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Development of regional variety of the biological standard of living in the Netherlands, 1812-1913

Highlights

- This study focuses on regional patterns in stature in Dutch society during the 19th and early 20th century (1813-1913). To analyze regional patterns and transitions the HSN Database Giants is used. Results confirm that in the first period (1830-1860) differences in the biological standard of living were substantial. The less market-oriented inland provinces had the highest level of standard of living. This is in line with the Komlos-thesis. The modernization of the Dutch economy in the second half of the 19th century was accompanied by a substantial increase in average height and a reversal of the spatial pattern as modernization was more important in the market oriented regions. Nevertheless, regional differences remained substantial and there was no pattern of convergence. Conscripts from the market-oriented coastal provinces took over the lead from the inland provinces. I tested for an urban premium for the last period (1890-1913). This was confirmed, although it did not manifest itself in cities like Amsterdam and Rotterdam but rather in medium-sizes and small cities.

Abstract

This study focuses on regional patterns in stature in Dutch society during the 19th and early 20th century (1813-1913). To analyze regional patterns and transitions the HSN Database Giants is used. Results confirm that in the first period (1830-1860) differences in the biological standard of living were substantial. The less market-oriented inland provinces had the highest level. This is in line with the Komlos-hypothesis. The modernization of the Dutch economy in the second half of the 19th century was accompanied by a substantial increase in average height and a reversal of the spatial pattern of living standards as modernization was more important in the market oriented regions. Nevertheless, regional differences remained substantial and there was no pattern of convergence. Conscripts from the market-oriented coastal provinces took over the lead from the inland provinces. I tested for an urban premium during the last period (1890-1913). This was confirmed, although it did not manifest itself in cities like Amsterdam and Rotterdam, but rather in medium-sized and small cities.

1. Introduction

For quite some time now, stature has been used as an indicator for well-being in - for example - historical studies. Height is a useful indicator since it is an excellent proxy for environmental conditions. Eighty percent of human stature is determined by individual genetic features but the remaining 20 percent by the environment. Since genetic features of populations do not have the tendency to change over a period of decades, differences in mean (or median) height are the result of environmental changes. Therefore, differences found in the average stature of a populations are caused by net nutrition, which is the result of diet, the quality and composition of nutrition, disease in the environment, hygienic conditions, workload climate and stress. I refer to these characteristics of the quality of life as the biological standard of living (Komlos 1994, Tassenaar 2000, Steckel 2009).

Human body growth stretches from conception to the late twenties but speed and annual change vary over this period. In general, *post partum* increase in heights during the first two years and during adolescence exceeds the average annual increase in stature. [Figure 1] During the period of growth the greatest percentage increase in stature is achieved *in utero*, the first few years of life, and during adolescence. The moment of adolescence peak has not been constant over time but is influenced by early life conditions. Recently in Western populations, the final height is approached around age 20 with an adolescence peak in the early teens (Tanner 1981, Cole 2003). It seems that in the

19th-century boys had their adolescence acceleration around age 16. The shift of adolescence to an earlier stage in life than was common in the 19th century seems to be a consequence of the secular trend. The velocity curve of recent Western male populations also contrasts with the past, when males could continue growing until their mid-twenties (Oppers 1963, Jacobs & Tassenaar 2004, A'Hearn, Peracchi Vecchi 2009, 5).

When less favorable conditions manifest themselves in early childhood, and especially during adolescence, this deprivation has two effects on the velocity curve. First, the annual height increase diminishes during the period of endurance and, secondly, it also extends the period of physical growth and stretches the velocity curve to the right. If we make use of conscription data from the 19th and early 20th century, we have to be aware that the conscripts did not yet complete their physical growth (Oppers 1963, Tassenaar 2000, Beekink and Kok 2017). This process of extended growth is especially the case for those conscripts who were (most) stunted and lived in less favorable conditions during adolescence. Consequently, differences in the average height of populations will be more explicit.

Height is a useful indicator to measure (regional) differences in standard of living (Steckel 1995, p. 1905). This study focuses on regional differences in Dutch society during the second half of the 19th century. Although the Dutch economy was to some extent market-oriented, there were substantial regional differences in consumption, mortality and other aspects of social and economic life (Curtis *et al.* 2017, p. 217). There are two reasons for regional differences in nutritional intake and the disease environment. Not all food products were available in the same quality and quantity in all places. For example, before mechanical refrigeration it was not possible to transport dairy products, fruit, legumes and vegetables without loss in quality. Even in the Netherlands the availability of food was less in larger cities and urbanized areas than in the countryside. Since the 17th-century the Western and Northern coastal parts of the country (Zeeland, Holland, Fryslân and Groningen) had, through a series of connected canals, a well-developed transport network (De Vries 1978, p. 65). But such a network did not exist in the more inland provinces. This, in line with the Komlos thesis which is described below, had a positive effect on the availability of food since it was exported less, or not at all, to other regions (Komlos 1998). So, in the beginning of the 19th century populations of those inland provinces should compare favorably with inhabitants from the export-oriented coastal provinces. Transport investments in the mid and late 19th-century have changed this regional pattern.

There are a large number of anthropometric studies but only few deal with the long-term changes in regional variability. In his impressive review article Steckel did not explicitly discuss the regional component although he pointed to some studies which referred to regional convergence in the late 19th century (Steckel 2009, p. 17). In his agenda for anthropometric research, Öberg (2017) did not devote any attention to this factor. Even in a small country such as the Netherlands regional variation in production, consumption and eating patterns was considerable (Segers *et al.* 2013, p. 234) Therefore, the regional factor should not be disregarded, and this study tries to fill that gap.

Although there are several regional height studies, or studies with a regional component, none has a long-term perspective on multiple regional systems employing individual data. Most regional studies focus on a short period (Heyberger 2014, Baten 1999) or a small region (Ayuda and Poche-Gil 2014, Öberg 2014, A'Hearn, Peracchi, Vecchi 2009, Alter, Neven, Oris 2004, Tassenaar 2000) or are based on aggregated data (Bassino 2006, Chanda, Craig, Treme 2008). In their 2004 study Alter, Neven and Oris stated that economic modernization before 1850 created a sharp distinction among large groups of losers and winners. The question arises whether this is also the case for the post-1850 period, which is characterized as a period of continuous growth and convergence. In particular, what has been the impact of different agricultural systems and their introduction in the national economic system on the development of the biological standard of living? Stature developments between conscripts from several provinces with different agricultural and economic systems will be compared. In addition there will be a specific focus on the changing differences between city-dwellers and rural residents.

We may assume that the levels of the biological standard of living in general, and regional variation in particular, changed during our research period. Van Zanden & Van Riel characterize the timespan 1840-1870 as a period of modernization; a time of international integration, industrialization, commodification of labour (-relations), and of

economic progress and transformation in all economic sectors (Van Zanden & Van Riel 2000, 307-308). Although the service sector fueled this economic transition, developments within the industrial and agricultural sector were also important game changers. An increase in industrial and agricultural production changed the availability of food as well as the economic structure of the Netherlands. Improvements in production and conservation methods increased the quality (Flandrin 1999, p. 18-21, Segers 2003, p. 265) and quantity of food (Knibbe 2001, Segers 2003), and also facilitated the transport of food over longer distances. This development was paralleled by infrastructural improvements like trains, steam ships, new and improved canals, and paved roads (Groote 1996). These trends must have influenced the availability as well as the distribution of food between Dutch regions. The differences in economic development, demographic growth and migration changed population density and the regional distribution of the population during this period.

For a regional comparison, data from conscripts from the regions Fryslân, North-Holland, Rotterdam, North-Brabant and Limburg will be used. This selection covers the 19th-century regional tripartite typology (Drukker & Tassenaar 1997) of socioeconomic systems of the Netherlands in (a) market-oriented (coastal) agricultural regions (Fryslân), (b) urban (coastal) regions (North-Holland and Rotterdam), and (c) (inland) rural regions with a dual socio agro system (Brabant and Limburg), and is to that extent representative for the Netherlands. Since individual data are available, it is possible to disaggregate the data for (North and South) Holland and make a distinction between the two Dutch metropolises (Rotterdam and Amsterdam) and the rest of the province of North-Holland, which is included in this study as a market-oriented agricultural region. Rotterdam and Amsterdam also represent the (old) centers of industrial economic activity although in the second half of the 19th century new industrial zones popped up in Twente (Overijssel) and Brabant. One of these new industrial zones is included in the database of this study.

Three theses for the Netherlands will be tested. The first is the so-called Komlos hypothesis, which claims that before modernization rural areas with less market integration had a higher biological standard of living (Komlos, 1998). Due to the infrastructural system, farmers in such regions were not able (or did not have enough incentives) to export a large proportion of their production. Food chains for products other than flour and butter were short. Even if agricultural products were exported, which was certainly the case in a market-oriented economy as the Netherlands, food decreased in quality and was, as Chanda Craig and Treme (2008, p. 23) state, *less dense in nutrients upon arrival*. Therefore, in these exporting areas the intake of high-protein dairy products must have been higher. According to the Komlos thesis, therefore, conscripts from these areas should have been taller than conscripts from other areas in the early 19th century, (De Pauw 2017, p 82, Komlos and Baten 2004).

Converging or diverging trends between the different economic systems in the late 19th and early 20th-century are the second aspect of this study. The Komlos thesis explains regional differences by appealing to insufficient food production and an unsatisfactory network to distribute these (insufficient) food supplies among the population. In line with this thesis is the expectation that a reallocation of nutrients caused by increased agricultural production and improvements in infrastructure should result in a pattern of convergence. This is in line with the Kuznets paradigm which predicts decreasing inequality in the late 19th century. The overall question is whether modernization and industrialization contributed to the reduction of regional variety and interregional convergence, or on the contrary resulted in divergence. Some anthropometric studies confirm a converging trend while others show divergence (Steckel 2008, Chanda, Craig & Treme 2008 31-35). These developments were accompanied by the modernization of society (infrastructure, medical care and hygiene) which also effected the development of the agricultural and service sector and social circumstances in all Dutch regions. The question is whether these effects caused convergence. One could argue that these trends were particularly in favor of the inhabitants (conscripts) of the coastal provinces.¹

¹ Unfortunately, especially after 1855 there are no regional or local data on food consumption while production data are less useful (Tassenaar 2000, p. 148-149). This hampers a test on a provincial level.

The third hypothesis concerns the existence of an urban penalty in pre-modern societies and the transition to an urban premium during modernization.² Several anthropometric studies have shown an urban penalty for the early and mid-19th century (Komlos 1998, Heyberger, 2014 p. 136, Ayuda and Poche-Gil 2014 p.108, Tassenaar 2000, 68; Komlos & Baten 2004; Baten 2009, 168-169 Blum & Baten 2011, p. 116). However less emphasis has been on the fading of this urban penalty over time and the variations among urban places in this process (Heyberger 2014, p.128). At least until the last quarter of the nineteenth century, city dwellers suffered under the urban penalty (Groote and Tassenaar 2018, Tassenaar 2000, Tassenaar & Drukker 1997, De Beer 2010 p. 70). Developments like improved sanitation, a fall in agricultural prices, improved transport and improvements in food processing may have changed this pattern (Komlos 1998, Steckel 2009). The question is when, and in which types of urban areas this transition originally took place, if it took place at all. One might expect that the stature of the inhabitants of urbanized regions and more in particular urban municipalities, converged to the level of the rural areas in the second half of the nineteenth century, and subsequently took over the position as the proverbial frontrunners.

The urban penalty or urban premium refers to the effect that living in an urban environment has on the standard of living. Since the early days of modern anthropometric research, comparisons of living conditions in urban and rural areas have revealed clear height differences (Fogel, Engerman, & Trussel 1982, pp. 417-418; Margo & Steckel 1983). These studies indicate that average stature of urban dwellers was significantly below those of people residing in rural areas (Drukker & Tassenaar 1997, Baten and Murray 2000, pp. 367-368, Komlos and Baten 2004, p 195, De Beer 2010, pp. 70-71), which indicates the existence of an urban penalty. Height differences observed are in the order of several centimeters (Blum & Baten 2011; Riggs 1994, Tassenaar 2000). The situation in the Netherlands before 1870 seems to fit this pattern. A study of detainees of a number of Dutch prisons shows residents of large or middle-sized towns to be more stunted than other detainees (De Beer 2010, p. 70). Crude anthropometric data indicate that even in smaller Dutch towns the conditions could be less favorable than in rural areas (Oppers 1963, Van der Loo 1986, pp. 238-239).³ The question is whether this changed with the start of the large spurt in economic growth from 1865 onwards (Van Zanden & Van Riel 2000, p. 278).

The problems of convergence or divergence on the one hand, and urban penalty on the other are to some extent interwoven. In comparison with other European countries the Netherlands were a highly urbanized country, although metropolises with more than half a million inhabitants were nonexistent. Some urban residents lived in agglomerations like Amsterdam and Rotterdam, but the majority of the urban residents lived in towns with a population 2,500 to 10,000 inhabitants. Urbanization occurred in all provinces, but the coastal provinces North-Holland and Fryslân were more urbanized than inland North-Brabant and Limburg. Modernization of Dutch society had an impact on these towns: it turned (some of) the urban centers of the inland and rural coastal provinces into nodes of trade and industrial growth. The biological standard of living reflects modernization and industrialization in the large cities like Amsterdam and Rotterdam and also in middle-sized or smaller cities in the other provinces which are being examined: Limburg, North-Brabant, Fryslân and the rest of North-Holland. Long-term developments in stature will serve as a proxy to assess the existence of an urban penalty and premium.

2. Data

From the French usurpation in 1811 onwards, all young males in the Netherlands were subject to conscription and compulsory examination. In the Kingdom of the Netherlands, this physical examination was continued until general military conscription was suspended in 1995. The aspects of physical and mental examination were expanded over time but height measurement was a constant factor in this check-up. During the whole period under investigation, height was measured in centimeters.⁴ The information pertaining to the examined males was collected in several

² The Netherlands started to modernize in the period 1840-1870. From 1870 onwards restructuring and growth in all economic sectors, social life and modern economic growth on an annual basis (GDP per capita) were manifest.

³ This is in comparison with average heights in Drenthe. Tassenaar 2000, p. 72.

⁴ In the Netherlands, like in Drenthe (Tassenaar 2000), measurements were in centimeters from 1821 onwards. In our database there are no measurements using traditional regional standards like *voeten en ellen* (inches and yards).

public registers. This registration initially occurred at a provincial but later at the national level. Although not all the registers survived, the available information allows us to sketch and study the development of regional variety in height over time. For that purpose, information of more than 5,000 conscripts examined in the years 1831 – 1913 (birth years 1812-1893) has been used.

Use has been made of the HSN database of 5,135 males, which contains measurements drawn from Brabant, Limburg (both in the southern parts of the Netherlands), Fryslân (northern), South and North Holland (western part of the Netherlands) and Gelderland (Eastern part of the Netherlands).⁵ According to Dutch law, namely the Laws on the Militia of 1817 (the 1817 system) and 1861 (the 1861 system), this means that either the conscript's parents, or occasionally, their guardians had their residence (*domicile*) in these provinces in the year that these men turned 19 (until 1861) or 20 (from 1863 onwards) (Tassenaar 2018, pp. 88-89).⁶ The place of residence of the parents or guardians was the legal place of residence of the conscript.⁷ Only, if the parents had passed away and no official guardians were available, did the place of living of the conscript serve as the place of residence. In practice, a vast majority of the conscripts lived with their parents. In general, they also grew up in that municipality under the environmental conditions of those areas. Since the HSN database is made up of a random sample of birth certificates, only conscripts that were born in one of the above-mentioned areas were included in the database. As a consequence conscripts from a (frequently) migrating family were lacking more frequently than more stay-at home types.

Unfortunately, quite some of those early registers (1817-system) did not survive the passing of time. This means that for the years before 1860, our picture is not as complete as desirable. However it is sufficient to create an overview and test the Komlos thesis. Registers of the countryside of North-Holland, (before 1870), Fryslân (before 1863) and Limburg (1831-1839 excluding Maastricht) are absent.⁸ Although the results from this early period have to be interpreted with care, they are sufficient to test the Komlos hypothesis.

In this study only the original measurements of the conscripts have been used. This is the examination in the year the men became 19 (under the 1817-system) or 20 (under the 1861-system). According to the legal standards (article 90, 91 *jo.* 94 Law of the Militia 1817 respectively article 47 *jo.* 94 Law of the Militia 1861), some conscripts were unfit for military service because they were too short or had other physical impairments. These exemption criteria did not exclude conscripts from the mandatory physical examination. With the exception of a minority of mentally as well as physically disabled men that were unfit for all military service, the unfit conscripts were re-examined the following year and (if necessary) the following three subsequent years. Successive examinations are an acknowledged flaw of anthropometric data, in particular since undersized conscripts are over represented in this category (Breschi, Fornasin & Quranta 2006, p.394-5). Furthermore, these conscripts had an additional period to grow and to increase their stature. Therefore, results of the successive examinations were excluded from the analyses.

An amendment of the Law of the Militia in 1861 (*Wet van den 19den augustus 1861 betreffende de nationale Milities* Stb. 1861, no 72) changed the year of the mandatory examination and conscription from the 19th to the 20th year of

⁵ The HSN database is constructed from a random sample from the Dutch birth certificates for the period 1812-1922 covering the whole of the Netherlands. SES is available for the moments of birth, marriage and death. For reasons of efficiency and standardization in this study only registration of occupation of the conscript and the parents (1817-system) from the military registers is used. For our period under study the military registers do not contain any information on instruction.

⁶ The quality and representativeness of the Dutch military registers is quite high. From 1817 onwards, examinations were to a high degree standardized (Tassenaar 2018). In general absenteeism was low and mainly restricted to sailors, soldiers and students. In general they lived on a large distance from their parents, which made it practically impossible to attend the conscription in person.

⁷ This meant that a person who was living in the Dutch East Indies, while his parents lived in the Netherlands had to be conscripted in the place of *domicilie* (where his parents lived). Of course, in that exceptional case, the conscript was absent.

⁸ The HSN-database contains conscripts from Utrecht under the 1817-system and 1863-system are incomplete. Apparently, those who did not reach the legal minimum height requirement (MHR) and in that undersized (1, 57 under the 1817-system Article 91 sub a Law of the Militia 1817) were not measured. The data of Utrecht are not included in this study since they suffer from the well-discussed truncation problems (A'Hearn, Peracchi, Vecchi 2009, Jacobs, Katzur & Tassenaar 2008).

life.⁹ Thus, conscripts from 1863 onwards were examined when they were a year older than the men under the 1817 system. Under the same conditions, they should have been taller since they were able to grow an additional year. It is difficult to make a precise estimate of the difference in height between conscripts from these two systems that can be attributed to the difference in age.

Under the 1817 system Dutch men grew by an average of 5-7 centimeters between their examination for the militia (19th year of life) and the examination for *de Schutterij* (Local militia) in the 27th year of life (Oppers 1963, Beekink and Kok 2017).¹⁰ In this stage of life (19-27) the velocity curve of the human growth process had a gradually decreasing pattern. Oppers reconstructed the growth curve for the 19th century and estimated a Yassis (yearly annually sex specific increase of stature, Brinkman, Drukker & Slot, 1988, p. 45) with an average increase of 3 centimeters in the 20th year of life (Oppers 1963). In this study regression analysis reveals that the difference in height between those born on January 1st (19 years and 2 months) and those born on December 31st (18 years and 2 months) was about 4 centimeters. The difference in average stature for the examinations in 1859-1861 (the last three cohorts of the 1817system) and 1863-1865 (the first three cohorts of the 1861 system) can also be measured. According to this database, the difference between the mean heights of the conscripts measured in the years 1859-1861 and 1863-1865 respectively is more than two centimeters. Since the height trends occurring during those two legal systems are studied separately, no correction for this flaw on an individual level took place.

3. Results

The general picture

In our sample, the average stature of Dutch conscripts in the 19th century developed according to a V-shaped pattern. For a more understandable visualization the moving average under the 1817 system is increased with three centimeters. Figure 2 shows a downward trend until the 1860's, followed by a strong upward trend. In the 1880-1890's, average height exceeded early 19th-century levels. This pattern is in line (see figure 2) with findings from earlier studies (Drukker & Tassenaar 1997, Jacobs & Tassenaar 2004, De Beer 2000), which underscores the representativeness of this HSN sample. Although all regions showed a V-shaped pattern, the ranking of the regions changed.

The Komlos hypothesis

For the first half of the 19th-century the Komlos hypothesis predicts a height differential between the residents of the sandy inland provinces, with many freeholders and easy access to land on the one hand, and urban & market-oriented coastal areas on the other (Komlos 1998, Cinnirella 2008). North-Brabant and Limburg were provinces with a dual agricultural sector. Farmers produced partly for the market, but own consumption was also an aspect of their economic system. Furthermore, almost all households, with the exception of the urban population of these provinces, had easy access to land and produced some of their own nutritional needs. This also made the rural population of less market-oriented regions less vulnerable for fluctuations on the food market.

The database does not contain enough residents of rural municipalities of a coastal province. Only data (35 examinations) from a few municipalities of Oostvoorne, a peninsula in the south-western corner of South-Holland are available. As an exponent of the urban population, the database contains data for Amsterdam. The average height of conscripts of the Dutch capital was continuously far below the level of the southern provinces, which confirms the phenomenon of growth retardation in urban agglomerations. Furthermore, table 1 shows a sharp decrease in average

⁹ The underlying argumentation of this legislative change was the downfall of the number of conscripts that could be conscripted. In the 1850's the percentage of undersized (< 157 centimeters, which were considered unfit for military service, rose spectacular.

¹⁰ The Oppers data give a post-military examination catch-up growth of 6.5 centimeters for the cohorts 1822-1861 (birth years 1803-1842), Rotterdam 6.3 centimeters, Goes and Leiden both 7.0 centimeters respectively. Beekink and Kok (2017) measured an increase of 4.8 centimeters for Woerden. Apparently, this difference is a result of pre-examination growth. The Oppers data show a strong relation ($r^2= 0.60$, $n = 118$) between average height and the increase afterwards. Regression suggests that a decrease in average height of conscripts of 1 centimeter resulted in an increase of catch-up growth of about 0.5 centimeters (and *vice versa*).

height of the conscripts (of the drafts) from the late 1840's and the 1850's in Amsterdam as well as in Brabant. As could be expected, this fall in height in both regions is accompanied by an increase in the Coefficient of Variance (CV).

The convergence-divergence question & urban penalty

From 1863 onwards, we have data for more areas than just Limburg, Brabant, and Amsterdam, which makes a more sophisticated approach possible. The second half of the 19th century shows another view. The rural traditional provinces lost ground to coastal provinces like Fryslân and North-Holland (including Amsterdam) and fell behind with regard to the biological standard of living (Figure 3). Conscripts from coastal provinces became taller than their counterparts from inland provinces. During the first decades a pattern of convergence is visible between the coastal and inland provinces. During the rest of the research period the increase in height of conscripts of the coastal provinces became more obvious. This resulted in a pattern of divergence.

The data confirm the existence of an urban penalty in the early 19th century at least for a large city like Amsterdam. The regression analysis (table 2) shows that the height of conscripts from cities in Limburg and North-Brabant was not significantly lower than that of conscripts from rural municipalities. The conscript years 1846-1861 do not demonstrate any convergence or divergence. Migrants, who were mainly part of the population of Amsterdam, had a more favorable socio-economic start than indigenous (local born) conscripts.

A visualization of the urban rural difference seems to support the disappearance of the urban penalty. Therefore, the municipalities in which the conscripts were examined have been split into two categories: urban and rural. The distinction between these categories is based on population size and population density.¹¹ This approach is more sophisticated than a limited indicator such as population size and makes it possible to include conscripts from smaller towns in the urban category. This is relevant, since most cities in the Dutch Kingdom were relatively small. In our database, we have 3,727 conscripts (2,107 from rural municipalities and 1,620 city-dwellers) who were measured in this period (1863-1912).

In the second half of the nineteenth century, the height gap between the townsmen and rural dwellers diminished. Figure 4 seems to suggest that there was no difference between conscripts from rural and urban municipalities. But regression analysis shows an urban premium when a distinction is made between conscripts from Amsterdam, Rotterdam, and the other town dwellers. A splitting of the period into two sub-periods of twenty-five years reveals a clear distinction. Regression analysis in table 4 (panel b) calculated a significant positive coefficient for conscripts from Limburg. On the other hand, the included dummy-variables of Fryslân and North-Holland (except Amsterdam) also shows an advantage for the market-oriented coastal provinces. This indicates that the biological standard of living in these provinces was higher than in the Dutch capital. Through the further rise in stature in Amsterdam, this positive sign is smaller in the last period of this study and is no longer significant. On the other side, the regression for the last part of this period (conscript years 1889-1913) shows a statistically significant positive sign for urban dwellers other than those living in Amsterdam and Rotterdam. The conscripts from middle-sized and small towns lived under better circumstances than those living in Amsterdam and especially Rotterdam.

Just like under the 1817 system, direct access to food constituted an advantage for the biological standard of living. The regression analyses in table 2 and 4 show significant differences for the children of farmers (1817 system) and conscripts in comparison with other professions. Those who were registered as a farmer under the 1863 system must have been working in an agricultural family business.¹² In general, one of their parents, has either owned or managed

¹¹ All conscripts living in places with more than 5,000 and a population density of at least 125 inhabitants per km² are classified as urban residents. To this category of urban residents, I also included all conscripts from smaller towns (< 5,000 inhabitants) with historical legal rights, which also met the second requirement of at least 125 inhabitants pro km².

¹² Under the 1817 system the occupation of the conscript as well as the occupation of the father was registered. If the father had died or was absent, the occupation of the mother was registered. The mother's occupation was not registered if the father of the conscript was still alive. Under the 1863 system only the occupation of the conscript was recorded in the military registers, which makes it difficult to have direct

the farm. On some occasions, when both parents had passed away, the conscript (and/or his brothers and sisters) may have managed the farm. In all of these situations, the conscript was part of a family system in which nutrients were produced and (partly) consumed. The coefficient associated with access to food production bear the sign that one would expect: farmers working in a family business producing food were better nourished than other conscripts. When comparing the two sub-periods under the 1863 system, one may note the decreasing magnitude of the coefficient. Apparently, proximity to nutrients became less important.

ACCEPTED MANUSCRIPT

information regarding the economic and social background. This makes it impossible to determine if a conscript was a son of a farmer and had chosen another occupation. The registers do not make a distinction between smallholders and large landholders.

4. Discussions

The indicator for the differences in age (day of birth) is significant in all regressions. This finding is in line with other studies (Breschi, Fornasin, Quranta 2006, p. 396). Nevertheless the impact of this factor (sign) diminishes during the period under study. Two factors may explain this trend. The first factor is related to the velocity curve. Conscripts under the 1863 system were on average one year older than their counterparts under the 1817 system, which means that their potential annual increase in stature was lower. Although the moment of the adolescence peak depends on environmental circumstances, this peak is always followed by a decrease of yearly increase in stature (Tanner 1989). The regression demonstrates that under the 1817 system the height increase in approximately the 19th year (18 y 2 m. - 19 y. 2m.) was 4,0 centimeters, while this was 1,85 centimeters under the 1863 system. The second factor is related to the secular trend and improvement of environmental conditions. Improvement of early life circumstances reduces growth retardation, but even more so, it shifts the adolescence peak to an earlier stage (Oppers 1963, Van Wieringen 1972).

Since data on market-oriented rural regions are missing and urban data are restricted to Amsterdam, it might be risky to make strong statements about the Komlos hypothesis. Nevertheless, the results fit the findings from earlier anthropometric studies of the Netherlands and more recently Flanders (De Pauw 2017, p. 82). Before 1860, the more inland and less market-oriented regions had a higher biological standard of living. They profited from the Arcadian bonus of a low population pressure and sufficient nutrition (Tassenaar 2000).¹³ The only study which is not in line with this higher biological standard of living in these southern provinces is the study of convict height by De Beer. But he also included Zeeland in the southern provinces and did not make a distinction between detainees born in the early and late 19th century (De Beer 2010, p. 70), which may explain these differing results. The results for Amsterdam are in line with the study of Heyberger, which measured a negative impact from the urban factor on the biological standard, most extremely for the residents of Paris (Heyberger 2014, pp. 130-134) and Cinnirella who found the same relation for Great Britain (Cinnirella 2008, pp 344, 349). Results for Munich (Baten 2009, p. 174) differ from this pattern. Apparently, the supply of protein products was sufficient in Munich and the hygienic circumstances were not as horrible as they were in the Dutch and French capitals.

The diverging tendency during the second half of the 19th century seems to be a consequence of the slow-growth pattern of the inland provinces. Under the 1863 system the Arcadian bonus of the southern provinces disappeared. Even under the 1817 system, the drop in average height in Brabant was strong and in accordance with an earlier study on the effects of the potato blight (Paping & Tassenaar 2007, p. 168). In an earlier study, Paping and Tassenaar noticed that conscripts in Brabant did worse than might be expected based on other indicators, since the potato dependency was not so manifest in this province (Paping and Tassenaar 2007, p. 179). On the other hand, these figures and developments are more in line with the pattern in Drenthe (Tassenaar 2000, p. 75), where the biological standard of living changed as a consequence of: structural decline of self-support of the population, especially for laborers (Paping and Tassenaar 2007, Tassenaar 2000); increasing exports (caused by a relative price difference between food prices and non-food commodities), and temporal phenomena (the hungry forties and fifties) (Tassenaar 2000). With respect to the development of height in the 2nd half of the 19th century, both inland provinces followed the pattern of France. After the 1850's the biological standard of living improved but this went gradually.

¹³ Especially before the construction of the railway network, the whole local production could not be transported to (long-distance) markets. This was especially the case for perishable food items and high-volume products like potatoes. A rough distinction between the transport system in the coastal provinces and the inland provinces has to be made. In general, places in the coastal provinces were easily accessible through the network of rivers, channels and canals. Apart from naval transportation on the Meuse and Rhine, the inland provinces were dependent on roads, partly unpaved and paved. The opportunities for transport were therefore much lower in the inland provinces, resulting in less export of the agricultural output.

To some extent, Limburg seems to be the exception since stagnation there was a bit later than in provinces like Brabant and Drenthe. It is not straightforward why Limburg followed a separate path. The question remains why Limburg, and to some extent Brabant, profited less from the national increase in the biological standard of living. Was it nutrition, since western provinces profited more from increased food imports, improved conservation and re-distribution of nutrients across the country? Until mining became a factor of importance Limburg did not have a strong economic driver, since large-scale industry and export-oriented agriculture were mainly absent. It may also be related to the state of health. It is striking that in this period Limburg also lost its relatively high life-expectancy. In Limburg and North-Brabant infant mortality rose in the last decades of the 19th-century, while the national trend was downward (Van der Heijden 1995, pp. 192-193).

Generally, especially the city dwellers seem to have profited from the changing economic and social conditions in the last part of the 19th century. In an earlier stage they had suffered from the absolute and relative increase in food prices during the 1840-1860's but from 1873 onwards they could profit from relatively low food prices (Paping 1995, Van Zanden and Van Riel 2000). The results from the regression analysis (table 4, panel b) confirm this assumption. Be aware that this indicator refers to the city-dwellers from small-sized and medium-sized cities in mainly North-Holland, Fryslân, and to a lesser extent those in North-Brabant and Limburg. Especially the first category must have profited from the improvement in the biological standard of living in their provinces. Since inequality declined it is expected that especially urban day laborers profited from the improved living conditions, which is in line with studies of other components of the standard of living, like relative prices, in the Netherlands (van Zanden and Van Riel, 2000, pp. 85, 309).¹⁴ This pattern is also in accordance with the study on heights in East Liege (Alter, Neven, Oris 2004, 241-243). One might argue that also improvements in sanitation and medical care may have played a role. Urban infant mortality rates fell very strong in the last quarter of the 19th-century. However, despite this improvement, infant mortality rates in urban municipalities were still higher than that of rural municipalities.¹⁵ In further research the contribution of infant and child mortality on height will be included

The question is how to interpret the low biological standard of living in Rotterdam in the late 19th century. In comparison with the improvement of the biological standard of living in Amsterdam and more medium-sized towns, the stagnation in stature was striking. The booming economy and demographic expansion may have contributed to those growing pains. The low average height in Rotterdam does not seem to be a result of the influx of small conscripts from other regions. Therefore, the percentage of conscripts that resided in Rotterdam and was born elsewhere (21%) and the difference in height (0,4 centimeter) between the conscripts born in Rotterdam and those who were born elsewhere, was too small. With regard to the regression analysis, even corrected for migration, the sign of Rotterdam remains negative for the last period under the 1863 system. The other agglomeration with a substantial amount of migrants,¹⁶ Amsterdam, even seems to have benefited from the influx of migrants with a higher standard of living. In the first period (conscript years 1863-1888) the sign for migrants is positive and significant, which can mainly be attributed to the (immigrated) conscripts from Amsterdam. In the second period (conscription years 1888-1913) the height differential between immigrants and native-born diminished, which is mirrored in the regression results (panel c).

Although the conscripts in Amsterdam faced better conditions than the conscripts in Rotterdam, they lagged behind their counterparts from smaller urban residencies. In this sense, the urban premium was not complete, but rather a

¹⁴ In earlier regressions a dummy variable was included for conscripts who were day laborers. Although the sign was negative, it was not statistically significant.

¹⁵ An examination of the infant mortality rate in the province of Fryslân (1890-1894) demonstrates that the infant mortality in the eleven urban municipalities was 135 pro 1,000 live births while this permillage was 103,5 in the thirty rural municipalities. Ministerie van Binnenlandse zaken, *Vijfjarig overzicht van de sterfte naar den leeftijd en de oorzaken van den dood in elke gemeente van Nederland gedurende 1890-1894*.

¹⁶ In the provinces of North-Brabant and Limburg migrants are almost absent, which seems to be a result of the data collection. The starting point for the data collection in these provinces are the persons born in these provinces. Since in general the number of migrants in this provinces was low, this probably does not affect the outcomes of the analysis.

characteristic of the urban residents from Holland (excluding Amsterdam), Fryslân, North -Brabant and Limburg. The question is whether it was more difficult to supply the populations of these Dutch metropolises or whether their growth was hindered more through the disease environment in the two places. In general, early childhood mortality remained higher in urban regions in the period 1880-1909 (Wolleswinkel *et al.* 2000, Van Poppel, Jonker and Mandemakers 2005, p. 302) but medium-size towns seem to have an earlier improvement of their disease environment. In the whole of the 19th century the infant mortality in Amsterdam stayed above the national level.

In general, the development of the Dutch average height in the period 1831-1913 is comparable with the pattern in other European regions like Swedish Scania (Öberg 2014) and Bavaria. The initial downfall in of the biological standard of living in the first decades of the 19th century was followed by continuous growth. The fall in the biological standard of living was accompanied by an increase in inequality (CV). A decrease in stature is frequently accompanied by an increase of this indicator (Tassenaar 2000, pp. 71-72). This phenomenon might be explained by the fact that in particular lower social strata are severely hit by nutritional crises, higher food prices or food availability (Öberg 2014, p 150) while the biological standard of living of other groups was not affected (Tassenaar 2000, p. 203-227, 241-251).

If the mid-19th century (conscript years 1863-1872) and early 20th century is taken as starting point, the magnitude of regional differences did not change over time. At first sight, it seems that there is some convergence around the 1880's, but in fact this pattern of intersecting lines (figure 3) is the consequence of two separate developments. First, there is the robust improvement in the biological standard of living in the coastal provinces with their internationally market-oriented economy. Second, there was stagnation followed by slow growth in the inland provinces with their dual socio-economic system. Although the biological standard of living in a relative sense declined in the last socioeconomic system, the inequality (CV) was still lower than in the more market-oriented regions (table 3). Certain groups stayed more vulnerable and could not profit fully from the improved living conditions of city life. An earlier study has pointed out that the increase in stature of some vulnerable groups, in this case Jewish conscripts in Amsterdam and Groningen, fell far behind the general increase (Hermanussen, Meitinger, Veldhuis *et al.* 2014, Bolk 1910, p. 1821).¹⁷ It is interesting to find out which other groups benefited to a lesser extent from this development.

The increasing interregional divergence in the late 1800's is a striking feature. Studies of Japan, the United States of America and the Habsburg monarchy for this period (late 19th century), showed a pattern of convergence instead of divergence (Bassino 2006 p. 79-80, Chanda, Craig and Treme 2008 p. 43, Komlos 2007). However, the Italian pattern is comparable with the development in the Netherlands.¹⁸ A'Hearn, Peracchi and Vecchi (2009) consider this trend as a system switch. The question rises which particular regional pattern in the Netherlands is the most remarkable one? The tremendous increase in height in the coastal provinces or the relative setback (and slow growth) of the biological standard of living in the inland provinces? For a province of North-Brabant the secular trend did not start before the 1890's (1870's birth cohorts). This pattern is in line with the developments in the Swiss population in the same period (Koepeke, Floris, *et al.* 2018). Of course, the question is what should be considered as the take-off of the secular trend. If this is the equivalent of breaking through the ceiling of previous levels, one should devote more attention to the difference in age. In this specific case, this would not lead to other conclusions.

Direct access to agrarian production and therefore nutrition had a positive and significant sign during the whole period. Being part of an agrarian family business had positive effects on one's biological standard of living, which is in line with almost all other anthropometric studies (Öberg 2014 p. 147, Heyberger 2014 pp. 128-130, De Beer 2010, p. 70, Baten 2009, Tassenaar 2000). Especially in the period before the infrastructure revolution of the 19th century and further improvement in food processing and distribution in the same period, direct access was beneficial for the biological standard of living. Nevertheless, the magnitude of this factor declined during the 19th century, but except in Scania it

¹⁷ Jewish conscripts were (significantly) smaller than other conscripts under the 1817 system (Tassenaar and Karel 2016, Beekink and Kok 2017). This was a result of a weaker economic position, less access to high-nutritional products and other menu preferences based on religious rules.

¹⁸ The study of Chanda, Craig and Treme (2008) shows statistically significant divergence for the birth cohorts, conditional convergence for the 1870-1880 birth cohorts and absolute convergence for the 1880-1900 cohorts (Chanda, Craig and Treme 2008, p. 33).

did not disappear completely (Öberg 2014, p. 150). This diminishing effect can be a consequence of further specialization in agricultural firms, but it is more likely that it is a consequence of an (stronger) improvement of the nutritional status of city-dwellers and rural non-agrarians. An improvement of infrastructure, food production and conservation, agrarian productivity, change in the relative price of arable and dairy products and real income may explain this development. Local agrarian production mattered less than it did in earlier periods. As in Italy, the benefits of urban life (health and food availability) seem to have outweighed the disadvantages (A'Hearn, Peracchi and Vecchi 2009, p. 16).¹⁹ The diminishing impact of food access is similar with a simultaneous tendency in Scania (Öberg 2014 pp. 147-148) and the eastern part of Liege (Alter, Nevis, Oris, 2004, p. 241).

Of course as with all aggregation this provincial comparison has its drawbacks since it does not take into account spatial differentiation within these provinces. The comprehensive study on Drenthe (conscript years 1818-1860) demonstrated that, on a provincial level, a further disaggregation to a regional typology was desirable since both levels and development of the biological standard of living varied (Tassenaar 2000). It is unlikely that within these provinces, or in the 2nd half of the 19th century, this situation was any different. Especially in Limburg, Brabant and Fryslân this regional variety may have been extensive, which would have resulted in a more discernible typology of value. Brabant as well as Limburg had regions with newly booming sectors like manufacturing (parts of Brabant) and - predominantly booming after 1890 (Gales 2002) - mining (Limburg), while Fryslân had a market-oriented dairy region in the southwest and west, an arable farming region in the north and a more inland agricultural zone in the (south-) east. The impact of sanitary improvement, medical professionalization, the agrarian depression and the upcoming agro-industry may have been different in those socioeconomic systems. The database has to be extended to test for this more sophisticated regional variety. An examination of infant and child mortality, cattle per capita on a municipal level may give more insight into the changing effects of locally available nutrients (Koepke & Baten, 2005, pp. 65-66, Tassenaar 2000, Haines, Craig & Weiss 2003).

5. Conclusions

In the 19th century the average stature of conscripts developed along a strongly upward trend. This upward trend was a phenomenon of the 2nd half of the century, since average stature decreased in the period 1840-1860. Dutch males became taller and their adolescence started at an earlier stage. At the end of 19th century (1870's birth cohorts) the Dutch were taller than ever before and had begun the secular trend. During the 19th century regional diversity in stature did not diminish, but the pattern changed fundamentally.

Of course, results are not straightforward and some regional deviations from this general pattern existed. The amount of regional and socioeconomic differences found in this analysis replicate those from other studies concerning the 19th century. In this study three theses have been tested. The conclusion is that during the first half of the 19th century the biological standard of living in rural inland provinces was much higher than in other Dutch regions. This is in line with earlier studies about the Netherlands and Drenthe and supports Komlos' view that less market-oriented rural areas were better off before modernization took place. However, the results for Brabant are not straightforward.

In the 1850's the average height (conscript years) reached in all regions its lowest point. In the 1860's and 1870's the biological standard of living increased, which was accompanied by a pattern of convergence. After Dutch height exceeded the levels of the early 19th century, a period of interregional divergence began. This combination of intraregional convergence and interregional divergence is intriguing. Furthermore, the urban penalty disappeared and was replaced by an urban premium at least for the middle-sized and smaller cities. The disease environment may have played a role in this process, but further study is needed. Apparently, improvements in infrastructure, food production and conservation made immediate proximity to places of food production no longer a necessary factor for tallness.

¹⁹ In Eastern parts of Europe, like the part of Poland occupied by Russia, this tendency is less evident. Conscripts from small towns and 'peasants' seem to have been of the same height (conscript cohorts 1866 -1913). In the later period (conscript cohorts 1892-1913) the conscripts of Warsaw seem to have been taller. Kopszynski 2011 pp. 206-208.

The scale of the urban agglomeration seems to be a factor of importance in this conditional premium. Since the Netherlands was a highly urbanized country, it may be a piece of the puzzle explaining the Dutch step to “giantism”.

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Figure Caption

Figure 1 Presumed and stylized velocity curve of 19th-century sub-populations. *Source:* based on Tanner (1989) and Oppers (1963).

Figure 2 Development of mean height in the Netherlands, conscription cohorts 1831-1913 (between brackets are the birth years of the conscription cohorts) in comparison with the development of the median height from the whole Dutch population. Note: the average/median height of the 1817-system is (in line with earlier studies: Drukker & Tassenaar 1997, Jacobs & Tassenaar 2004) increased with three centimeters. *Source:* HSN Database Giants, release December 2017.

Figure 3 Development of mean height in five Dutch regions, conscription cohorts 1861-1913 1913 (between brackets are the birth years of the conscription cohorts). *Source:* HSN Database Giants, release December 2017.

Figure 4. Mean height and height inequality (CV) in urban versus rural municipalities, conscription cohorts 1863-1912, birth cohorts 1843-1892. *Source:* HSN Database Giants, release December 2017.

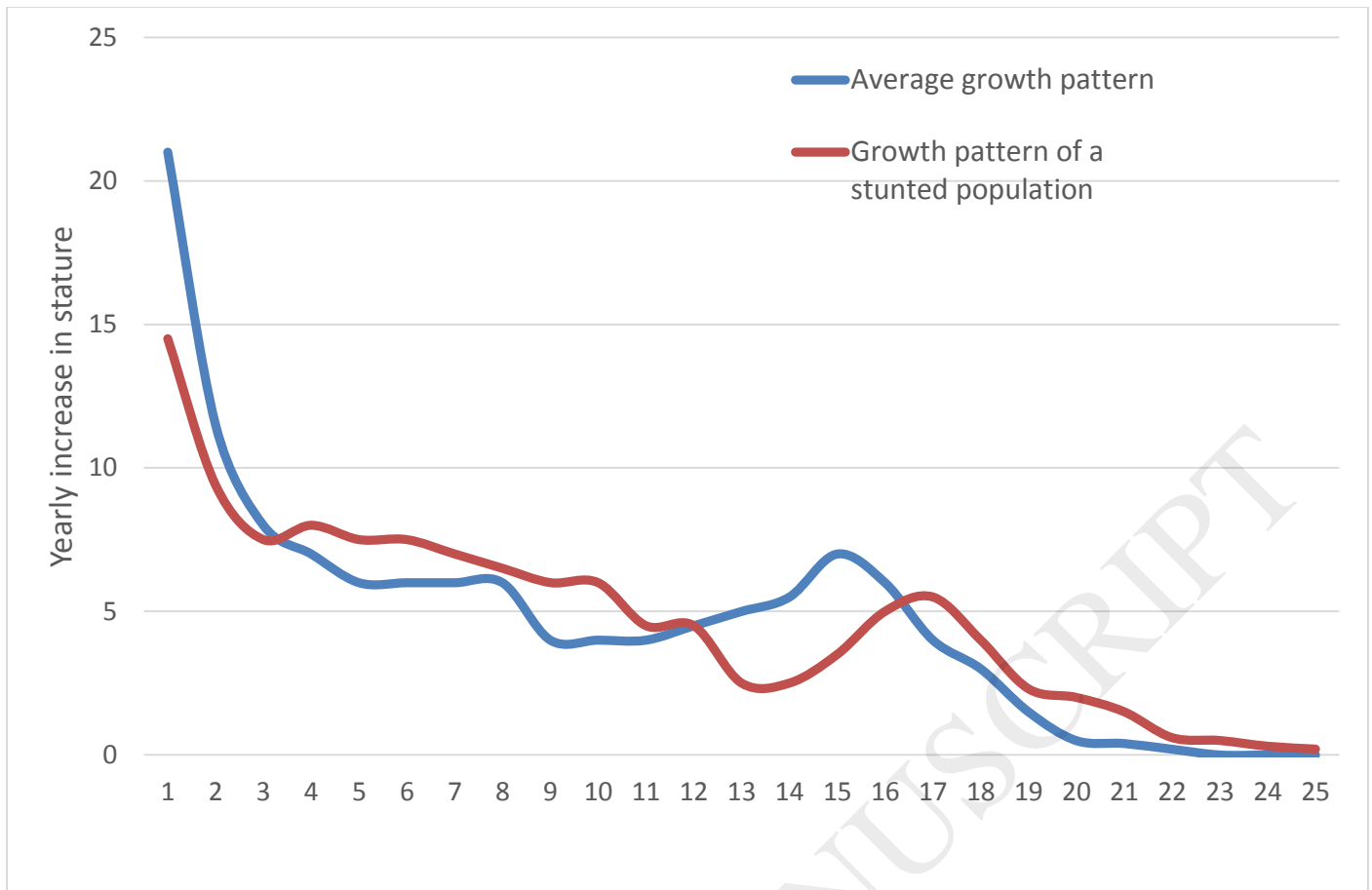


Figure 1 Presumed and stylized velocity curve of 19th-century sub-populations. *Source:* based on Tanner (1989) and Oppers (1963).

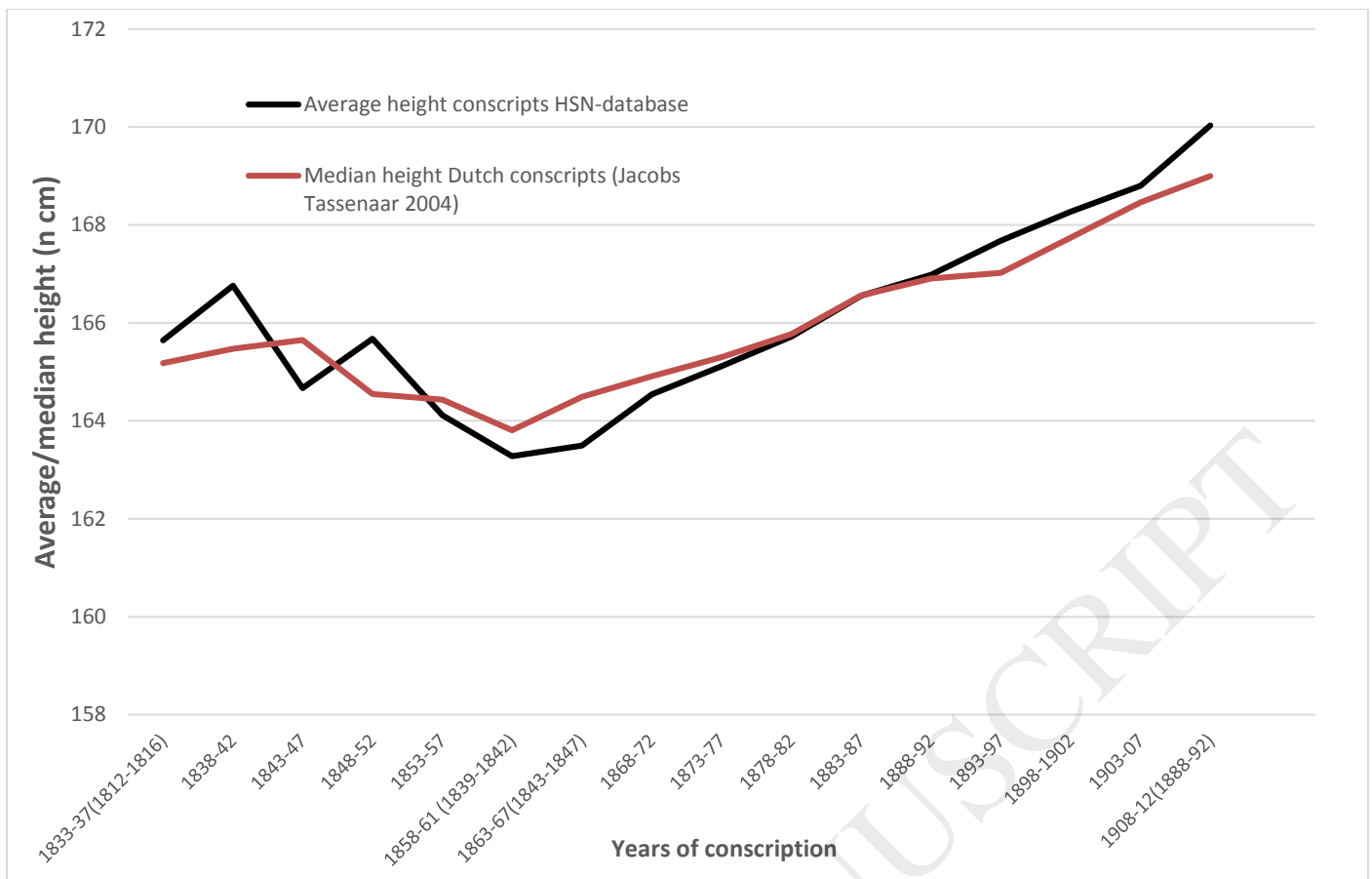


Figure 2 Development of mean height in the Netherlands, conscription cohorts 1831-1913 (between brackets are the birth years of the conscription cohorts) in comparison with the development of the median height from the whole Dutch population. Note: the average/median height of the 1817-system is (in line with earlier studies: Drukker & Tassenaar 1997, Jacobs & Tassenaar 2004) increased with three centimeters. *Source*: HSN Database Giants, release December 2017.

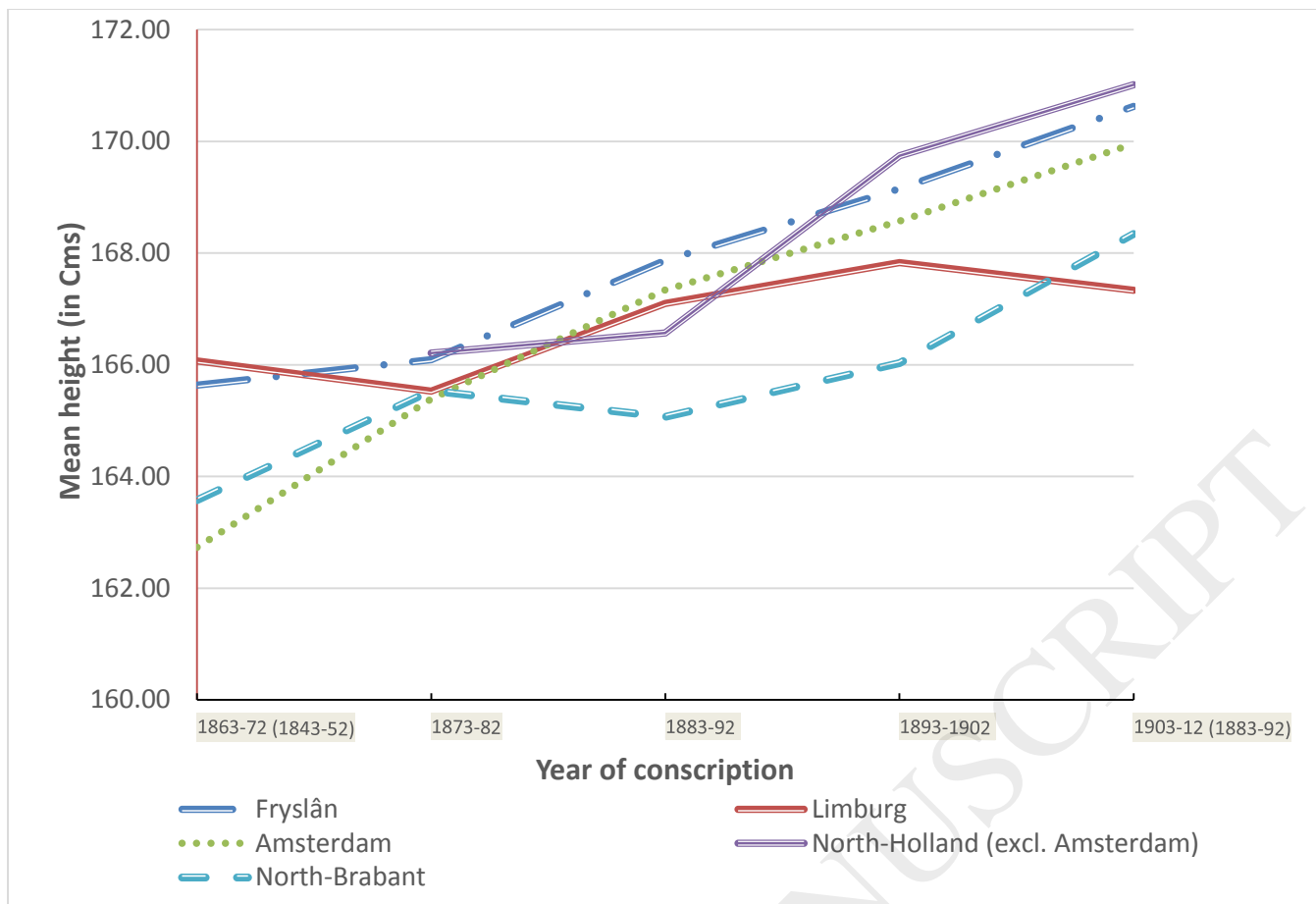


Figure 3 Development of mean height in five Dutch regions, conscription cohorts 1861-1913 1913 (between brackets are the birth years of the conscription cohorts). *Source:* HSN Database Giants, release December 2017.

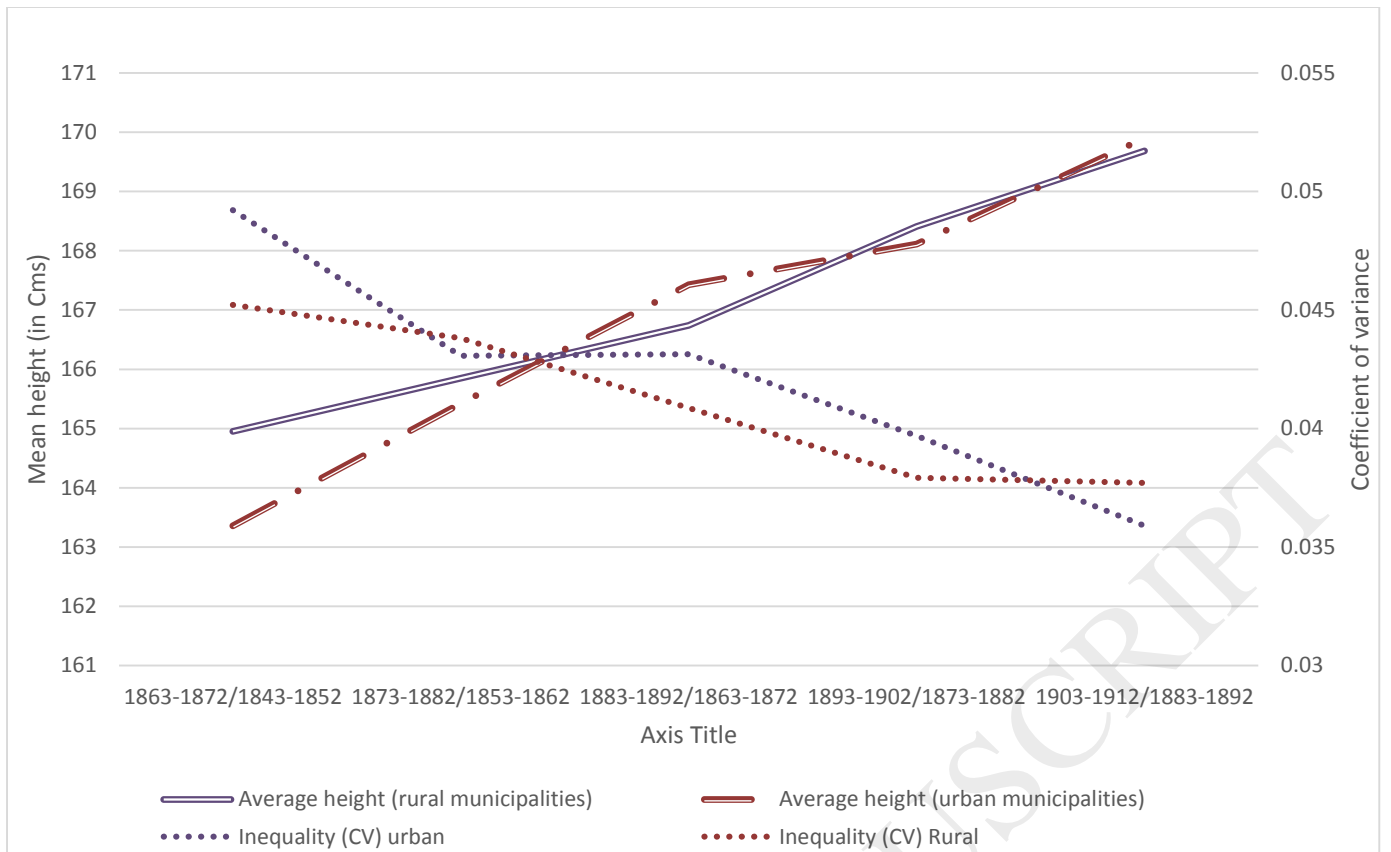


Figure 4. Mean height and height inequality (CV) in urban versus rural municipalities, conscription cohorts 1863-1912, birth cohorts 1843-1892. *Source:* HSN Database Giants, release December 2017.

Table 1. Anthropometric characteristics by place/province of residence in the Netherlands (conscript years 1831-1861)

Place/province of residence	N	μ			Coefficient of Variance (CV)		
		1831-1861	1831-1845	1846-1861	1831-1861	1831-1845	1846-1861
Amsterdam	279	160,06	160,66	159,64	0,056	0,053	0,058
North-Brabant	424	161,56	162,19	161,14	0,052	0,051	0,052
Limburg	244	164,67	165,76	164,18	0,045	0,043	0,046
The Netherlands	1235	161,76	162,35	161,37	0,053	0,052	0,053

Place or province of residence refers to the municipality of residence from the legal place of residence of the parents or guardians under the law of Militia 1817. Source: HSN Database Giants, release December 2017.

Table 2. Estimated effects for heights in multivariate regression, Dutch regions, examined 1831-1861

Dependent value: height (cm)	
Panel a (System 1817)	
R ²	0,07
Number of observations	1235
Intercept	163,15
Day of birth	-0,011^c
North-Brabant	Ref.
Limburg	2,93^c
Amsterdam	-1,89^c
Urban residence in rural province	-0,13
Drafted 1831-1846	1,28^c
Drafted 1847-1860	Ref.
Migrant	1,72
Parents unskilled labourers	-1,95^c
Parents/guardians are farmers	1,43^b
^a Significance P < 0.10, ^b Significance P < 0.05, ^c Significance P < 0.01. Coefficients are in bold if the probability of obtaining this value is < 0.10 when the zero value is zero.	

Table 3. Anthropometric characteristics by place/province of residence in the Netherlands (conscript years 1863-1913)

Place/province of residence	N	μ			Coefficient of Variance (CV)		
		1863-1913	1863-1888	1889-1913	1863-1913	1863-1888	1889-1913
Amsterdam	711	167,46	165,01	169,2	0,0435	0,0448	0,0394
Rotterdam	197	166,88	166,08	167,49	0,0375		
Fryslân	729	167,8	166,66	169,1	0,0464	0,0495	0,0414
North-Holland (excluding Amsterdam)	834	167,77	165,48	169,41	0,0445	0,0449	0,0404
North-Brabant	600	165,56	164,72	166,74	0,0411	0,0428	0,0373
Limburg	595	166,76	166,07	167,76	0,0372	0,0404	0,0342
The Netherlands	3727	167,1	165,56	168,6	0,0432		

Place or province of residence refers to the municipality of residence from the legal place of residence of the parents or guardians. Source: HSN Database Giants, release December 2017.

Table 4 Estimated effects for heights in multivariate regression, Dutch regions, examined 1863-1913

Dependent value: height (cm)	Panel b	Panel c
	Conscript years 1863-1888	Conscript years 1889-1913
R ²	0,02	0,03
N	2014	1888
Intercept	165,86	169,54
Day of birth	-0,004^c	-0,004^c
Amsterdam	Ref.	Ref.
North-Brabant	0,401	-1,896^c
Rotterdam	1,34	-1,755^c
Fryslân	2,475^c	0,695
North-Holland (excl. Amsterdam)	1,849 ^b	1,065 ^a
Limburg	1,673^b	-0,973^c
Medium-size towns	0,476	0,959^a
Immigrant	1,691 ^b	0,816
Conscript = farmer	1,682^c	0,890^a

^a Significance P < 0.10. ^b Significance P < 0.05 ^c Significance P < 0.01. Coefficients are in bold if the probability of obtaining this value is < 0.10 when the zero value is zero.