The urban-rural height gap in late nineteenth-century Catalonia

Ramon Ramon-Muñoz
(University of Barcelona)
Josep-Maria Ramon-Muñoz
(University of Murcia)

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Abstract

This paper aims to explore whether and to what extent there was a gap in biological living standards between rural and urban areas. It focuses on the north-eastern Iberian region of Catalonia by making use of a new and large dataset (more than 16,000 observations) based on military records for the cohort of males born in the year 1890 and enlisted in the year 1911. By combining individual heights with information at municipal level, we conclude that the 1890 cohort of conscripts living in villages and towns up to 5,000 inhabitants were shorter than those that resided in towns and cities with more than 20,000 people. We also show that the relationship between height and population size may vary depending on the geographical area under study. This might suggest the existence of a qualified rural height penalty in late nineteenth-century Catalonia.

Key words: biological living standards, well-being, urban premium, rural penalty.

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Ramon Ramon-Muñoz
(University of Barcelona)[a]
Josep-Maria Ramon-Muñoz
(University of Murcia)[b]

1. Introduction

The comparison of biological living standards between urban and rural areas has attracted the attention of a large number of scholars. This is particularly true for north-western Europe. As far as this geographical area is concerned, there is an extensive body of historical research showing that in the first stages of modern economic growth the combination of industrialisation and rapid population growth resulted into an urban height penalty and, by opposition, a rural height premium emerged between the late-eighteenth and the mid-nineteenth centuries (e.g. Komlos 1985 and 1998, Riggs 1994, Drukker and Tassenaar 1997, A'Hearn 2003, Heyberger 2007, Cinnirella 2008, Heyberger 2014, and for summaries, Steckel & Floud 1997, Komlos and Baten 2004, Floud, Fogel, Harris and Hong 2011, Blum 2016 and Meinzer & Baten 2016).

There are various reasons explaining why the heights of urban dwellers decreased relative to rural heights. To start with, a number of cities grew in parallel to the spread of factory-based industrialisation and this transformed both working and living conditions. In Britain, for example, leisure time declined as working hours increased by around 25-30 per cent in the century after 1750 (Voth 1998, 2001, 2003). The irregular working patterns that characterised pre-industrial times were also progressively substituted by the more regular, monotonous and disciplined schedules of the mechanised factories (Thompson 1967, Clark 1994). Child labour was used intensively during the Industrial Revolution and, to some extent, reduced married women's labour (Humphries 2010). While working conditions probably became harder between the mid-eighteenth and the mid-nineteenth centuries, they were not compensated by either substantial gains in real wages or clear improvements in food consumption. In fact, diets were in general less diverse and poorer in industrial than in rural areas (Meinzer & Baten 2016). Finally, the new

[a] *Affiliation:* University of Barcelona (UB) | Research Centre in Economics and Economic History 'Antoni de Capmany' (CEAC) | Network of Reference in Economics and Public Policies (XREPP) | *Corresponding address*: Department of Economic History, Institutions, Policy and World Economy. Faculty of Economics and Business. University of Barcelona | Diagonal, 690 | 08034-Barcelona | E-mail: ramon@ub.edu | Tel: +34 93 402 19 30.
[b] *Affiliation:* University of Murcia | *Corresponding address*: Department of Applied Economics. Area of Economic History and Institutions. Faculty of Economics and Business. University of Murcia | Campus de Espinardo | 30100-Murcia | E-mail: jmramon@um.es | Tel: +34 868 88 38 54.

industrial cities tended to be overcrowded and had poor housing and sanitary conditions, increasing the transmission of diseases.

The rural height premium did not last forever. The existing gap between rural and urban heights declined over time and finally the rural premium reversed into a penalty. The construction of railways, and domestic and international market integration, increased the supply of food products in urban areas, making the former rural advantages in nutrition less apparent. Public investment in water supply and sanitation, such as sewerage systems, improved health conditions in the urban areas (Szreter & Mooney 1998), and medical services tended to expand more rapidly in cities and large towns than in rural areas. As a final result, in the last decades of the nineteenth century the gap between urban and rural heights shortened or simply vanished (e.g. Heyderberger 2007), and from the early twentieth century onwards, urban populations became taller than their rural counterparts (Komlos and Baten 2004).

This general account of an urban height penalty reversing into a rural height premium was, nevertheless, far from universal. For eastern Belgium, Alter, Neven and Oris (2004) found that urban-born men remained taller than their urban counterparts all throughout the nineteenth century. Twarog (1997) reached similar conclusions by comparing rural areas and small towns in the southern German territory of Württemberg. Also in Germany, Baten (2009) concluded that in the first-half of the nineteenth century "urban men were relatively tall in Bavaria", whereas "the areas near towns (…) [were] among the districts with lower average height", partially because of the former drained food from the latter (Baten 2009: 175).

In sharp contrast to these previous findings, there is also evidence showing a rather permanent rural height advantage, both in north-western Europe and in the USA. For example, Riggs and Cuff (2013) documented a height advantage of about 2 cm. in the rural cohorts born in late-nineteenth century Scotland by comparing rural and urban members of the military forces serving in World War I. And Zehetmayer (2013) concluded that the cohorts of US soldiers born in rural counties between 1847 and 1890 were taller than those born in the 10 largest cities or in the 90 next-largest cities of the USA (1.5 and 0.9 cm taller, respectively). Nevertheless, Zehetmayer also observed that urban height converged over time: by mid-nineteenth century "the best urban place to live in terms of height were small cities, while in the end of the nineteenth century, it was in larger cities with about 250,000 inhabitants, but not in the largest cities" (Zehetmayer 2013: 175).

This complex nature of the rural-urban gap is also found in nineteenth-and early-twentieth century southern Europe. Iberia provides a good example of this complexity. In the Iberian Peninsula, young males were shorter than their north-western European counterparts (Hatton and Bray 2010). Nevertheless, height disparities between rural and urban dwellers also emerged. For Spain, aggregated analyses at country-level show that in the last quarter of the nineteenth century recruits from provincial capitals and towns with more than 10,000 inhabitants were taller than rural conscripts and so continued until the early 1930s (Quiroga 2001). With urban conscripts being taller than the rural ones, the absence of a rural premium (or an urban penalty) was also found in south-eastern Spain for the

cohorts born between 1837 and 1900. Yet, rural heights experienced a strong process of convergence towards the urban ones from this latter birth cohort to that of 1915 (Martínez-Carrión and Moreno-Lázaro 2007, see also Martínez-Carrión & Pérez-Castejón 1998 for particular towns). A similar situation applies to the Basque country for the cohorts born between 1856 and 1915. In this case, however, the process of convergence began earlier and it was less intense than in south-eastern Spain (Martínez-Carrión, Pérez-Castroviejo, Puche-Gil and Ramon-Muñoz 2014). Urban conscripts born in the region of Castile-La Mancha were on average slightly taller than the rural ones from the birth cohort of 1887 to 1933 and were able to widen their height advantage from then to the cohorts born in the early 1960s (Cañabate and Martínez-Carrión 2017). Similarly, a permanent rural height penalty was characteristic of the region of Extremadura for the birth cohorts of 1904 to 1954 (Linares Luján and Parejo Moruno 2013). The absence of an urban height penalty has been also found in Portugal for the whole nineteenth century. The biological standard of living in Lisbon – a large city by European standards – was not lower than in the rest of the (mostly rural) country: conscripts from Lisbon were, in fact, slightly (less than half a cm.) taller than those from outside this capital city (Reis 2009).

Whereas the absence of an urban height penalty seems to have prevailed in Iberia, the same cannot be said when protoindustrial and industrial areas of this peninsula are taken into consideration. In the central Iberian region of Castile-Leon, rural and urban heights were about the same between the 1830s and the 1860s, but from then to the 1910s urban heights increased and intermittently were situated above rural heights (Martínez-Carrión and Moreno-Lázaro 2007, see also Hernández and Moreno-Lázaro 2011 for a more detailed analysis). Having said this, it is also true that in the central decades of the nineteenth century episodes of urban penalty cannot be ruled out in proto-industrial areas of Castile-Leon owing to the over-exploitation of the workforce in the domestic industry of the region and, in fact, between 1851-55 and 1861-65 urban conscripts became shorter than their rural counterparts (Martínez-Carrión and Moreno-Lázaro 2010).

In Catalonia, episodes of urban height penalty are found during the first two thirds of the nineteenth century. Indeed, between the 1840s and the 1860s urban heights began to decline more rapidly than rural heights and in the 1860s the former were about 0.5 cm lower than that the latter. However, from then onwards urban heights improved. In the early 1870s, the conscripts born in urban areas were already taller than those born in villages and so remained until the outbreak of World War I (Ramon-Muñoz, J.M. 2009 and 2011). The initial drop in the stature of the Catalan urban dwellers is even more apparent in the industrial and densely populated town of Igualada: in the mid-1860s the conscripts born in this middle-sized Catalan town were 2 cm. shorter than those born in rural Catalonia. However, this difference vanished over time and in the first decade of the twentieth century the former were already 1 cm. taller than the latter (Ramon-Muñoz, R. and Ramon-Muñoz, J.M. 2015 and 2016).

There are other examples of urban height penalty. They can be found, for example, in the south-eastern industrial town of Alcoi, particularly for the cohorts born between the early 1860s and the late 1870s, and perhaps in Antequera, a town located in the southern region of Andalusia, for the cohorts born in the third quarter

of the nineteenth century (Martínez-Carrión, Pérez-Castroviejo, Puche-Gil and Ramon-Muñoz 2014 and Puche and Cañabate 2016, for Alcoi, and Martínez-Carrión and Cámara 2015, for Antequera). In the same line, height data for the Mediterranean region of Valencia show that rural conscripts were between 0.5 and 1.0 cm. taller than their urban counterparts. Although a process of convergence took place, by the first third of the twentieth century the former were still taller than the latter, but only when residing in a rural irrigated area (Ayuda and Puche-Gil 2014).

Owing to the diversity of situations, categorical conclusions on the evolution of the rural-urban gap are difficult to obtain for nineteenth-century southern Europe. In the particular case of Iberia, the evidence presented above clearly shows that in some parts of this peninsula a rural disadvantage in terms of biological living standards was already in place in the central decades of the nineteenth century, and even before, and so remained from then onwards. Thanks to available evidence it is also known that heights in some industrial and urban areas of Iberia declined relative to rural territories before the turn of the century. Whereas this urban disadvantage tended to reverse over time, it is nevertheless unclear whether, where and to what extent urban heights had already equalized or surpassed the rural ones by the end of the nineteenth century. Moreover, in Iberia, and probably in other parts of southern Europe, the picture of the rural-urban gap is still far from comprehensive as the available evidence is generally based on samples consisting of a limited number of villages, towns and cities. With some remarkable exceptions, these samples also lack big cities. Finally, and as a result of the low number of localities the existing samples generally consider, they do not tend to qualify the concepts of rural or urban through the establishment of settlement hierarchies (e.g. small towns, middle towns large towns, cities, large cities).

This study aims at contributing to partly fill these gaps. It explores whether and to what extent there was a rural-urban height gap in the north-eastern Iberian region of Catalonia by the last decade of the nineteenth century. It uses a new and large dataset (more than 16,000 observations) based on military records for the cohort of males born in the year 1890 and enlisted in the year 1911. The dataset has been designed to provide height evidence at individual level for each of the almost 1,000 current Catalan municipalities. This large geographic coverage represents a novelty when the present research is compared with previous Iberian studies. It also means a clear advantage relative to previous analyses: rather than following the current binary strategy according to which localities are simply classified as urban or rural, our dataset allows to test for linear (and non-linear) relationships between height and the size and economic nature of villages, towns and cities.

The paper is organised as follows. Based on secondary and primary sources, section 2 provides a brief overview on the evolution of biological living standards in nineteenth-century Catalonia. Section 3 presents the new dataset and some preliminary results. Section 4 applies an econometric model to test for the relationship between population size and biological living standards as well as the results of this test. Section 5 concludes by pointing out the existence of a qualified rural penalty in late nineteenth-century Catalonia.

2. The evolution of biological living standards in nineteenth-century Catalonia: an overview

Situated in the north-eastern part of Iberia (Figure 1), Catalonia underwent industrialisation unusually early as compared to other regions of the European periphery (Pollard, 1981). The origins and development of the Catalan industrialisation process are well-known. Initially, they were associated to the establishment of calico printing and, later on, to the progressive growth of cotton spinning and weaving (Sánchez 1989; Thomson 1992). A new step in the Catalan industrialisation took place in the early 1830s, when the cotton manufacture began an intensive process of mechanisation and, as a partial result, the factory-system emerged (Nadal 1975; Sánchez, 1989). Between 1835 and 1850, the number of mule-jennies multiplied by a factor of more than 17, from 27,220 to 475,490 (Nadal 1975: 196). As modern manufacturing developed, industrial production expanded rapidly in Catalonia: in the 1830s it grew at annual rate of more than 7 per cent; and in the 1840s and 1850s this percentage was 5.4 and 5.7 per cent, respectively (Maluquer de Motes 1994: 61).

Figure 1
Map of Catalonia: provinces, counties and municipalities
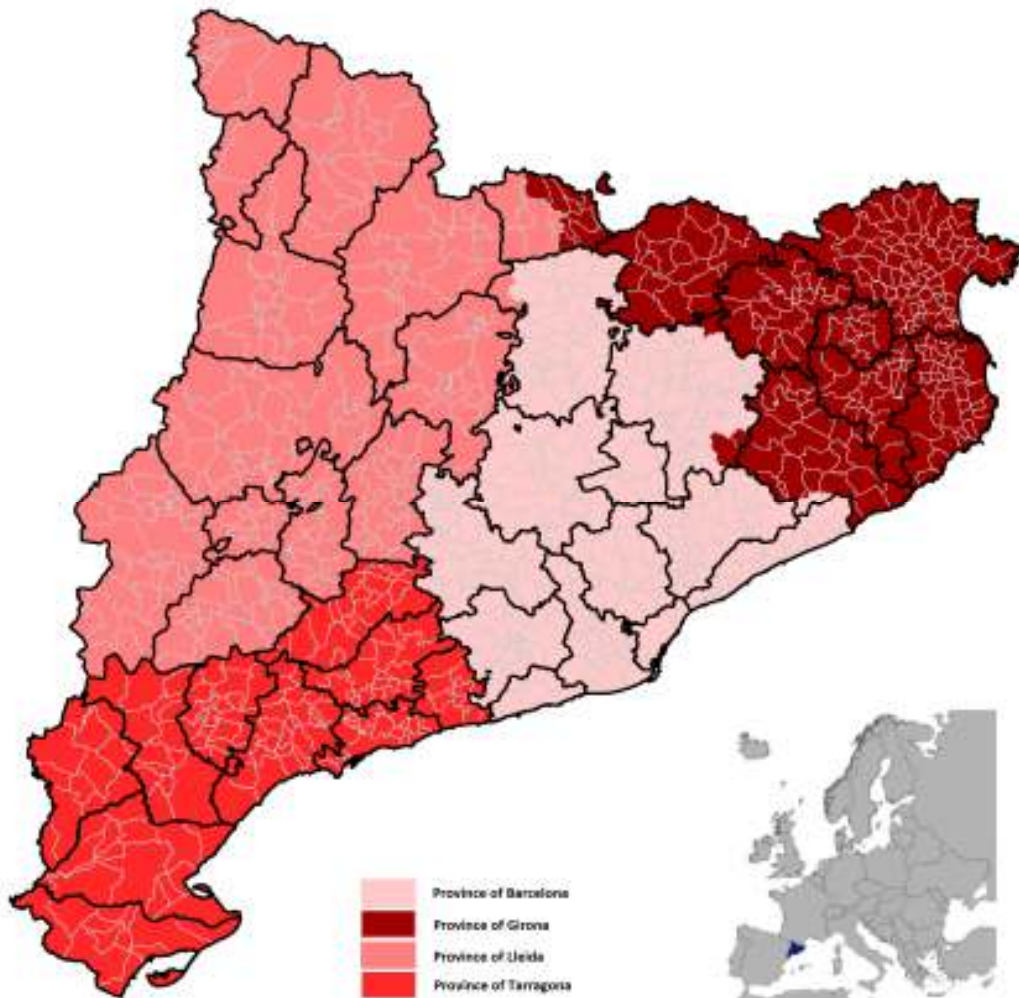
Notes and sources: Based on Eurostat (http://epp.eurostat.ec.europa.eu) and Municat (http://municat.gencat.cat).

Did industrial and economic growth influence biological living standards? In the United Kingdom, and in other north-western European countries, the early stages of modern economic growth coincided with a decline in heights, giving rise to the so-called "early-industrial growth puzzle" (Komlos 1998). The recent estimates by Cinnirella (2008) shows, for example, that the mean height of a young man aged 18 years declined by around 4 cm during the second half of the eighteenth century and by around 3 cm during the 1820s and the 1840s.

Figure 2
Industrial Production Index (IPI) and Urban Heights trend in Catalonia，
**1840-1914** (five-year moving averages, 1914=100)
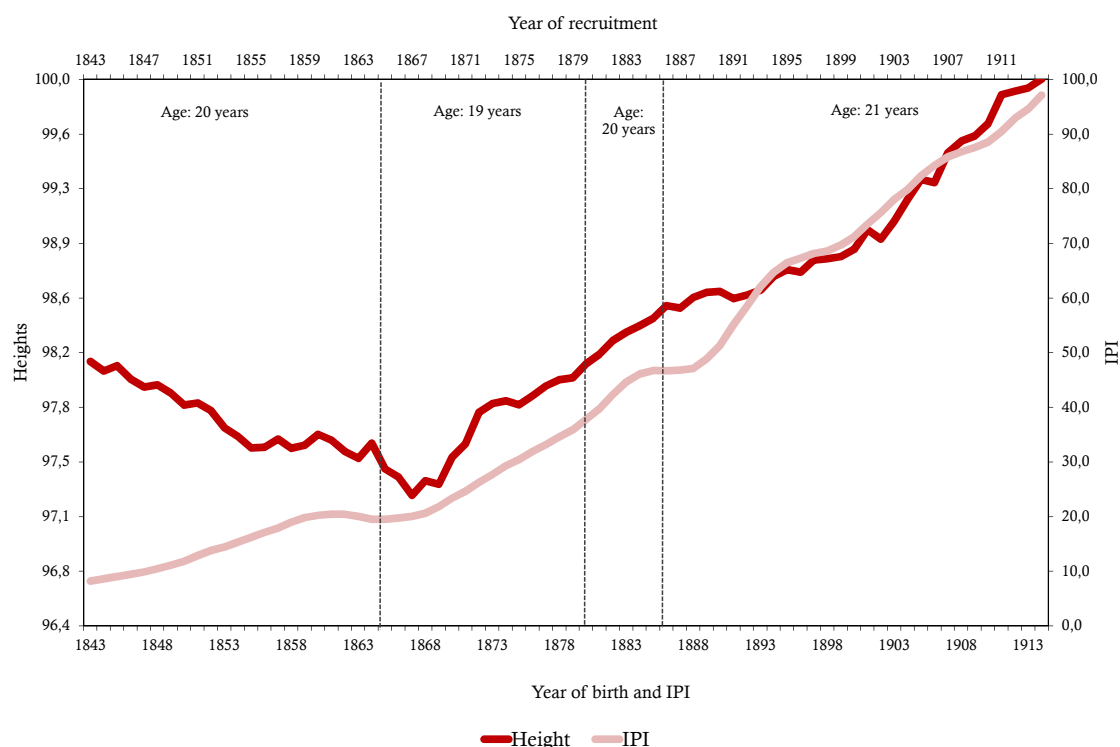
Notes and sources: Own elaboration based on data from Maluquer de Motes (1994:70) and the *Actas de Clasificación y Declaración de Soldados*, 1863-1935.

In Catalonia, there is some evidence showing also the existence of an "early-industrial growth puzzle". The case of Igualada, a middle-sized industrial town in central Catalonia, is illustrative in this respect. In the second third of the nineteenth century, the economy of Igualada experienced a rapid growth due mainly to the expansion of the cotton industry. New and large factories were set up and by the 1840s Igualada and its surrounding area had become Catalonia's largest cotton centre, in terms of both numbers of workers and numbers of spindles (Ramon-Muñoz and Ramon-Muñoz 2015 and 2016). However, at the time that local economy was growing, the mean height of the males was dropping. In particular, the mean height of the cohorts of conscripts born between the 1830s and the 1860s decreased by more than two centimetres, from around 165 cm to around 162 cm. The data presented in Figure 2 suggest that the "early-industrial growth puzzle" found in Igualada can be extended to other towns and, perhaps, to the whole

industrial Catalonia, at least for the cohorts born between the early 1840s and the early 1860s.

Figure 3
Heights of conscripts from Rural Western Catalonia (RWC) and Industrial Central & Southern Catalonia (ICSC) in the nineteenth and early-twentieth centuries
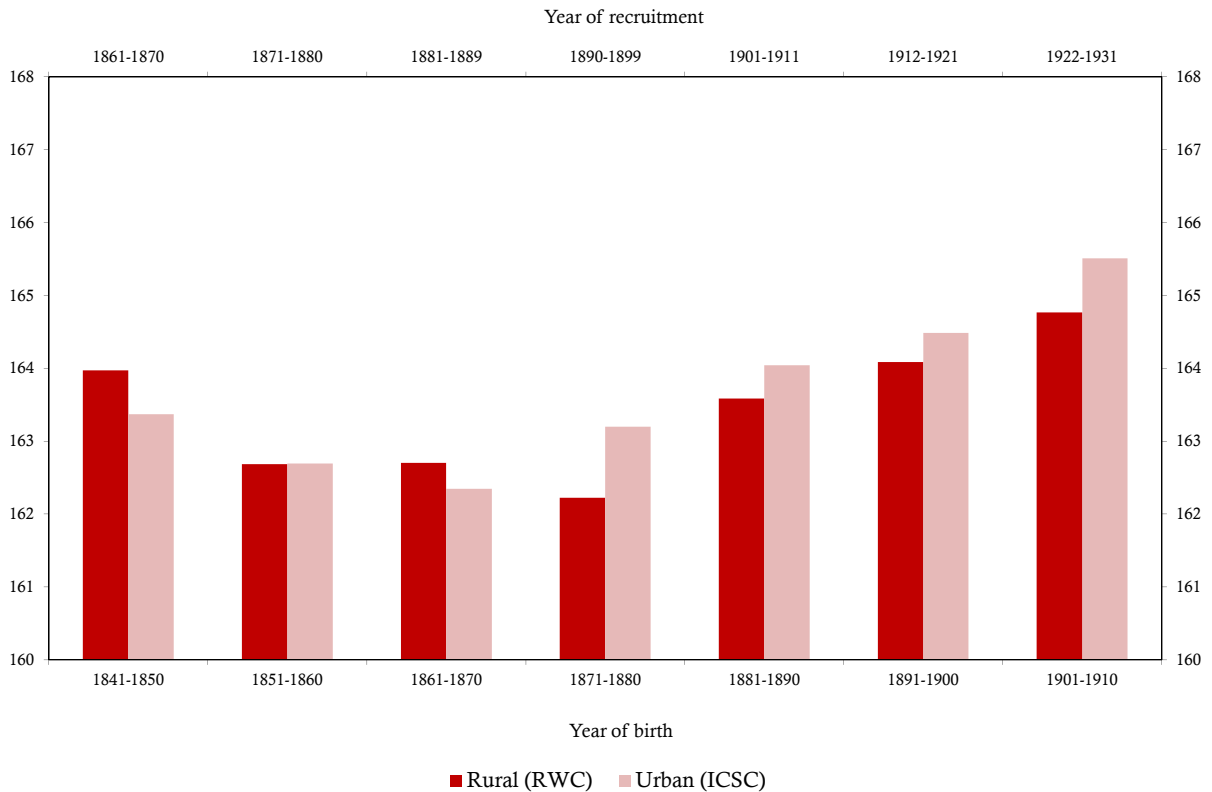
Notes and sources: Own elaboration based on data from Ramon-Muñoz, J.M. (2009, 2011, updated data), and Ramon-Muñoz, R. & Ramon-Muñoz, J.M. (2016).

In the Iberian context, the drop of the Catalan urban male heights during the early stages of industrialization was rather an exception. The mean height of the male cohorts born between 1841-45 and 1866-70 also declined in the region of Castile-Leon (-0.6 cm), although slightly less than in Catalonia (-0.8 cm). By contrast, male heights remained flat or increased modestly in Portugal (0.1 cm), the region of Valencia (0.05 cm) and South-eastern Spain (0.2 cm) (Martínez-Carrión and Moreno-Lázaro 2007, Puche-Gil 2011, Ramon-Muñoz, J.M. 2009 and 2011, updated data, and Stolz, Baten & Reis 2013).

With urban male heights declining between the 1840s and the 1860s, one might expect the emergence of an urban penalty in Catalonia. This is what the data displayed in Figure 3 suggest. By the early 1840s, Catalan rural conscripts had already a higher physical stature (+ 0.6 cm) than their urban counterparts (t=-1.899; p=0.058). As can be seen from Figure 3, rural heights dropped after the 1840s, paralleling the urban trend. The duration of this dropping period was, nevertheless, restricted to the decade of 1850 and contrasts with the evolution of urban heights. In this latter case, reductions in physical stature were rather permanent and lasted

until the 1860s. By then, rural conscripts were again taller (+ 0.5 cm) than the urban ones (t=-1.810, p=0.070).

A new cycle in the evolution of Catalan heights emerged in the course of the last third of the nineteenth century. Regarding urban heights, Figure 3 shows an increase of more than 3 cm for the cohorts born between the 1860s and the early 1910s. There is a variety of reasons explaining this remarkable improvement. Nevertheless, one might suggest that it was precisely during the last third of the nineteenth century when the expected productivity gains derived from industrialisation began to be more equally distributed. There is some evidence supporting this hypothesis. In the industrial town of Igualada, height inequality, as measured through the coefficient of variation, was rising throughout the third quarter of the nineteenth century. However, it fell sharply in the course of the following years, a period in which the mean height also began to improve (Ramon-Muñoz, R. & Ramon-Muñoz, J.M. 2015 and 2016).

Figure 4
Mean male height trends in Iberia, 1840-1914
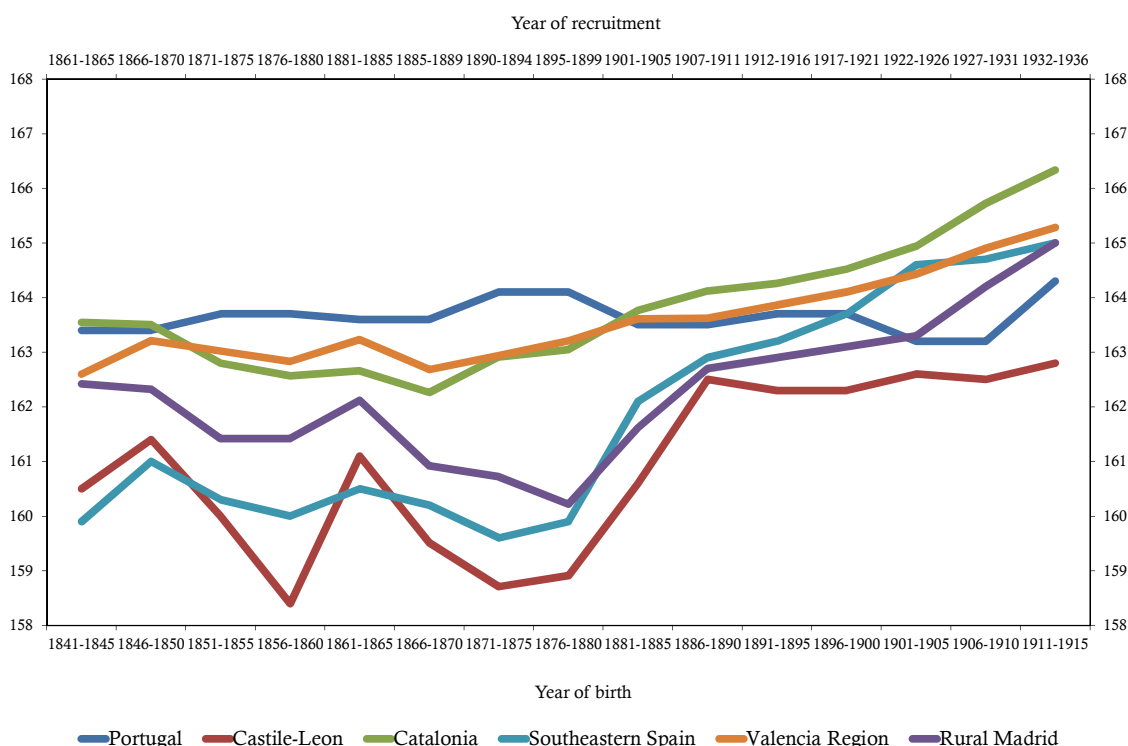
Notes and sources: For Portugal, it is only included height data for the cohorts born in 1840, 1850, 1860, 1870, 1880, 1890, 1900 and 1910. Own elaboration based on data from García Montero (2009), Martínez-Carrión and Moreno-Lázaro (2007), Puche-Gil (2011), Ramon-Muñoz, J.M. (2009, 2011, updated data), Ramon-Muñoz, R. and Ramon-Muñoz, J.M. (2016) and Stolz, Baten & Reis (2012). We exclude from the sample regions with samples formed by less than 5 municipalities as well as regions for which data have not been made available.

If urban heights evolved positively, the same was true for the heights of the cohorts of rural conscripts born from the 1870s onwards. Although the causes explaining the emergence of positive trend in rural heights would require further analysis, there is evidence showing a positive association between rural heights and rural wages for

the cohorts born between the mid-1890s and the early 1910s. A similar association could be established when agricultural production and land productivity is taken into consideration (Ramon-Muñoz, J.M. 2009).

In any case, the improvement of Catalan heights in both urban and rural areas had a final consequence: the emergence of Catalonia as a leading Iberian region in terms of biological living standards. By the eve of World War I, the mean male height was 166 cm in Catalonia, against 165 cm in the region of Valencia, rural Madrid and South-eastern Spain, 164 cm in Portugal and 163 cm in Castile-Leon (Figure 4). At that time, Catalonia had already become "Spain's factory" and, as a result, it was also the Spanish region with the highest GDP per capita (Nadal 1985, Parejo 2001, Rosés, Martínez-Galarraga and Tirado 2010).

Interesting as it might be, this account of the evolution of biological living standards in nineteenth century Catalonia needs to be complemented. The cycle of growth in the Catalan heights that began in the late 1860s was hand in hand with a reversal in the urban penalty. In fact, by the last quarter of the nineteenth century urban heights situated above the rural ones and so continued in the course of the following four decades. The available evidence suggest, therefore, that in Catalonia the urban-rural height gap evolved in the course of the second half of the nineteenth century from an urban height penalty to an urban height premium. Unfortunately, the Catalan data upon which this interpretation depends is still rather fragmentary. It is based on 5 rural municipalities and 3 industrial towns, which means that the current dataset covers a very low percentage of the Catalan territory. In order to fill this gap, a new dataset has been constructed. The next section describes the main features of this dataset, as well as its potential shortcomings.

3. A new and unique dataset on Catalan heights: description and potential shortcomings

The dataset used in this paper is based on military records generated during the enlistment process for military service in early-twentieth century Spain. In particular, and mainly due to data availability, the information we collected refers to the recruitment year of 1911, which corresponds to the birth cohort of 1890. For this cohort, the military service was compulsory and, as a result, all 21-year-old men had been called up for military service. A first step in the conscription process was measurement and medical inspection, which was conducted at local level. The authorities of every single municipality had to prepared local lists of recruitment, the so-called *Actas de Clasificación y Declaración de Soldados* (Acts of Classification and Declaration of Soldiers), which included, among others, the name, birth year, and the physical stature of the draftees. Based on height measurements and other additional information, local boards established whether or not conscripts were fit to serve.

A second step in the conscription process took place at provincial level (Cámara, 2006). The Recruitment and Replacement Act of 1896 established the creation of examination commissions in the provinces, the so-called *Comisión Mixta* (Mixed Commission). These commissions had the aim of ruling about the fitness and other declarations stated by the potential soldiers to be excused from the obligatory

military service. The information collected in both the local and the provincial recruitment rounds was summarised in the *Libros de Reemplazo* (Recruitment Books).

A third step in the conscription process took place once the procedure of inspection had finished. All conscripts fit to serve were included in a local lottery, a public event that aimed at selecting the conscripts that would finally join the Spanish army. The exact number of selected conscripts varied from one year to another, depending on the military requirements. This number was established at the beginning of each year by the Spanish Government who then distributed the required number of conscripts by provinces and in accordance with the population of each province. Subsequently, the provincial authorities did the same and, therefore, established the corresponding distribution at municipal level. In any case, for the conscripts that finally joined the army, the provincial authorities were asked to send to the Ministry of War detailed information about the given conscript (Molina 2012). This information was summarised in the so-called *Hojas de Filiación de los Expedientes Reglamentarios de Tropa* (Registration Records from the Troop Statutory Files).

Table 1
Number of conscripts and Municipalities included in the current dataset

| Province	Total conscripts	Conscripts with		No. of municipalities	
		height information	height data	province	dataset
Barcelona	10,076	9,060	9,004	314	299
Girona	3,135	3,011	3,011	223	212
Lleida	3,200	2,763	2,763	227	224
Tarragona	1,774	1,750	1,750	184	174
Total	18,185	16,584	16,528	948	909

Notes and sources: See text.

Our dataset uses height data originated in each of the phases that composed the conscription process. It is, therefore, formed by information collected from the Acts of Classification and Declaration of Soldiers, the Recruitment Books and Registration Records from the Troop Statutory Files of the conscripts enlisted in the recruitment year of 1911. In total, we use information from 18,185 individuals and height data from 16,528 conscripts (Table 1). The difference between the former and the latter figures are related to the existence of several shortcomings in the original sources. Although all young men were called up for military service, some of the draftees deserted before inspection and, therefore, height information lacks for some individuals. In addition, there were conscripts that were living outside their official places of residence at the time of enlistment, and they could not attend the call of the local or provincial authorities. Finally, inaccuracies and changing criteria in the registration process prevent us to use a larger number of height data.

In spite of these shortcomings, the dataset we have constructed is able to cover a very large percentage of the cohort of men born in 1890. The mean height of this birth cohort has been calculated to be 1,643 mm. In contrast with Quiroga's estimates (2002), our data indicate that the cohort of Catalan males born in 1890 was more than 1 cm taller than previously thought (Table 1), the differences

probably arising from sample coverage and data source considerations. Whereas we consider data from 16,528 conscripts, Quiroga's data is based on a sample of 30 conscripts taken from the Registration Records (Figure 5). Contrary to the case of Quiroa, the mean height of our dataset is about same as that provided by Ramon-Muñoz, J.M. (2011), which is based on data from 7 Catalan municipalities (1,643 mm). It is also very similar to the mean height estimated by Gómez-Mendoza and Pérez-Moreda (1985) for the cohort of males bon in 1892 (1,640 mm). In their estimates, these authors make use of height data published in the *Estadísticas de Reclutamiento y Reemplazo del Ejército* (Ministerio de Instrucción Pública y Bellas Artes 1915, MIPBA 1915 hereafter), which provides height information at provincial level for the conscripts that both reached the official minimum stature and effectively joined the army.

Figure 5
**The mean height of the Catalan male cohort s born in1890 and 1892**
(in mm)
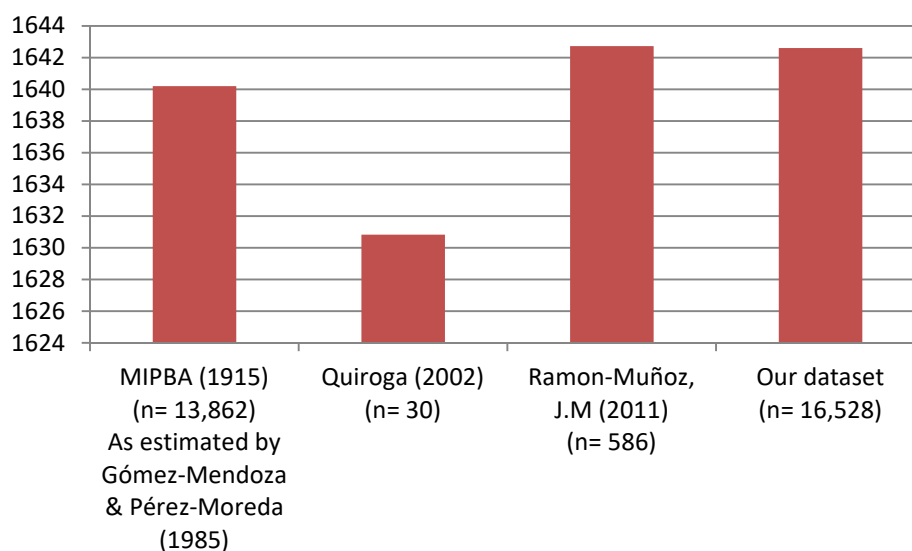
Notes and sources: See text.

Figure 6 compares our dataset with height information included in MIPBA (1915). In particular, it differentiates by stature intervals by applying the same distribution as in this latter source. Although data refer to two different conscription years (1890 and 1892, respectively), the distribution of heights is very similar. As can be seen, most of the values are situated between 1,600 and 1,699 mm, whereas the other two intervals concentrated about 20 per cent of the heights each.

Are then the heights in our dataset normally distributed? Figure 7 suggests a positive answer to this question. More precisely, it shows that our data follow a quasi-normal (Gaussian) pattern, with a negative skew due to the existence of several extremely low heights which are not necessarily explained by measurement errors. Very low heights have also been found in other Iberian regions (e.g. Ayuda & Puche-Gil 2014). Having said this, it is also true that the number of extreme heights in our dataset is very small. For example, less than 0.1 per cent of heights were lower than 1,400 mm and less than 1.0 per cent lower than 1,500 mm. Similarly, the percentage of official stunting (below 1,540 mm) was also rather modest, namely around 4 per cent. On the right side of the distribution, only 2

heights out of 16,528 were above 1,900 mm, while those conscripts with a stature above 1,800 accounted for about 0.6 per cent of the total dataset. Finally, the distribution presented in Figure 3 also suggests that our dataset is not affected by truncation, one of the main potential shortcomings in military samples (e.g. Komlos, 2004). This statement will require some qualification hereafter when we talk about the potential shortcomings of our dataset.

Figure 6
The distribution of heights in our dataset (birth cohort of 1890) and in the
Estadísticas de Reclutamiento y Reemplazo **(birth cohort of 1892): conscripts residing in Catalonia with a stature equal or above 1,540 mm**
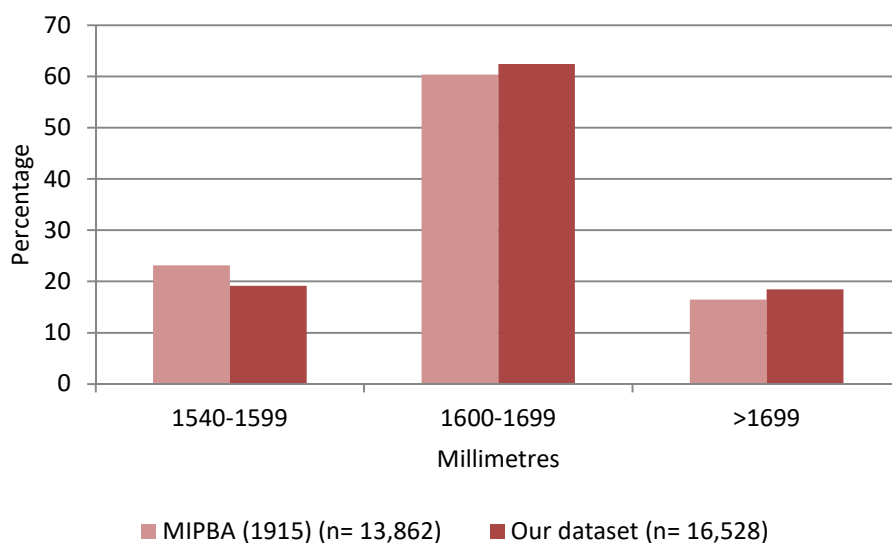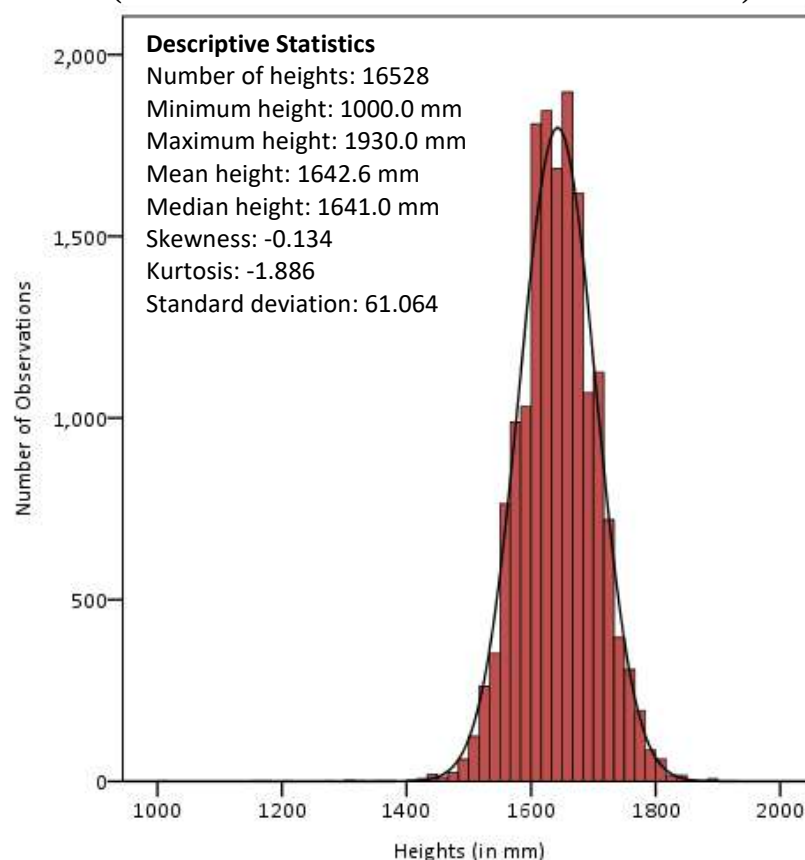

Notes and sources: 1,540 mm. was the minimum height established by law to serve in the army. See also text.

While our dataset covers a large percentage of the male cohort born in 1890, it also has a broad geographic coverage. It includes data for 909 out of the 948 municipalities currently existing in Catalonia (Table 1). In other words, the municipalities covered by this dataset account for 99.6 per cent of the population residing in Catalonia around 1890. Perhaps even more interesting, the distribution of both conscripts fits extraordinarily well to the distribution of population by municipality size as measured by the number of inhabitants (Figure 8). To be sure, the geographical coverage of the dataset used in this study represents a novelty relative to other datasets available for Iberia as well as for some other European countries and regions. For example, the broadest dataset for nineteenth-century Iberia has been constructed for the region of Castile-Leon (Hernández García and Moreno Lázaro 2009 and 2010). It is a strong dataset which includes almost 68,000 observations for the male cohorts born between 1839 and 1915. It takes into account the largest towns of the region as well as a remarkable of rural areas. Nevertheless, the total number of localities included in this dataset is, for obvious reasons, limited, namely 25 localities out of the 2,248 municipalities that currently form this region[1].

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[1] Certainly, there are other broad datasets in Iberia, although they are not always designed to search for the existence of a rural-urban height gap. The datasets which include a rather large number of localities refer to Extremadura (30 localities, cohorts of males born from 1870 to 1880), rural

Figure 7
Distribution of heights of Catalan conscripts and descriptive statistics
(male cohort born in 1890 and enlisted in 1911)

Descriptive Statistics
Number of heights: 16528
Minimum height: 1000.0 mm
Maximum height: 1930.0 mm
Mean height: 1642.6 mm
Median height: 1641.0 mm
Skewness: -0.134
Kurtosis: -1.886
Standard deviation: 61.064

Notes and sources: See text.

Of course, and despite its broad coverage, our dataset might be affected by several potential shortcomings that need to be considered. Firstly, for most of the conscripts we do not have information on the place of birth but on the place of residence, a consequence of limitations in the data sources as well as in the process of data collection. Therefore, conscripts' height data are always organized by municipality of residence – using the current municipal boundaries as reference – at the time of enlistment rather than by municipality of conscripts' birth. As will be explained below, this might introduce some bias in the interpretation of the results, particularly for the municipalities belonging to the province of Barcelona (Table 2). Nevertheless, the data reported by the Spanish Population Census of 1910 show that for the rest of Catalan provinces, i.e. Girona, Lleida and Tarragona, more than 90 per cent of the inhabitants resided in the same province (and perhaps locality) than they had been born. Consequently, we assume a positive and a rather high correlation between the place of birth and the place of residence, although we agree that this statement would require a number of qualifications.

Catalonia (26 localities, cohorts of males born from 1879 to 1896) and rural Madrid (18 localities, cohorts of males born from 1837 to 1915). See Linares Luján and Parejo Moruno (2016), Ramon-Muñoz, J.M. (2009), and García Montero (2009), respectively.

Figure 8
The distribution of conscripts and population by population size of the municipalities in Catalonia
(male cohort born in 1890 and enlisted in 1911)
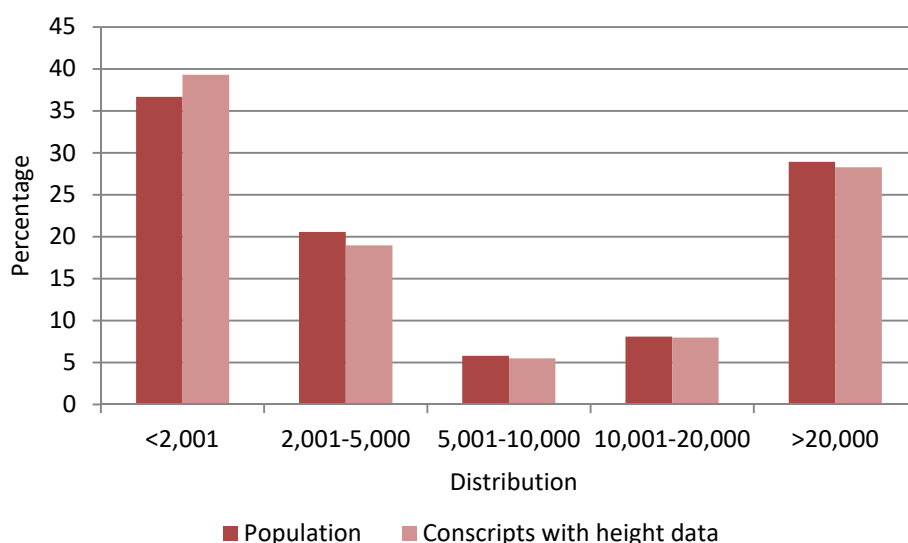
Notes and sources: See text.

Secondly, during the process of data collection we noticed that for some localities the available information on conscript height was affected by censuring. In these cases, the sources we used offered no information on the stature of the conscripts below 1540 mm, which was the minimum height required to join the army at that time. Yet, the sources did detail the number of conscripts below the minimum stature required. Certainly, the number of records affected by censoring was rather low, 56 out of 16,584 records. However, they were mostly concentrated in the province of Barcelona. To make things worse, conscripts residing in this latter province were on average taller than in the rest of the country. Consequently, one might conclude that the height advantage in the province of Barcelona arose because of part of the short draftees did not enter in our sample of conscripts with height data due to censoring problems. However, the percentage of conscripts with a stature below 1,540 mm was not very important (less than 4 per cent) and is was similar to the rest of Catalonia, suggesting that the Barcelona height advantage lay in factors other than data shortcomings.

Table 2
Distribution of the Catalan population by place of birth, 1910 (percentages)

Province	In the same province	In other provinces	Abroad	Unknown
Barcelona	72,53	26,27	0,85	0,34
Girona	91,82	7,39	0,79	0,00
Lleida	94,50	5,04	0,35	0,12
Tarragona	93,58	6,22	0,20	0,01
Total	81,91	17,22	0,67	0,21
Barcelona*	58,22	39,85	1,36	0,57

Notes and sources: (*) City of Barcelona. Our own elaboration from the Population Census of 1910.

Thirdly, we expected to find truncated height samples for some localities, particularly when we had to rely on data summarised in the Registration Records from the Troop Statutory Files. As this source only recorded information for those conscripts that effectively joined the army, we foresaw a lack of conscripts with a stature below the required minimum height, namely 1,540 mm. Reality is always complex and we did find short conscripts serving. It is true that data shortcomings associated with truncation could be found in several localities in our sample. However, it is doubtful that this represents a serious obstacle in our study. It is also unclear to what extent the use of Registration Records from the Troop Statutory Files (hereafter Registration Records) may bias our results.[2] This does not seem to have been always the case, at least in urban areas. To give an example, in Reus – the largest urban concentration in the province of Tarragona – the male cohort born in 1890 (and residing in the city in 1911) was 1,648.5 mm tall (n=185). This result was obtained by using local data from the Acts of Classification and Declaration of Soldiers. If instead of this source, we took into account data from the Registration Records the mean height for Reus would be rather similar, 1,650.8 mm (n=95).

Figure 9
The mean height of conscripts by population size of the municipalities in Catalonia
(male cohort born in 1890 and enlisted in 1911)
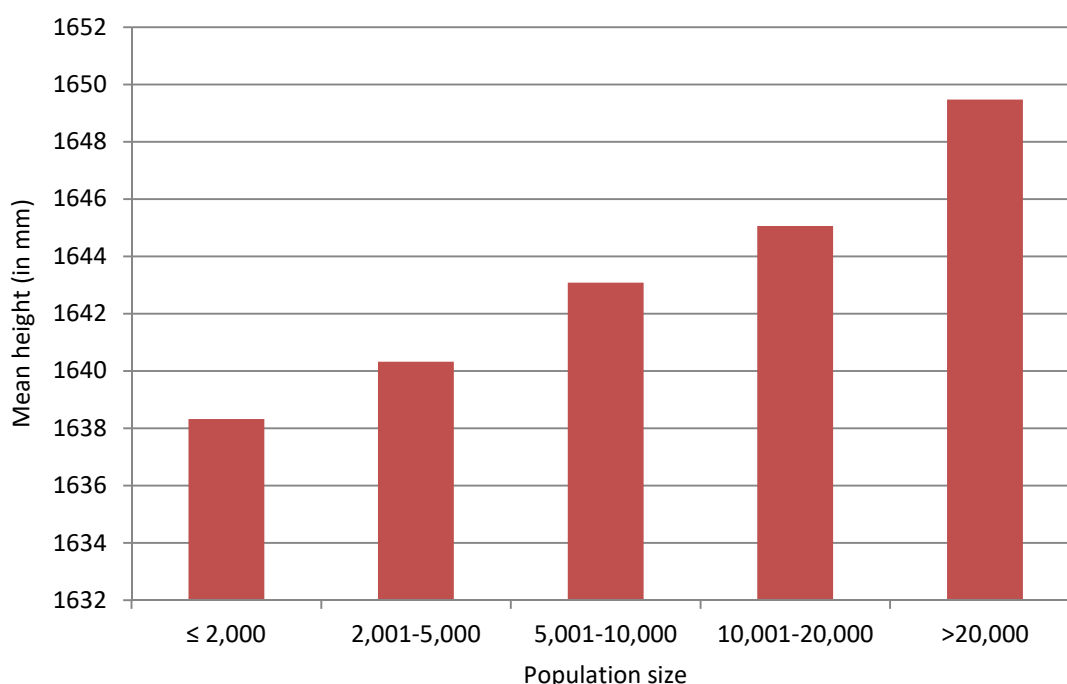
Notes and sources: See text.

Although far from ideal, this new dataset add valuable information on biological living standards in southern Europe. It should also allow shedding new light on some of the most discussed topics in the literature on historical anthropometrics. The existence of an urban-rural height gap is one of these topics. Figure 5 shows the mean height of the Catalan conscripts born in 1890 by population size of the

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[2] The use of this source has been rather extensive for the municipalities of the province of Tarragona.

municipalities they resided. The figure speaks by itself. It suggests a positive and linear relationship between height and population size. As those conscripts residing in municipalities of less than 5,001 inhabitants were shorter than the rest, it seems also to support the existence of a rural penalty in late-nineteenth century Catalonia. As interesting as it is, the picture emerging from Figure 9 is, nevertheless, far from being conclusive and it is through the use of quantitative methods that we may asses the robustness of our findings.

4. Testing for a rural height penalty: model and results

This section aims at testing the relationship between population size and height. It analyses whether and to what extent the rural-urban gap, and, in particular, the rural height penalty, that the available statistical description suggests is confirmed through econometric analysis. To this end, we apply a model that uses cross sectional data and is based on ordinary least squares (OLS). In this model, the dependent variable is the height of most of the Catalan young men that were called up for military inspection in the 1911 draft. As explained in the previous section, they were born in 1890 and were measured and enlisted at the age of 21 years. The total number of conscripts with height data is set to 16,528, belonging to 909 municipalities.

Regarding the independent variables included in the econometric model, there are two preliminary issues that need to be mentioned. Firstly, the independent variables we use always refer to the period around the year of birth of the conscripts. This decision has a simple explanation. Following most studies in anthropometric history, we assume that the stature of the 21-year-old Catalan conscripts was mostly influenced by environmental and nutritional factors during the conscripts' first years of life rather than during the conscripts' teenage years (Tanner 1978, Van Zanden et al. 2014: 119). In other words, the height of the Catalan young men measured and enlisted in 1911 was mainly reflecting the biological living conditions of the Catalan (male) population in the early 1890s.

Secondly, due to limitations in the data sources, the independent variables included in the econometric analysis are variables at municipal-level. This means that we link the individual height information for each of the 16,528 conscripts that form our dataset with some factors characteristic of the 909 municipalities where the given conscript officially resided at the time of military inspection. Unfortunately, data sources limitations also prevent us – as would ideally be desirable – to have precise information on the locality where the conscripts were born and lived during their early childhood. As mentioned in the previous section, we are well aware that this might bias our results since there are a number of conscripts that at the time of military inspection had the residence in a municipality that was different from where they were born and raised.

Keeping all this in mind, we have constructed four different independent variables to be included in the model. The main variable of interest is the population size of the municipality where the considered conscript resided when measured and enlisted. Population data have been taken from the Spain's population census of 1887, which is the closest census to the birth cohort of 1890. In line with other

studies (e.g. Heyberger 2007, Zehetmayer 2013), we have constructed several categories of municipalities in order to take into account municipal population size. The considered categories are the following: below 2,000 inhabitants, between 2,001 and 5,000 inhabitants, between 5,001 and 10,000 inhabitants, between 10,001 and 20,000 inhabitants, and more than 20,000 inhabitants. The two first categories might be considered to fall clearly into the definition of rural areas (Gómez-Mendoza and Luna-Rodrigo 1986), whereas a clear definition for the remaining groups is more difficult to stablish. In the Catalan context of the late nineteenth century, municipalities between 5,001 and 20,000 inhabitants might be defined as towns of different population size, although some scholars might prefer to include them into the category of rural areas. Finally, municipalities with more than 20,000 inhabitants fall clearly into the definition of urban areas and, in some cases, they might be defined as industrial cities. These five categories of municipalities have entered into the regression as dummy variables (e.g. if the considered conscript resides in a municipality of less than 2,000 inhabitants 1, otherwise 0). Descriptive statistics suggests a positive relationship between population size and height.

Whereas the population size of the municipalities is the main variable of interest, we also consider other potential factors that might affect the stature of the Catalan young men called up for military service. They are included as controls in the regression. The first (and perhaps obvious) variable we take into consideration is population density. Certainly, this variable is highly (and positively) correlated with population size (R^2= 0.99, p=0.000). Nevertheless, it may contribute to capture the potential (negative) impact of overcrowding on biological living standards, as discussed in the introduction section. Population data has been taken again from the Spain's population census of 1887. As we use the current municipal boundaries, we have taken information on municipal areas from IDESCAT (the Statistical Institute of Catalonia) for 2016 (http://www.idescat.cat/en/).

The second variable of control included in our regression aims at measuring access to railroad transport and, therefore, market integration. There is a large body of literature that shows that railroad had an influence on heights. On the one hand, this influence could be positive in the case of urban dwellers since railroads facilitated the importing of foodstuffs from rural to urban areas. As a result, foodstuffs became cheaper and more abundant in towns and cities, which finally might contribute to improve the nutrition of urban dwellers (e.g. Solakoglu 2007, Yoo 2012, Zehetmayer 2013). On the other hand, railroads might be detrimental to the biological living standards of rural population. Firstly, it might facilitate the spread of diseases from cities to rural areas. Secondly, it might contribute to take away proteins and other nutrients from the countryside, negatively affecting the height of rural communities (e.g. Komlos 1987, Haines 1998, Haines et al. 2003, Haines 2004). In order to capture these potential impacts, we have constructed a dummy variable that states whether the considered conscript resided in a municipality with railroad station or not (1 and 0, respectively) at the time that was called up for military service. Using data provided by Pascual (2016: Appendixes) as well as other complementary information, this variable only considers the municipalities that had a station in broad gauge railroad lines in 1890, coinciding with the year of birth of the conscripts. By that year, the railroad lines with broad gauge accounted for more than 90 per cent of the longitude of all railroad lines operating in Catalonia (Pascual 2016: 27-30).

Table 3
Matrix of correlations

	Height of individuals (birth cohort 1890)	Population size of municipalities (1887)	Population density of municipalities (1887)	Altitude of municipalities
Height of individual (birth cohort 1890)	1.0000			
Population size of municipalities (1887)	0.0640	1.0000		
Population density of municipalities (1887)	0.0660	0.9946	1.0000	
Altitude of municipalities	-0.0971	-0.4776	-0.5003	1.0000

Notes and sources: * All results are statistically significant at the 1 percent level.

The last variable of control we have considered in our econometric model is the altitude of the municipalities where the conscript was officially residing at the time of inspection. This variable, which we have taken directly from IDESCAT, has been considered in several studies on biological living standards, either implicitly or explicitly. For example, for Argentina Bejarano et al. (2009) found a negative relationship between mean height and geographical altitude in a sample of 48,589 conscripts born between 1870 and 1960. By reviewing the findings of a Portuguese physical anthropologist, Da Costa Leite (1998: 460) explains that in the 1890s men were found to be "shorter in the areas of higher altitude" of Northern Portugal. Ramon-Muñoz, R., Ramon-Muñoz, J.M. and Koepke (2015) arrived at similar conclusions for late-nineteenth century western Catalonia using a sample of 16,389 conscripts born between 1879 and 1890. This negative association between stature and altitude might reflect a number of factors, including, among others, climatic conditions, agriculture orientation, poor economic conditions in highlands, transport costs, isolation, as well as difficulties to access to richer and more abundant resources. In addition, altitude is also correlated to other variables that might negatively affect height. In our dataset, and as expected, it is significantly and negatively correlated with population size and population density (Table 3). However, in both cases the R^2 is not as strong as it might be thought (around 0.25). Interestingly, the matrix of correlations presented in Table 3 also shows a negative relationship between altitude and height. Instead, height correlates positively with both population and population size, as suggested above.

$$(1) \quad \text{HEIGHT}_{jit} = \beta_0 + \beta_1 \, \text{CATMUNPOPSIZE}_{jit} + \beta'_2 \, Z_{jit} + \mu_{iit}$$

The basic model to be estimated in this study is summarized in Equation (1). It includes the height of the recruit j residing in municipality i born in year t (HEIGHT_{jit}) as a dependent variable, the category of municipality i by population size where the recruit j resided at the time of enlistment t ($\text{CATMUNPOPSIZE}_{jit}$) as the main independent variable, and a series of control variables designated as Z_{jit}, namely population density, railroad station and altitude of the municipalities where the given conscript resided, and, finally, the error term μ_{jit}.

Table 4
The impact of population size on male heights in Catalonia
in the cohort born in 1890
(Dependent variable: Individual male height, mm)

| Variables	(1)	(2)	(3)	(4)
Population Size:				
≤2,000 inhabitants	-11.144***	-10.561***	-10.103***	-6.539**
	(1.158)	(2.449)	(2.521)	(2.547)
2,001 - 5,000 inhabitants	-9.142***	-8.572***	-8.146***	-6.619**
	(1.377)	(2.521)	(2.590)	(2.595)
5,001 - 10,000 inhabitants	-6.390**	-5.845*	-5.336*	-4.393
	(2.255)	(3.019)	(3.104)	(3.106)
10,001 - 20,000 inhabitants	-4.408**	-3.912	-3.448	-3.698
	(1.877)	(2.627)	(2.700)	(2.695)
> 20,000 inhabitants	Ref.	Ref.	Ref.	Ref.
Population density		0.000	-0.001	-0.001
		(0.001)	(0.002)	(0.002)
Railways station			0.768	0.268
			(1.077)	(1.075)
Altitude				-0.018***
				(0.002)
Constant	1,650***	1,649***	1,648***	1,652***
	(0.860)	(2.361)	(2.451)	(2.482)
R-squared	0.006	0.006	0.006	0.010
Observations	16,528	16,528	16,528	16,528

Sources and Notes: *** p<0.01, **p<0.05, *p<0.10. Robust standard errors are given in brackets.

Table 4 presents different specifications of the model. The results indicate a positive and a statistically significant association between male heights and population size, but with some qualifications. This association is always statistically significant in absence of control variables (Table 5, Column 1). It is also a linear relationship among the different categories of municipalities: relative to the conscripts that resided in cities,, which is the reference category, those that lived in other areas were -4.4, -6.4, -9,1 and -11,1 mm shorter depending whether they resided in larger or smaller towns or in larger and smaller villages, respectively.

By adding control variables to the basic regression, the direction of the association between population size and height remains, but then both the coefficients and the statistical significance of the population size variables vary. This is particularly true when, in addition to population density and railways station, we also control for the altitude of the considered municipalities. Now, the differences between the heights of those conscripts residing in municipalities with less than 5,001 inhabitants and those living in towns and cities (>5,000 inhabitants) drop substantially. The conscripts living in towns (5,001-20,000 inhabitants) remain shorter than those residing in cities, although the difference is now not statistically significant. In fact, it is only among the rural conscripts (those residing in municipalities with less than 5,001 resident) that heights are significantly shorter compared to those of the conscripts residing in cities (>20,000 inhabitants). Once controlled by population density, railways station, and altitude, the existence of a rural penalty for late-nineteenth century Catalonia is confirmed.

Interestingly, the results presented in Table 4 also suggest that part of the rural-urban gap is explained by differences in the altitude of the municipalities where the conscripts resided. This finding will require further analysis in future work. By contrast, residing in a municipality with a high population density or with railways station does not seem to have had any significant impact on the height of the conscripts born in 1890. These results, particularly those related to railways, call for further attention. As already mentioned, the existing literature on this field tends to stress that railways had an influence on height, which could be positive or negative, depending on the category of the settlement. In our case, the overall influence of railways is positive, but not statistically significant. It cannot be ruled out different results in case we used a different proxy for measuring the impact of railways on height (Heyberger 2014).

Figure 10
Male population employed in the agricultural sector in Catalonia, 1887-1910
(in percentages)
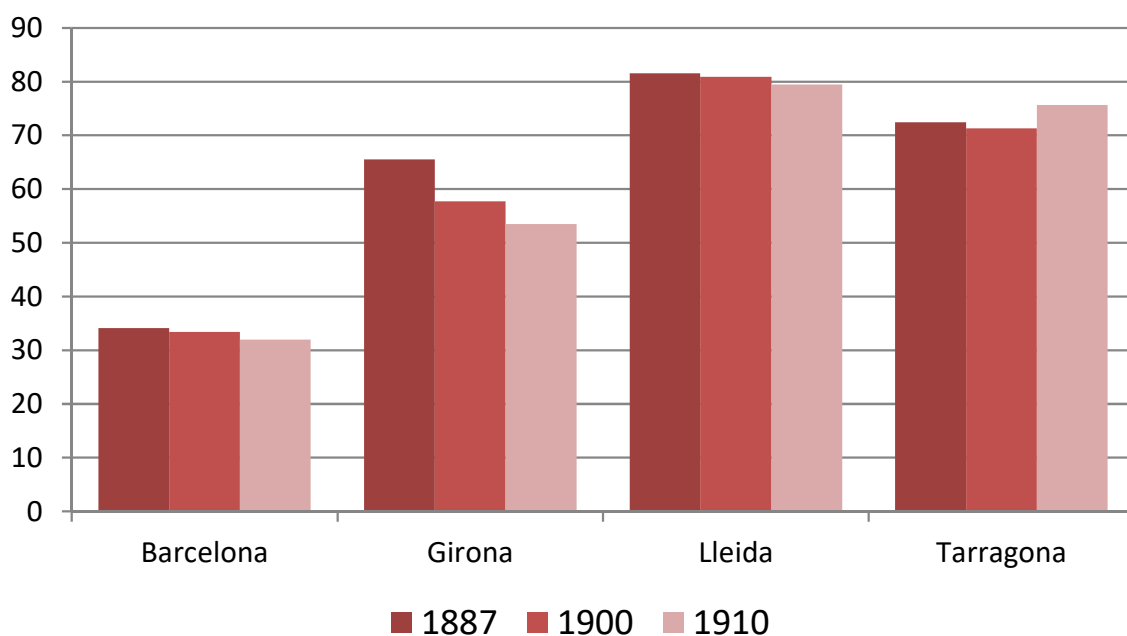
Notes and sources: Own elaboration based on data from Nicolau (1990: 53).

Did the impact of population size on height vary across the Catalonia? We might expect a positive answer to this question. This is simply because of the size, distribution, nature and characteristics of population settlements were far to be homogenous across Catalonia. For example, in the province of Barcelona –the most industrialised and densely populated province of Catalonia – the average size of those municipalities with more than 20,000 inhabitants was 8 times larger than in the rest of the country, mainly because of Barcelona city. Similarly, the largest urban areas in the province of Barcelona (municipalities with more than 10,000 residents) were more industry-oriented than their counterparts in the rest of Catalonia, as the province of Barcelona was more oriented towards industry and services compared to the rest of Catalan provinces (Figure 10). In order to test for

this potential variation, we split our dataset into two groups of conscripts, i.e. those residing in municipalities located in the province of Barcelona and the rest.

Table 5
The impact of population size on male heights in the province of Barcelona and the rest of Catalonia (brith cohort of 1890)
(Dependent variable: Individual male height, mm)

Variables	Province of Barcelona		Rest of Catalonia	
	(1)	(2)	(1)	(2)
Population Size:				
≤2,000 inh.	-12.473***	-4.894	-11.779***	-5.376
	(1.575)	(4.480)	(2.821)	(3.444)
2,001 - 5,000 inh.	-10.781***	-8.283*	-9.734***	-4.592
	(2.064)	(4.540)	(2.960)	(3.473)
5,001 - 10,000 inh.	-2.224	4.163	-9.520***	-7.648**
	(4.081)	(5.640)	(3.605)	(3.764)
10,001 - 20,000 inh.	-4.979**	-2.150	-3.027	-4.503
	(2.063)	(4.286)	(4.647)	(4.983)
> 20,000 inh.	Ref.	Ref.	Ref.	Ref.
Population density		-0.001		0.007
		(0.003)		(0.007)
Railways station		0.546		0.124
		(1.635)		(1.623)
Altitude		-0.023***		-0.016***
		(0.004)		(0.003)
Constant	1,649***	1,651***	1,651***	1,651***
	(0.909)	(4.638)	(2.641)	(3.601)
R-squared	0.008	0.012	0.003	0.009
Observations	9,004	9,004	7,524	7,524

Sources and Notes: *** $p<0.01$, **$p<0.05$, *$p<0.10$. Robust standard errors are given in brackets.

By applying the model described in Equation 1, Table 5 makes it clear that the rural-urban gap may vary depending on the geographical area under study. At first glance, the rural height penalty seems to find confirmation both in the province of Barcelona and in the rest of Catalonia (Table 5, column 1). In both cases, the conscripts residing in municipalities up to 5,000 inhabitants were around 1 cm shorter than those living in cities, the difference being statistically significant. Nevertheless, the rural penalty becomes less apparent when control variables are included in the model (Table 5, column 2). In the case of the province of Barcelona, the height penalty only remains for those conscripts living in settlements of between 2,001 and 5,000 population, but not for those residing in smaller areas. For the rest of Catalonia, rural conscripts were not significantly shorter than the urban conscripts living in the largest agglomerations of the provinces of Girona, Tarragona and Lleida, which in general were either administrative cities or agro-cities. In this part of Catalonia, instead, a height penalty is found among the conscripts living in towns of between 5,001 and 10,000 residents. Unfortunately, at the present stage of research we cannot provide a satisfactory interpretation to explain why the population size-height relationship varies across Catalan regions. We have identified the settlements with a significant height gap relative to the reference group, namely conscripts residing in the largest agglomerations of each area. And we believe that delving into the characteristics of these settlements we might provide insights into the complex relationship between biological living standards and population size.

5. Conclusions

This study has explored whether and to what extent there was an urban-rural height gap in the north-eastern Iberian region of Catalonia in the late nineteenth century. It has used a new dataset consisting of more than 16,000 observations for the cohort of males born in the year 1890 and enlisted in the year 1911. This new dataset is able to cover 909 out of the 948 municipalities that form current Catalonia. The broad geographic coverage of our dataset represents a remarkable novelty in the context of historical anthropometrics in Iberia. And it has allowed us testing for the existence of a linear relationship between height and population size.

By applying cross-sectional data and an ordinary least squares (OLS) model, this linear relationship seems to find initial confirmation. For the cohorts of Catalan conscripts born in late-nineteenth century, those that resided in villages at the time of inspection were shorter than those living in towns. In turn, the physical stature of these latter was lower than that of the conscripts residing in larger urban areas. The taller conscripts were those living in cities of more than 20,000 inhabitants, which include the city of Barcelona, whereas the shorter ones resided in municipalities up to 2,000 inhabitants.

However, by adding control variables to our regressions, this existing linear relationship between height and population size vanished. Now, what we found was the existence of a rural height penalty in late-nineteenth century Catalonia as the heights of the conscripts residing in municipalities up to 5,000 inhabitants were statistically significantly shorter compared to those conscripts residing in municipalities of more than 20,000 inhabitants. Interestingly, height differences were not statistically significant among those conscripts living in municipalities of more than 5,000 inhabitants. In addition, a different specification of our econometric model also shows that the urban-rural gap may vary depending on the geographical area under study.

This is still a work in progress. The narrative of the evolution of the urban-rural height gap in Catalonia needs to be improved and better compared with other European regions. The channels that explain the existence of rural penalty have to be better identified. The econometric model needs to be refined, by including additional control variables that, among others, can help to capture individual-level characteristics of the conscripts that form the dataset. Therefore, the results presented in this paper have to be considered as provisional, awaiting further analysis.

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