual growth instead signals delayed economic development. Indeed, one century later, French men already reached adult maturity at 20 (Sempé et al. (1975)). Growth after 20 accords with the norm of reaction pattern of the life history literature, that men in small-scale less advanced economies display a shorter adult stature and reach maturity at a later age. I complement this stylized fact by observing that a similar pattern actually holds within cohort. Indeed I find that men whose height is above the mean height of their cohort when they are examined by the review board no longer significantly grow. The 0.39cm average gain in height is entirely due to short men: the shorter the man, the stronger his

[6]Late growth was commonplace at the turn of the 19th century: some have even proposed a delayed enlistment to reduce exemptions (the difficulties encountered by short men to handle long rifles then justified exemption) arguing that men did not reach adult maturity at 20 years old (see, e.g., Rampal (1884)).

growth; at the bottom of the height distribution 150cm tall men register the highest growth of nearly 1cm over one year.

The article is organized as follows. I first retrace in sections 2 and 3 the selection process of draftees born at the end of the 19th century in France and I discuss evidence about the moment at which the height reported in the registration form is recorded. A synthesis is given in section 4. Section 5 reports various summary statistics about the men born in 1887 in Corrèze. In section 6 I use a fixed effects model to quantify individual height growth of these men. The instruments for the endogenous decision of enlistment and discharge made by the review board are based on family composition and examination ranking of men at the review board. Finally, in section 7, I enrich the fixed effects model to fit the norm of reaction pattern by allowing for heterogeneity of height growth across men. I give height growth estimates for rural and urban areas, and birth places subject to various types of early industrial activities that may have come with pollution. I also suggest that the men absent from the board could have displayed low growth potentials leading to a slightly over-estimated growth at the bottom of the height distribution.

2 Legal insights on height in the registration form

2.1 Recruitment list and registration forms

Following the Maurice Berteaux Law of 21 March 1905, a census of all French men born in $t-20$ must be conducted in each municipality at the end of every year t.[7] The listed men from the municipalities of the same county then are all called to be examined in the same session by the review board early in year $t+1$.[8] Men deemed fit for service by the review board will

[7]The civilian division of the territory does group municipalities in counties, counties in arrondissements, arrondissements in départements, and départements in régions. It partially differs from the military division where arrondissements are grouped into recruiting offices. Men from the department of Corrèze are allocated to either Brive or Tulle recruiting offices.

[8]Men living outside the department can be allowed for 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. As a result, given the high childhood mortality, the report of the review board includes every man born in the county, indepen-

be enlisted during the fall of $t+1$. The others are either exempted from service or discharged. In the case of discharge the review board postpones its decision to year $t+2$, when the men born in $t-19$ in the county will in their turn be subject to examination. If the man discharged in $t+1$ is deemed fit by the review board of $t+2$, then he is enlisted during the fall $t+2$. Otherwise he is definitely exempted.

Height is recorded for every man present at the review board. It is reported in the so-called county recruitment list ("Tableau de recrutement cantonal"), a report which completes the censuses of the municipalities of the county with the information collected during the review board. The date on which the review board is held is publicly widely reported; it is mentioned at the beginning of the recruitment list and it can also be found in local newspapers and the official Bulletin of Administrative Acts (Bulletin des Actes Administratifs).

Individual registration forms ("fiches matricule") are only created for men deemed fit for military service by the review board. The registration form gives basic civil status information, an occupation and some literacy indicator. It contains no identity photograph of the man. Instead there is 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 registration form also has two items for the height of the man and a "rectified" height.[9]

The military Instruction legal text published at the head of the register compiling the registration forms specifies that the "register $[\cdots]$ is $[\cdots]$ held by the commander of the recruiting office." However, unlike 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. This makes the status of the height reported in the registration form unclear. The Instruction only states that the "recruiting office commanders must start the register as soon as possible" after the selection of draftees

dently of where he actually lives at 20. The sample is therefore immune to selection due to migration; rural exodus from Corrèze actually begins in the early 1890s.

[9]The file of the registration forms of all the men is freely available in each region of France from the Archives Départementales website. Access for Corrèze follows the link `http://www.archinoe.fr/cg19/recrutement.php`. The specific format of the registration form described above, with one full page for each soldier, applies in Corrèze since 1878.

by the review board. In view of this recommendation, one can consider two main alternatives regarding the status of height in the registration form: first the recruiting office can merely report on the registration form the individual height recorded during the review board; the second alternative involves various physical examinations designed for men deemed fit when they are close to being enlisted.

2.2 Departure and enlistment examinations

The enlistment process includes two successive examinations conducted under the sole auspices of the Army.[10] The men are first subject to the departure examination ("visite de départ") organized within the recruiting office, the goal of which is to allocate the men selected by the review board to the various military units. If not reformed at the outcome of this first examination, they must join within a few days their unit where they undergo the enlistment examination ("visite d'incorporation"); again they can still be reformed at the outcome of this new examination.[11]

These two examinations are laid down by the Instruction of October 22, 1905, on Physical Aptitude to Military Service (see in particular section IV page 49 and thereafter). Insightful is the fact that the text insists on the importance of recording height, though at this 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 [$\cdots$]. The main physical requirements are: height, ability to walk, horse riding abilities and capacities to handle heavy loads.[12] The

[10] Anecdotal evidence suggests that the Army had reservations against the decisions of aptitude made by the review board. On top of military representatives, the review board includes the civilian administration represented by the Préfecture of the department. The civilian mayors of all the municipalities of the county must attend the board, though they have no decision-making power. The role played by each Party is discussed in appendix B.

[11] Cf. Colin (1899), page 316; and Bertschy (2019), page 208. Based on the Statistiques Médicales de l'Armée, Bertschy (2019) reports a volume of men "reformed before enlistment" of 30 per 1000 every year until year 1901. Rasmussen (2016) states that the enlistment examination "still excludes whole sections of the contingent."

[12] The quoted requirements were actually ranked in a previous version of this same Instruction published in 1891: "first height and then ability to walk" (see section V page 76 of the Instruction of 1891). The Law of 2 April 1901 abolished the minimum height

first of these requirements [$\cdots$] 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 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 in the recruiting office, and finally in their regiment once enlisted.[13] Height is taken during the review board. The Army recommends to use height of men deemed fit by the review board as a selection device and specifies how height can be taken during the enlistment process, after the examination by the review board.

3 Distributional evidence on height in the registration form

The Archives Départementale de Corrèze provided me with an exhaustive raw file of the registration forms of the men born in the department between 1863 and 1901. The file, which was prepared as part of the Mémoire des Hommes national project to celebrate the hundredth anniversary of World War I, mostly contained civil status information. The young men born in 1887, during the Great Depression period when huge market contraction implied on-farm consumption of a large part of the production, form one of the few cohorts before the war for which a complete sample of all the county

restriction at 154cm.

[13]Indeed the departure and enlistment examinations can be viewed as particular instances of the general recommendation that every man should be examined when allocated to a new military unit (see art. 38 of the 25 November 1889 Decree). We have few information about the actual operational process of the departure examination (some details are however given in chapter 4 of Roynette (2000)). 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 (2016)). A colorful description of the examination is given in a Louis Auguste Picard (1913) 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).

recruitment lists is available, with a filled individual height for most men.[14] For every man born in 1887 I entered the (handwritten) height reported in the registration form and, if available, his "rectified" height. I also entered the (handwritten) enlistment date and several (handwritten) information from the recruitment list: the height, the review board that actually examined the man, the exemption/discharge/enlistment decision taken by the review board in 1908. This yields a file with $3,077$ observations.[15]

3.1 Height of the absentees

It is clear that the Army sometimes completes height in the registration form after the review board: indeed height is filled in the registration form for most men absent from the review board. In the sample there are 94 observations where height is only filled in the registration form: they mostly concern men absent from the review board, who are automatically "deemed fit for armed duty" (Art. 30 of the Law of 21 March 1905). As an example, Antoine Escalier's form (registration number 501 of the recruiting office of Tulle), absent from the review board of 1908 and enlisted into the 44th Infantry Regiment on October 7, 1908, contains a complete anthropometric description including an height of 162cm.[16]

[14]Collignon (1893) provides anthropometric summary statistics on the men born in Corrèze in 1871 using information from the 1892 review board report, and Grillière (1913) reproduces a similar exercise on the men born in 1880.

[15]In the recruitment list there are only $2,932$ men born in 1887. The $3,077 - 2,932$ number of observations difference between the two data sets is mainly due to men exempted from military service in 1908 who appear twice in the completed file: one observation corresponds to the exempted man (exemption in 1908 implies no registration form and so the data reports height as missing in the registration form) and the other observation corresponds to the same man if re-examined and enlisted several years later during a recall procedure in August 1914, March 1915 and May 1917, with a late registration form that in principle should include height information. To a small extent, men omitted from the recruitment list, as not identified in municipality census, also contribute to the difference. See below in section 5.

[16]Other examples include François Michelou (registration number 790 from the recruiting office of Tulle) or François Vaux (registration number 831 from the recruiting office of Tulle).

3.2 Individual heights differ in the two sources

Of course it could be that only few specific cases are re-examined during the enlistment process, but evidence from the height sample shows that this is not the case. Let us consider the subsample of the 2,717 men deemed fit by either the 1908 or 1909 review board. This amounts to discard available information on the men exempted in 1908 or 1909 but enlisted much later during the war following a recall procedure, who were plausibly treated differently from the others. In this subsample I select the 2,537 observations with height filled in both the recruitment list and the registration form. Hence I do not consider men absent from the review board.

There are 2,081 men who display equal height in the two data sources, a high figure that possibly contributes to explain why the two sources are often regarded as providing nearly identical information on height. Still, this leaves 456, i.e., nearly 20 percent of the 2,537 observation sample, for which height differs in the two sources. It could be that height in the registration form is always copied from the recruitment list for men enlisted in the fall of 1908, whereas it is left blank for some men discharged in 1908 and filled later when they are enlisted in 1909, e.g., because the Army would take into account a likely growth over a more than one year period. But the hypothesis does not resist the facts: among these 456 men, we find 324 men enlisted in 1908 and only 75 enlisted in 1909 (the remaining cases correspond to volunteers who anticipated the call).

In the 2,537 observation subsample, the average height is 164cm in the recruitment list and 164.44cm in the registration forms, yielding an average difference of 0.44cm. The right panel of figure 1 plots the height distribution in the recruitment list (in black) and in the registration forms (in red). For every height below (resp. above) the peak of 163cm the number of men in the recruitment list is greater (resp. lower) than the number of men in the file of registration forms.[17] The middle panel depicts for every height the difference between the number of men in the files of registration forms and in the recruiting table. The spread is negative for short men and positive

[17]Both distributions display excess bunched masses at 160cm and 170cm, a feature possibly related to some attraction toward rounding heights. Appendix 1 of the military Instruction of April 16, 1910, reports height required to enter specific military units; for instance, height thresholds at 159cm and 170cm are relevant in cavalry. We also detect small biases toward even neighboring heights.

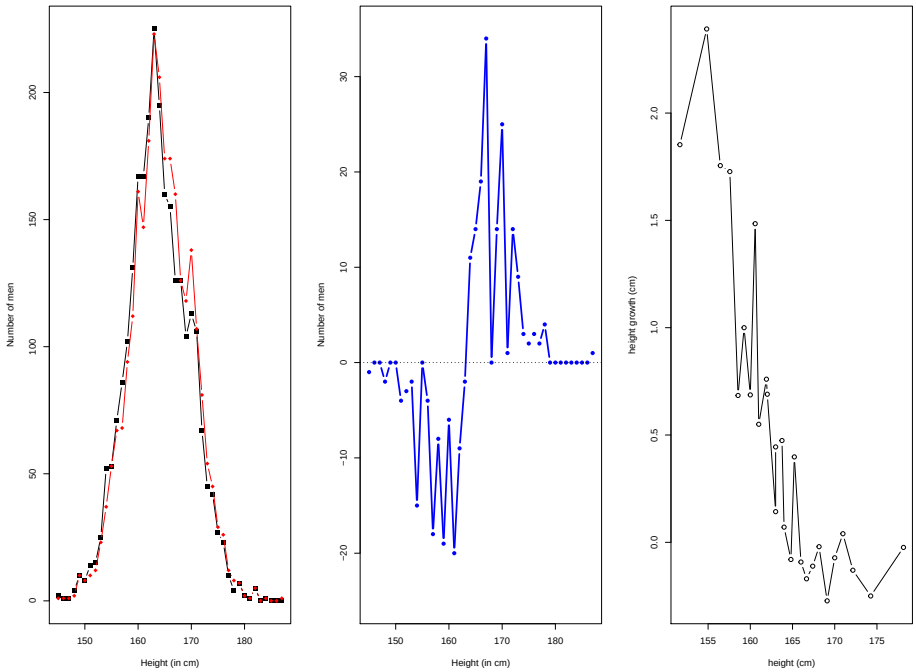

Figure 1: Evidence from height distributions

for tall men. It reaches its highest magnitude when switching from negative to positive values, around the peak of 163cm. To give a first account for this pattern, the right panel ranks the men in the order of increasing height in the recruitment list and gives the average height difference between the registration forms and the recruitment list for every class of 100 men. This difference is decreasing with the height recorded in the recruiting table (in the horizontal axis): for the shortest men, with height below 157cm, the difference is greater than 1cm; instead it is close to 0 and possibly negative for the tallest men. The pattern observed in figure 1 is consistent with some height increase of men with a height below the 163cm peak whereas the heights of taller men would nearly coincide in the two sources.

4 The status of height in the registration form

4.1 The registration form reports height at enlistment

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 at the recruiting office.

Based on (1) the primary military legal requirement that height must be recorded once again at enlistment, after the review board, (2) the partial evidence from the completed height of absent men from the review board and (3) the global regularities from the height distributions in the two sources, I state that the height of men in the registration form is taken after the review board, during the departure examination. In the appendix I discuss further evidence based on specific registration forms supporting this choice. Although the available data provides no information on the date of this examination, it is known that it comes a few days before the enlistment (Roynette, 2000, page 211). The data neither provides the exact date of the enlistment examination, but it plausibly occurs at enlistment, the date of which is reported on the registration form. In the sequel, the date of the departure examination is therefore proxied by the enlistment date.

4.2 A classification of typical cases

I adopt the following rules for the height reported in the registration form:

1. The height of men enlisted in 1908, or discharged in 1908 and deemed fit in 1909, is their height at enlistment.

2. The height of men discharged in 1908 and exempted in 1909 is their height measured during the review board of 1909.

   A registration form is created in 1908 for the men discharged in 1908. These men are re-examined by the review board of 1909 with the men born in 1888 in the same county.[18] Among the 54 men discharged by the review board of Corrèze in 1908, height is reported in the registration form for 50 men, and there are 5 cases where height differs in the recruitment list of 1908 and the registration form. Note that height information cannot come from military examinations since these men were never enlisted. The archives hold several forms of discharged men re-examined by a review board outside Corrèze filled with their height at the moment of the last examination.[19] I bear on the evidence that

[18] In fact we find two different types of men classified as discharged. The first type consists of the men discharged in 1908 to be subject to a new examination in 1909. This is the one considered in this item. The Bulletin of Administrative Acts of year $t+1$, which officially reports the dates at which the counties are examined in $t+1$, specifies the volume of men born in $t-20$ and of discharged men born in $t-21$ in every county. Both are examined during the same session. The second type concerns cases that cannot be decided on the day the review board of the county of birth is held, e.g., because the men are temporarily sick or because they are examined outside their county of birth and the information from the review board of the county where they live is still missing. Special sessions of the review board are scheduled after the examination of all the counties to decide about the status of the last type of discharged men; in 1909 the main one was scheduled on May, 27.

[19] See within R53 reference documents in the archives; the template form is number 7 in the Instruction of 20 October 1905. Actually I found no 1909 height records in the archives for the men examined in Corrèze. In the recruiting table there are many instances of a pre-filled height that is corrected once, especially in the Brive district, but one should not consider the initial height as the height of the man in 1908 and the corrected height as the one in 1909. Indeed such corrections also apply to men enlisted in 1908. In addition, handwriting evidence suggests that the initial height is a self-reported height declared before the municipality office (this height appears in the municipality census on which the recruitment list is based): in the recruitment list the initial height and civil status information are reported by the same hand; the corrected height and the decision of the

a new height measure is taken by the review board in 1909 to consider the registration form height of men exempted in 1909 as their height taken during the 1909 review board. This is a conservative choice in the assessment of individual height growth since for many of these men this amounts to set no growth over a long period of time.

3. The height of men exempted in 1908 and recalled during the war is height when enlisted.

   If still alive, the men exempted by the review board in 1908 or 1909 were re-examined during the war and often recalled for army service. A typical example is Jules Bernard Gaude (registration number 1797 from the recruiting office of Tulle). The man is 163cm tall at the review board of 1908. He is then exempted because of the "loss of the right eye." Hence no registration form is created in 1908. He is recalled in 1917 and enlisted on May 15, 1917. We find a filled height unchanged at 163cm in the registration form created in 1917.

4. A "rectified" height is filled if the height form field is already completed when the man is enlisted. It reports the height of the man at the moment of his last enlistment.

   A filled "rectified" height especially concerns men enlisted but reformed in 1908 or 1909. Their registration forms contain filled height information, and an updated information several years after 1908/1909 may ask for a revised height. This rectified height is set to be the height at enlistment during the war. René Aupetit (registration number 1633 from the recruiting office of Tulle) is discharged in 1908 with a short height of 154cm, but deemed fit in 1909 and enlisted on October 7, 1909. His height in the registration form is still equal to 154cm. But he is reformed for "insufficient weight" as of 12 October 1909, plausibly at the outcome of the enlistment examination; his weight indeed was only 48kg in 1908. He is nevertheless enlisted 5 years later in October 1914 and his rectified height is filled and set at 158cm.[20]

review board of 1908 are reported by another hand. In the special case of a discharged man eventually exempted in 1909 a third hand has reported the final exemption decision made in 1909.

[20] Analogous cases concern volunteers, rather than recalled men. Denis Louradour (registration number 1586 from the recruiting office of Tulle) is 170cm tall at the review board

5 Data sample and descriptive statistics

I reorganize the 3,077 observation sample so that the height of exempted or reformed men in 1908 in the recruitment list is associated with their height at enlistment reported in the registration form when the man was recalled during the war. After suppressing the resulting duplicates, one gets a new database with 2,961 observations only. I remove men taken off of the recruitment list (most of them were actually judged as falling within the field of competence of a review board from another department) or dead to get a sample of 2,948 observations. This slightly differs from the 2,932 men in the recruitment list because of the few men born in 1887 but omitted from the 1907 recruitment list and, symmetrically, because some observations correspond to men born in 1886 but omitted from the recruitment list in the previous year. Keeping men born in 1887 yields a sample of 2,919 observations.[21] In this sample we are able to recover 2,750 men with a filled enlistment date.

If a rectified height is filled, I form two observations for the same man: one where his height at the review board is associated with his height in the registration form, and the other where it is associated with his rectified height in the registration form. Through this channel one gets 104 additional observations, yielding a consolidated sample of 2,854 observations. To keep with a measure of height growth from the review board, I do not consider information based on the difference between height and rectified height in the registration form.

Finally I deal with a balanced panel by keeping the 2,703 observations where height is filled in both the recruitment list and the registration form.

Some descriptive statistics about age and height in this sample are reported in table 1. The height measurements on the same man are on average spaced by about a year: although 2,039 observations concern an enlistment in the fall of 1908, this age difference actually slightly exceeds one year because 306 observations concern men discharged in 1908 and enlisted in the

of 1908. He is first discharged and then exempted from military service in 1909. His height at the 1909 review board is still 170cm. He decides to volunteer when war is declared. He enlists on October 6, 1914. His height is rectified at 172cm.

[21] The height distribution of the men born in 1887 and maintained on the recruitment list of men from Corrèze nearly coincides with the distribution published in the Comptes Numériques et Sommaires.

Table 1: Height and age descriptive statistics

	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Height at the review board (cm)	163.71	5.689	145	160	168	184
Height at enlistment (cm)	164.31	5.67	145	161	168	188
Age at the review board (year)	20.71	0.29	20.14	20.46	20.95	21.28
Age at enlistment (cm)	21.80	2.02	16.02	21.04	21.68	30.60
Height growth (cm)	0.59	2.70	−11	0	0	23
Age difference (year)	1.09	2.01	−4.91	0.53	0.63	9.65

Number of observations: 2,703

fall of 1909, and 215 concern the men recalled in 1914, 1915 or 1917. Individual height growth ranges between −11cm and 23cm, and the average height growth equals 0.59cm.

Some reports of negative height growth involve volunteers, who enlist before the review board. However extreme values of height growth and instances of a negative growth associated with a positive age difference are due to measurement errors. Errors can be made when height is measured during the review board (we find anecdotes where the man is lying or shod when measured) and/or when reporting height on the recruitment list. The last type of errors is more likely to occur if the man is examined outside Corrèze since in this case his height has to be transmitted to the review board of Corrèze through a prefectoral (civilian) channel. Furthermore it is known that the review boards operating in the biggest cities were examining a very large number of men in a short time. For instance, Roynette (2000) computed an average individual examination lasting 38 seconds in the densely populated Seine department (which included Paris). Indeed, in the subsample of the 2.5% lowest and 2.5% highest reported height growth, we only find half of the men examined in Corrèze, and one-third among them correspond to recalled men. For this reason, I will now focus on the 2,591 observation sample that discards the bottom and top 2.5% percentiles of the height growth distribution. The resulting height growth distribution is shown in figure 2; the right panel restricts to non-zero growth observations.

6 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

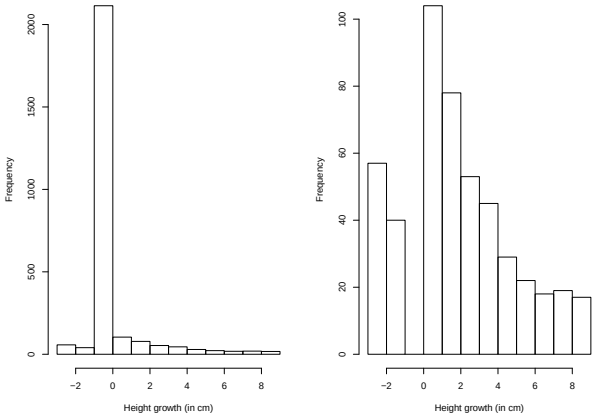

Figure 2: Height growth distribution

effects model where after 20 height h_{it} (in cm) of man i at time t is

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

where a_{it} represents age of the man at time t, and γ_i captures individual (potentially non-observable) characteristics of the man, e.g., some given genetic factors. The variable t is a time dummy that takes value 0 at the review board and 1 at enlistment. The linearity 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 section 7. By time-differencing (1) we get

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

where $\Delta h_i = h_{i1} - h_{i0}$ and $\Delta a_i = a_{i1} - a_{i0}$.

The β parameter gives the individual height growth (in cm) over the one-year period following the review board. The precision of the first difference estimator of this parameter relies on the dispersion in the age difference Δa_i across individuals. Dispersion originates in both the sequence of enlistments and county examinations. Most enlistments have occurred in October and November 1908 and 1909, while counties were examined over a two-month period from mid-February 1908 to mid-April. In 1908, the 417 municipalities of Corrèze are grouped into 29 counties. The order in which counties are

visited is chosen to minimize the review board travel costs: the sequence of examinations started in 1908 from the plain of East Corrèze with the county of Ayen on February 18, and ended with the examination on April 13 of men born in the county of Eygurande, located in the mountainous region far West of Corrèze.[22]

The top-left panel in figure 3 depicts the distribution of age differences. The two main masses correspond to men enlisted in 1908 and 1909. Remember that volunteers are associated with negative age differences; and men recalled in 1914, 1915 and 1917 respectively yield masses of men at 6.5, 7 and 9 years after the review board of 1908. The top-right panel focuses on men enlisted in 1908 and 1909. Following the classification in section 4 men discharged in 1908 and exempted in 1909 are assigned an age difference equal to the time elapsed between the two examinations of men from their county of birth by the review boards of 1908 and 1909, which gives rise to a small mass of men located around just over 1 year after the review board of 1908. The two bottom panels of figure 3 focus on enlisted men in 1908 (left panel) and 1909 (right panel) highlight the impact of heterogeneity of enlistment dates within a year, implying a number of possible age difference outcomes that far exceeds the number 29 of counties.

6.1 OLS height growth estimates

The OLS estimate of β is given in table 2. Height growth of the man in the year following the review board would be of 0.24cm in the full (balanced) sample used in column (1) and only of 0.21cm in the subsample in column (2) that excludes the 5% extreme height growth observations. The estimates thus are very similar to Quételet (1870) benchmark for the annual growth of Belgian males between 20 and 25 years old, born around 1850, i.e., 35 years before the young men from Corrèze under scrutiny. There is a negative correlation between estimated residuals $\hat{u}_i$ and fitted height growth $\hat{\beta}\Delta a_i$ indicating that the OLS over-estimates (resp. under-estimates) the height

[22]The information reported in the official Bulletin of Administrative Act is actually inaccurate: the Archives hold the original poster that releases the dates on which men will be examined for each county, and a corrective poster that modifies the dates for the counties of Meyssac, Corrèze, Seilhac, Egletons and Laroche-Canillac. The corrected information fits the dates at which the review board representatives signed the allocation decisions reported in the county recruitment lists.

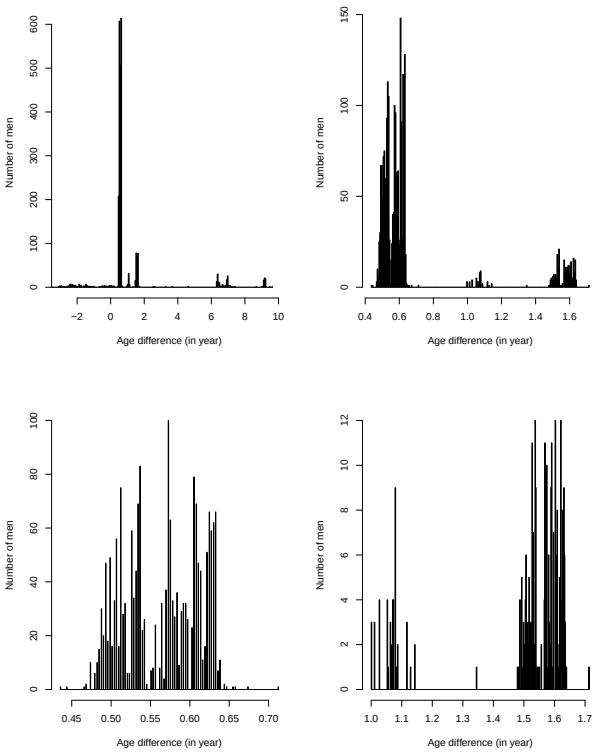

Figure 3: Age differences distribution

Table 2: Quantifying height growth – OLS

	Height growth (cm)			
	OLS		*Robust standard error*	*Robust clustered by county standard error*
	(1)	(2)	(3)	(4)
Age difference (years)	0.238***	0.211***	0.211***	0.211***
	(0.023)	(0.013)	(0.020)	(0.016)
Observations	2,703	2,591		
R^2	0.039	0.087		
Adjusted R^2	0.038	0.087		
Notes:	***Significant at the 1 percent level.			
	**Significant at the 5 percent level.			
	*Significant at the 10 percent level.			

growth of men enlisted earlier (resp., later), i.e., the largest biases apply to volunteers and to those recalled during the war. Robust standard error estimates from the $2,591$ observation subsample are given in column (3), and robust standard errors clustered at the county level are given in column (4). The reported 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 exempted/recalled men than within men enlisted in 1908 or 1909.

6.2 Enlistment/discharge decision

The recent economic history literature on height (Bodenhorn, Guinnane and Mroz (2017), Zimran (2019) or Gao and Schneider (2020)) deals with sample selection issues. Such problems are absent in our setup since all (living) men at 20 are called for examination before the review board. However the OLS estimate in Table 2 does not account for the endogeneity of age at enlistment: age at enlistment is determined by the man if volunteer, and otherwise by the review board and, later during the war, by the military administration alone. In principle a delayed enlistment should concern those men whose physical condition is assessed as fragile by the review board. It seems plausible that these men can also register a growth lower than the growth of the average man over the same time window, i.e., 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 the growth of those discharged/exempted in 1908 and actually measured in 1909 or later. Table 3 reports some determinants of age at enlistment that could potentially serve as instruments for the endogenous age at enlistment, and thus the endogenous age difference used in (2).

In order to limit the volume of men taken off the land, Art. 20 of the Law of 21 March 1905 grants a preferential treatment to brothers born in the same year and to men with some brother currently on active duty, i.e., in the first two years of military service. Our data does not give individual blood ties but, in a region of small rural villages, a credible proxy for the number of serving male siblings is the number of registration forms of men with the same last name, born in the same village between 1885 and 1887 and having similar levels of education; this proxy is certainly less accurate for men born in more densely populated areas. Column (1) shows that this control indeed

Table 3: Enlistment/discharge decision

	Age difference (years)		
	(1)	(2)	(3)
Number of enlisted (male) siblings (log)	−0.4165***	−0.4189***	−0.4215***
	(0.0671)	(0.0679)	(0.0720)
Number of men from the last absent in the county		0.0072*	0.0076*
		(0.0039)	(0.0040)
Two physicians (ref: one)			0.1473
			(0.1276)
Three physicians (ref: one)			−0.4716***
			(0.0822)
Constant	1.1259***	1.0236***	1.0481***
	(0.0745)	(0.0753)	(0.0731)
F Statistic	38.479	19.924	28.107
Observations	2,591	2,591	2,591
R^2	0.0222	0.0253	0.0351
Adjusted R^2	0.0218	0.0245	0.0336

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.
Robust standard errors clustered at the county level.

has a significant influence on the time elapsed between the review board and the enlistment. However, unlike the aim of the legal provision, the effect is negative: the existence of a family member already on active service favors an earlier enlistment.

The explanatory variable used in column (2) refers to the examination ranking of men during the review board. Men born in 1887 are examined in their county of birth from older to younger. Based on the within county ranking, I compute for every man the number of men from the last man absent from the review board. If, for instance, the nth man is the only absentee in the county, then there is no absent men before the nth man, and the variable takes value ℓ for the man ranked $n + \ell$. The ranking of the last absent also influences the enlistment decision: the further away the last absentee from the man subject to examination, the more willing to exempt or discharge the review board proves to be.

The Law of 21 March 1905 and the military Instruction of 29 December 1905 which rules the actual functioning of the review board emphasizes the fundamental role played by the physicians in the enlistment decision. The Law states that the board can give its decision only after hearing the physician's opinion (Art. 16). Art. 60 and 67 of the Instruction specify that the

physicians "recommend discharge" and must outline the disabilities "that justify exemption." The importance of the physicians' opinion is reflected by the fact that the physicians chosen must be kept secret until the very last moment and the existence of heavy penalties incurred for collusion with men to be called for duty. In practice the number of physicians depends on the number of men in the county. Art. 19 stipulates that the review board will be assisted by one physician if the total number of men, i.e., men born in 1887 and those born in 1886 and discharged in 1907, is below 100; there are two physicians in counties where this number of men falls between 101 and 200; and three physicians otherwise. Column (1) of table 3 indicates that early enlistment is promoted when switching from one or two to three physicians. As shown in table 6 in Appendix B, the effect is even reinforced when one controls for the number of men born in 1887, which might suggest some mutual monitoring among physicians favoring an early enlistment.

Table 6 gives additional information on the enlistment decision related to the timing of the review board, the institutional balance between the relative powers of the civilian and military authorities, and other concepts of examination rankings that do not refer to absentees. In every variant the roles played by the number of enlisted male siblings, the distance from the last absentee and the number of physicians remain unchanged. Municipality mayors appear to oppose to both the prefect and military recruiting offices by favoring early enlistment; we also note that a late examination within the whole department comes with a late enlistment.

6.3 Height growth of the man

The three explanatory variables used in table 3 provide us with potentially relevant instruments for the individual age difference between the review board and the enlistment.[23] Appendix C shows that the use of these instruments tends to concentrate the age difference slightly above 1 year, yielding a pattern closer to the age difference of men discharged in 1908 and eventually

[23]The variant used in column (2) of table 3 might appear as the weakest one. This is however very sensitive to the tails of the height growth distribution. Elimination of the observations in the bottom and top 5 (rather than 2.5) percent of the distribution yields to F-statistics of 129.52, 90.06 and 72.04 in columns (1), (2) and (3), respectively. The main estimation results in table 4 are identical for the three specifications. Estimated growth on the subsample of 90 percent of the observations, that gives more importance to zero height growth observations, is lower than in table 4, falling around 0.31cm.

enlisted in 1909. The estimation results of the two-step regression with an instrumented age difference are reported in table 4. Height growth over the year starting from the examination by the review board is revised upward from 0.21cm to 0.39cm. This is consistent with an OLS bias such that men enlisted later indeed display physical weaknesses, leading to a growth weaker than the growth of the men actually enlisted earlier.

Table 4: Quantifying height growth – IV

	Height growth (cm)			
	(1)	(2)	(3)	(4)
Age difference (year)	0.3928***	0.3895***	0.3899***	0.3833***
	(0.0382)	(0.0321)	(0.0378)	(0.0367)
Instruments	Siblings	Absents	Siblings-Absents	Siblings-Absents-Physicians
Hausman test p-value	1.48e-07	1.70-07	1.71e-07	1.71e-07
Sargan test p-value			0.54	0.008
Observations	2,591	2,591	2,591	2,591
R^2	0.0228	0.0252	0.0248	0.0293
Adjusted R^2	0.0224	0.0248	0.0244	0.0289

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.
Robust standard error clustered at the county level

Table 7 in appendix C shows that the instruments have no impact on the height measured during the review board. However the Sargan test in table 4 suggests that the number of physicians may be an invalid instrument. A possible reason is that the county population size, which determines the number of physicians operating at the review board, also directly affects growth because of, e.g., specific living conditions in cities subject to early industrialization. This is explored in section 7 and Appendix E. In all the sequel, the number of physicians is excluded from the set of instruments. In view of the results in table 7, there is no clear reason why the two other variables would directly impact height growth; in particular Corrèze is known for applying strict equal treatment of brothers (Todd (1991)).

7 Extensions

7.1 A norm of reaction

Life history theories deal with the role of environment on stature referring to the concept of norms of reaction. The synthesis in McIntyre and Kacerosky (2011) emphasizes the existence of two regimes: in traditional small-scale societies, later age at maturity is associated with shorter adult height whereas industrialized societies display both early maturity and taller height. The results reported in table 4 accord with this view by showing that men still grow after 20 in an economically backward area at the end of the 19th century.

Our data allows us to discuss the possible shape of the relation between age and height at maturity by reproducing our analysis disaggregated at the level of clusters of men with the same height when examined by the review board. To this aim, I now consider the enriched fixed effects model

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

where $\mathbf{1}_i^d$ equals 1 if the height of conscript i is equal to d at the review board, and 0 otherwise. The results are given in appendix D. They are summarized in figure 4, with bold plain dots standing for growth estimates significant at the 5 percent level. Tall men with a height above the average height of 167cm no longer grow after the examination by the review board while shorter men below 164cm still experience growth; figure 4 shows that growth actually decreases with the height measured at the review board.[24] This implies a partial catching-up over one year and so yields a within cohort pattern similar to the cross-country norm of reaction: tall men have reached adult maturity before 20 whereas maturity occurs later for shorter men.[25]

[24] As in section 3 there is some attraction toward reporting an even height when height is rounded; see figure 1. Recall also that 170cm is a minimal threshold height requirement to enter specific military units, in particular cavalry.

[25] This catch-up pattern supports the finding in Beekink and Kok (2017) that upper social class Dutch men are taller at 19 and grow less between 19 and 25 than the less well-off part of the men.

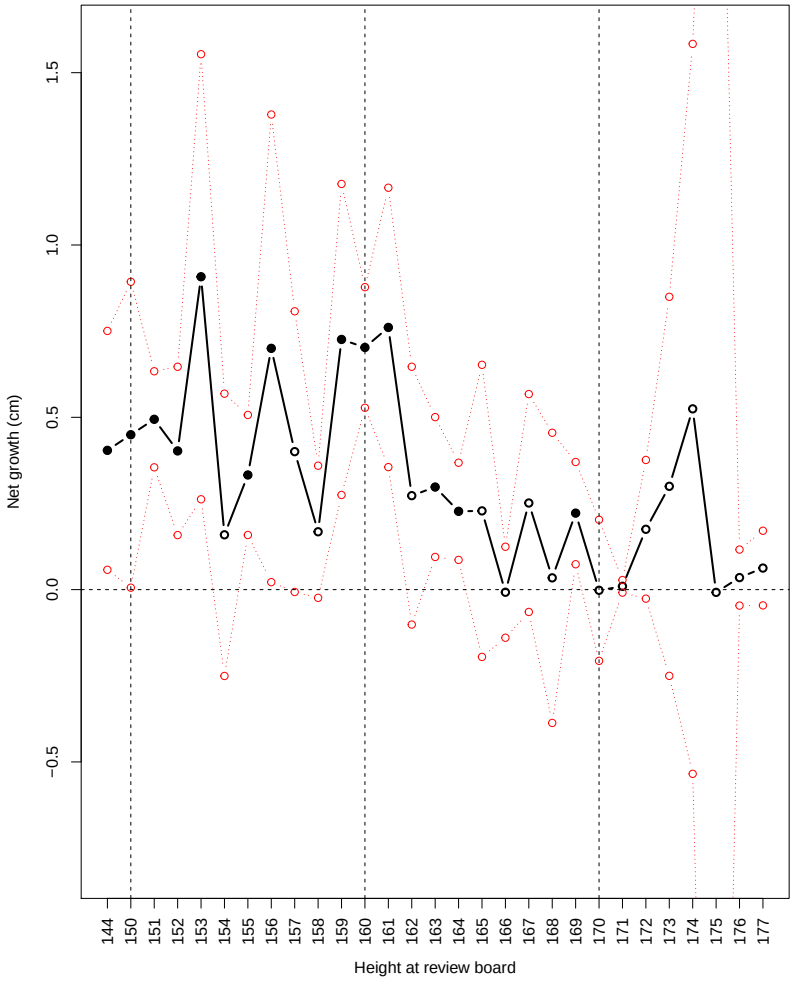

Figure 4: Height growth per review board height

7.2 Early industrialization and pollution

Let us associate every man with the population of his place of birth, proxied by the total number of conscripts born in the same location over the whole period 1867-1901. Men in the group of the bottom 20 percent of the population size distribution are born in small rural villages providing the Army with less than 238 men over this 35 year period. The top 20 percent instead provided more than 943 men; it consists of only 12 cities, among which the largest figures apply to Brive (3,145 men) and Tulle (4,445 men). Growth is found greater in cities (0.59cm with 0.09 robust standard error clustered at the county level) than in medium size towns (0.35cm with 0.03 standard error) and sparsely populated territories (0.36cm with 0.05 standard error)

These urban versus rural estimates do not fit well the insights from table 4 since the average height at the review board is also increasing with population density (it is 164.32cm in small size villages, 163.48cm in medium size towns, and 164.40cm in the top 20 percent of the urban population size distribution). A partial reconciliation obtains from table 9 in appendix E, which further disaggregates height growth by height in the recruitment list. Shorter men tend to display higher growth when the population density of their birth area is controlled for.

The fact that men are taller in cities echoes a specificity of early industrialization in Corrèze. Indeed, according to Quincy (1983), there was only one significant industry in Corrèze, a manufacture of weapons in Tulle, with around 3,000 workers in the 1880s. Quincy (1983) reports the location of all the industries in 1875 using a 6-category classification of activities: mining and quarrying, food (breweries, oil and industrial mills), wood industries (including papermaking plants), metallurgy (which includes the manufacture in Tulle), textile and processing industries (tanneries, brick and roof tile factories, and gas plants processing). The manufacture coexisted with many small-scale industries exploiting mineral resources (slate quarry and coal mines) in medium size towns or some food processing industries, especially (walnut) oil in the neighborhood of small villages in the Brive district.[26]

To assess the overall impact of industrial development, I first estimate

[26]Industries include textile in Bort along the Dordogne river, roof tile factories in Donzenac, lime kilns in Beaulieu and a variety of activities, e.g., stationers and clog-making factories, smaller in size in Brive.

the model

$$\Delta h_i = \beta_{\text{rural}}\ \Delta a_i + \beta_{\text{industry}}\ \Delta a_i \times \mathbf{1}_i^{\text{industry}} + u_i, \tag{3}$$

where $\mathbf{1}_i^{\text{industry}}$ takes value 1 if man i is born in an area where some industrial activity was established in 1875, and is 0 otherwise. All men born in a given area thus are considered as exposed to the industries in this area; it may still be that area characteristics reflect specific family values (see Bailey et al. (2016) for developing strategies using additional rich census data to identify the role played by childhood environment). The results reported in column (1) of table 5 show no height growth premium in industrialized areas.

Table 5: Early industrialization and pollution

	Height growth (cm)			
	(1)	(2)	(3)	(4)
rural	0.3776***	0.3753***	0.3746***	0.3722***
	(0.0479)	(0.0471)	(0.0436)	(0.0438)
industry	0.0529		0.2472*	
	(0.1066)		(0.1323)	
food		−0.2576*		−0.2951**
		(0.1491)		(0.1207)
wood		0.1527		0.4231
		(0.2031)		(0.2634)
metallurgy		−0.1135		0.1874
		(0.3353)		(0.2639)
mines		0.4475		0.3846
		(0.2743)		(0.2716)
textile		0.1817		0.5362**
		(0.1618)		(0.2654)
processing		0.0645		0.2431
		(0.1333)		(0.1537)
pollution			−0.3466**	−0.4818**
			(0.1725)	(0.2043)
Instruments	Siblings and Absents			
Observations	2,590	2,590	2,590	2,590
R^2	0.0202	0.0130	0.0271	0.0065
Adjusted R^2	0.0194	0.0103	0.0259	0.0034

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.
Robust standard error clustered at the county level

There is however some heterogeneity in the effects of industrial development on growth. Column (2) of table 5 gives the estimation results of the

model

$$\Delta h_i = \beta_{\text{rural}}\ \Delta a_i + \sum_d \beta_d\ \Delta a_i \times \mathbf{1}_i^d + u_i, \tag{4}$$

where $\mathbf{1}_i^d$ now is 1 if man i is born in an area where industry d is active in 1875, and 0 otherwise. Height growth over one year is β_{rural} in rural areas, i.e., birthplaces with no operating industry ($\mathbf{1}_i^d = 0$ for every d), and $\beta_{\text{rural}} + \beta_d$ when man i faces industry d only. All industrial areas still display no height growth premium, except food industry that actually exhibits a growth penalty of 0.25cm.

The height growth slowdown observed in the presence of food activities may come from a direct penalty from industrial development on young men previously employed in this sector; the Law of 2 November 1892, applied until the 1920s, sets the maximum duration of a working day to 10 hours at 13 years old, including work nights. But it may also be linked to pollution of air, soil and surface or underground water from, e.g., effluents, sewage and elimination of waste from oil extraction that are still problematic nowadays.

To discuss the impact of industrial pollution on height growth, I rely on the BASIAS data set from the French Ministry of the Environment, which identifies industrial sites that could have been subject to pollution. The data set contains the type, the location and the starting date of the polluting activity, but completion dates are typically missing. Once again activities starting before 1908 in Corrèze are merged with the height panel by birth location, so that every person born in an area listed in the BASIAS data set is considered as concerned by potential industrial pollution in this area.[27]

The impact of industrial pollution on height growth of the man is captured by adding the new term

$$\beta_{\text{pollution}}\ \Delta a_i \times \mathbf{1}_i^{\text{industry}} \times \mathbf{1}_i^{\text{pollution}}$$

into the right-hand sides of (3) and (4), where the pollution dummy $\mathbf{1}_i^{\text{pollution}}$ takes value 1 is man i is born in an area listed in the BASIAS data set. As shown in column (3) of table 5, controlling for pollution allows us to recover a positive impact from industrial development: absent pollution, height growth

[27] BASIAS mostly uses information from the Archives (see 5M44 – 74 references) and prefectoral authorization decrees. It is not exhaustive and there is no guarantee that the site is/was actually polluted.

exposed to some industrial activity in 1875 would reach 0.62cm over the year following the review board. But this is offset by a high penalty from pollution of 0.34cm, yielding a net growth of only 0.27cm in polluted industrial areas, i.e., growth is now penalized by 0.10cm compared to rural areas.

Industry specific height growth is reported in column (4) accounting for pollution. The impact of pollution is magnified compared to column (3), which suggests that omitted pollution in column (2) blurs the effect of industrial development. The penalty from exposure to food industries only slightly changes: it is therefore likely unrelated to pollution, but possibly due to poor working conditions. All the remaining industry specific effects remain unchanged but textile. Textile activities covers laundry bleaching processes and dyeing industries located along the three main rivers of Corrèze, e.g., the Megemond millinery in Bort along the Dordogne river from 1878 or the Monjauze spinning and weaving factory in Uzerche along the Vézère river starting from 1870. This is the only group of activities that contributes to the enhancing growth impact of industrial development. A possible interpretation for the absence of significant effect of textile on height growth in column (3) is that the high height growth premium of 0.53cm obtained when facing such activities is completely reversed by the 0.48cm penalty from pollution.

Although the results in columns (2) and (4) strongly suggest that textile was the most polluting activity at that time, the available data makes it difficult to work with industry specific pollution. Indeed, since the global picture in Quincy (1983) is a snapshot of industrial activities in 1875 whereas the potential industrial pollution identified in the BASIAS data set applies to industries created before the review board of 1908, some polluting industries may have disappeared in 1875 whereas others correspond to activities created after 1875. An example that well illustrates the discrepancies between the two data sets is the wool spinning mill grouped within the textile industry and listed by Quincy (1983) as the only industrial activity in 1875 in Meymac. The town also appears in BASIAS as potentially polluted, but the identified pollution would originate in two mines running from 1867 and 1878 exploiting bismuth. The discrepancies however can be exploited to provide some preliminary assessment about the timing of polluting industries: the estimation results in (4) are nearly identical using the BASIAS sample restricted to activities starting before 1875, which points toward a penalty from

pollution due to a first ancient wave of industries that may have disappeared in 1875, rather than new industries created between 1875 and 1908.

7.3 Height growth of the absentees

There were 132 men absent from the review board. They are not included into our final data set since their initial height is missing, and definitively lost. Some of these men were eventually retrieved by the Army and enlisted. The registration forms report the height of 89 absentees. They are shorter than the men present at the review board, with an average height is 163.98cm. The results in section 7.1, with higher growth for shorter men, suggest that our assessment of the height growth of the man could be under-estimated, but it is also possible that these men display a lower growth potential. To discuss the possible bias from the men absent from the review board, I have matched each of these men with the man present at the review board with the nearest propensity score. The score is computed referring to the age of the man at the review board, his height at enlistment and his county of birth. Finally absent men are imputed the height at the review board of their nearest neighbor. This allows us to get a sample of $2,788$ observations. The revealed poor military aptitude of absent men implies a lower estimated height growth when these men are reintroduced into the sample: using the same instruments as in the variant reported in column (3) of table 4 the height gain falls from 0.39cm to 0.37cm. The overall picture of section 7.1 still holds but we observe a dampening of growth of men shorter than 160cm.

8 Concluding comments

This article combines two military data sources to build a panel of French men around their 20s. The panel is used to assess height growth in an economically backward small rural area of France where most production may not transit through the market. Only the shortest male population is found to register growth beyond 20 years old; the others already reached adult maturity at this age. The average growth would be of 0.39cm over one year.

1. There is little robust empirical evidence on the relation between income inequality and growth (Banerjee and Duflo, 2003). The within-cohort

norm of reaction pattern found in section 7.1 has height growth reducing height inequality. The fact that the analysis considers the last phase of height growth of the man makes it consistent with the downward part of the Kuznets curve, but the finding is difficult to reconcile with the low level of economic development of Corrèze before World War I. Qualifications could thus come from reproducing similar exercises on other cohorts from Corrèze. It would also be interesting to reproduce the analysis on richer industrialized regions from North-East France to discuss the stylized fact that income inequality is often found magnified in poor countries; comparing such regions with Corrèze could bear additional insights into norm of reaction theories, e.g., whether shorter men did reach adult maturity in the north-east of France.

2. 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 19s rather than 20s. The same timing was applied to the cohort of men born in 1894, but the war called for an even earlier enlistment of the subsequent cohorts during the year following their 18s. Exploiting the younger age of the last cohorts should allow us to sketch a final growth episode and possibly identify the precise age of adult maturity of the tallest men.

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A Some specific registration forms

Here I bear on specific examples of men born in 1887 in Corrèze to discuss the status of height reported in the registration forms. I suggest that the registration form of men discharged in 1908 could have been created before the departure examination of 1908 but then filled only partially with civil status information, the completion occurring in 1909.

1. Handwriting evidence. In many case it is difficult to exploit such evidence to identify the registration forms where height differs from the one in the recruitment list. Indeed, the same writer usually filled both civil status and anthropometric information (including height) in the registration form of men enlisted in 1908; see, e.g., the registration form of Léonard Monzat (number 125 from the recruiting office of Brive) where height is 160cm while at the moment of the review board it was only of 159cm. This suggests that the registration forms may have been created by the recruiting office following the departure examination for such men. However there also exist registration forms where civil status information and height are reported by different writers for these men; see, e.g., the case of Antoine Escalier discussed in the main text as absent from the review board, or Louis Féral's form (registration number 46 from the recruiting office of Brive). That different writers intervene on the same registration form seems to be more frequent when the man is enlisted in 1909; see, e.g., Léonard Pouchoux (registration number 1485 from the office of Tulle).

2. Height left blank. Armand Bernical's form (number 990 from the office of Brive) contains civil status information, the recorded decision of 1908 to discharge and the ranking number in the county completed by the same writer; however, the centimeters of the height are left blank. Armand Bernical's height is 159cm when examined by the 1908 review board. He is enlisted in the fall of 1909. The incomplete information on height suggests that in some cases the recruiting office may create the registration forms of discharged men in 1908 but fill height following the departure examination in 1909.

3. Premature death. The height of some (not exempted from service) men examined in 1908 who died before enlistment is sometimes reported in

the registration form. See, e.g., Pierre Besse (registration number 1481 from the Tulle office) and François Mignon (number 824 from the Tulle office) deceased in May 1908, Alphonse Vincent (number 157 from the Tulle office) died in July 1908, or Léon Chassagne (number 1091 from the Tulle office) died in August 1908. The early death of François Mignon occurs before the departure examination held around the end of September 1908. In each case the height coincides with the height recorded in the recruitment list. It is still possible that the whole registration form is filled by the recruiting office in the fall of 1908, but height information then duplicates the height in the recruitment list. All the cases but François Mignon concern men to be enlisted in 1908. On François Mignon's form, the writing of number 6 is the same for the birth date in the civil status and for the registration number in the details of the services. The same applies to number 8 in the information for the year in the review board decision. On the other hand, the writing of number 5 for the part of the contingent in which the young man is classified in 1908 (the 5th part consists of men discharged in 1908) is different from that of the same number 5 appearing in the reported height of 155cm. This accords with the view that the registration forms of discharged men could have been prepared before the departure examination during the summer of 1908 but filled partially with information about the civil status and the review board decision. Height would then have been left blank waiting for the decision of the 1909 review board. Once the death of François Mignon is known, the military administration completes height referring to the last recorded height. For the other men, a plausible timing accounts of death in the course of the departure examination as the same writer seems to have operated in their registration forms.

4. Corrected height. There are a few registration forms of men discharged in 1908 and enlisted in 1909 where the hand-written reported height has one or more disguised digits, with the height reported initially coinciding with the recruitment list. This is the case of, e.g., Jean Joseph Aimé Vert (number 72 from the Tulle office), heightened at 161cm during the review board, whose height on the registration form is first indicated at 161cm and then corrected to 164cm. See also Pierre Auboiroux (number 339 from the office of Tulle) measured at 162cm

during the review board, and whose height on the registration form is first entered at 162cm and then resumed at 163cm by correcting the 2 into a 3; the height of François Chappoux (number 10 from the office of Tulle) is 161cm at the review board, is first reported at 161cm on the registration form and then revised to 166cm; Jean Lafarge (number 1611 of the office of Tulle), measured at 168cm during the review board, has reported height of first 168cm and then 160cm; François Sagne (number 1673 of the office of Tulle), measured at 155cm during the review board, whose height on the registration form is first indicated at 155cm then recovery at 158cm. In these cases the registration form is first filled in 1908 with a height copied from the recruitment list, and then corrected at enlistment in 1909 when noticing a height difference.

B Further on the enlistment decision

Column (1) of table 6 introduces the total number of men born in 1887 in the county in the set of explanatory variables. This number does not influence the age difference provided that one controls for the number of physicians present at the review board of the county; it actually displays a weak correlation (significant at the 10 percent level) with the age difference in the absence of this control.

Column (2) focuses on the institutional balance of power within the review board. A civilian servant from the Prefecture replaces the Prefect in the case where the latter cannot attend the board. In 1908 Charles Filhoulaud replaced the Prefect François Calmes 9 times (over 29 counties). François Calmes appears more willing to postpone enlistment than his subordinate. The mayors of the municipalities attached to the county instead encourage an earlier enlistment. The recruiting office seems more demanding on military aptitude, and thus oppose the various mayors. This echoes the high share of men computed by Bertschy (2018) who are reformed by the Army though deemed fit by the review board.

The enlistment/discharge decision also varies when the review board is scheduled. Starting later within the half-day increases the number of discharged men. Column (3) controls for the number of men born in 1887, as a delayed start plausibly reflects a lower volume of men to be examined.

Column (5) accounts for the order in which men are examined over the

Table 6: Additional determinants of the discharge decision

	Age difference (years)			
	(1)	(2)	(3)	(4)
Number of enlisted (male) siblings (log)	−0.422***	−0.434***	−0.420***	−0.431***
	(0.072)	(0.070)	(0.072)	(0.067)
Number of men from the last absent in the county	0.007*	0.006*	0.007*	0.006*
	(0.004)	(0.003)	(0.004)	(0.004)
Two physicians (ref: one)	0.081	0.105	0.196*	0.166
	(0.122)	(0.099)	(0.106)	(0.122)
Three physicians (ref: one)	−0.698***	−0.388***	−0.439*	−0.475***
	(0.261)	(0.087)	(0.225)	(0.083)
Number of men in the county	0.002		0.001	
	(0.002)		(0.002)	
Prefect is absent (ref: is present)		−0.277***		
		(0.075)		
Number of mayors		−0.024*		
		(0.014)		
Recruiting office of Tulle (ref: Brive)		0.246***		
		(0.076)		
Review board start time: 10am (ref: 9am)			0.334***	
			(0.128)	
11am			0.581***	
			(0.103)	
1pm			0.159*	
			(0.083)	
2pm			0.313***	
			(0.087)	
Age at the 1908 review board				−0.173
				(0.136)
Examination ranking in Corrèze				0.074*
				(0.038)
Constant	0.908***	1.237***	0.631***	4.120
	(0.192)	(0.164)	(0.173)	(2.876)
F Statistic	25.168	31.709	19.115	22.689
Observations	2,591	2,591	2,591	2,591
R^2	0.035	0.042	0.039	0.037
Adjusted R^2	0.034	0.040	0.036	0.035

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.
Robust standard errors clustered at the county level.

whole sequence of review boards in the counties of Corrèze. Given the age, which partially determines the order of examination, those examined later tend to be more often discharged.

Unreported F-tests show that the sets of new variables introduced in table 6 in general are weakly correlated with the age difference. An exception concerns measures related to age at the review board, e.g., the age itself and various concepts of examination order within or across counties. The validity of such variables, if used as instruments for the age difference, is however subject to caution as they are plausibly correlated with height growth (see section 7.1); as part of the fixed effects in (1), they cannot be used as additional direct controls in (2).

C Validity of instruments

Table 7 shows that the three variables that could be used as instruments discussed in section 6.2 have no significant influence on the height measured at the review board.

Table 7: Height at the review board

	Height measured during the review board		
	(1)	(2)	(3)
Number of enlisted (male) siblings (log)	0.0728	0.0730	0.0818
	(0.0853)	(0.0862)	(0.0849)
Number of men from the last absent in the county		−0.0006	−0.0001
		(0.0083)	(0.0084)
Two physicians (ref: one)			−0.5971
			(0.4275)
Three physicians (ref: one)			0.4232
			(0.3525)
Constant	163.8354***	163.8436***	163.9461***
	(0.1932)	(0.2095)	(0.2422)
Observations	2,591	2,591	2,591
R^2	0.0001	0.0001	0.0038
Adjusted R^2	−0.0003	−0.0007	0.0023
Notes:	***Significant at the 1 percent level.		
	**Significant at the 5 percent level.		
	*Significant at the 10 percent level.		
	OLS estimates, robust standard errors clustered at county level		

Figures 5 and 6 illustrate how these instruments does alter the actual age difference. The instrumented age difference is positive for most men; for

ease of reading the diagram abstracts from low masses of volunteers. The age difference of men recalled in 1914, 1915 and 1917, which ranges from 6 to 10 years, is reduced to less than two years once instrumented; men discharged in 1908 and enlisted in 1909 are treated as if enlisted earlier in 1909. Symmetrically the majority of men, enlisted in 1908, are treated as if enlisted later in 1909.

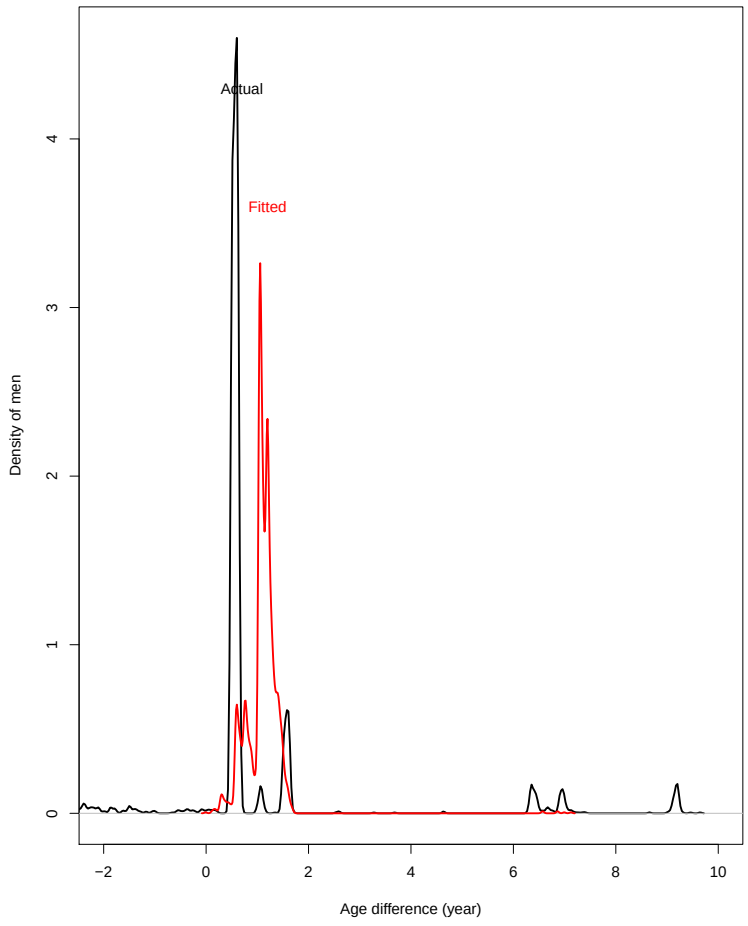

Figure 5: Actual and fitted age difference distributions

Figure 6 allows us to isolate the individual adjustments of instrumented age differences. The left panel considers the full age difference distribution.

The right panel focuses on men enlisted in 1908 or 1909. The instrumented age difference falls around 1.1 year. The right-panel also exhibits regular sequences where the adjustment decreases linearly with the actual age difference: they correspond to men enlisted simultaneously, so that heterogeneity in the age differences then mostly reflects the timing of county examinations.

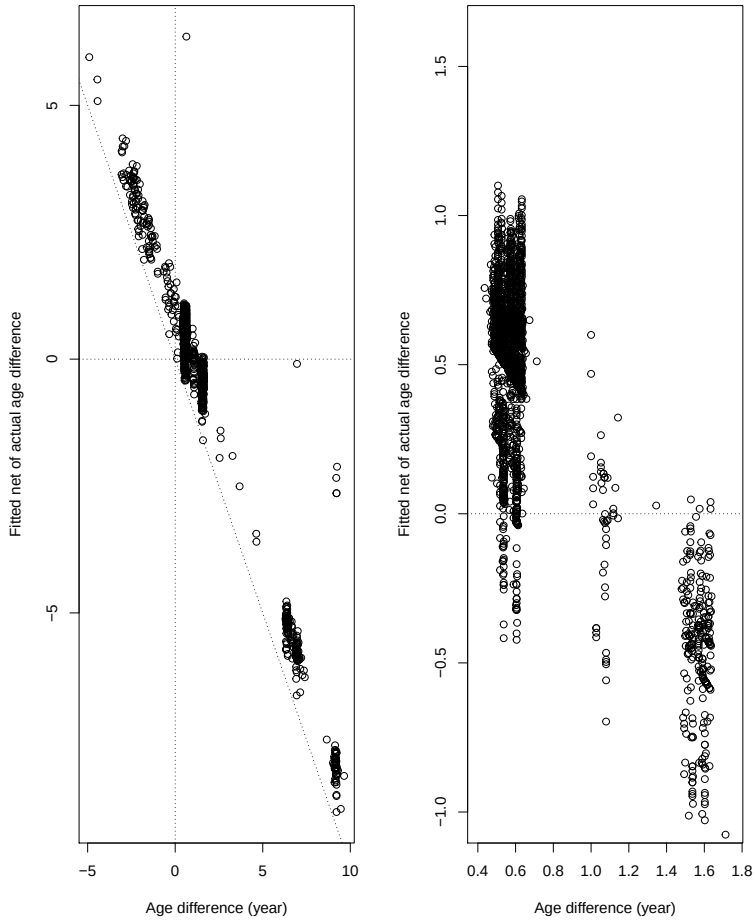

Figure 6: Fitted net of actual age difference

D Norms of reaction: detailed results

Table 8: Height growth distribution

	Height growth (cm)		Height growth (cm)
$\hat{\beta}_{(144,150]}$	0.4041***	$\hat{\beta}_{(164,165]}$	0.2272***
	(0.1767)		(0.0719)
$\hat{\beta}_{(150,151]}$	0.4495**	$\hat{\beta}_{(165,166]}$	0.2285
	(0.2263)		(0.2161)
$\hat{\beta}_{(151,152]}$	0.4942***	$\hat{\beta}_{(166,167]}$	−0.0076
	(0.0711)		(0.0673)
$\hat{\beta}_{(152,153]}$	0.4024***	$\hat{\beta}_{(167,168]}$	0.2513
	(0.1245)		(0.1612)
$\hat{\beta}_{(153,154]}$	0.9078***	$\hat{\beta}_{(168,169]}$	0.0341
	(0.3293)		(0.2147)
$\hat{\beta}_{(154,155]}$	0.1590	$\hat{\beta}_{(169,170]}$	0.2220***
	(0.2089)		(0.0757)
$\hat{\beta}_{(155,156]}$	0.3327***	$\hat{\beta}_{(170,171]}$	−0.0020
	(0.0888)		(0.1044)
$\hat{\beta}_{(156,157]}$	0.7001***	$\hat{\beta}_{(171,172]}$	0.0096
	(0.3460)		(0.0093)
$\hat{\beta}_{(157,158]}$	0.4004*	$\hat{\beta}_{(172,173]}$	0.1750
	(0.2077)		(0.1026)
$\hat{\beta}_{(158,159]}$	0.1679*	$\hat{\beta}_{(173,174]}$	0.2997
	(0.0978)		(0.2805)
$\hat{\beta}_{(159,160]}$	0.7259***	$\hat{\beta}_{(174,175]}$	0.5245
	(0.2301)		(0.5401)
$\hat{\beta}_{(160,161]}$	0.7027***	$\hat{\beta}_{(175,176]}$	−0.0079
	(0.0892)		(1.5880)
$\hat{\beta}_{(161,162]}$	0.7608***	$\hat{\beta}_{(176,177]}$	0.0349
	(0.2067)		(0.0415)
$\hat{\beta}_{(162,163]}$	0.2727	$\hat{\beta}_{(177,184]}$	0.0625
	(0.1908)		(0.0552)
$\hat{\beta}_{(163,164]}$	0.2976***		
	(0.1035)		
Instruments	Siblings and Absents		
Observations	2,591		
R^2	−0.0142		
Adjusted R^2	−0.0257		
Notes:	***Significant at the 1 percent level.		
	**Significant at the 5 percent level.		
	*Significant at the 10 percent level.		
	Robust standard error clustered at the county level		

E Rural versus urban growth

Table 9: Urban vs. rural growth

	Height growth (cm)
$\hat{\beta}_{(144-152]\times[62-238]}$	0.4596***
	(0.1387)
$\hat{\beta}_{(144-152]\times(238-943]}$	0.5205***
	(0.2014)
$\hat{\beta}_{(144-152]\times(943-4{,}440]}$	0.0038
	(0.0128)
$\hat{\beta}_{(152-155]\times[62-238]}$	0.8083
	(0.5956)
$\hat{\beta}_{(152-155]\times(238-943]}$	0.4845**
	(0.2087)
$\hat{\beta}_{(152-155]\times(943-4{,}440]}$	0.6229**
	(0.2652)
$\hat{\beta}_{(155-158]\times[62-238]}$	0.6787
	(0.4208)
$\hat{\beta}_{(155-158]\times(238-943]}$	0.3175***
	(0.1108)
$\hat{\beta}_{(155-158]\times(943-4{,}440]}$	1.0843
	(0.6880)
$\hat{\beta}_{(158-161]\times[62-238]}$	0.4323*
	(0.2413)
$\hat{\beta}_{(158-161]\times(238-943]}$	0.5478***
	(0.1360)
$\hat{\beta}_{(158-161]\times(943-4{,}440]}$	0.7275***
	(0.0842)
$\hat{\beta}_{(161-164]\times[62-238]}$	0.6053**
	(0.2450)
$\hat{\beta}_{(161-164]\times(238-943]}$	0.3747***
	(0.1403)
$\hat{\beta}_{(161-164]\times(943-4{,}440]}$	0.5748***
	(0.2224)
$\hat{\beta}_{(164-167]\times[62-238]}$	0.2158**
	(0.0951)
$\hat{\beta}_{(164-167]\times(238-943]}$	0.1477
	(0.1112)
$\hat{\beta}_{(164-167]\times(943-4{,}440]}$	0.1020*
	(0.0607)
$\hat{\beta}_{(167-184]\times[62-238]}$	0.0664
	(0.1094)
$\hat{\beta}_{(167-184]\times(238-943]}$	0.1157
	(0.1726)
$\hat{\beta}_{(167-184]\times(943-4{,}440]}$	−0.1109
	(0.1095)
Instruments	Siblings and Absents
Observations	2,578[1]
R^2	−0.0223
Adjusted R^2	−0.0307

Notes: 1. There are 13 missing birthplaces.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.
Robust standard error clustered at the county level.