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ORIGINAL PAPER

Gender inequality in a transition economy: heights and sexual height dimorphism in Southwestern France, 1640–1850

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Abstract
The secular trend in average female and male adult height can reveal sex-specific patterns in resource allocation as final heights, to a large extent, reflect access to food and the degree of parental investment in nutrition, particularly over early childhood. This article examines the issue by reconstructing the long-term evolution of heights and sexual height dimorphism for the cohorts born between the 1640s and the 1850s in Southwestern France, an area characterized by among the highest levels of gender inequality and the lowest level of development in France at the time. To make so I rely on hospital, passports, and prison records and show how these different sources can be combined to study long-term patterns in adult statures. The analysis reveals that sexual height dimorphism charted an inverted U-shaped trajectory in the period considered. The study of the correlates of gender dimorphism also suggests that this varied in relation to the amount of resources available as well as the demographic cycle. The progressive reduction in Malthusian constraints and the early French fertility decline were accompanied by a general reduction in inequality possibly associated with an increase in expenditure on female quality.

Keywords Gender inequality · Heights · Sexual height dimorphism · France · Fertility transition

JEL Classification J16 · N33 · O11

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1 Introduction

Gender inequality is one of the most important and contentious issues in economic history. Yet, aside from a number of classic contributions focusing on gender differences in the labor markets, less is known about other domains encompassing non-market forms of gender inequality, particularly in the allocation of nutrients.[1] Well-nourished children are generally more productive and hence more likely to earn higher incomes than poorly fed ones implying that gender differences in the allocation of resources at the very early stages of life (Burnette 1997; Neal and Johnson 1996) can crucially affect physical development and future job prospects of boys and girls differently (Anderson 1980; Humphries 2008; Johnson and Nicholas 1997). Nutrition not only can explain individual economic outcomes but also figures prominently in current debates about cross-country comparisons of living standards and the origin of the Industrial Revolution. One leading interpretation, for instance, maintains that better nutrition made British males healthier and taller on average than elsewhere in Europe thus leading to more physical strength and cognitive ability as well as higher labor productivity of the British workforce (Kelly et al. 2014). Owing to the special role played by women during the Industrial Revolution, differences in nutrition can also be at the very origin of the English and North Sea area economic primacy. Importantly, the level of nutrition of women crucially affects the well-being of the next generation as healthier mothers tend to give birth to taller and healthier infants (Mason et al. 2012; Koepke et al. 2018).

Identifying gender differences in nutrition is a daunting task, though. Input measures, such as expenditure in calories and nutrition, would allow us to infer how the allocation of resources takes place but often this direct information is scattered or difficult to interpret.[2] In these cases, other metrics need to be considered, particularly those output variables that measure the welfare impact of variations in food provision on individual characteristics such as height, weight, and life expectancy (Horrell and Oxley 2013).

This study concentrates on final adult height, a well-known indicator of nutritional status which measures the birth cohort's net nutritional intake (Steckel 1995). Adult stature is not merely a function of dietary intake as it also depends on external factors, such as work effort, the requirements made on the body by external temperature, the effects of diseases as well as catch-up growth experienced later in time (Eveleth and Tanner 1976; Harris 1998; Schneider 2017). Still, to a large extent, adult heights reflect access to food and the degree of parental investment in nutrition, particularly over early childhood (Baten 2000; Steckel 1995). Ultimately, the secular trend in average female and male adult height can reveal women's relative living standards and illuminate sex-specific patterns in resource allocation (Guntupalli and Moradi 2009; Guntupalli and Baten 2009; Horrell and Oxley 2013).

The contribution of this paper is threefold.

[1] For a comprehensive analysis of the evolution of the gender wage gap in pre-industrial Europe, see De Pleijt and van Zanden (2021).

[2] Gender asymmetries in food expenditure and consumption can simply result from the different caloric needs of men and women rather than discrimination.

First, it presents new high frequency series on final adult height by sex for the cohorts born in Southwestern France between the 1640s and the 1850s. To the best of my knowledge, these series provide the first evidence on sexual height dimorphism, i.e. the difference in male and female adult stature in France over such a long historical period, and contribute altogether to expanding our understanding of male and female height patterns in Southern Europe. This is important since the available evidence concerns Northern and Central Europe (England, Germany, Ireland, Scotland, and Switzerland) and mostly dates back to the nineteenth century. The case of Southwestern France thus provides a useful vantage point to understand secular trends in sexual height dimorphism and to contrast the experience of this Southern region, characterized by among the highest levels of gender inequality in nineteenth century France, with that of Northern Europe (Diebolt and Perrin 2017). In considering this part of France, it is important to remember that Southwestern France is unlikely to be representative of the whole of Southern Europe. Nevertheless, its demographic and cultural traits fit well in what can be broadly termed as the 'southern norm,' namely a societal structure involving patriarchal cultures, low women activity rates and access to education as well as high gender disparities in labor market reward (De Pleijt and Van Zanden 2021). Furthermore, the rich archival base of this area as well as its character of a transition economy makes this a particularly important case for study.[3] In the years spanning from the early seventeenth to the mid-nineteenth century, Southwestern France underwent 'three great transitions': the transition from a high to a low fertility regime by about the end of the eighteenth century (Perrin 2022); the transition from a phase of relative economic prosperity centered around the big Atlantic trades up to the late eighteenth century to the ensuing partial deindustrialization arising from the Napoleonic Blockade (Charles et al. 2021; Crouzet 1959); and finally, the transition from a regime characterized by frequent subsistence crises up to the early eighteenth century to another in which the South West and generally France were much less vulnerable to famines (Ó Gráda and Chevet 2002). The interrelationship between these changes and heights offers a fertile testing ground to shed some light on several important questions: How did dimorphism evolve through time? What are the main factors accounting for gender inequality patterns? Were the patterns in resource allocation dominated by deep cultural factors or did they respond to economic and demographic factors? How did sexual height dimorphism relate to other forms of gender inequality such as the gender wage gap?

Second, this paper offers new methodological insights into how different sources can be combined to construct long-term series of heights. As of now, most anthropometric literature has focused on large samples drawn from one source type (typically prison or military records) to estimate long-term developments in stature.[4] This study instead relies on several types of sources, e.g., hospital, passports, and prison records to form a unique series. As no single source covers the entire period

[3] To the best of my knowledge, the lack of sufficient information on heights does not allow to test similar hypotheses for other areas of France over such a long time span.

[4] A noteworthy exception is Koepke et al. (2018) whose study uses prison, passport, maternity hospital, and voluntary army auxiliary records.

considered, combining different sources gives me the unique opportunity to chart trends in heights across centuries. Nevertheless, this approach presents a series of challenges given the heterogeneity of the sources, the non-random nature of the samples, and the potential selectivity and compositional issues related to them. In what follows, I discuss these issues and show how several steps can be taken to mitigate these concerns and still provide a coherent picture of the phenomenon under study. Hopefully, this approach could offer some guidance for researchers in the field who may face similar problems.

Third, this paper sheds new light on the evolution of gender height dimorphism and its long-term determinants. The results show that gender inequality charted an inverse U-shaped pattern characterized by growing inequality during the early stages of development between the seventeenth and first half of the eighteenth century but falling inequality thereafter. Furthermore, the analysis of the impact of conditions at birth on the gender gap in adult height suggests that cohorts born during periods of nutritional stress display a higher sexual dimorphism in adulthood. Conversely, the size of the male-female height gap tended to decrease when conditions at birth improved. This evidence suggests that on average the allocation of nutrients was not set by custom. Rather, external market forces and internal household economic conditions such as the availability of financial resources and family size crucially affected inequality in this particular historical setting. The results also show that the history of heights intersects the history of fertility as the early fertility transition experienced by this area of France led to a significant reduction in sexual height dimorphism. In contrast, the last big famines of the seventeenth century seem to have pushed a brake to the secular increase in inequality, but their effect was only temporary.

The rest of the paper is structured as follows. Section 2 reviews the literature while Sect. 3 provides context. Section 4 describes the sample and Sect. 5 shows the results of the regression analyses of the height series, followed by a discussion of the main issues related to the interpretation of the series and possible ways to address them (Sect. 6). Section 7 identifies the main determinants of gender inequality and discusses the reported trend. Section 8 concludes.

2 Review of the literature

Biology plays a large role in determining height differences between men and women, but other factors like nutrition, health care, and disease are important for explaining sexual height dimorphism. Here we are interested in the component of sexual dimorphism that is affected by nutrition and that therefore casts light on sex-specific differences in the allocation of nutrients within a society (Boix and Rosenbluth 2014). This component is likely to be large—so that about 20 percent of human growth is driven by the cumulative net nutritional history of a population (Deaton 2007; Silventoinen 2003)—and sensitive to environmental conditions particularly during the first three years of birth, so that later influences on growth appear to have only a limited impact on final adult height (Baten 2000; Eveleth and Tanner 1976).

Empirical studies on the evolution of the gender height gap in a historical perspective can be broadly classified into three main groups. The first focuses on sexual height dimorphism during the early stages of industrialization across a limited set of European countries, namely England, Ireland, Scotland (Johnson and Nicholas 1995; Nicholas and Oxley 1996; Oxley 2004), Switzerland (Koepke et al. 2018), and Germany (Baten 2000; Baten and Murray 2000).[5] The second includes work in biology drawn from prehistoric populations across several areas of the world (see Guntupalli and Baten 2009). The third comprises a number of contributions offering an unprecedented long-term perspective on sexual dimorphism over the last two millennia based on human bones from archeological excavations (Galofré-Vilà et al. 2018; Koepke and Baten 2005; Steckel et al. 2019) or height ratios derived from linear enamel hypoplasia a permanent defect on teeth formed during the crown formation and resulting from poor health and malnutrition during early childhood (Maravall Buckwalter and Baten 2019).[6] Perhaps unsurprisingly, given the heterogeneity of the sources and places considered, these studies provide contrasting accounts of the evolution of the gender height gap. On the one side, the empirical evidence drawn from prehistoric populations suggests that sexual dimorphism in stature is lower in societies with low levels of nutrition than in societies where individuals are well nourished as in the former males achieve a lower percentage of their genetic growth potential compared to females (Greulich 1951). These findings support the so-called "female resiliency" hypothesis positing that females are naturally more resistant than men to adverse conditions. However, new research within the field of economics and economic history has challenged this interpretation, arguing that, not only biological factors but also economic, demographic, and cultural conditions need to be considered to understand sexual height dimorphism. For instance, Nicholas and Oxley (1993) showed that English rural women suffered more than their male and urban female counterparts during the troubled years of 1800–1815 while Johnson and Nicholas (1995) found that the decline in English female stature was higher compared to males during the period of nutritional stress between the early 1820s and the mid-1850s. In Germany, height dimorphism was relatively high in the first half of the nineteenth century, but after the famine years, it decreased in the late 1850s and 1860s implying that "better times are even better for women" (Guntupalli and Baten 2009). All in all, this evidence sits uneasily with the "female resiliency" hypothesis and provides support to the idea that gender disparities tend to increase during periods of economic want.

Several scholars have sought to determine the main factors accounting for these patterns. An important strand of the literature has connected height dimorphism in adulthood to the allocation of resources within the household during the early stages of life. As allocations are determined by parents, parental consumption choices must

[5] To this should be added research on male and female heights in the USA. See, for instance, Carson (2011) and Sunder (2011).

[6] See Guntupalli and Baten (2009), Steckel et al. (2019), and Harris (2021) for a comprehensive review of this literature. Furthermore, a growing body of literature has explored developments in the gender height gap in the twentieth century in countries like Chile (Castellucci et al. 2021), India (Guntupalli and Moradi 2009), Spain (Costa-Font and Gil 2008), North and South Korea (Pak 2004).

have been crucial in determining children's adult height (Weir 1993). One leading economic theory argues that parents take investment decisions so as to maximize long-run household income (Becker 1991; Anderson 1980). In this utility-maximizing framework, the optimal investment decision rule coincides with equal partitioning only in such cases in which the expected future return for male and female offspring is equal. If, however, labor market institutions value more men than women, parents should allocate resources in favor of the former. This is sometimes referred to as the 'earner bias model' (Horrell and Oxley 2013). If this system was used, one would expect that the size of the height gap would be larger in places where the male expected market return is higher. A second interpretation instead maintains that investment in the nutrition and care of children is, to a large extent, the result of the differential bargaining power of men and women within the household (Horrell and Oxley 2013, 2016; Wall 2009). In this process, women fared badly because power within the household was concentrated in male hands. Power, in turn, relates not only to the earnings brought into the household, 'but also to cultural expectations around who performed unpaid domestic labors, female obedience, the ease or difficulty of exiting and forming new relationships, legal status, and more.'[7] Differently from the previous model, this second interpretation usually referred to as the 'gender-bias model' is more tightly linked to deep social and cultural norms which sanction the primacy of the male heads of household and fully employed elder sons no matter what children's abilities and economic prospects are (Ross 1993). Finally, biological studies based on mammals and birds argue that parental investment decisions are largely due to the amount of resources available, implying that as soon as parents have enough resources, they shift to more egalitarian division rules.[8] This would imply that parents are not naturally biased toward males. Whether the allocation of nutrients followed one model or the other is difficult to tell as these practices were often correlated.

Evidence from nineteenth century developing countries seems to be quite consistent with both the biological interpretation emphasizing resource availability and the gender-bias model. Guntupalli and Moradi (2009), for instance, show that culturally determined discrimination patterns in the allocation of resources existed and tended to surface and increase disproportionately with poverty leading to an increased height differential between males and females in poor times. Similarly, Das Gupta (1993) argues that acute scarcity results in gender bias. In contrast, Horrell and Oxley (2013) found that household decision-making in nineteenth century Britain may have been consistent with the 'earner bias model.' Specifically, women's height tended to be above average in those areas where male-biased diets were followed, but there was also work for women. Conversely, irrespective of the dietary regime, female adult statures were below average in those areas where women had few employment opportunities. This implies that, even if the gender bias model was adopted, good economic prospects for women tended to mitigate inequality and appeared to raise women bargaining power allowing them more influence over the intra-household allocation of nutrients. This result chimes well with several studies

7 Horrell and Oxley (2013, p. 149).

8 See Hertwig, Davis, and Sulloway (2002) for a review of the literature.

emphasizing the link between height dimorphism and women's labor market participation (Holden and Mace 1999; Nicholas and Oxley 1993). Quite consistent with the 'earner bias model' is also the observed correlation between sexual dimorphism and economic structure. Klasen (1998), for instance, argued that grain-oriented societies were characterized by larger height (and educational) gender gaps than cattle-growing ones as grain cultivation, requiring more upper-body strength, incentivized these societies to invest more in nutrition and care of their male offspring. Relatedly, Boix and Rosenbluth (2014) point out that the transition from hunter-gather societies to sedentary cultivation that disproportionately utilizes male brawn increased sexual dimorphism. Furthermore, population growth seemingly boosted gender inequality as agriculture became more dependent on human brawn while industrialization led to a reduction in sexual dimorphism as it tended to reduce the so called 'brawn premium.'

3 Southwestern France and 'the three great transitions'

With an area of ten departments of over 3.1 million inhabitants at the 1821 census, corresponding to about 10 percent of the French population of the time, Southwestern France constitutes the broad setting of the present study.[9] For the specific geographic distribution of the sources, however, this paper focuses more specifically on the department of Pyrénées-Atlantiques, an area with c.360,000 inhabitants at the 1801 census, c.12,000 of whom living in Bayonne the largest city and one of the two sub-prefectures of the department.[10]

Economic, demographic, and cultural traits make this area particularly interesting for our purposes. A well-established tradition dating back to the nineteenth century but resonating also into the twentieth century histories of France has described the South West as one of the most backward areas of the country. The contrast is sharp in Stendhal's *Memoirs of a Tourist* where 'the Modern and civilized' Northern France, the France of steam engines,' the one that is in the process of becoming 'English,' is compared to the South West, an 'encrusted' region inhabited by individuals lacking those fundamental 'characteristics that ensure success in commerce.' While the game of spotting 'the two Frances' has changed over the years,[11] a similar picture of relative underdevelopment emerges from more recent quantitative studies investigating differences in literacy rates (Furet and Ozuf 1980), numeracy (Crayen and Baten 2010), wages (Ridolfi 2019), and output per capita across France (Toutain 1978). This backwardness also re-emerges when one looks at anthropometric data. In their classic contribution concerning nineteenth century conscripts,

[9] The departments are Ariège, Gers, Gironde, Haute Garonne, Hautes-Pyrénées, Landes, Lot et Garonne, Pyrénées-Atlantiques, Tarn, and Tarn and Garonne. This follows the definition of the INED's inquiry (Houdaille 1977). Population data come from the 1801 population census.

[10] These data are based on the 1801 population census and Bairoch, Batou, and Chèvre (1988).

[11] Dupin, in 1826, was one of the first to emphasize the economic heterogeneity of France, exemplified by a line dividing France between an area of prosperity north of a line connecting Mont Saint-Michel to Genève and a Southern region characterized by relative backwardness (Fleury and Valmary 1957). See also Braudel (1984, pp. 338–351).

Le Roy Ladurie and co-authors found that south of a line connecting Saint-Malo to Geneve, French soldiers were shorter than average and the proportion of stunted males was much larger than in the north-eastern corner of the French hexagon (Le Roy Ladurie et al. 1976).[12] According to Komlos (2003), the height disadvantage of Southwestern France dated back at least to the early eighteenth century and was large (at least 2 cm) compared also to the Mediterranean South.

From time to time, several factors have been suggested to explain the low level of development of the South West including the insufficient natural resources and infrastructures, cultural values placing emphasis on laziness and caution rather than industriousness as well as societal structures which conferred great patriarchic control over offspring (Diebolt and Perrin 2017) and tended to promote investment in land rather than the accumulation of capital (Armengaud 1960; Minovez 1996). A long-term study of the Southwestern economy, however, paints a picture that is quite different from that of a *société immobile* trapped in poverty. In his 1959 seminal contribution about the timing and origins of the South West *décalage*, Crouzet was the first to clearly point out that the Southwestern region was not always poor and located the timing of the reversal in the years of the Revolution and the Empire. He argued that, in the eighteenth century, the South West was not significantly less industrialized than the rest of the country nor its industries were noticeably more archaic than elsewhere in France. Not only the main Atlantic ports of Bordeaux and to a lesser extent Bayonne but also various manufacturing and textile industries scattered across the inland areas, rendered this area dynamic and widely open to the outside despite its predominantly rural economic structure (Crouzet 1959; Poussou 1983; Forrest 2020). Quantitative data provide support to Crouzet's hypothesis. The increase in human stature between the seventeenth and the nineteenth centuries paints a picture of improved nutritional conditions (Komlos 2003). Similarly, high fertility rates and the sustained population growth of the region (Braudel 1984) as well as the expanding trade activities of the ports of Bordeaux and Bayonne between the 1720s and 1770s testify to the dynamism of the area (Daudin 2012). The disruptions caused by the blockade, in some cases anticipated by the Seven Years' War, seemingly put an end to this process and very quickly led to the deindustrialization regretted by the nineteenth century commentators (Crouzet 1959). Even more importantly, the effects of the Napoleonic wars appear to have been long lasting as neither the end of the conflict nor the resumption of maritime trade reversed the trend until the end of the nineteenth century (Crouzet 1959; Poussou 2000). In sum, the picture that emerges combining different indicators of living standards and looking at the evolution of wheat prices and population (Fig. 1) is one of improved economic conditions before the French Revolution and decline or mild recovery thereafter.

In the eighteenth century, following a pattern begun in Northern France, the South West experienced another transition which marked the passage from a high to a low fertility regime. As pointed out by Perrin (2022), this process resulted from a variety of demographic, cultural, and economic factors and entailed complex regional dynamics depending on the type of marriage pattern, level of human

[12] The far greater share of stunted men in Southwestern France in the nineteenth century has been also observed by Angeville (1836) and Postel-Vinay and Sahn (2010).

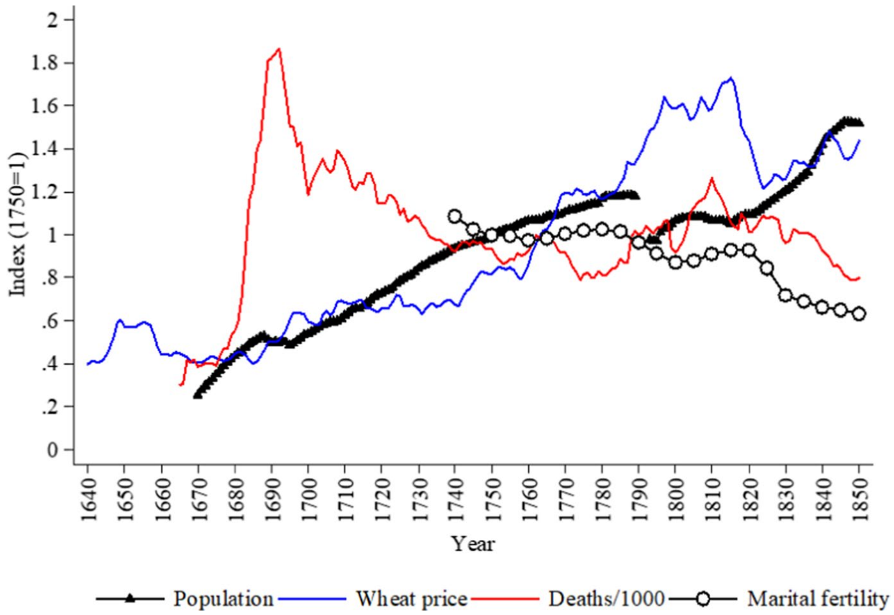

Fig. 1 Mortality, fertility, population, and prices in the South West (1640–1850). *Sources*: Population and deaths over population per 1000 inhabitants refer to Bayonne, see Appendix C, Section 1; wheat prices in Toulouse, Frêche and Frêche (1967); marital fertility in the South West, Houdaille, Blum, Tugault (1987), Table 11

capital, religious practice, and gender relations. In Southwestern France, as shown in Fig. 1, the Coale index of marital fertility passed from about 0.69 to about 0.43 between the 1780s and the 1850s (Blum 1988). Nevertheless, by that year, this region was still characterized by below average human capital stock, a mostly agrarian population, and a demographic structure that, except for the Pyrénées-Atlantiques and Hautes-Pyrénées, fitted well with the Eastern European Marriage Pattern where low fertility control was the norm (Perrin 2022). Finally, a third transition took place in the period considered, namely a shift from a regime of high mortality in which France suffered several major famines (the Frondeurs in 1650/1652, the "accession crisis" of 1660/1662, the famines of 1693/94, and 1709/10) to a new phase where the country became virtually free of subsistence crises (Appleby 1979; Ó Gráda and Chevet 2002).[13] This is evident from the evolution of the number of deaths per 1,000 inhabitants in the area of Bayonne shown in Fig. 1. Here the highest death toll was reached during the 1693/94 famine and to a much lesser extent in

[13] As shown by the high mortality rates attained during the major famines of 1693/94 and 1709/10 in the area of Toulouse (Appleby 1979; Frêche and Frêche 1967), diversification in grain crops provided some protection against adverse climatic conditions but was not sufficient to prevent starvation. Maize, however, seemingly helped prevent the wheat harvest failure of 1652–53 from turning into a demographic catastrophe.

1709/10. Thus, while the South West continued to suffer from periodic subsistence crises until the end of the Old Regime, a clear reduction in mortality took place by the early eighteenth century.[14]

All in all, these economic and demographic traits combined to form an area with among the highest levels of gender inequality in nineteenth century France (Perrin 2014; Diebolt and Perrin 2017). According to the historical gender index estimated by Perrin (2014), around 1850, the Southwestern area was characterized by large gender disparities, particularly in the domains of economic and educational gender inequality. However, it is unclear how this trend evolved historically. Little is known, indeed, about gender inequality in this area (and in France more generally) prior to the nineteenth-century official state statistics.

This study takes a step in this direction by analyzing heights, sexual height dimorphism, and the economic, demographic, and cultural factors that shaped women's relative welfare.

4 Sources

This study uses two largely unexplored sources for historical height data, namely the hospital admission registers and the passports for abroad and complements this set of information with a more traditional source, the prison records. The result is the construction of a height sample covering the birth cohorts born between the 1640s and 1850s. In what follows, I provide a detailed description of the various sources and the overall sample.

4.1 Hospital records

The first sample comes from the admission registers of Saint-Léon's hospital in Bayonne and describes male and female individuals at the time of their hospitalization. Founded in the sixteenth century, Saint-Léon's hospital was the most important health institution in Bayonne. The first entry register analyzed in this study dates back to 1724, the year in which the hospital was transformed by royal decree into a public institution financed by the state and managed by a bureau of eight directors elected from the elites of the city (1746 statute). While the entry registers continue almost invariably into the nineteenth century, these records alone do not allow me to cover the entire period under study. Indeed, the quality of the height data deteriorates by the mid-eighteenth century: rounding of heights becomes more frequent in relative terms and general statements replace precise measurements of the height of patients. Worse still, registers never report statures in the post-revolutionary phase. For these reasons, only the registers from 1724 to 1762 were retained. The information gathered includes 6263 individuals born between the 1640s and

[14] The low values of mortality in the early seventeenth century are due to the low population level and possibly some underreporting of deaths.

1750s corresponding to about 67 percent of the overall sample (Table 1). The hospital records were usually considered as purely administrative documents reporting patients' personal details but not their stature, an information that was medical in nature.[15] This feature limits the geographic scope of this study to Bayonne's hospital which was probably an exception for the time. Height data are measured in pieds (1 pied equivalent to 12 pouces) and pouces (1 pouce corresponding to about 2.7 cm) rounded to the nearest pouce. Information about the name of patients, diocese of birth, age, current and sometimes past occupation is reported as well as the reason for hospitalization and the hospital entry and exit dates.[16] For instance, in the period considered, fever was the leading cause accounting for about 48 percent of the total instances, followed by treatment of injuries (7 percent). In about 22 percent of the cases, the nature of the disease is not clearly specified although in only a few instances the health status of patients is unknown (c.1 percent).

The institutional structure of the hospital did not undergo relevant variations over the period considered. As already mentioned, the most important changes, indeed, preceded 1724 the first year in which registers start. This suggests a certain degree of homogeneity in the way data were collected and processed at least up to the 1760s after which, and then more markedly in the nineteenth century, the institution was progressively transformed into a hospital proper abandoning its traditional function as a refugee for the poor. The analysis of the entry registers suggests that the flow of patients changed over time. There was a phase characterized by a high number of hospitalizations between 1724 and 1733 (about 360 patients per year), a drop in the years 1734–44 (c.190 patients per year), and a recovery thereafter when the number of admissions again remained stable at about 390 patients per year between 1745 and the 1750s.[17] Matching this information with a detailed reconstruction of the finances of the hospital, one may observe a strong positive correlation between the amount of revenues accruing to the hospital and the number of hospitalizations. The main sources of financing were rents, tax receipts from trade duties (the *octroys*) as well as conspicuous financial support from the crown. Until 1733, the revenues of the hospital averaged around 37,000 livres tournois.[18] After that date, there was a drop in the revenues and a down in 1739 when these plummeted to only about 17,000 livres tournois, over 50 percent less than in the previous period. With some fluctuations, by 1744 onwards the revenues started to increase averaging c.40,000 livres tournois between 1744 and 1760 with peaks of about 64,000 livres tournois per year in 1757 and 1760. However, these variations were paralleled by a progressive stabilization of the net revenues of the hospital. The years 1725–1733 were

[15] The admission registers of Marseille, Pau, Avignon, and several Languedoc's hospitals do not report statures.

[16] Fig. 8 Appendix A, reports an example of hospital entry register.

[17] See Fig. 10 Appendix A for the evolution of hospitalizations.

[18] To provide perspective, this corresponds to the annual income of about 200 regular building laborers assuming a 250-day work year and an average daily wage of 0.74 livres tournois per day over the years 1724–33 (Ridolfi 2019).

Table 1 Characteristics of the sample: age distribution by gender and source

MALES			FEMALES		
Age group	Freq	Percent	Age group	Freq	Percent
HOSPITAL					
14–19 years	579	13.61	14–19 years	313	15.58
20–29 years	1693	39.80	20–29 years	555	27.63
30–39 years	713	16.76	30–39 years	344	17.12
40–49 years	468	11.00	40–49 years	242	12.05
50–59 years	380	8.93	50–59 years	203	10.10
Age > 60 years	421	9.90	Age > 60 years	352	17.52
Total	4254	100.00	Total	2009	100.00
PASSPORTS					
14–19 years	96	8.66	14–19 years	46	6.72
20–29 years	406	36.64	20–29 years	320	46.72
30–39 years	385	34.75	30–39 years	218	31.82
40–49 years	140	12.64	40–49 years	65	9.49
50–59 years	58	5.23	50–59 years	25	3.65
Age > 60 years	23	2.08	Age > 60 years	11	1.61
Total	1108	100.00	Total	685	100.00
PRISONS					
14–19 years	35	4.51	14–19 years	55	13.03
20–29 years	296	38.14	20–29 years	123	29.15
30–39 years	203	26.16	30–39 years	96	22.75
40–49 years	126	16.24	40–49 years	74	17.54
50–59 years	79	10.18	50–59 years	47	11.14
Age > 60 years	37	4.77	Age > 60 years	27	6.40
Total	776	100.00	Total	422	100.00

Sources: see text and Appendix A, Section 1

characterized by a budget deficit of about 1900 livres tournois followed by a net balanced position in the years 1734–1744 and a surplus of about 7000 livres in the period 1745–1760.[19] These variations can potentially change the composition of the sample over time, particularly over the decade 1733–44 when the reduction in the revenues possibly sharpened the selectivity issue, a concern that is specifically addressed in Sect. 6.

4.2 Passports

The second set of information comes from the passports for abroad issued by the department of Gironde between 1800 and 1850. Passports were already in use under

[19] The computations are based on data reported in AD Pyrénées-Atlantiques, Controle des recettes et dépenses, H DÉPÔT Bayonne E 54, 1724–1777. See Fig. 11 Appendix A for a visual presentation of the patterns.

Louis XIV, who signed "passports" for French people traveling abroad (transport by sea). The use of passports, however, was formally regulated only under the Revolution and the Empire. According to the decree of 1 February 1792 (art. 5), no one could travel abroad without it. Passports were issued by the prefect of police and renewed at least once a year.[20] The information given typically includes name, surname, age, sex, place of birth, domicile, occupation of the traveler, and sometimes the signature of the passport holder and the witnesses.[21] As established by the imperial decree of July 11, 1810, the passports were issued against payment. Specifically, the price for the passports for abroad was set at 10 francs.[22] Between 1800 and 1889, the department of Gironde issued more than 44,000 passports. Overall, the number of trips much like in the case of hospital admissions changed over time, passing from an average of c. 250 per year before 1815 to an average of about 440 after that date, a trend that can be possibly related to the stabilization of conditions after the Napoleonic wars.[23] Of the total amount of passports released by the Gironde in these years, I focus on the period from the 1800s to the 1870s and, for consistency with the hospital records, I select the subsample of all individuals born in the departments of Pyrénées-Atlantiques and Landes as well as samples from the nearby departments so as to broaden the coverage of the Southwestern area. The dataset includes 1793 individuals born between the 1740s and 1850s (Table 1) accounting for about 20 percent of the total. Height data are measured in centimeters with virtually no rounding. Three groups of travelers emerge from the analysis of the passport records. The first which accounted for the vast majority of passport data was given by people moving to the Americas, especially Southern America (73 percent of the passport sample). These were predominantly semi-skilled and unskilled workers employed in services (28 percent), manufacturing (27 percent), and to a lesser extent agriculture (6 percent). Only a small share came from skilled and high skilled occupations or from the group of agricultural owners (c. 12 percent). The second group, instead, was given by travelers to other European countries (25 percent of the passport sample) while the latter included a limited number of travellers to other continents like Africa and Asia (c.2 percent of the passport sample).[24]

4.3 Prison records

The third source of information is given by the entry records of Bayonne's prison, the so-called *registres d'ecrou*. Each prison had a jail register that contained

[20] For a history of passports, see the classic study by Hartoy (1937).

[21] See Fig. 9 Appendix A for an example of passport records.

[22] The price of inner passports instead was 2 francs while some free passports were released for indigents. For details on the legal framework regulating passports, see the 'Décret impérial (N°. 5729.) concernant la fourniture, la distribution et le prix des Passe-ports et Permis de Port d'armes de chasse. Au palais de Rambouillet, le 11 Juillet 1810.'.

[23] The rise is faster after 1824. Computations are based on data from AD Gironde, Passeports pour l'étranger (1800–1830), 4 M 677 à 4 M 710.

[24] These were mostly unskilled and semi-skilled workers employed in manufacturing and services. Among the travelers to Europe, the share of skilled and high skilled workers was slightly higher (c.18 percent), though.

essential information on the detainees such as age, profession, conviction, date of entry, exit as well as physical characteristics. The organization of departmental prisons in nineteenth-century France stemmed directly from the Revolution with the creation in 1790 of a court of first instance for each arrondissement. District prisons were thus established at each court of first instance. These establishments were of three types, namely the *maisons d'arrêt*, *maisons de correction* and *maisons de justice*. The first (*maison d'arrêt*) hosted defendants waiting for a judgment of the criminal court. The condemned, whose judgment was rendered by the court, were directed to the *maison de correction* while the defendants awaiting trial in the Assize Court (located in the capital of the department) were imprisoned in the *maison the justice*. In this study, I collect information from the prison records of the *maisons de correction* of Bayonne (over the years 1836–1859) and Saint-Palais (1837–1845), the *maison d'arret* of Bayonne over the years 1832–1837 as well as the registers for defendants and accused awaiting interrogation of Bayonne from 1872 to 1887. Height data measured in centimeters for 1,198 prisoners were finally collected (c.13 percent of the sample). Unlike the central prisons which received prisoners sentenced to long-term imprisonment, these prisons were intended for common criminals accused of minor offenses which typically led to imprisonment lasting less than one year.[25] Specifically, one can group offenses into seven main categories: theft, violence, fraud and trade infringement, minor crimes, rebellion, vagrancy, and crimes against morality. Among them, theft ranks first accounting for about 35 percent of total instances, followed by violence (23 percent), trade infringements (c.12 percent), and in about 6 percent of the cases rebellion (mostly to public officials). About 9 percent of the data do not specify the type of offense.

4.4 Description of the data

Overall, the combination of these sources allows the construction of a large dataset including 9254 individuals whose main characteristics by gender and source type are summarized below. In what follows, I concentrate on three attributes that characterize the sample and that were likely to be important determinants of adult height, e.g., age, region of origin, and occupation.

Table 1 shows the age distribution of the sample by source and gender. The sample includes 6138 males of which about 72 percent were aged from their early 20s to late 40s, about 16 percent were older than age 50, while c. 12 percent were less than 20 years old. However, there were differences across sources which reflect the functions performed by various institutions. The hospital sample is more skewed toward older and younger individuals compared to the passports and prison records. The proportion of patients aged more than 49 was about 19 percent compared to about 15 percent in the prison records and about 7 percent in the passports sample. Similarly, the share of males aged less than 20 was close to 14 percent in the hospital sample, about 9 percent in the passport records, and about 4.5 in the prison records.

[25] Including also the cases in which the length of imprisonment is not reported (25 percent), the detention period lasted less than one month in 44 percent of the instances and less than one year in about 70 percent of the cases.

This age distribution suggests that the overwhelming majority (about 80 percent) of male travelers/migrants and prisoners were adults in the age range 20–49. The dataset also includes 3116 females. The age distribution of females chimes well with the male sample though younger and older females were slightly more numerous, accounting for about 13 and 21 percent of the total, respectively. The breakdown of the female sample by source type reveals the same patterns highlighted above for men. Again, the share of female patients aged 50 or more touched c. 28 percent, decreased to about 18 percent in the prison records, and dropped to about 5 in the passports records. Conversely, the share of adults in the age range 20–49 peaked in the passport sample (88 percent), fell to 69 percent among prisoners and decreased further as one considers patients (c.57 percent).

The individuals retained for the analysis were born in the decades between 1640 and 1850. The hospital records include individuals born in the birth cohorts 1640s−1750s; the passport registers in the period 1720s−1850s and the prison registers in the birth cohorts from 1760 to 1850s. The distribution of observations is uneven over time. The sample size is smaller at the beginning and the end of the period: about 90 percent of males and about 87 percent of females were born between the 1680s and 1830s. The number of observations also falls between 1740 and 1770. Despite these sample imbalances, the absolute sample size seems to be large enough for reliable regression estimates over the entire period.

Table 2 describes the dataset in terms of region of origin splitting the sample by source type and gender. Overall, as expected, most individuals came from the department of Pyrénées-Atlantiques, namely over 40 percent of males and about 66 percent of females. The proportion, however, was larger in the prison (91 percent) and passport (69 percent) records while it fell to 25 percent in the hospital sample (Table 2).[26] The overwhelming majority of females again came from the department of Pyrénées-Atlantiques even if in the hospital and prison records the proportion tended to diminish. About 30 percent of males and c.20 percent of females were reported to be from the bordering departments of Landes, Gers, and Hautes-Pyrénées as well as from Haute Garonne, confirming that Bayonne, with its diversified economic structure, was able to attract immigrants from neighboring regions. Overall, almost 80 percent of men and over 90 percent of women were native-born of Southwestern France, the remaining share including foreigners (c.7 and 4 percent of the male and female samples, respectively), other native-born French (14 percent of males and 4 percent of females) and, to a much lesser extent, individuals for which the region of origin was not recorded (less than 1 percent of both male and female samples). As shown in Table 2, the share of natives of Southwestern France decreased to about 70 percent in the sample of male patients and was over 90 percent in the other subsamples for both males and females. Over 40 percent of men and about 50 percent of women were born in urban areas.

Another important issue is the occupational structure of the data. The occupational titles declared by the individuals were classified into groups with the aim to capture the sectoral composition of the workforce as well as the differences in social status. Based on this, I identify six categories: agricultural workers and agricultural

[26] This also reflects the sampling procedure.

owners, manufacturing, high skilled, skilled, and unskilled workers employed in the service sector; workers in the construction sector, poor, and beggars. When no occupational title was reported, this was classified with the label 'NA.' In 227 instances, the occupational status of women was inferred from the occupation of the husband or the father. Overall, work in agriculture accounted for about 30 percent of the full set of recorded male occupations while the share of males engaged in the service sector was almost identical to that in manufacturing (both accounting for over 20 percent of the sample). Women's occupational structure was rather different confirming well known patterns of employment at the time (Poussou 1983). Most females found occupation in the service sector (c.25 percent) followed by manufacturing (c.11 percent) while only a few women declared to be employed in agriculture (c.8 percent). Compared to males, underreporting was much more frequent, mostly because married and young women tended to define themselves in terms of their husband or father's occupational status, especially in the earlier years. Perhaps unsurprisingly, given the nature of the institutions from which the data are drawn, a relatively large share of individuals—corresponding to about 4 percent of the males and close to 7 percent of females—declared to be poor and infirm.[27]

Table 3 also describes the occupational structure of the sample by source type and gender. The hospital and prison records were characterized by a similar sectoral composition of the workforce. Agriculture was the main sector of employment followed by manufacturing and services. The largest share of agricultural workers is found in the prison records (c. 49 percent) while in the hospital sample the proportion is lower (c.33 percent). Employment in manufacturing accounts for about the same proportion (18–23 percent) in both the hospital and prison records while the number of people in the service sector is slightly higher among patients. On the contrary, the passport sample is more skewed toward urban occupations with a neat prevalence of workers employed in the service sector (about 45 percent). The share of workers in manufacturing, accounting for 22 percent of the sample, is comparable to that found in the other sources while agriculture falls to only about 12 percent. The share of poor and wealthy individuals also changes by source type. Hospital records were characterized by a larger share of poor and beggars compared to prison and passports[28] while high skilled workers were more frequent in the passport sample, followed by the hospital and prison records.

For the reasons mentioned above, identifying the occupational status of females starting from this type of record is fraught with difficulties. Nevertheless, it is always possible to find some broad patterns underlying the data. The share of females employed in the service sector was broadly similar across the three source types ranging between 20 (hospital) and 30 percent (passports). Occupational differences were larger in manufacturing and agriculture. Thus, for instance, the percentage of women employed in manufacturing ranged from 4 percent in the hospital sample

[27] Note that in the Middle Ages and early modern period, hospitals played a variety of functions that stretched far beyond the care of sick people including the care of abandoned children as well as the poor and the needy.

[28] No individual from this category is found in the passport records.

Table 2 Characteristics of the sample: region of origin by gender and source

Males			Females		
Region of origin	Freq	Percent	Region of origin	Freq	Percent
Hospital					
Pyrénées-Atlantiques	1061	24.94	Pyrénées-Atlantiques	1241	61.77
Others, France	837	19.68	Landes	309	15.38
Haute Garonne	569	13.38	Haute Garonne	122	6.07
Landes	527	12.39	Others, France	110	5.48
Abroad	443	10.41	Abroad	102	5.08
Hautes-Pyrénées	312	7.33	Hautes-Pyrénées	48	2.39
Gers	193	4.54	Gers	28	1.39
Gironde	176	4.14	Gironde	27	1.34
Others, Southwestern France	108	2.54	Others, Southwestern France	19	0.95
NA	28	0.66	NA	3	0.15
Total	4254	100.00	Total	2009	100.00
Passports					
Pyrénées-Atlantiques	765	69.04	Pyrénées-Atlantiques	422	61.61
Landes	155	13.99	Landes	72	10.51
Hautes-Pyrénées	52	4.69	Gironde	61	8.91
Gers	36	3.25	Hautes-Pyrénées	38	5.55
Others, Southwestern France	27	2.44	Haute Garonne	30	4.38
Haute Garonne	19	1.71	Others, France	16	2.34
Others, France	18	1.62	Gers	14	2.04
NA	14	1.26	Others, Southwestern France	12	1.75
Abroad	11	0.99	Abroad	11	1.61
Gironde	11	0.99	NA	9	1.31
Total	1108	100.00	Total	685	100.00
Prisons					
Pyrénées-Atlantiques	706	90.98	Pyrénées-Atlantiques	384	91
Landes	42	5.41	Landes	15	3.55
NA	11	1.42	NA	15	3.55
Gers	6	0.77	Others, France	4	0.95
Others, France	5	0.64	Others, Southwestern France	2	0.47
Others, Southwestern France	3	0.39	Abroad	1	0.24
Hautes-Pyrénées	2	0.26	Hautes-Pyrénées	1	0.24
Haute Garonne	1	0.13			
Total	776	100.00	Total	422	100.00

Sources: see text and Appendix A, Section 1

to over 20 percent in both prison and passport records. Agriculture was marginal in the hospital and passports samples while it accounted for a large share of female employment in the prison records. As for males, there was a relatively larger share of poor and beggars in the hospital sample than in the other records. The share of high skilled women instead was balanced and extremely low across the three subsamples.

Table 3 Characteristics of the sample: occupational structure by gender and source

Males			Females		
Occupation	Freq	Percent	Occupation	Freq	Percent
Hospital					
Agriculture	1390	32.68	NA	1160	57.74
Manufacturing	987	23.20	Services unskilled	409	20.36
Services unskilled	673	15.82	Beggar, poor, infirm	204	10.15
NA	450	10.58	Manufacturing	78	3.88
Construction	299	7.03	Agriculture	54	2.69
Beggar, poor, infirm	211	4.96	Services skilled	51	2.54
Services high skilled	137	3.22	Construction	32	1.59
Services skilled	105	2.47	Services high skilled	21	1.05
Agricultural owner	2	0.05			
Total	4254	100.00	Total	2009	100.00
Passports					
Services unskilled	342	30.87	NA	264	38.54
Manufacturing	250	22.56	Manufacturing	187	27.30
NA	130	11.73	Services unskilled	177	25.84
Construction	91	8.21	Services skilled	28	4.09
Services skilled	85	7.67	Agricultural owner	10	1.46
Agriculture	80	7.22	Agriculture	9	1.31
Services high skilled	73	6.59	Services high skilled	7	1.02
Agricultural owner	57	5.14	Construction	3	0.44
Total	1108	100.00	Total	685	100.00
Prisons					
Agriculture	377	48.58	Agricultural owner	118	27.96
Manufacturing	141	18.17	Manufacturing	91	21.56
Construction	79	10.18	Agriculture	73	17.30
Services unskilled	77	9.92	Services unskilled	66	15.64
Agricultural owner	33	4.25	NA	33	7.82
Services skilled	32	4.12	Services skilled	27	6.40
NA	19	2.45	Beggar, poor, infirm	11	2.61
Beggar, poor, infirm	12	1.55	Services high skilled	2	0.47
Services high skilled	6	0.77	Construction	1	0.24
Total	776	100.00	Total	422	100.00

Sources: see text and Appendix A, Section 1

4.5 Selectivity issues

The complexity of the populations considered in the analysis makes it difficult to draw inferences on the stature of the population at large as various characteristics of interest such as age, origin, and occupation can be distributed quite differently in the sample compared to their actual distribution in the population. For instance, while in recent years, prison data have proved to be a valuable source of historical height data, anthropometric scholars typically acknowledge that prison samples are not representative of the wider population as they tend to be biased toward the working classes (Komlos 2003). Furthermore, if the poorer and the sick needy are shorter and more likely to enter the hospital, the average terminal heights would be downward biased. Similarly, travelers are unlikely to have been representative of the whole population if migration flows were characterized by positive or negative selection.[29]

In this paper, the issue of selectivity is not addressed directly as, unfortunately, we have little quantitative evidence to tell how individuals for which height is observed differed from the population at large. The issue is complicated further by the fact that the time span considered in this study is wide and likely to be characterized by changes in the occupational and demographic structure which make it implausible to rely on mid-nineteenth century data to re-weight the sample so as to make its composition resemble the broader population. Despite that, at least two steps can be taken in order to mitigate concerns about selectivity issues. The first is a preliminary discussion of the likely direction of the bias contained in the sources while the second is the implementation of some sensitivity analysis.

To begin with, it is useful to identify the direction of the bias by looking at official statistics. Specifically, I compare the occupational structure of the height sample with analogous information from the city of Bayonne, the department of the Pyrénées-Atlantiques (from which most data originate together with Landes), and the overall Southwestern area. The first is meant to capture a pure urban milieu while the second and the third offer fairly accurate pictures of the population means.[30] One limitation of this exercise is that comparisons are made relying on a few points in time. The population census of Bayonne indeed refers to 1730 while the other statistics refer to 1851.

Table 4 summarizes the results of this comparison. In the department of the Pyrénées-Atlantiques and more generally in the overall Southwestern area, agriculture is, by far and large, the most important sector of employment, averaging above 60 percent for males and over 80 percent for females while it falls to a negligible share when one considers the population of Bayonne. However, employment in agriculture accounts for about 32 percent of the height sample with differences across sources as already mentioned above. Manufacturing and the service sector together account for about 47 percent of the total in the male height sample, over 70 percent in the Bayonne census but only 25 percent in the entire Southwestern area. If one excludes the instances in which occupation is unknown, this proportion becomes even higher

29 Previous research on Swiss and US passport applicants suggests these were taller than average (Koepke et al. 2018; Sunder 2011). Koepke et al. (2018) argue that at least part of the positive selection in the passport sample can derive from the fact that applicants had to pay an issuing fee. In France, the cost of passports for abroad seems to have been relatively low (10 francs) corresponding to about 7 working days of a male building laborer and c. 4.5 days of a building craftsman (based on the average wages for the period 1810s-1850s computed using data from Ridolfi 2019).

30 Note that population censuses are often fraught with difficulties especially when it comes to count female occupations.

for females: about 70 percent in the height sample, about 84 in the Bayonne census, and only 13 percent in the 1851 occupational census.

As a second step, to test the representativeness of the data, I compare the height sample with information drawn from death and marriage records. To be sure, one cannot rule out the possibility that these sources, in turn, are affected by selection problems since marriage and mortality patterns could have been correlated with other economic factors. However, these kinds of records constitute the most important demographic source for the pre-industrial period and are particularly useful for our purposes because they provide continuous information on the occupation and skill of individuals across various birth cohorts. This allows me to draw information on the average composition of the workforce over a long time span rather than a single year as is the case of census records. The new information gathered from marriage and death records refers to about 9800 individuals born between the 1640s and the 1840s. Since most of the height data come from Bayonne and its surrounding area, I drew upon the parishes of this city to provide continuity in the source-producing institutions and compare the characteristics of the individuals in the two samples. About 30 percent of the data come from individuals born in rural areas aged, on average, 37 if males and 31 if females. As shown in Table 4, male employment in agriculture accounted for about 23 percent of the sample, slightly less than in the height dataset (32 percent). The shares of manufacturing and services instead are broadly similar across the two samples. Perhaps unsurprisingly, the height sample includes a higher proportion of poor and infirm. As for females, the main difference lies in the relative weight of agriculture: about 27 percent in the marriage/death sample against only c.9 in the other. Furthermore, manufacturing and services together account for over 20 percent of the sample compared to about 35 percent in the height data. The shares of underreporting instead are similar.

In sum, these comparisons suggest that the occupational structure of the height sample underestimates employment in agriculture and is intermediate between a pure urban milieu dominated by services and manufacturing and the regional averages where employment in agriculture is overwhelming. This 'mixed scenario' is not surprising if one considers the type of institutions and the context from which our height data originate. Saint-Léon hospital and Bayonne's prison, indeed, were urban institutions. However, they hosted people from the surrounding area, thus creating an interesting stratification of the sample. Furthermore, a comparison with marriage and death records suggests similar results in terms of occupations, especially for males.

5 Heights in Southwestern France

5.1 Methodology

Four regression models including controls for age, birth year, occupation, and region of origin were run to estimate male and female adult terminal heights. The categories are those illustrated in the tables before. All model specifications also include

Table 4 Occupational structure from the 1730 and 1851 population censuses and a sample of marriage and death records

	1730 CENSUS Bayonne (intra muros)	1851 CENSUS Pyrenées-Atlantiques	1851 CENSUS Southwestern France	MARRIAGE/DEATH RECORDS Bayonne
MALES				
Agriculture	4.54	66.66	64.91	22.42
Manufacturing	35.03	15.82	15.86	29.06
Construction	11.90	5.78	5.29	17.50
Services	48.24	10.09	12.50	26.40
Poor, infirm	0.28	1.65	1.44	0.11
NA				4.50
Total	100.00	100.00	100.00	100.00
Observations	1764	155,438	1,387,543	7336
FEMALES				
Agriculture	2.16	82.56	83.72	26.97
Manufacturing	41.62	0.34	1.26	11.64
Construction	8.11			1.66
Services	45.40	13.45	12.07	9.75
Poor, infirm	2.70	3.65	2.94	0.20
NA				49.78
Total	100.00	100.00	100.00	100.00
Observations	185	105,870	928,820	2,525

Source: 1730 census, elaborations from Iglesias (2000a; b); 1851 census, elaborations from Statistique Générale de la France; marriage/death records, see Appendix A

dummies for individuals born in an urban area,[31] a control to account for all individuals whose height in the hospital registers of 1730–50 was extremely short compared to the average height-by-age profile, as well as a dummy to account for rounding of female statures in the hospital entry registers of 1750–1762. The reference category is an adult (individual aged 25–49) employed in agriculture born in the department of Pyrénées-Atlantiques in the decade 1840–49.

As shown above, a non-negligible share of the data, accounting for about 18 percent of the population, was older than 50 years in our sample.[32] Discarding this set of data involves a large loss of information, especially for the earlier decades for which the average age was above 50 years. Therefore, following Morgan (2009) and Prince and Steckel (2003), I adjust heights for the decline in stature using the coefficients for age-related shrinkage estimated by Cline et al. (1989) and Chandler and Block (1991) using longitudinal data. The use of these data indeed allows to follow

[31] The urban dummy takes value one for cities with 5000 inhabitants or more in 1800 and zero otherwise. The city size is based on Bairoch, Batou, and Chèvre (1988).

[32] See Appendix B for a detailed analysis of the height-by-age profile.

individual subjects over time and thus makes it possible to compute individual rates of shrinkage net of confounding effects typical of cross-sectional data. What emerges from these studies is that the rate of shrinkage was linear and the cumulative effect fitted a polynomial trend.[33] Based on these results, I adjust heights for those aged more than 40 years. I then use the original dataset and the two adjusted samples in height regression models to examine the evolution of the average terminal height in Southwestern France between the 1640s and 1850s. Model 1 reports the coefficients using the sample of those aged 14 years and older with no adjustment for shrinkage. Models 2 and 3 report the coefficients based on the population aged 14 years and older with heights adjusted to account for shrinking based on Cline et al. (1989) and Chandler and Block (1991), respectively. Finally, Model 4 fits the same regression model with no adjustment for the decline in stature with age but restricts the sample to the age range 20–59 years.

5.2 Results

In examining the factors underlying height differences, what emerges is a distribution of heights by occupation with differences between sexes (Table 5). As expected, high skilled workers employed in the service sector stand at the top of the male height distribution, being about 2.3 cm taller than agricultural workers, the reference group. These were followed by skilled workers in the service sector and agricultural owners, respectively. The former were, on average, 1.9 cm taller than the reference group while the latter 1.2 cm. These differences were statistically significant at conventional levels across various model specifications (Table 5). Workers employed in the construction sector and unskilled workers in the service sector were also significantly taller than the reference group although the size of the premium, on average, was lower than for the categories mentioned above (about 1 cm). Male workers employed in manufacturing were also taller than their male counterparts in agriculture (0.37–0.30 cm). At the bottom there were poor and paralytics who were between 1.3 and 1.9 cm shorter than the reference group. When considering females, the situation appears rather different, though. There are no statistically significant differences between women in terms of occupations except for the poor and infirm who were significantly shorter than the reference group (between 1.5 and 1.8 cm). This result possibly reflects the low degree of specialization of female employment in an area where most females were employed in agriculture, or in the service sector and manufacturing as unskilled workers. The thin sample size for some highly skilled occupational titles also implies that results can be possibly driven by a few outliers.

[33] Cline et al. (1989) proposed the following adjustment for height by age for men and women, respectively: $h_{am} = h_m + 3.277 - 0.165(\text{age}) + 0.002(\text{age})^2$,$h_{af} = h_f + 5.138 - 0.234(age) + 0.003(age)^2$while Chandler and Block's (1991) study implies the following adjustment for men $h_{am} = h_m + 0.064(age - 40)$ $+0.0017(age - 40)^2$ and this for women: $h_{af} = h_f + 0.062(age - 40) + 0.0024(age - 40)^2$ where h_{am} is maximum male stature, h_{af} is maximum female stature, h_m and h_f are male and female heights.

The regression table also provides insights into average differences in stature across space. The coefficients on the region of origin reveal few differences between male individuals born in the Pyrénées-Atlantiques, the reference case, and those from neighboring areas. With respect to the reference department, the range of variation is comprised between minus 0.5 and plus 0.2 cm. The shorter males came from Gers and Landes and the taller ones from Hautes-Pyrénées and Haute Garonne even if the coefficients on the two latter departments are not statistically significant. Even if the sample mostly draws upon the Pyrénées-Atlantiques, owing to the few spatial differences between this department and its neighboring areas, these results appear to provide a fairly good picture of the entire Southwestern area. Height differences are much larger and statistically significant when one compares male individuals born in the Pyrénées-Atlantiques with foreigners and French individuals born outside the Southwestern region. Men born abroad were about 2 cm taller than the reference case. This height premium was seemingly the result of the large share of mariners and soldiers among foreigners. Similarly, French individuals born outside Southwestern France were significantly taller than their counterparts born in this area of France (0.6 cm on average). This result can reflect both the lower nutritional status of Southwestern individuals and the fact that those who self-selected to migrate were generally taller than the population (Humphries and Leunig 2009; Koepke et al. 2018). To a large extent, regional patterns in female statures resemble those of their male counterparts. Again, within the region, the shorter people come from Landes and Gers, the tallest ones from Hautes-Pyrénées and Haute Garonne and Gironde while those born abroad and in other parts of France enjoy a statistically significant height premium over the reference group.

The results of Table 5 also show that the urban dummy is never statistically significant across various model specifications. As already pointed out by Weir (1993), urbanization acted as a ‘two-edged sword’ which on the one hand enhanced child nutrition by raising employment opportunities in higher-paying and less calorie-demanding occupations and on the other taxed nutrients by raising the incidence of disease, especially in the largest congested urban settings. Evidence from nineteenth century France indicates that urbanization worsened nutrition and health, particularly in the largest cities like Paris (Komlos 2003; Postel-Vinay and Sahn 2010). Living in an urban area of Southwestern France, however, does not seem to confer a statistically significant penalty in terms of stature over rural dwellers, seemingly reflecting the low degree of urbanization of this region.

The coefficient on the dummy for stunting reveals that on average malnourished individuals were between 16 and 18 cm shorter than average either for males or females, e.g., about 11 percent shorter than average.[34] Finally, the dummy on height heaping reveals that the size of rounding on average corresponds to an upward bias of around 4 cm.

[34] The average terminal height was around 165 cm for males and 155 cm for females.

Table 5 Regression of the height in Southwestern France, 1640–1850

	MALES				FEMALES			
	Model 1: Age + 14	Model 2: Age + 14, Cline et al.'s (1989) adjustment	Model 3: Age + 14, Chandler and Block's (1991) adjustment	Model 4: Age 20–59	Model 1: Age + 14	Model 2: Age + 14, Cline et al.'s (1989) adjustment	Model 3: Age + 14, Chandler and Block's (1991) adjustment	Model 4: Age 20–59
Occupation								
Agricultural owner	1.21***	1.20***	1.21***	0.89**	– 0.80	– 0.79	– 0.77	– 0.86
Poor, infirm	– 1.28***	– 1.31***	– 1.32***	– 1.85***	– 1.57**	– 1.69**	– 1.75***	– 1.51**
Construction	1.17***	1.15***	1.14***	0.88***	0.38	0.34	0.31	0.47
Manufacturing	0.40**	0.40**	0.40**	0.37*	– 0.37	– 0.38	– 0.39	– 0.50
NA	– 0.09	– 0.11	– 0.11	0.08	– 0.89*	– 0.88*	– 0.88*	– 0.86
Services high skilled	2.30***	2.31***	2.32***	2.17***	– 0.27	– 0.31	– 0.39	– 0.76
Services skilled	1.88***	1.87***	1.87***	1.83***	– 0.01	0.03	0.04	0.21
Services unskilled	1.05***	1.04***	1.04***	0.96***	– 0.60	– 0.60	– 0.61	– 0.61
Age								
14	– 18.77***	– 18.76***	– 18.79***		– 7.84***	– 7.71***	– 7.67***	
15	– 15.06***	– 15.06***	– 15.09***		– 6.92***	– 6.73***	– 6.66***	
16	– 8.40***	– 8.40***	– 8.43***		– 5.47***	– 5.31***	– 5.27***	
17	– 6.86***	– 6.87***	– 6.90***		– 2.61***	– 2.49***	– 2.46***	
18	– 3.60***	– 3.61***	– 3.63***		– 1.40***	– 1.27***	– 1.23***	
19	– 2.87***	– 2.87***	– 2.90***		– 0.78	– 0.67	– 0.64	
20	– 2.09***	– 2.09***	– 2.12***	– 2.10***	– 0.53	– 0.42	– 0.39	– 0.70
21	– 1.84***	– 1.85***	– 1.88***	– 1.86***	– 0.86***	– 0.77***	– 0.75***	– 1.05***
22	– 1.17***	– 1.17***	– 1.20***	– 1.18***	– 0.89***	– 0.82***	– 0.81***	– 0.82***
23	– 0.50*	– 0.51**	– 0.53**	– 0.53**	– 1.03	– 0.98	– 0.97	– 0.87
24	– 0.89***	– 0.90***	– 0.93***	– 0.88***	– 1.02**	– 0.97*	– 0.96*	– 1.01**

Table 5 (continued)

	MALES				FEMALES			
	Model 1: Age + 14	Model 2: Age + 14, Cline et al.'s (1989) adjustment	Model 3: Age + 14, Chandler and Block's (1991) adjustment	Model 4: Age 20–59	Model 1: Age + 14	Model 2: Age + 14, Cline et al.'s (1989) adjustment	Model 3: Age + 14, Chandler and Block's (1991) adjustment	Model 4: Age 20–59
50–59	– 0.37	0.00	0.64***	– 0.21	0.61**	0.76***	1.46***	0.56*
Age > 60 years	0.34	1.65***	2.78***		– 0.19	1.14*	2.60***	
Region of origin								
Abroad	2.08***	2.09***	2.09***	1.96***	0.83***	0.79***	0.77***	1.12***
Gers	– 0.51***	– 0.52***	– 0.52***	– 0.49***	0.15	0.12	0.09	– 0.96***
Gironde	– 0.21*	– 0.21*	– 0.22**	– 0.28**	0.92*	0.83*	0.74*	0.95**
Haute Garonne	0.06	0.09	0.09	– 0.13	0.00	0.06	0.05	0.48***
Hautes- Pyrénées	0.22	0.22*	0.20	0.12	1.64***	1.63***	1.61***	1.91***
Landes	– 0.36***	– 0.34***	– 0.34***	– 0.40***	0.08	0.07	0.06	– 0.00
NA	– 0.55***	– 0.54***	– 0.52**	– 0.63***	1.25***	1.37***	1.44***	1.67***
Others, France	0.60**	0.59**	0.58**	0.58**	1.74***	1.72***	1.70***	2.22***
Others, SW France	– 0.47	– 0.51	– 0.54*	– 0.93***	0.79	0.77	0.76	0.54
Urban								
Urban dummy	0.06	0.06	0.05	0.11	– 0.22	– 0.20	– 0.20	– 0.13
Stunting								
Height (1730–50)	– 18.27***	– 18.28***	– 18.28***	– 18.10***	– 16.64***	– 16.69***	– 16.71***	– 15.16***
Rounding of female heights								
Height (1750–62)					3.67***	4.15***	4.36***	4.39***
Constant	164.99***	165.01***	165.03***	164.54***	155.18***	155.06***	155.04***	153.62***
Birth year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 5 (continued)

	MALES				FEMALES			
	Model 1: Age + 14	Model 2: Age + 14, Cline et al.'s (1989) adjustment	Model 3: Age + 14, Chandler and Block's (1991) adjustment	Model 4: Age 20–59	Model 1: Age + 14	Model 2: Age + 14, Cline et al.'s (1989) adjustment	Model 3: Age + 14, Chandler and Block's (1991) adjustment	Model 4: Age 20–59
Observations	6,121	6,121	6,121	4,940	3,079	3,079	3,079	2,291
R– squared	0.37	0.37	0.38	0.19	0.24	0.24	0.27	0.17

Source: see text. *Note*: Model 1 includes the full sample with no adjustment for ageing; Models 2 and 3 adjust the full sample for aging based on Cline et al. (1989) and Chandler and Block (1991), respectively. Model 4 restricts the age range to 20–59 years. Standard errors are clustered at the department level. Significance levels are: ***$p<0.01$. **$p<0.05$. *$p<0.1$

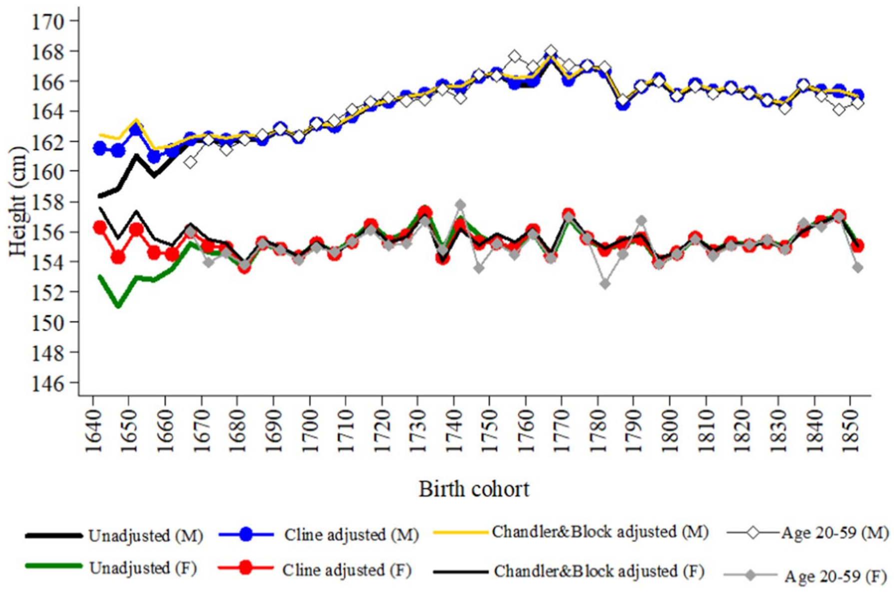

Fig. 2 Heights in Southwestern France, 1650–1850. *Source*: see text. Table 2 the estimated mean heights are based on the regression models illustrated in Table 5. See text for details. In the figure legend, 'M' stands for males and 'F' for females

Figure 2 compares the height patterns derived from the various specifications presented in Table 5. From Model 1, which uses the full sample of individuals aged 14 and over with no adjustment for shrinkage, male height increases sharply between about 158 and 166 cm from the 1640s to the 1750s-1760s and then begins to decline afterward averaging about 165 cm in the 1850s. The estimated female height based on Model 1 instead rose from about 153 cm in the 1640s to 157 cm in the 1730s, declined to 154 cm in the 1790s, and increased to peak at about 156 cm in the 1840s.

Model 2 reports the estimated coefficients for males and females, respectively, obtained using the sample corrected for the age-related shrinkage based on Cline et al.'s (1989) method. Estimates are almost identical to the previous models from the 1660s onwards, but the effect of the correction is to raise (on average) the estimated male height by about 2.2 cm and female height by about 2.9 cm for those born prior to the 1660s. Similarly, Model 3 corrects heights for shrinkage following Chandler and Block's (1991) approach. This correction procedure implies an even higher upward revision in average terminal height for the birth cohorts of 1640-1660s, namely about 3 cm for males and 4 cm for females. Finally, restricting the age range to 20–59 years (Models 4 and 8), reassuringly, has no bearing on the height pattern of the cohorts born after the 1660s. However, this restriction produces somewhat more erratic patterns and does not allow to go back to 1640 because those aged more than 60 years are now excluded. In what follows, I will use Model 2 reported in Table 5 as the baseline specification.

6 Exploring height data

This section aims to check the reliability of the previous results. Specifically, I seek to answer the following questions. First, how much does source composition affect the results? Second, are the estimates driven by changes in the structure of the workforce, particularly at the top and the bottom of the distribution? Third, how much recidivism can bias the estimates? Fourth, are the male and female height series affected by the composition of the sample in terms of region of origin? Finally, are the level and trend predictions comparable to previous anthropometric literature dealing with France?

6.1 Source composition

Previous results were obtained by pooling the three sources together. This approach allows to estimate continuous series of male and female heights spanning two centuries while accounting for the potential confounding factors affecting the data as well as other issues. Nevertheless, one natural question is the extent to which results are driven by the composition of heterogeneous sources. Anthropometric scholars typically acknowledge that prison samples are not representative of the wider population (Komlos 2004) as they usually tend to be biased toward the working class. Similar considerations can be applied to hospitals, especially if one considers the multifaceted role played by these institutions in the pre-industrial period during which they were not only healthcare institutions but also provided shelter to unemployed and beggars (Gutton 1974). Passport records, on the contrary, are more likely to contain wealthy people who were able to travel across country boundaries (López-Alonso 2007). Furthermore, different sources might be characterized by different selectivity mechanisms. For instance, evidence suggests that people are more likely to commit crimes and migrate in times of hardship (Bodenhorn et al. 2012), but the magnitude of the response is unlikely to be the same. Overall, pooling can potentially bias the estimates if the sources present different characteristics and the share of the sample in each year from each source changes over time (Cinnirella 2008).

To address these concerns, I use a two-step procedure. To begin with, I compare the baseline series obtained using the full sample with the raw average stature by subsample and gender for the age class 20–60 for which growth and shrinking of stature is less than a problem. The results are shown in Fig. 3. A distinction should be made between the trend and level of heights. As for the trend in statures, what emerges is a broad agreement between the baseline and the source-specific series, suggesting that the combination of different sources does not affect the general evolution of statures. It is also instructive to notice that the raw averages by source are affected by several problems as is evident by the sharp rise in average terminal stature of females in the decades 1730–1750. As already pointed out in the previous sections, this depends on the consistent heaping of female statures in the hospital records over these years. In terms of levels, the results chime well with the expectations derived from previous literature. Male heights from passports are generally higher than those derived from prison records. Females' statures, instead, appear to be broadly similar across different sources. This result is consistent with the occupational structure by gender of the passport sample which shows a much larger share of unskilled workers among females than males.

As a second step, I fit source-specific regressions and compare the level and trend predictions with the baseline model. One advantage of using source-specific regressions is that they allow to account for various sources of heterogeneity affecting the data as well as some source-specific patterns that cannot be accounted for by the raw averages. The three source-specific regressions thus contain the same set of covariates as the baseline model plus a group of source-specific regressors. As already pointed out in Sect. 3, the analysis of the passport's records, for instance, reveals that migration flows starting from the port of Bordeaux varied in intensity. This is a factor that can potentially affect the composition of the sample. In particular, the number of passports increased after 1825. To account for this pattern, the regression includes a period dummy taking value one if the register is dated 1826 or later. Similarly, in the decade 1734–1744, the number of hospitalizations falls as well as the total revenues accruing to the hospital. This reduction in the number of patients that could be cared for by the hospital could possibly affect the estimates as well. Again, to account for this pattern I include a period dummy for this decade. The hospital regression also controls for the health status of patients while in the passport sample, I control for the destination of travelers.[35] As in the baseline model, these source-specific regressions have been run on the population aged 14 and plus. To account for late shrinking, statures are adjusted using Cline's approach while age dummies are included to control for age effects of individuals who still had not reached maturity. I set the same base cases as the models presented in Table 5, e.g., a rural agricultural worker aged 25–49 born in the Pyrénées-Atlantiques. Figure 4 compares the estimates of the baseline model with those of the source-specific regressions. Three points emerge. First, the source-specific regressions correct the problems highlighted by the raw averages, particularly the height heaping of female statures and the presence of some outliers. Second, except for some short-term differences possibly related to source-specific issues, the baseline model and the source-specific regressions predict similar height developments in the long run. Yet, the baseline is less volatile than the source-specific series suggesting that the quality of the fitting tends to improve when more information is properly used to predict average values. Finally, the series are broadly consistent in terms of levels. In particular, the male heights from passports are close to the baseline and generally lower than the raw average shown in Fig. 3 (green scatter). This suggests that the raw average stature of male travelers was upward biased due to oversampling from services and manufacturing.

6.2 Changes in the occupational structure

All model specifications presented in Table 5 take into account differences in occupation. Still, there could be concerns related to changes in the occupational

[35] I also controlled for the type of offense in the prison sample, but the variable was not statistically significant, so I opted for the more parsimonious specification.

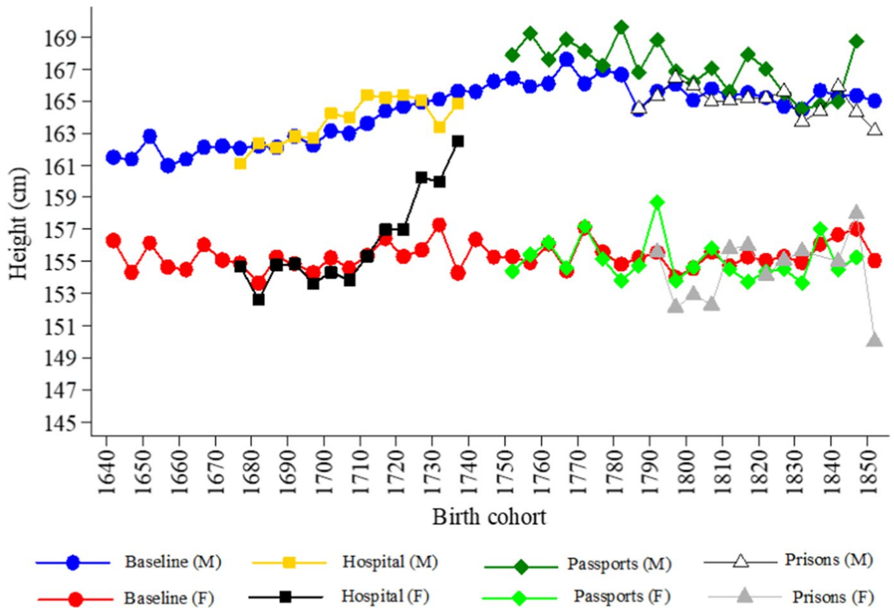

Fig. 3 Comparison of the benchmark model with the raw averages by source-type. *Source*: see text. *Note*: 'Baseline' shows the regression estimates of Model 2 Table 5, fitted on the full sample (5-year average). The series 'Hospital', 'Passports', and 'Prisons' are 5-year raw averages. In the figure legend, 'M' stands for males and 'F' for females

structure of the sample. For instance, the share of poor tends to decrease over time passing from about 9 percent prior to 1760 to about 1 percent thereafter.[36] Thus, if these individuals are shorter than average as shown in regression Table 5, then there could be an artificial increase in average stature induced by selectivity issues or source composition rather than a genuine change in the structure of the workforce. Similar considerations can be extended to the top of the distribution as the share of wealthy people increases over time (from about 3 percent prior to 1760 to about 10 percent thereafter).[37] Again this pattern can reflect both an effective increase in the specialization of the workforce and changes in the composition of the sources, particularly passports, which tend to be biased toward wealthy people compared to prison and hospital records. Importantly, the shares of workers employed in agriculture, manufacturing, construction, and services (unskilled) remain broadly similar suggesting that changes mostly take place at the top and at the bottom of the occupational structure.

Ideally, one should account for these sample imbalances by relying on post-stratification procedures which allow to reweight the sample by occupation looking at sectoral weights derived from the population (typically census data). However, this approach is unfeasible in this context given the absence of precise information on

[36] These figures exclude individuals for which no occupation is reported.

[37] This includes high skilled workers in services and agricultural owners.

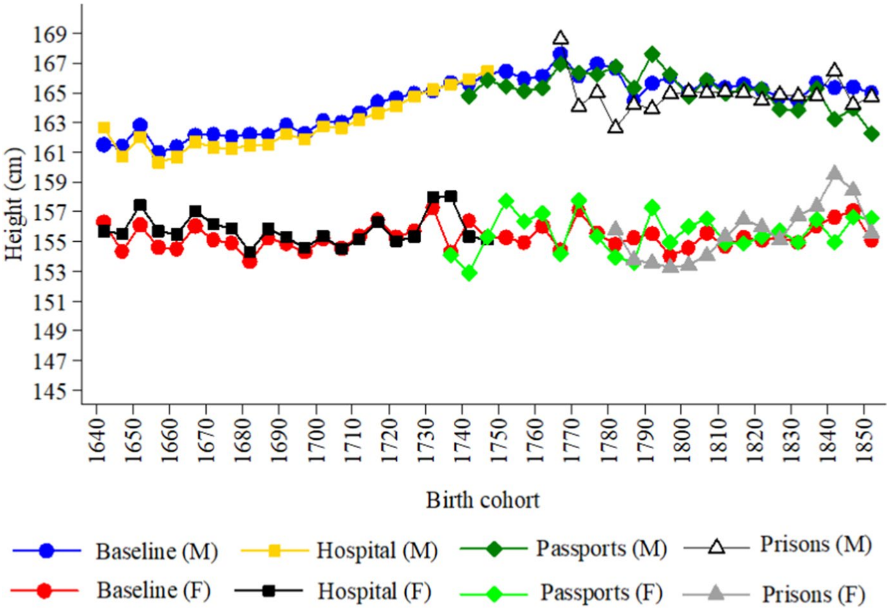

Fig. 4 Comparison of the benchmark model with the source-specific regression models. *Source*: see text. *Note*: In the figure legend, 'M' stands for males and 'F' for females. All series are 5-year averages. 'Baseline' shows the regression estimates of Model 2 Table 5, fitted on the full sample. 'Hospital' stands for the regression estimates of Model 2 Table 5 plus source-specific controls (see text), fitted on the subsample of patients; 'Passports' stands for the regression estimates of Model 2 Table 5 plus source-specific controls (see text), fitted on the subsample of travelers; 'Prisons' stands for the regression estimates of Model 2 Table 5, fitted on the subsample of prisoners

the changes in the sectoral composition of the workforce over time. To account for these factors, thus I rely on an alternative procedure, namely I fit the baseline regression model on the reduced sample excluding poor and beggars as well as the more affluent individuals (agricultural owners and high-skilled services) and then compare the results with the baseline regression model. Reassuringly, as shown in Fig. 5, the main patterns remain unaltered suggesting that the pooled regression framework properly addresses the occupational imbalances characterizing the sample.

6.3 Recidivism

A third issue is related to recidivism. Recent anthropometric research based on the study of prison records has shown that recidivism rates are a particular issue of concern in the analysis of height developments (Depauw 2020; Fyson and Fenchel 2015). Some institutions indeed came in contact with the same individuals more than once for short time periods. If the group of recurrent individuals was shorter or taller than the average population, recidivism can lead to bias in the estimates. For instance, using a sample of more than 27,000 individual admissions to Belgian prisons in the nineteenth century, Depauw (2020) shows that recidivists formed a specific subset of the prison population whose characteristics differed from the

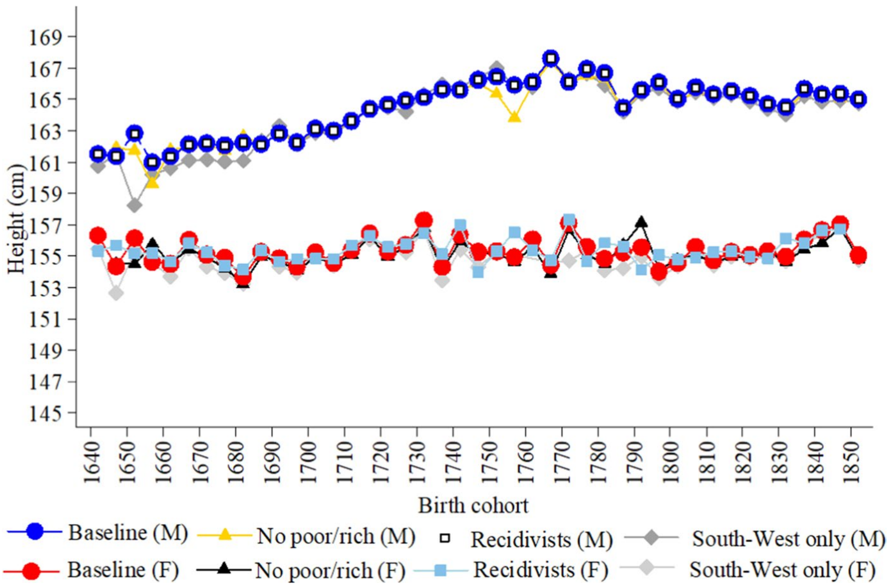

Fig. 5 Comparison of the benchmark model with alternative specifications. *Source*: see text. *Note*: In the figure legend, 'M' stands for males and 'F' for females. All series are 5-year averages. 'Baseline' shows the regression estimates of Model 2 Table 5, fitted on the full sample. 'No poor/rich' shows the regression estimates of Model 2 Table 5, fitted on the subsample excluding poor and high skilled workers in the service sector; 'Redicidivists' shows the regression estimates of Model 2 Table 5, but controlling for recidivism; 'South-West only' shows the regression estimates of Model 2 Table 5, fitted on the subsample of individuals born in the Pyrénées-Atlantiques and its bordering departments, e.g., Landes, Gers, and Hautes-Pyrénées

prison population as well as the population at large. A detailed comparison of recidivists and nonrecidivists, indeed, reveals that male recidivists were predominately low-wage workers shorter than the average prisoner while most female recidivists were drawn from low-skilled workers and were taller than one-time offenders. Other studies based on prison records acknowledge the possible bias induced by the presence of prisoners with multiple incarcerations but generally find that the share of recidivism is rather limited.[38] These findings have consolidated the view that the incarcerated population as a whole was not a special criminal underclass. Yet, little is known about the phenomenon of recidivism in other contexts. The hospital and passport records, however, could be affected by similar problems if the same people were hospitalized more than once or traveled several times, for instance, for business reasons.

[38] Ó Gráda (1991) in his study of Irish prisoners found that the majority of prisoners was admitted only once while Riggs (1994) in his analysis of Scottish prisons found that 86 percent of the prisoners were either first or second offenders. In addition, Inwood et al. (2015) find that about 77 percent of prisoners were convicted just once in a nineteenth-century Tasmanian sample. Similarly, Nicholas (1988) in his study of the British convicts transported to the Australian penal colonies found that most inmates were first-time or single-time offenders.

In the dataset analyzed in this study, the share of recidivists corresponds to 3.5 percent of the overall sample equivalent to 160 individuals of which 53 were women. Instances of recidivism, here intended as people being imprisoned, hospitalized, or traveling more than once were found in all source types but in different proportions. About 80 percent of recidivists come from the hospital sample, followed by passports (c.15 percent) and prison records (c.5 percent). Cases of recidivism ranged from one reiteration (18 individuals) to a single instance of four reiterations, e.g., the case of Jules Durruty a merchant of Bayonne, aged 32 at the time of the first trip in 1851 who appears other three times in the following years (1852, 1855, and 1856). The overwhelming majority of individuals (about 80 percent of the sample of recidivists) reiterated twice. These proportions should be interpreted with care as, in some instances, potential disambiguation problems make it difficult to identify the same individual over time. Nevertheless, they should unveil the main traits and the order of magnitude of the phenomen of recidivism. In terms of occupations, it can be observed that most male recidivists were employed in agriculture and manufacturing consistent with the general structure of employment of the sample. Among females, there is a large proportion of poor, beggars, and infirm recidivists (15 percent) as well as a large share of individuals for which occupation is not reported.

Several approaches have been used in the literature to deal with recidivism (Hans de Beer 2010; Baten and Murray 2000; Tatarek 2006). Here, I re-fit the baseline regression model now controlling for recidivism by the inclusion of a dummy which takes value one if an individual is recidivist and zero otherwise. The dummy on recidivism is positive but not statistically significant for males while for females the coefficient is negative and statistically significant at conventional levels. In particular, it appears that female recidivists were 0.62 cm shorter than the average female. This difference is likely to reflect the fact that most female recidivists were drawn from the poor and beggars. This result differs from the evidence on Tasmanian recidivists analyzed by Inwood et al. (2015) who find that female recidivists did not differ from the prison population while their male counterparts were consistently shorter on average. Figure 5 also compares the baseline specification with the model which controls for recidivism. The results reassuringly confirm similar levels and trend predictions for both males and females.[39]

6.4 Region of origin

As shown in the previous sections, the height sample is heterogeneous in terms of region of origin. While most individuals come from Southwestern France, a non-negligible share, accounting for about 8 percent of the sample, originates from other areas of France as well as from abroad. These individuals tended to be taller and sometimes much taller than average as shown by the regression coefficients of

[39] As a further check, I fit the baseline regression model by dropping all recidivists. I reached similar conclusions. Regression coefficients are not reported but results are available upon request from the author.

Table 5. Thus, in this section, I test whether the presence of this specific subsample of the population as well as changes in its composition and relative numerosity can affect height trends. In order to test this argument, I fit the baseline regression model on the reduced sample of heights including only those individuals that were born in the Pyrénées-Atlantiques and its bordering departments, e.g., Landes, Gers, and Hautes-Pyrénées. Figure 5 shows that results are not substantially altered when using the restricted sample.

6.5 Comparison with other studies

A final issue refers to the representativeness of the series and how they compare to previous literature. Figure 6 seeks to address this concern by comparing the male series with the available estimates from other scholars.[40] Two interesting patterns emerge. First, the height development in Southwestern France was broadly similar to the long-term pattern highlighted by Komlos (2003) and Weir (1997) for France using military records. This is an important result because it suggests that improvements in nutritional status were fairly widespread across France between the mid-seventeenth and the mid-eighteenth centuries as well as in the post-revolutionary phase. This evidence also chimes with the French GDP per capita estimates provided by Ridolfi and Nuvolari (2021) which imply a sustained growth in output per capita during the seventeenth and the early decades of the eighteenth century, the same years in which statures grew more. Conversely, between c. the 1720s and the French Revolution, output per capita fluctuated without trend or slightly declined. The slower pace of economic growth also affected, with some delay, the nutritional status of the cohorts born in the second half of the eighteenth century as suggested by the decline in adult stature. Second, the level of heights in Southwestern France is quite consistent with analogous evidence for the same area (Fig. 6). The scattered estimates provided by Angeville (1836) and Villermé (1829) for the military recruits born over the revolutionary phase fit fairly well with the predictions of our series. Similarly, the data from the Statistique Générale de la France have an almost perfect matching with our estimates. Nevertheless, our series are slightly higher than Aron et al. (1972) over up to the 1830s, but lower than these in the following decade when the average stature of soldiers fells dramatically as a result of the reduction in the minimum height standards. Overall, the evidence provided in Fig. 6 suggests that the combination of different sources can provide a coherent picture of the height development in Southwestern France.

To sum up, the previous tests indicate that results are not affected by the combination of different sources as well as the specific selectivity mechanisms characterizing the various source-producing institutions. Similarly, changes in the composition and numerosity of various and relevant subsets of the population (poor and wealthy people, recidivists, and foreigners) have no substantial bearing on final results. Finally, while I do not directly address the issue of selectivity by resorting to formal

[40] To the best of my knowledge, there are no comparable series to set up analogous comparisons for females over the period and area considered.

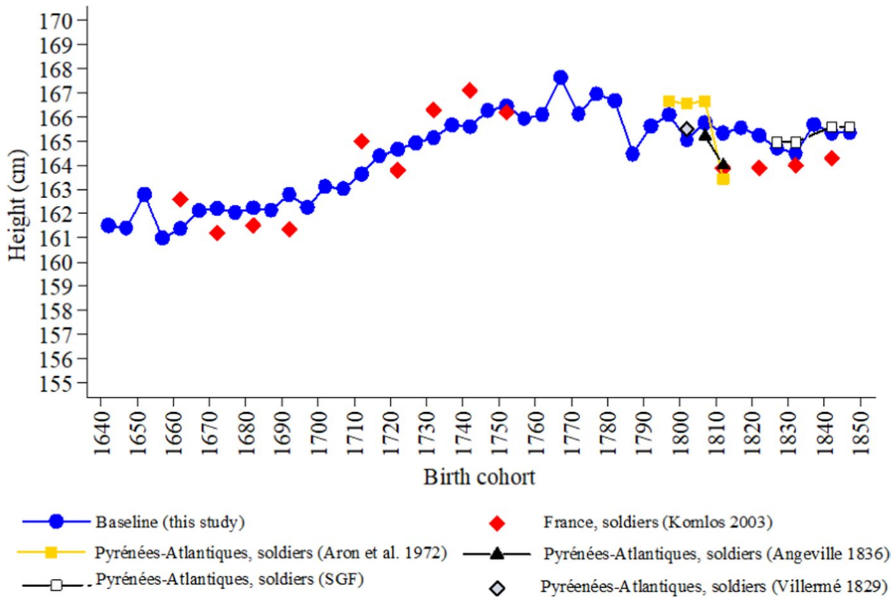

Fig. 6 Comparison of male heights with alternative estimates

econometric testing, I find that the level and trend predictions chime well with other anthropometric studies focusing on France. This suggests that the evidence brought to debate should provide a good picture of the height trends in Southwestern France.

7 The gender height gap and its determinants

7.1 The evolution of the gender height gap

Figure 7 shows the evolution of the gender height gap in Southwestern France over more than two centuries, from the 1640s to the 1850s. Dimorphism is defined as the difference between male and female terminal height over male adult height (percent). The estimates of male and female terminal height are based on the baseline model illustrated above (Model 2, Table 5). What emerges is an inverted U-shaped pattern characterized by two phases. The first witnessed a steady increase in gender inequality during which the height gap passed from about 4 percent in the 1640s to more than 6 percent in the 1760s. Beginning around the 1780s, however, a new phase of falling inequality started which unfolded until the 1850s, when the gap fell to about 5 percent. Figure 7 also compares Southwestern France with other European areas, namely England and Wales, Ireland, Switzerland, Germany as well as London. The comparison indicates that sexual height dimorphism in Southwestern France was lower than elsewhere in Europe. Between the 1790s and the 1840s, the height gap was about 6 percent in Southwestern France, slightly higher in Germany and England, above 7 percent in Ireland and Switzerland, and above 8 percent in London. This suggests that at

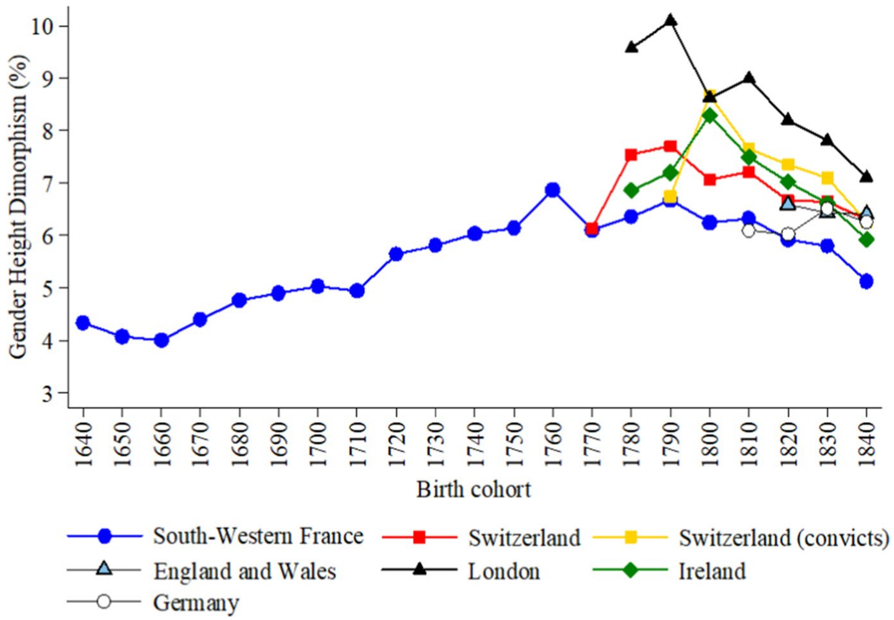

Fig. 7 Gender height gap in Southwestern France in comparative perspective, 1640–1850. *Sources*: Southwestern France, this study. The series is a 10-year average of the height series estimated using Models 2 of Table 5; Switzerland, Koepke et al. (2018, Table 2); England and Wales, Johnson and Nicholas (1995, Table 5, p.479); London and Ireland, Horrell et al. (2009, Table 5, p.106); Germany, Baten and Murray (2000). *Note*: the gender height gap is defined as the difference between male and female terminal height over male adult height (percent)

least in the domain of nutritional status, Southwestern France fared well compared to Northern Europe, a result that can be perhaps explained by the relatively low degree of complexity of its economy.[41] Furthermore, between the late eighteenth and early nineteenth century other countries, except for Bavaria, underwent a similar decline as the South West.[42] In most of cases, the diminishing height gap between males and females since the late eighteenth century was the result of the stagnation or even decline in male stature and the contemporaneous increase in female heights. The literature has interpreted these diverging trajectories as a sign of improvement in female net nutritional status related to gradual industrial transition—which opened up a whole host of work opportunities for women—as well as other concurring factors like mass migration, emancipation, and improvements in female incomes (Baten and Murray 2000; Koepke et al. 2018; Sunder 2011). As the available height series begin around the late eighteenth and early nineteenth century, our knowledge of long-term gender inequality

[41] Naturally, these international height comparisons can also depend on other non-economic factors like genetic differences (A'Hearn 2016).

[42] This trend is also consistent with evidence outside Europe. For instance, Santiago-Caballero (2021) found that the height gap of Spaniards migrating to Mexico decreased from 15 cm in the 1850s to 8.6 cm in the 1890s.

patterns and their determinants is still largely unexplored. In what follows, I will try to shed some light on these issues.

7.2 Analysis of the determinants: methodology

This section aims to explore the main factors underlying the evolution of height dimorphism in Southwestern France. Several approaches have been used in the literature to address this issue such as correlation analysis, various regression analyses, decomposition procedures, and qualitative description of the series.[43] Following most of the literature, in this paper I use a regression framework. Specifically, I fit simple regression models of the following form:

$$y_t = y_{t-1} + \mathbf{X}_t'\beta + \delta_p + \varepsilon_t \quad (1)$$

The dependent variable y_t is the gender height gap again measured as the difference between male and female terminal height over adult male height. All model specifications include the lagged dependent variable (y_{t-1}) so as to control for changes in the height gap arising from age heaping problems. Furthermore, the various specifications include period dummies δ_p for the famine of 1687–1694 and for the period 1789–1815 corresponding to the troubled years of the French Revolution and the Empire. The regression models also include one or more covariates (**X**) which aim to capture the conditions under which the various cohorts grew up.[44] As already pointed out by the previous literature, indeed, conditions at birth played a crucial role in shaping future height developments, especially during early childhood (Baten 2000; Depauw and Oxley 2019). Thus, controlling for these environmental conditions is likely to improve the predictive power of the regressions as shown in other contexts (Baten and Murray 2000; Weir 1993). Specifically, the matrix **X** includes four groups of variables: economic conditions, food availability, demographic factors, and inequality at birth. Since all the series are free of unit-roots, I estimate a simple OLS regression model in levels and standardize all variables as z-scores to ease the interpretation of coefficients.[45] In order to address

[43] Regression analysis is a widespread tool used to analyze the determinants of height dimorphism using models where dimorphism is the dependent variable (see for instance Guntupalli and Moradi 2009) or separate regressions for male and female heights (see for example Baten and Murray 2000). Costa-Font and Gil (2008) instead use Blinder-Oaxaca decomposition analysis to identify how much of the height gap can be explained by observed environmental factors while Castellucci et al. (2021) rely on Spearman correlation analysis.

[44] Various measures of the gender height gap have been proposed in the literature such as the ratio between male and female stature or the difference between the mean heights of the genders expressed as a percentage of male height (Guntupalli and Baten 2009). Here I use the latter as it provides an intuitive representation of the percentage gap between men and women. Results, however, are not affected by the specific measure used.

[45] Note that non-stationary leads to problems of spurious correlations. The ADF tests using optimal lag-length reject the null hypothesis that the variables follow a unit root process. See Appendix C, Section 2 for details.

multicollinearity concerns, I estimate regressions between the dependent variable and the main regressor.[46]

7.3 Analysis of the determinants: data

Several archival and secondary sources were explored to collect the data necessary to carry out the analysis. Only a few of them, indeed, were available from secondary literature. The gap is particularly large for demographic data as the existing information before the nineteenth century consists only of a scattered set of benchmark estimates and some sporadic assessments from coeval authors. As a general matter of rule, I relied on area-specific covariates. However, when information was missing, I draw upon national series.[47] A comprehensive list of primary sources and a more detailed description of all variables is found in Appendix C, Section 1.

The regression analysis includes three economic indicators which are meant to capture changes in household income of day laborers and consumers that did not rely on market wages: wheat prices, real grain wages, and output per capita. Wheat prices in Toulouse come from Frêche and Frêche (1967), new series of real grain wages for agricultural and construction workers in Southwestern France have been constructed combining information from Ridolfi (2019) and new archival data (Appendix A, Section 1), while French output per capita is drawn from Ridolfi and Nuvolari (2021). The correlation between economic variables and gender inequality is a priori undetermined. Rising household incomes over early childhood imply more resources to devote to the care of offspring (Baten and Murray 2000), but the effect on gender inequality depends on the intra-household allocation of resources. A male-oriented allocation of resources implies greater investments in the quality of males leading to a widening of the height gap at maturity.

Proxies for food availability are also considered. The first is a series of French food per capita estimated by means of a simple demand function which includes prices of agricultural and manufacturing products as well as real wages to explain per capita consumption of agricultural products (Allen 2000). This series comes from Ridolfi and Nuvolari (2021) and is meant to proxy general patterns in food availability. Rains capture a similar effect. Since Southwestern France was a predominantly rural society, heavy rains or a shortage of it could produce crop failures and reduced food availability.[48] A series of spring rains for Bayonne is estimated using data from Luterbacher et al. (2004).

[46] The regressions are based on yearly time series. However, in Appendix C, Table 8, I fit the same models using 3-year averages and find that the results are not driven by year-to-year changes in the number of observations.

[47] While this approach can lead to measurement error, the use of national indicators seems to be quite appropriate in this context. The close agreement between national and regional height developments in France (Fig. 6) indeed suggests that broad patterns should have played a major role in the height development of this area.

[48] According to Appleby (1979), Southern France and the Mediterranean littoral were more troubled by drought than by excess precipitation. The heavy rains of 1693, for instance, threatened northern agriculture and led to crop failures while were beneficial to the Mediterranean littoral so that the harvest seems to have been near normal in this area.

I also consider demographic indicators, namely population, marital fertility, and mortality. Population growth, which is typically associated with falling incomes and lower investment in the quality of children over the pre-industrial Malthusian societies—again would imply greater inequality in height in the presence of male-oriented allocation of resources. Against an uncertain and fragmented evidence, I resort to new archival data on births and deaths as well as census data to construct a new yearly population series for Bayonne from 1670 to 1850.[49] The focus on this city is suggested by considering the high weight of this area in the height sample. The Coale index of marital fertility is instead used to measure the effect of changes in the quantity-quality tradeoff on the relative living standard of females. Finally, I proxy conditions at birth with crude death rate defined as the number of deaths per thousand in Bayonne. Lastly, I construct a new series of the wage gap to account for inequality at birth.[50]

7.4 Analysis of the determinants: results

Table 6 reports the regression results. I begin by considering the effect of economic conditions at birth on dimorphism. Model 1 shows the correlation between wheat prices at birth and the height gap in terminal heights while Models 2 and 3 study the persistence of the correlation over the second and third years of life using a distributed lag model (Baten and Murray 2000). Models 4 to 6 are similar, but use real male daily wages instead of wheat prices as the main regressor.

Economic conditions at birth turn out to be important determinants of dimorphism. Wheat prices during the first year of life are positively associated with growing gender inequality (Model 1). This relation holds also during the second and third years of life (Model 2 and 3) leading to a cumulated effect that ranges from 0.34 and 0.4 standard deviations increase in the adult height gap per one standard deviation increase in wheat prices at birth. Real wages provide a fairly similar picture. As shown in Model 4, one standard deviation increase in real male daily wages during the first year of life leads to about a 0.3 standard deviation decrease in the gender height gap. Models 5 and 6 also attempt to assess the effects of conditions in the second and third years of life upon height dimorphism. Again, real male daily wages appear to be negatively and significantly associated with gender inequality leading to a cumulative effect of real wages on inequality in the range of 0.3 and 0.48 standard deviations. This result is consistent with previous literature. For instance, Baten and Murray (2000), using a sample of Bavarian conscripts, found that women's heights were far more systematically related to changes in real wages than were men's suggesting that an improvement in real wages was reducing the height gap.[51] Similarly, evidence from nineteenth century India points to a significantly negative correlation between rural real wages and dimorphism in stature (Guntupalli and

[49] From 1830 onwards the population series has a 5-year frequency.

[50] See Appendix C, Section 1 for a detailed description of sources and methods used to construct this variable.

[51] It should be noticed, however, that the lag distribution of their model implies that the cumulative effect tends to zero in the distributed lag model with 2 and 3 lags (Baten and Murray 2000, p.366).

Table 6 Regression results of the determinants of the gender height gap in Southwestern France: 1640–1850

Dependent variable: Gender height gap	Model 1: wheat	Model 2: wheat, lag (1)	Model 3: wheat, lag (2)	Model 4: real wages	Model 5: real wages, lag (1)	Model 6: real wages, lag (2)	Model 7: GDP per capita
Economic variables at birth							
Wheat price (year 1)	0.315***	0.221	0.291*				
Wheat price (year 2)		0.116	– 0.215				
Wheat price (year 3)			0.322**				
Real wage (year 1)				– 0.311***	– 0.124	– 0.199*	
Real wage (year 2)					– 0.254**	0.059	
Real wage (year 3)						– 0.337***	
GDP per capita							– 0.020
Famines (1687–1694)	– 0.275	– 0.261	– 0.234	– 0.204	– 0.157	– 0.104	– 0.570***
Period dummy (1789–1815)	0.123	0.116	– 0.000	0.302	0.258	0.179	0.619***
Lagged dimorphism	– 0.011	– 0.016	– 0.029	– 0.095	– 0.125	– 0.161*	0.028
Constant	– 0.005	– 0.003	0.012	0.010	0.021	0.032	0.009
Observations	189	187	185	182	180	178	176
R– squared	0.132	0.137	0.156	0.145	0.169	0.206	0.084
	Model 8: food per capita	Model 9: rains	Model 10: population	Model 11: fertility	Model 12: mortality	Model 13: wage gap	Model 14: lagged heights
Food availability at birth							
Food per capita	– 0.095						
Rains		– 0.041					
Demographic factors at birth							
Population			0.314***				
Marital fertility				0.223**			
Mortality (Deaths/1,000)					– 0.022		
Inequality at birth							

Table 6 (continued)

	Model 8: food per capita	Model 9: rains	Model 10: population	Model 11: fertility	Model 12: mortality	Model 13: wage gap	Model 14: lagged heights
Wage gap (males over females)						– 0.268***	
Lagged male terminal height							0.210***
Famines (1687–1694)	– 0.476**	– 0.562***	– 0.300		– 0.598**	– 0.241	– 0.497**
Period dummy (1789–1815)	0.599***	0.597***	0.487***	0.384**	0.608***	0.465**	0.376*
Lagged dimorphism	0.052	0.028	– 0.147	– 0.229**	– 0.029	– 0.078	– 0.103
Constant	– 0.035	0.012	0.112	0.412***	0.087	0.003	0.120
Observations	192	176	162	96	161	185	161
R– squared	0.084	0.085	0.190	0.111	0.087	0.144	0.131

Source: see text and Appendix C, Section 1. *Note*: All regressions include robust standard errors. The estimates of the gender height gap are based on the estimates of Models 2, Table 5. Significance levels are: ***$p<0.01$. **$p<0.05$. *$p<0.1$

Moradi 2009). Model 7 also considers the relationship between general economic conditions at birth as proxied by GDP per capita and the height gap. Consistent with the previous findings, the relation is negative although the coefficient is not statistically significant. To be sure, this result can be potentially affected by measurement error as the output measure refers to France as a whole. Nevertheless, it should be noticed that other studies, in various contexts, have stressed the weak and often not statistically significant contribution of GDP per capita to height variation, which perhaps reflects the composite nature of this indicator (Castellucci et al. 2021; Guntupalli and Moradi 2009). Overall, ceteris paribus, the previous results suggest that during phases of economic distress parental decision rules in the allocation of food resources tended to privilege males.

As a second step, I investigate the issue of whether changes in food availability at birth can affect dimorphism. To proxy for food availability, in Model 8 I use a measure of food per capita for the whole of France estimated following the approach illustrated in the previous subsection while in Model 9 I use a measure of local rains.

The results show that a one standard deviation increase in food per capita would yield a 0.1 standard deviation decrease in the adult height gap, but the coefficient is not statistically significant. Furthermore, it appears that inequality is not systematically related to rains. Again, this result can be compared to nineteenth century evidence on developing countries. For instance, while for Africa the effect of rainfall is not entirely neat (Moradi 2009), in nineteenth century India an increase in rainfall has been associated with a statistically significant reduction in height dimorphism, possibly reflecting the crucial role played by monsoon in the production of rice in that context (Guntupalli and Moradi 2009).

Models 10 to 12 test the extent to which inequality in adulthood was related to demographic conditions at birth which likely shaped family size and resources per capita. In particular, I test whether population was systematically related to inequality patterns (Model 10) and eventually which forces underlying demographic expansion between fertility and mortality were more important to explain gender inequality (Model 11 and 12, respectively). The regression coefficients of Model 10 show that one standard deviation increase in population yields a 0.31 standard deviation increase in the adult height gap. By itself, this variable explains 19 percent of the variance in sexual dimorphism. This can be perhaps interpreted relying on a classic Malthusian argument: population growth and higher population density during early childhood pushed household incomes down which in turn boosted pro-male allocations of resources.

Model 11 explores the link between the fertility transition and the gender height gap. According to Weir (1993), the fertility transition had a significant positive effect on French male heights. Specifically, he found that a fall of 0.5 in the Coale index would add about 0.25 cm to height—about the full magnitude of the nineteenth century French gain. Here I test the same argument on sexual dimorphism in the South West and particularly check whether the substitution of increased quality for decreased quantity after 1790 led to a reduction in dimorphism. The results confirm this hypothesis as a one standard deviation decrease in marital fertility led to a 0.22 standard deviation decrease in the sexual dimorphism in heights.

Consistent with previous findings, mortality had a negative effect on inequality, although the effect is small in magnitude and not statistically significant (Model 12). The low significance of the mortality coefficient of Table 6 can be perhaps explained by the fact that the models control for famines implying that after accounting for large mortality shocks, there was a reduced influence of mortality on gender inequality over normal years.

The sign of the observed relationship between mortality and dimorphism chimes well with anthropometric evidence which has long emphasized the puzzling relationship between mortality and statures. Height, indeed, is typically associated with a decreased risk of chronic disease death, even if in contexts where infectious disease death was more common, as was the case in pre-industrial societies, the relationship seems to have been weaker (Moradi 2009; Thompson et al. 2020) or in some cases even positive (Thompson et al. 2022). Complicating further the issue are differences between sexes. Using a sample of Bavarian conscripts in the nineteenth century, Baten and Murray (2000), for instance, found that greater infant mortality led to taller adult women on average while the opposite was true for men. Castellucci et al. (2021) found a statistically significant negative correlation between dimorphism and infant mortality rate using data from twentieth century Chile while Engeland et al. (2003) found a curvilinear relationship between height and mortality for women, but a negative, linear relationship for men in a current sample of Norwegians.

It is also interesting to better explore the effect of famines on the height gap. As shown by the period dummies included in various regression models, the last famines of the seventeenth century seem to have pushed gender inequality down. The relation between short/long-term mortality patterns and dimorphism brings us to consider another important issue, e.g., the potential for selective mortality to bias the height estimates by gender. For instance, if poor conditions like high wheat prices are more likely to lead to deaths of male infants and young children and this mortality is correlated with height, then that would lead to an increase in male stature that was unrelated to gender disparities. Previous studies for instance have shown that selective mortality can bias the estimates in the short-run while having much less effect in the long term when trends are largely dependent on the allocation of nutrients (Schneider 2020; Cogneau and Kesztenbaum 2016). The regression coefficient chimes with this interpretation. Furthermore, while direct evidence on Southwestern France is missing, aggregate figures for France from Blayo (1975) show that mortality of male children aged less than one was higher on average than for females, but trends were broadly similar so that the size of the gender gap in infant mortality rates, apart from some short-run fluctuations, remained stable over the period 1740–1829. Consistent with previous results, this evidence suggests that gender differences in survival bias were not going to explain the long-run trends in dimorphism highlighted above.

Overall, the results suggest that population dynamics mattered for inequality. In this regard, the main demographic driver in the long run seems to have been reduced fertility rather than reduced mortality.

Previous research has also stressed the close relationship between different measures of gender inequality. For instance, Koepke and Baten (2005) analyzing height developments in Europe over the past two millennia found that gender inequality as proxied by gender dimorphism was negatively correlated with average stature. The available evidence for twentieth century developing countries also suggests that height dimorphism was positively correlated with gender inequality, particularly in the domains of health, education, and child mortality rate (Agarwal et al. 1992; Castellucci et al. 2021; Deaton 2008). Less instead is known about the relationship between gender inequality and dimorphism prior to the twentieth century.

Models 13 to 14 explore these arguments measuring the effect of various dimensions of inequality at birth on sexual height dimorphism. The first measure is the wage gap of male to female unskilled casual workers employed in agriculture and the construction sector. This is meant to capture the link between labor market inequality at birth and parental investment decisions in the nutrition of children (Model 13). Since the gender wage gap can be interpreted as the expected return to invest in males relative to females, a higher wage gap might discourage households' investments in female nutrition if households follow a utility maximization behavior in the allocation of resources within family members (Klasen and Lamanna 2009). The regression analysis provides little support for this argument, highlighting instead a negative and statistically significant link between the wage gap at birth and the adult height gap. One possible explanation for this result is that the wage gap here works more as a proxy for overall household income than as a proxy for future market rewards. Indeed, a simple correlation analysis reveals that the wage gap is strongly correlated with both prices and male real wages (the two measures of income per capita used before) as well as with population. If this is true, households could have interpreted the growing wage gap not as an incentive for investing in nutrition and care of male offspring, but as an indication of increasing future household income. In an economy in which family incomes were largely dependent upon male employment, owing to the large and persistent wage gap as well as the intermittent female employment, higher incomes could have induced parents to adopt a more egalitarian intra-household allocation of resources consistent with biological models of resource allocation.[52]

Model 14 also explores the issue of whether past inequality in the allocation of food resources can affect future inequality. In the absence of direct measures of intrahousehold allocation of food, I use the average male terminal height at birth as a proxy for past pro-male allocation of resources. A one standard deviation increase in average male terminal height at birth would yield a 0.21 standard deviation increase in the adult height gap.[53] Ceteris paribus, this evidence appears to suggest a certain degree of persistence in inequality patterns: birth cohorts born over periods in which height inequality was higher tended to display high inequality as well. Nevertheless, this tendency was not unchanging as improved economic conditions appear to have mitigated this pattern.

[52] Based on the 1852 Agricultural survey (1858), on average, the annual female income of a French day laborer in agriculture was about 40 percent of its male counterpart.

[53] One standard deviation increase in average female terminal height at birth, instead, has no statistically significant effect on dimorphism.

8 Conclusions

Using a large set of data coming from hospital, passports, and prison records, this article reconstructs secular trends in heights and sexual height dimorphism for the cohorts born in Southwestern France over more than two centuries from the 1640s to the 1850s. A deep investigation of the data and the source-producing institutions is made and a procedure to aggregate these sources is suggested as well as various steps to mitigate potential selectivity issues and compositional biases affecting the data.

Overall, sexual height dimorphism charted an inverted U-shaped trajectory in the period considered and the size of the gap appeared relatively small compared to other parts of Europe. In the first phase spanning from the 1640s to about the 1780s, growing inequality was coupled with demographic expansion, increasing demand for foodstuff as proxied by the trend in wheat prices, and expanding trade activity. In the same years, per capita incomes fell and household size possibly increased putting mounting pressure on resources per capita. Against this background, it appears as if the last great famines of the seventeenth century acted only as temporary brakes to the secular trend of increase in gender dimorphism in stature. The great reversal took place by the late eighteenth century just at the same time in which population growth as well as the demand for foodstuff and trade languished, possibly as a consequence of the economic downturn fostered by the troubled years of the Revolution and the Empire (Crouzet 1959; Charles et al. 2021). Importantly, this egalitarian turn intersects the history of fertility as greater investment in the quality of children was paralleled by a reduction in sexual height dimorphism.

Changes in relative heights across various birth cohorts also allow to draw inferences on parental attitudes in the allocation of resources within the family setting. Overall, there is little support for the argument that parental investment decisions were set by custom. Rather, the allocation of resources within the households appears largely as a function of the amount of resources available consistent with studies of contemporary developing countries (Guntupalli and Moradi 2009) and industrializing Britain (Johnson and Nicholas 1997) as well as models of evolutionary biology. In this regard, the less parents had, the more biased they appeared in their distribution of food but at the same time as resources became more plentiful, parents tended to shift to a more egalitarian distribution of nutrients. This implies that gender discrimination rules were not time-invariant and fixed by custom. Rather, as shown in the case of industrializing England (Horrell and Oxley 2013), good economic prospects tended to mitigate inequality leading to more nutritious variants for women.

Appendix A

1. *Sources*

Heights

Hospital.

Arch. dép. Pyrénées-Atlantiques Fonds de l'hôpital de Bayonne, Rôle d'entrée des malades H DÉPÔT BAYONNE F 2. Period 1724–1729.

Arch. dép. Pyrénées-Atlantiques Fonds de l'hôpital de Bayonne, Rôle d'entrée des malades H DÉPÔT BAYONNE F 4. Period 1729–1734.

Arch. dép. Pyrénées-Atlantiques Fonds de l'hôpital de Bayonne, Rôle d'entrée des malades H DÉPÔT BAYONNE F 6. Period 1734–1745.

Arch. dép. Pyrénées-Atlantiques Fonds de l'hôpital de Bayonne, Rôle d'entrée des malades H DÉPÔT BAYONNE F 7. Period 1745–1754.

Arch. dép. Pyrénées-Atlantiques Fonds de l'hôpital de Bayonne, Rôle d'entrée des malades H DÉPÔT BAYONNE F 8. Period 1754–1767.

PASSEPORTS.

Arch. dép. Gironde, Passeports pour l'étranger (1800–1830), 4 M 677 à 4 M 710.

PRISONS.

Arch. dép. Pyrénées-Atlantiques:

Registre d'écrou pour la maison d'arret de Bayonne, 28 mars 1832–26 janvier 1837, 2 Y 1/44.

Registre d'écrou pour la maison de correction de Bayonne, 7 fevrier 1836–7 avril 1839, 2 Y 1/110.

Registre d'écrou pour la maison de correction de Bayonne, 22 avril 1839–29 décembre 1842, 2 Y 1/111.

Registre d'écrou pour la maison de correction de Bayonne, 5 janvier 1843–3 février 1846, 2 Y 1/112.

Registre d'écrou pour la maison de correction de Bayonne, 28 août 1849–11 mars 1852, 2 Y 1/114.

Registre d'écrou pour la maison de correction de Bayonne, 13 mars 1852–26 décembre 1855, 2 Y 1/115.

Registre d'écrou pour la maison de correction de Bayonne, 31 décembre 1855–31 janvier 1859, 2 Y 1/116.

Registre d'écrou pour la maison de correction de Saint-Palais, 19 janvier 1837–28 octobre 1845, 2 Y 5/37.

Registre d'écrou pour les prévenus et accusés attendant leur interrogatoire, 11 septembre 1872–3 décembre 1876, 2 Y 1/92.

Registre d'écrou pour les prévenus et accusés attendant leur interrogatoire, 3 décembre 1876-1er septembre 1887, 2 Y 1/93.

Marriage registers

Arch. dép. Pyrénées-Atlantiques Ayherre: Collection départementale, Mariages, 1811–1842.

Arch. dép. Pyrénées-Atlantiques Bayonne, Paroisse Notre-Dame: Baptêmes, mariages, sépultures, 1691–1702.

Arch. dép. Pyrénées-Atlantiques Bayonne, Paroisse Notre-Dame: Baptêmes, mariages, sépultures, 1703–1712.

Arch. dép. Pyrénées-Atlantiques Bayonne, Paroisse Notre-Dame: Baptêmes, mariages, sépultures, 1713–1722.

Arch. dép. Pyrénées-Atlantiques Bayonne, Paroisse Notre-Dame: Baptêmes, mariages, sépultures, 1723–1733.

Arch. dép. Pyrénées-Atlantiques Bayonne, Paroisse Notre-Dame: Baptêmes, mariages, sépultures, 1734–1743.

Arch. dép. Pyrénées-Atlantiques Bayonne, Paroisse Notre-Dame: Baptêmes, mariages, sépultures, 1743–1754.

Arch. dép. Pyrénées-Atlantiques Bayonne, Paroisse Notre-Dame: Baptêmes, mariages, sépultures, 1755–1767.

Arch. dép. Pyrénées-Atlantiques Bayonne, Paroisse Notre-Dame: Baptêmes, mariages, sépultures, 1767–1784.

Arch. dép. Pyrénées-Atlantiques Bayonne: état civil, 1793—an IX.

Arch. dép. Pyrénées-Atlantiques Bayonne: état civil, an VI—an XII.

Arch. dép. Pyrénées-Atlantiques Bayonne: état civil, an XII—1813.

Arch. dép. Pyrénées-Atlantiques Bayonne: état civil, 1826—1837.

Arch. dép. Pyrénées-Atlantiques Bayonne: état civil, 1838—1851.

Arch. dép. Pyrénées-Atlantiques Bayonne: état civil, 1852—1863.

Arch. dép. Pyrénées-Atlantiques Bayonne: état civil, 1863—1873.

Arch. dép. Pyrénées-Atlantiques Bayonne, Paroisse Saint-Esprit: état civil, an II—1813.

Arch. dép. Pyrénées-Atlantiques Bayonne, Paroisse Saint-Esprit: état civil, 1814—1854.

Arch. dép. Pyrénées-Atlantiques Bayonne, Saint-Étienne-Arrive-Labourd: Baptêmes, mariages, sépultures, 1757–1779.

Arch. dép. Pyrénées-Atlantiques Bidache: Collection départementale, Mariages, an II-1842.

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Births and deaths

Bayonne, Arch. dép. Pyrénées-Atlantiques, Registres paroissiaux et d'état civil.

From 1670 to 1699: Bayonne, Paroisse Notre-Dame: registres paroissiaux, 1670–1699.

From 1700 to 1792: Bayonne: état civil, Tables, 1668–1792.

From 1792 to 1821: Bayonne: état civil, Tables, 1792–1842.

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Arch. dép. Pyrénées-Atlantiques Couvent des Jacobins de Bayonne Comptes des recettes et dépenses, H 100.

Arch. dép. Pyrénées-Atlantiques Couvent des Jacobins de Bayonne Comptes des recettes et dépenses, H 101.

Arch. dép. Pyrénées-Atlantiques Couvent des Jacobins de Bayonne Comptes des recettes et dépenses, H 102.

Arch. dép. Pyrénées-Atlantiques Couvent des Jacobins de Bayonne Comptes des recettes et dépenses, H 105.

Arch. dép. Pyrénées-Atlantiques Couvent des Jacobins de Bayonne Comptes des recettes et dépenses, H 108.

Arch. dép. Pyrénées-Atlantiques Couvent des Jacobins de Bayonne Comptes des recettes et dépenses, H 109.

Arch. dép. Pyrénées-Atlantiques Couvent des Jacobins de Bayonne Comptes des recettes et dépenses, H 112.

Arch. dép. Pyrénées-Atlantiques Couvent des Jacobins de Bayonne Comptes des recettes et dépenses, H 113.

Arch. dép. Pyrénées-Atlantiques Couvent des Jacobins de Bayonne Comptes des recettes et dépenses, H 118.

Arch. dép. Pyrénées-Atlantiques Couvent des Jacobins de Bayonne Comptes des recettes et dépenses, H 120.

Arch. dép. Pyrénées-Atlantiques Couvent des Jacobins de Bayonne Comptes des recettes et dépenses, H 121.

Period: 1572–1737.

Arch. dép. Pyrénées-Atlantiques Couvent Sainte-Claire de Bayonne, Registres des recettes et des dépenses, H 175.

Arch. dép. Pyrénées-Atlantiques Couvent Sainte-Claire de Bayonne, Registres des recettes et des dépenses, H 176.

Arch. dép. Pyrénées-Atlantiques Couvent Sainte-Claire de Bayonne, Registres des recettes et des dépenses, H 177.

Arch. dép. Pyrénées-Atlantiques Couvent Sainte-Claire de Bayonne, Registres des recettes et des dépenses, H 178.

Arch. dép. Pyrénées-Atlantiques Couvent Sainte-Claire de Bayonne, Registres des recettes et des dépenses, H 179.

Period: 1646–1770.

Arch. dép. Pyrénées-Atlantiques Couvent des Carmes de Bayonne, Comptes des recettes et dépenses, H 124. 1763–1775.

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Arch. dép. Pyrénées-Atlantiques Fonds de l'hôpital de Bayonne, États de dépenses faites par l'hôpital, H Dépôt Bayonne E 86. 1691.

Arch. dép. Pyrénées-Atlantiques Fonds de l'hôpital de Bayonne, États de dépenses faites par l'hôpital, H Dépôt Bayonne E 87. 1692–1696.

Arch. dép. Pyrénées-Atlantiques Fonds de l'hôpital de Bayonne, États de dépenses faites par l'hôpital, H Dépôt Bayonne E 88. 1697.

Arch. dép. Pyrénées-Atlantiques Fonds de l'hôpital de Bayonne, Comptes et quittances, H Dépôt Bayonne E 89. 1660–1666.

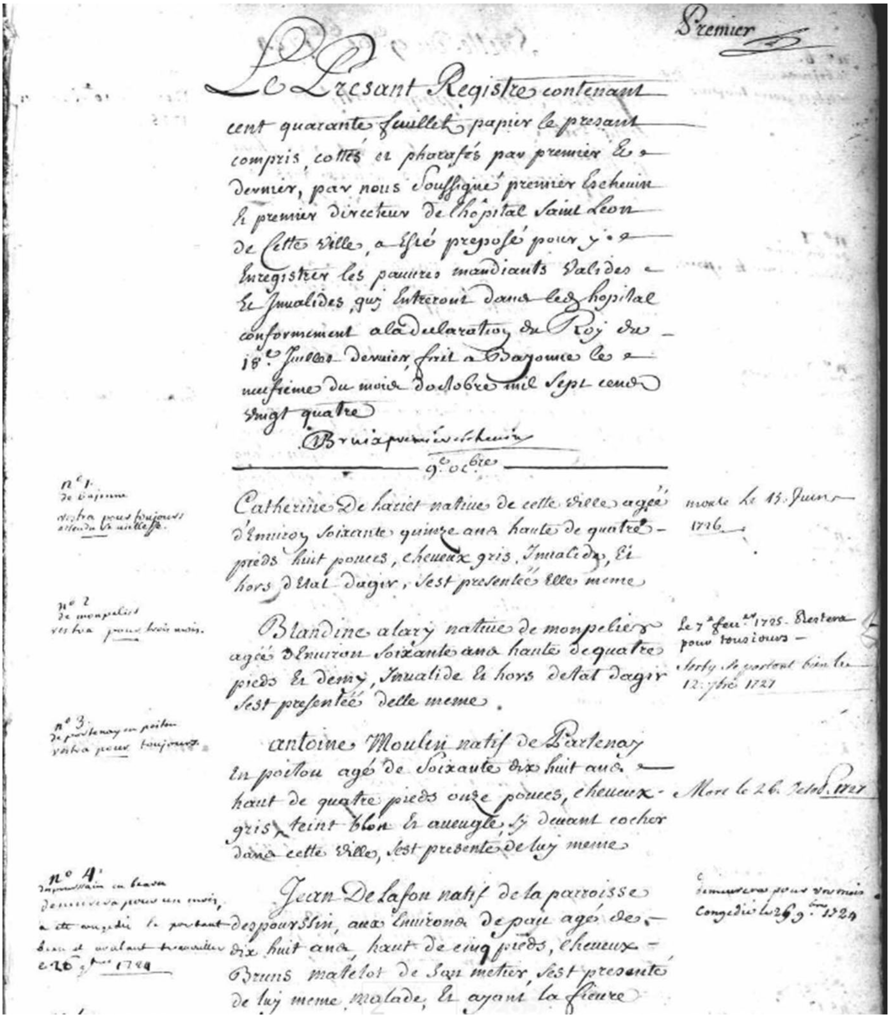
Arch. dép. Pyrénées-Atlantiques Fonds de l'hôpital de Bayonne, Comptes et quittances, H Dépôt Bayonne E 90. 1721–1722.

Arch. dép. Pyrénées-Atlantiques Fonds de l'hôpital de Bayonne, Quittances et mandats de paiement, H Dépôt Bayonne E 91. 1766.

Arch. dép. Vaucluse Hopital Sainte-Marthe, E 197 1624–1632.

2. *Examples of hospital and passports records*

See Figs. 8, 9, 10 and 11.


Premier

Le Present Registre contenant
cent quarante feuillets papier le present
compris, cottés et paraphés par premier et
dernier, par nous soussigné premier Eschevin
et premier directeur de l'hôpital Saint Leon
de cette ville, a esté preposé pour y
enregistrer les pauvres mandiants valides et
invalides qui entreront dans led. hopital
conformement a la declaration du Roy du
18e juillet dernier, fait a Bayonne le
neufieme du mois d'octobre mil sept cent
vingt quatre

9e 8bre

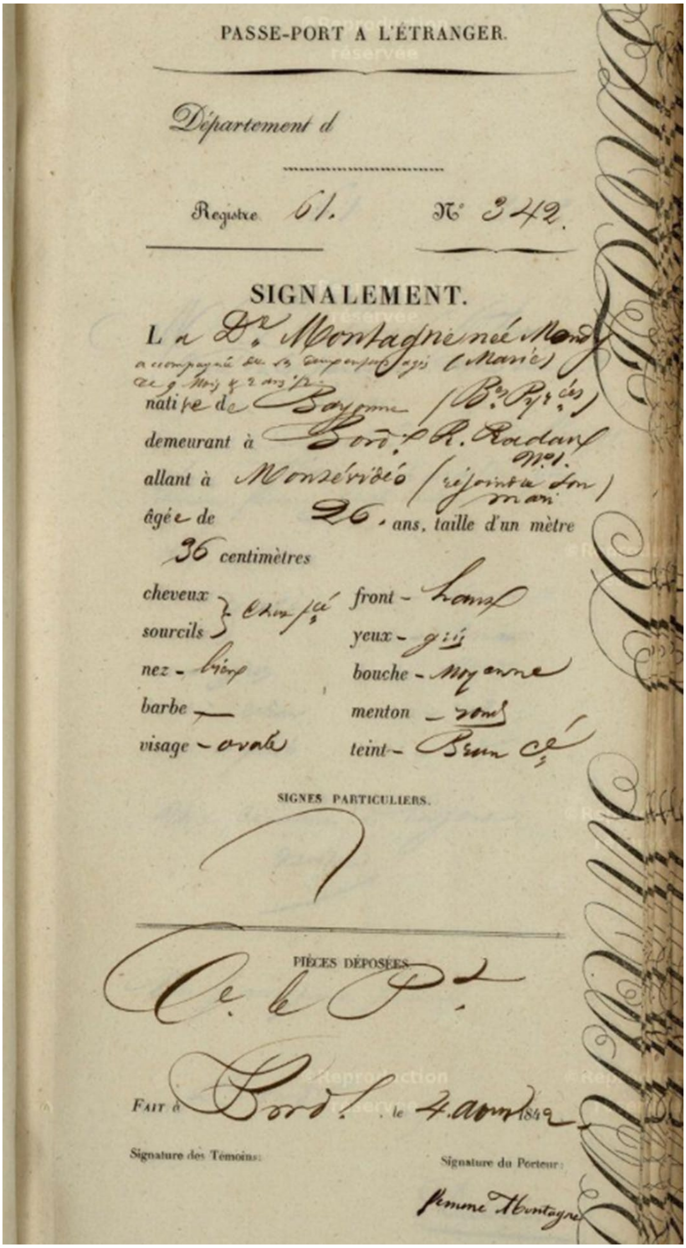
n° 1. Catherine De hariet native de cette ville agée d'environ soixante quinze ans haute de quatre pieds huit pouces, cheveux gris, invalide, et hors d'etat d'agir, s'est presentée elle meme — morte le 15 juin 1726

n° 2. Blandine alary native de monpelier agée d'environ soixante ans haute de quatre pieds et demy, invalide et hors d'etat d'agir s'est presentée d'elle meme.

n° 3. antoine Moulin natif de Partenay en poitou agé de soixante dix huit ans haut de quatre pieds onze pouces, cheveux gris, teint blon et aveugle, cy devant cocher dans cette ville, s'est presenté de luy meme — Mort le 26 … 1727

n° 4. Jean De lafon natif de la parroisse despourssin, aux environs de pau agé de dix huit ans haut de cinq pieds, cheveux bruns matelot de son metier, s'est presenté de luy meme, malade, et ayant la fievre

Fig. 8 Hospital entry register. Source: H DÉPÔT BAYONNE F 2, Rôle d'entrée des maladies


PASSE-PORT A L'ÉTRANGER.

Département d

Registre 61. N° 342.

SIGNALEMENT.

La Dme Montagne née Mondy

native de Bayonne (Bses Pyrénées)

demeurant à Bordx R. N°1.

allant à Montévidéo (rejoindre son mari)

âgée de 26. ans, taille d'un mètre 36 centimètres

cheveux } Châtains front - haut
sourcils } yeux - gris
nez - bien bouche - Moyenne
barbe - menton - rond
visage - ovale teint - Brun clair

SIGNES PARTICULIERS.

PIÈCES DÉPOSÉES.

FAIT à Bordx, le 4 août 1842

Signature des Témoins: Signature du Porteur: Femme Montagne

Fig. 9 Passport for abroad. *Source*: 4 M 722/342—Passeport de Marie Mondy—04 août 1842 Archives départementales de la Gironde

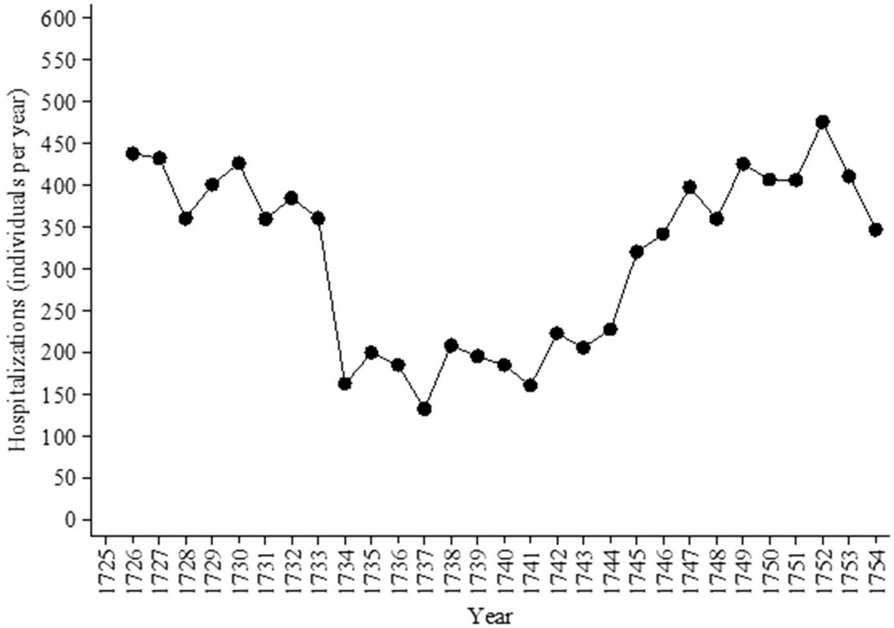


Fig. 10 Number of hospitalizations per year: Bayonne's hospital, 1724–1754. *Source*: see Appendix A, Section 1

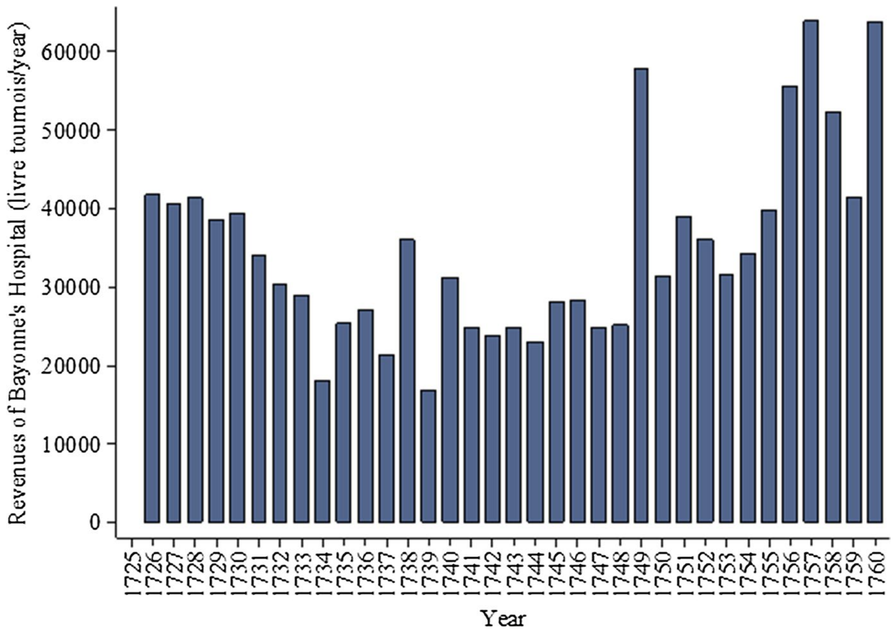


Fig. 11 Evolution of the revenues of Bayonne's hospital (livres tournois per year). *Source*: AD Pyrénées-Atlantiques, Controle des recettes et dépenses, H DÉPÔT Bayonne E 54, 1724–1777

Appendix B

Height-by-age profile

The analysis of the height for age profile provides a good indication of living standards (Eveleth and Tanner 1976). Nutritional factors and external environmental conditions indeed generally affect the age at which terminal height is attained and the time at which individuals begin to shrink. Therefore, the effect of the delayed adolescent growth spurt and shrinkage is to bias downward the mean height relative to the terminal height. A simple cross-section age-related regression of the sample population with no controls shows that males achieved final adult height around 24–25 years of age and females around 18–19 (Fig. 12). Compared to contemporary standards, the growth spurt for children living through this period began about one year later and continued about three to four years longer. The evidence of a later and longer spurt with respect to current standards indicates that a combination of factors like insufficient food intake or adverse environmental conditions were generally affecting French males and females. However, a long and delayed growth spurt was also typical of other parts of Europe in the late eighteenth and early nineteenth centuries as suggested by Oxeley's (2004) study of English and Irish females.

Figure 12 also shows that male shrinkage begins after the fifties such that by age 80 males were about 6.0 cm shorter than their peak adult height. Female shrinkage instead is discernible only by the sixties. This evidence is consistent with the rate of shrinkage highlighted by several longitudinal studies based on contemporary

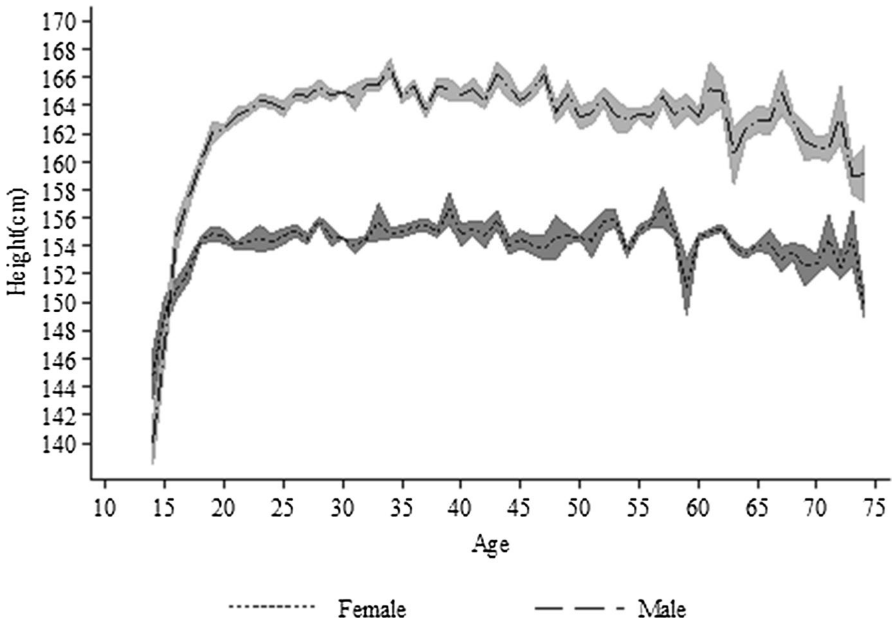


Fig. 12 Estimated height for age profile and the 95% confidence interval

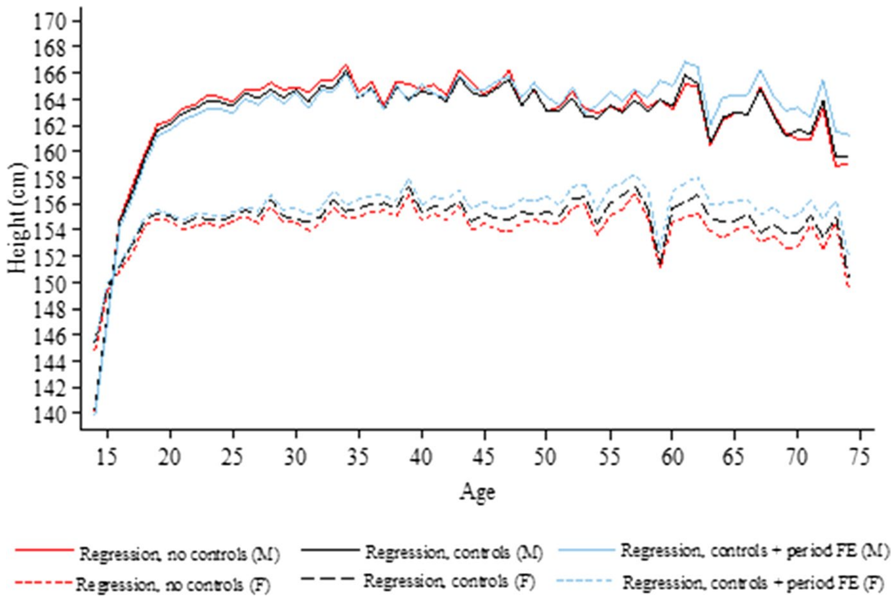


Fig. 13 Estimated height for age profile: different model specifications

data (Cline et al. 1989; Chandler and Block 1991). This overall picture is not substantially altered if one also considers the composition of the sample. As shown in Fig. 13, including controls for region of origin, sector, and place of birth (urban dummy) the picture is generally consistent with the baseline model without controls. The coefficient on the urban dummy is positive and statistically significant at conventional levels. Overall, this suggests that the height-by-age profiles of rural and urban born males and females were slightly different. This contrasts with Nicholas and Steckel's (1991) analysis of women's growth-spurts in industrializing England which consistently highlights a more vigorous spurt for rural born females. This result can be explained by the low rates of urbanization and relatively small size of cities in this area which possibly reduced the adverse effects of urban life compared to the more urbanized contexts analyzed by Nicholas and Steckel. This result also chimes with other indicators of living standards such as numeracy which according to Crayen and Baten (2010) was fairly uniform at low levels in this part of France. Including birth period dummies in the estimation of the height-by-age profiles instead reduces the rate of shrinkage, especially for females, suggesting that at least part of the decline in stature with age can be due to a birth cohort effect.

Appendix C

1. *The determinants of gender height gap in South-Western France: variables construction*

This section describes sources and methodologies used for variables construction in the regression Table 6. The variables are grouped into economic variables, proxies for food availability, demographic variables, and inequality at birth.

Economic variables

Wheat prices

Wheat prices come from the city of Toulouse (Frêche and Frêche 1967). Note that the level of prices in Toulouse is unlikely to correspond to the average regional price level. However, given the high correlation of wheat prices over time and across space (Ridolfi 2017; 2019), this series should proxy fairly well regional price movements.

Nominal and real wages

In the baseline specification I construct a new series of real grain wages. This is obtained dividing male nominal day wages by wheat prices. The data on nominal day wages for males in Southwestern France come from Ridolfi (2019). I complement this information with new evidence on female day wages. Wheat prices come from Frêche and Frêche (1967). I constructed a new dataset comprising over 1,200 wage observations drawn from local archives, secondary sources, and late eighteenth and nineteenth century official statistics (Appendix A). The gathered information spans, with several gaps, from the Middle Ages to the nineteenth century and covers several departments in Southern France (Fig. 14). This area displays a remarkable degree of heterogeneity in terms of occupations and employment relations. Hence, in order to render the subject somewhat less unmanageable, I concentrate on unskilled workers employed casually in agriculture and the construction sector. While this sampling approach takes a restricted view, which ignores other sectors and that part of workers that relied on long-term employment and task-payments, still it has the advantage of providing fairly homogeneous information about two occupational groups which together accounted for a large share in total labor force.[54]

As an unadjusted indicator, the gender pay gap gives a picture of the differences between men and women in terms of pay, which does not necessarily reflect discrimination between sexes. A part of the gap in earnings can arise from sectoral and occupational gender segregations. To circumvent this problem, I draw matched pairs of male and female wages for the same place, unskilled occupation, and year.[55] Furthermore, it is sometimes held that the workday of women was shorter than that of men while the value of board was lower for women, implying that part of the observed gap in day wages reflected these usually unobserved components. While

[54] Day-laborers in Southwestern France accounted for c.30 percent of agricultural workers while share-croppers were about 12 percent according to the 1852 agricultural survey.

[55] This means that for a certain occupation and year I only considered those places for which both male and female wages were available.

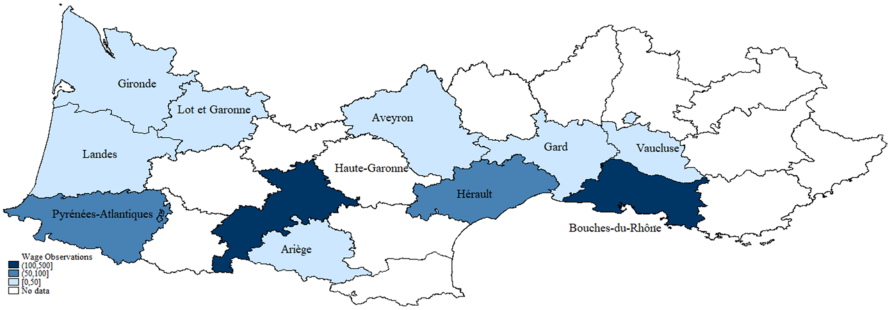


Fig. 14 Distribution of nominal wage data

the sources allow to distinguish with a certain degree of reliability workers paid in cash from mixed forms of remuneration, they do not report the hours worked per day, meaning that the female-male wage ratio is possibly downward biased.[56] Finally, to account for compositional biases in the aggregating procedure, I estimate the following OLS regression model for both males and females:

$$\ln(w_{it}) = \alpha + \sum_i \sum_t \beta_{it} \mathrm{DPERIOD}_t \mathrm{DREGION}_i + \sum_j \gamma_j \mathrm{OCC}_j + \sum_k \vartheta_k \mathrm{DSEAS}_k + \varepsilon_{it} \tag{2}$$

where w is the daily wage in location i at time t; DPERIOD is an indicator for each decade with a wage observation and DREGION is a dummy taking value one if the wage comes from the Mediterranean area and zero if it comes from Southwestern France, while the estimated coefficient β_{it} on the interaction term gives the time effect by region conditional on a set of controls. Specifically, OCC is a set of occupational dummies for agricultural tasks, work in the construction industry, and vintage while DSEAS includes seasonal indicators for summer, winter, and mean, where "mean" refers to cases in which the wage observation is an annual average.[57] The regression results confirm the well-known role played by seasonality and sectoral differences in shaping the level of wages. The pattern shown in Fig. 15 provides a long-term perspective on wages in Southwestern France which is consistent with the more general evolution highlighted by Ridolfi (2017, 2019) for France with three phases of sharp increase: the first after the Black Death, the second over the mid-sixteenth century, and third beginning around the late seventeenth century (Fig. 16).

[56] Failure to account for gender differences in the value of board should lead to an upward biased estimate of the female-male wage ratio while differences in hours worked per day should result in a downward bias.

[57] I set as base case a harvester from Southwestern France. See also Federico et al. (2021) for a similar estimating approach in a multi-sectoral framework.

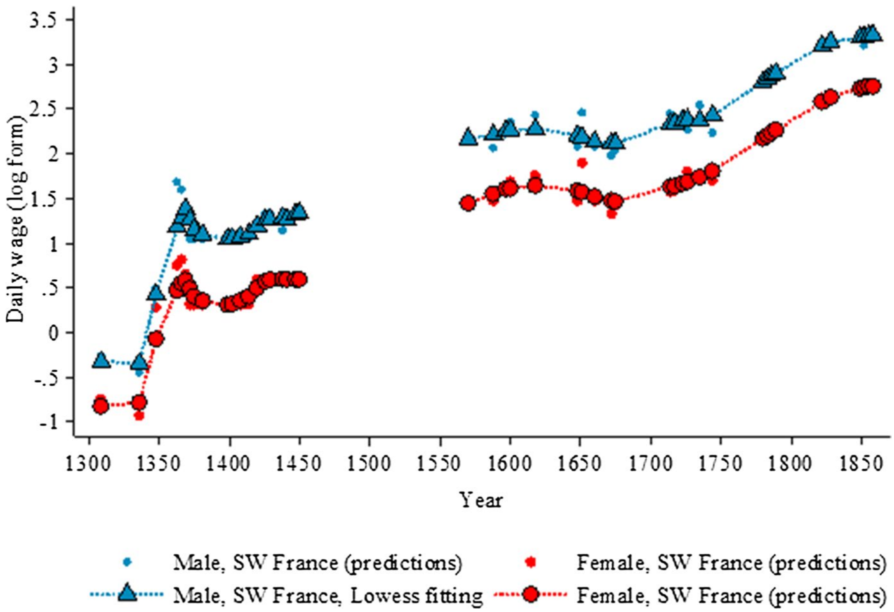


Fig. 15 Day wages in Southwestern France

GDP per capita

The series of total output per capita comes from Ridolfi and Nuvolari (2021) and regards France.

Food availability

Food per capita

The series of food per capita comes from Ridolfi and Nuvolari (2021) and regards France. This is obtained by modeling a demand function of the following type (Allen 2000):

$$c = W^{\alpha} \bullet {P_A}^{\beta} \bullet {P_M}^{\gamma} \tag{3}$$

where W is the real wage per day (which is used as proxy for per capita income), P_A is the real price of agricultural products (i.e., the price index of agricultural products divided by the consumer price index), P_M is the real price of manufactures (i.e., the price index of manufactures divided by the consumer price index) and α, β, and γ are the income, own price, and cross price elasticities of demand. Standard microeconomic theory suggests that $\alpha + \beta + \gamma = 0$ (Deaton and Muellbauer 1980, pp. 3–24).[58] Provided that suitable wages and price data are available, after having made an assessment of r, it is possible to construct a series of per capita food consumption using Eq. (3).

Rains

Spring rains in Bayonne have been estimated using Luterbacher et al.'s (2004) dataset.

Demographic variables

Population

The existing information about Bayonne population before the nineteenth century consists of a scattered set of benchmark estimates from household population surveys usually collected for taxation purposes and some sporadic assessments from coeval authors. Against this uncertain and fragmented background, the construction of a new high-frequency population series was a hard but necessary step. I construct a new series of the population in Bayonne using the following sources. From 1793 onwards I rely on the official population censuses available online from Cassini.[59] Bayonne underwent a mayor administrative change between 1790 and 1856 as the suburb of Saint-Esprit was detached from the city and it was again incorporated after 1856. Since the main interest of this study was in population growth rather than levels, I reconstruct the population at constant boundaries, always including the suburb of Saint-Esprit which accounted between about 25–30 percent of total population. Excluding this would have implied a major population drop after 1790 for mere administrative rather than demographic reasons. A population benchmark is also available for 1789 from the Statistique Générale de la France which sets Bayonne population at about 20,000 inhabitants, not too far from Pontet's (1990) figure of about 18,000 inhabitants at the end of the eighteenth century.

Prior to 1789 I rely on a different approach which allows me to get yearly population estimates. Ideally, to reconstruct annual population figures one would require a reliable population data at the beginning of a benchmark year (P_t) adding up annually the natural increase in population, that is, births (B_t) minus deaths (D_t), less net emigration (M_t). Thus, population at time t would equal:

[58] The assumption underlying Eq. (3) is that the real wage can serve as a plausible proxy of per capita income. Since most wage data refer to male workers, this method does not consider explicitly the role of women and children. In principle, one could formulate Eq. (3) as a household demand function considering activity rates, days worked and earnings of all family members. Unfortunately, for most European pre-industrial economies data on these variables are extremely scarce and very fragile.

[59] For the period 1793–1820 the gaps between the census years are filled using the trend given by the net births from the parish registers.

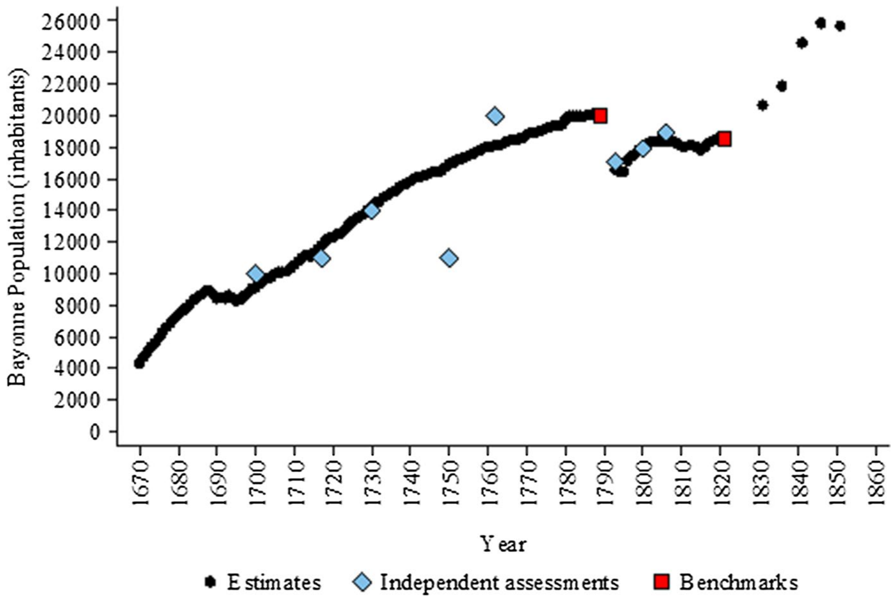


Fig. 16 Estimates of Bayonne population, 1670–1860

$$P_{t+1} = P_t + B_t - D_t - M_t \tag{4}$$

As already mentioned, several population benchmarks are available at various dates, while data on the total number of births and deaths in Bayonne from 1670 to 1789 have been retrieved from the birth and death records preserved at the archive of Pyrénées-Atlantiques (see Appendix A for details).[60] As no yearly migration data are available to the best of my knowledge, I assume that net migration flows are negligible over time before 1789 and I crosscheck the plausibility of this assumption, indirectly using different benchmarks. I extrapolate backward the population of Bayonne using the 1789 benchmark.

Owing to the high degree of uncertainty surrounding demographic data before the first official statistics, I perform some sensitivity analysis in order to check the reliability of the series. Figure below compares the series with some independent assessments of Bayonne population. What emerges is a good fitting between the early eighteenth century estimates and our series. This implies a population of over 9000 inhabitants in 1700 against the 10,000 inhabitants of Bairoch, Batou, and Chèvre's estimate (1988). Similarly, the 1730 census, implies a population of 10,842 inhabitants intra-muros (Iglesias 2000a; 2000b). If one assumes that Saint-Esprit

[60] I exclude the death of soldiers from the computations over the years of the French Revolution and the Empire.

was 25–30 percent of total population,[61] this should have been about 14,000 inhabitants in 1730. This is very close to our prediction of about 14,300 inhabitants in the same year. D'Expilly, in his Dictionnaire geographique de la France, provides a further indication for the second half of the eighteenth century, namely about 20,000 inhabitants in 1762 which confronts with 18,123 of our series. According to Jaupart (1966), D'Expilly's estimate certainly includes Saint-Esprit. Finally, Lespès de Hureaux indicates a population of 11,000 inhabitants for Bayonne in 1717 against 11,800 of our series (Jaupart 1966).

Births/1000 inhab

Total number of births come from the archive of Pyrénées-Atlantiques (see Appendix A for details). Total population, see previous section.

Marital fertility

Marital fertility is measured by means of the Coale's index of marital fertility (I_g). The source of these data is Houdaille et al. (1987, table 11, p.517). The quinquennial data from 1740 to 1825 correspond to the Coale index I_{g1} (average Coale index for South-Western France taken from nine villages) while the data from 1830 onwards correspond to the Coale index I_{g4} (weighted average based on South-western départements).

Crude death rate

This is defined as the number of deaths per thousands. Total number of deaths come from the archive of Pyrénées-Atlantiques (see Appendix A for details). Total population, see previous section.

Inequality at birth

Wage gap

The wage gap is defined as the ratio of nominal male to female daily wages. The series are those presented above.

Lagged male and female terminal height

See Appendix A and the text for the sources and methodologies. The terminal height of birth cohort *t* is lagged 30 years so as to proxy average height of an adult at birth. Sensitivity analysis suggests that different time lags from 20 to 35 provide the same results.

[61] This proportion is estimated by comparing the ratio of Saint-Esprit to Bayonne population over the census years 1793, 1800, and 1806. Between 1821 and 1851 the share fluctuated in the range 0.26–0.30.

Table 7 Time Series Diagnostics: Augmented Dickey–Fuller Tests

Variable	T– stat	p– value	lags
Height dimorphism	– 2.747	0.000	4
Wheat price	– 1.629	0.052	3
Male real grain wage	– 1.963	0.026	5
Male real wage	– 5.795	0.000	1
Food per capita	– 4.828	0.000	2
GDP per capita	– 2.882	0.002	4
Rain	– 4.492	0.000	2
Population	– 2.474	0.007	2
Births/ 1000 inhabitants	– 3.928	0.000	2
Death/1000 inhabitants	– 5.740	0.000	1
NRI	– 5.673	0.000	1
Marital Fertility	– 0.461	0.323	2
Gender pay gap	– 0.903	0.228	10
Male terminal height	– 2.509	0.001	10
Female terminal height	– 11.210	0.000	1

The tests are made on the variables in level. Optimal lag length based on AIC, HBIC, and SBIC criterions. All models are tested using a drift. Computations are based on 'varsoc' STATA routine

2. *Time series diagnostics*

Estimating the regressions of Table 6 by OLS may lead to problems of spurious correlations. Specifically, the use of OLS is admissible when the series are stationary, or the series are non-stationary, but the residuals follow a stationary process (in this case the series are said to be cointegrated). Table 7 presents the results of the Augmented Dickey-Fuller unit-root test for various variables used in the regression exercises. The results suggest that the variables do not generally follow a unit root process, thus providing support for the use of OLS.[62]

3. *The determinants of gender height gap*

Table 8 shows the estimates of the same regression models as Table 6 using 3-year averages instead of yearly series. The coefficients as well as the levels of significance are similar to those presented in Table 6. This suggests that results are not affected by year-to-year changes in the number of observations.

62 The only exception are wage gap and fertility. Note however, that the series of wages and to a lesser extent fertility involve several interpolations which can reduce the power of the test (Ryan and Giles 1999), namely increase the probability of a type II error (failure to reject the null when the alternative hypothesis is true).

Table 8 Regression results of the determinants of gender height gap in South-Western France, 1640–1850: 3-year averages

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Economic variables							
Wheat price	0.31***	0.23*	0.24*				
Wheat price (year 1)		0.10	0.05				
Wheat price (year 2)			0.10				
Real wage				– 0.33***	– 0.29***	– 0.28***	
Real wage (year 1)					– 0.16*	– 0.14	
Real wage (year 2)						– 0.09	
GDP per capita							– 0.04
Famines (1687–1694)	– 0.16	– 0.15	– 0.16	0.04	0.07	0.03	– 0.30
Period dummy (1789–1815)	– 0.03	0.03	– 0.07	0.03	0.05	– 0.01	0.30
Lagged dimorphism	0.15	0.12	0.08	0.28**	0.18	0.11	0.51***
Constant	0.03	0.02	0.05	– 0.01	0.02	0.04	0.03
Observations	69	67	65	67	65	63	65
R-squared	0.35	0.37	0.41	0.52	0.58	0.60	0.42

	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Food availability							
Food per capita	– 0.09						
Rain		0.10					
Demographic factors							
Population			0.20**				
Fertility				0.19**			
Mortality at birth					0.06		
Inequality at birth							
Wage gap						– 0.15*	
Lagged male terminal height							0.49***
Famines (1687–1694)	– 0.34*	– 0.27	– 0.20		– 0.49**	– 0.08	– 0.36*
Period dummy (1789–1815)	0.40**	0.25	0.32*	0.30	0.29	0.31	0.52**
Lagged dimorphism	0.29*	0.51***	0.21	– 0.07	0.43***	0.38**	0.12
Constant	0.02	0.04	0.10*	0.37***	0.09	– 0.03	– 0.11
Observations	70	65	59	38	59	68	60
R-squared	0.27	0.43	0.44	0.21	0.37	0.41	0.44

Source: see text. *Note*: All regression include robust standard errors. Significance levels are: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

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