Economic Development and the Distribution of Nutritional Resources in Bavaria, 1797-1839: An Anthropometric Study.

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Abstract

This study examines and confirms Kuznets' 'Inverted U'-hypothesis of income distribution on the basis of the physical stature of Bavarian conscripts in the first half of the nineteenth century. We find that the inequality of nutritional status was greater in industrially more developed regions and towns and that nutritional inequality increased over time.

Simon Kuznets (1955) asserted that income inequality traces an inverted U-shaped path during the process of industrialization. He based this hypothesis on fragmentary time-series data from industrialized countries and some cross-sectional evidence from less developed countries in the 1950s. Since this change in income distribution is of considerable social and political importance in the contemporary world, several studies were published by economic historians on long term trends in inequality in a quite a few countries.[1]

While the trend toward greater equality in more developed countries during the twentieth century until very recently is now widely accepted, the notion of a widening of income gaps during the previous century is still under discussion.[2] It is especially difficult to estimate real incomes or standards of living for different social groups before the middle of the 19th century. Peter Lindert pointed out that most income statistics refer to wage-earners, while we know little about those drawing income from self-employment and property (Lindert. 1991, p. 215). Wealth distributions give us important information on these groups, but discounted wealth is far from being equal to income. In predominantly agricultural countries with medium-sized plots, the share of the self-employed group was well above one half of the population. However, one important aspect of the standard of living, nutritional status, can be measured for even those groups by using anthropometric methods. Since the height of human beings is determined by net nutrition (i.e. the intake of nutrients during their growing years minus claims resulting from diseases and physical exertion), the distribution of heights in a population might be used as a proxy for the distribution of nutrients.[3]

This paper focuses on the following issues:

1. Are Kuznets' findings on income distribution observable in a cross sectional analysis of height distributions? Was nutritional inequality higher in regions with a relatively large industrial sector compared with regions still dominated by agriculture?
2. Was nutritional inequality in Bavaria increasing in the early nineteenth century, when many countries experienced the beginning of Modern Economic Growth?
3. Do different measures of this new approach point in the same direction?
4. Is it possible to explain the diverging trend between physical stature and GDP by looking at height inequality? When cliometric historians started anthropometric research some twenty years ago, the basic hypothesis was that GDP per capita was closely correlated with heights, as higher income was expected to translate into better nutrition. However, several cases were soon identified in which a rapidly rising GDP per capita coincided with declining heights, most notably in the USA and the UK in the second quarter of the 19th century, the so-called "antebellum puzzle" (Margo and Steckel. 1983, Komlos. 1987, 1993). This lead to the search for the economic causes of the decline in physical stature in a growing economy. Several reasons have been proposed for this mystery, including rising inequality of income, which Steckel (1995) has found to be associated with shorter stature in the 20th. While Soltow (1992) argued that inequality did not increase in the US before the Civil War, in the Dutch, British and Swedish cases rising inequality might have been a major reason for declining heights.[4] Because of this controversy and because of the potential importance of rising inequality to resolving the antebellum puzzle, we examine the distribution of nutritional resources in the early 19th century.

This is possible for the Bavarian case, because in contrast to most recruitment systems of the time, in Bavaria nearly all men were measured at a fixed age, including the son of the finance minister as well as that of the seamstress.[5] Therefore, these measurements can be regarded as a census of young men. The calculations of height variation in this paper are based on the measurements of approximately 15,000 Bavarian conscripts.

One could argue that Bavaria is not a good case to examine the effect of Kuznetsian Modern Economic Growth and industrialization. In fact, Bavaria was a "lagging region" in German industrialisation (Tipton. 1976, Orsagh. 1968). The industrial and service sector did not increase it's share of the labor force in the early 19th century, as much as it did in Westphalia, the Rhineland, or Saxony. The share of the non-agricultural sector was 28% in Bavaria, below the German average of 41% in 1849. Its national product was only 77% of the German average (Frank. 1994). However, some of its regions were industrialized to a considerable extent (parts of the Palatinate, Swabia, Middle and Upper Franconia), even if in the main it remained specialized in agriculture. In addition, GDP is estimated in the early 19th century only with a large margin of error. This is important because the production of those agricultural items increased fastest in Bavaria that are typically not measured by GDP, such as milk consumed in the farmer's own households (Boehm. 1996).

1. Anthropometric methods for measuring nutritional inequality

Biologists have shown that the mean stature of a population of constant ethnic mix depends on the consumption of calories and proteins net of such claims as work effort and the incidence of diseases during growth years. Two factors influence the variation in heights: Human biology and the environment. Heights of adults are approximately normally distributed, which is nature's contribution. In order to consider the environmental contribution theoretically, let us assume two economies A and B. In fictional economy A, the distribution of nutritional resources is perfectly equal, while in B the distribution is unequal (Figure 1 and 2) . Since in A only natural variation (s_{nat}) plays a role, the variation is lower than in B. In fictional economy B there are two groups with average heights in group 1 greater than in group 2. This difference is referred to below as *between-group difference (BGD)*. If each of the two groups has the same natural variation (s_{nat}), the composite distribution has a larger variation.[6]

How much does variation of heights differ between countries and regions in the 20th century? Among the rural Bavarian birth cohort of 1937, for instance, the distribution of heights had a coefficient of variation of 3.72 cm and a mean of 171.8 cm (Table 1). The differences in variation between urban and rural areas were extremely small. By 1965, the coefficient of variation had decreased to 3.65, while the average height rose to 178 cm.[7]

Human biologists and anthropologists have analyzed the relationship between height variation and economic development for the late 20th century. In figure 3, height differences between 7.5-year-old boys from poor and rich families are shown for developed and less-developed countries. In India, the most extreme case, the difference in means is about 10 cm. If both groups are large enough to influence the overall variation of the country, one would expect the variation to be larger in the less-developed countries.[8] In fact, the coefficients of height variation among children and youth in India and Thailand are larger than in the UK (Harrison and Schmidt. 1989). Within the same geographic region, the CV of heights of poor children in urban Guatemala was much larger than the one of rural Mayas (Bogin. 1991). Bogin argues that this larger height variation is caused by the heterogeneity of the urban environment for lower classes: Even within the lower classes, some families did relatively well, while others did not. This is supported by the fact that within the well-off strata of Guatemala city, CV of height is much smaller than among the poor. It is important to note that the difference between economic groups is much larger for individuals that are still growing, because the better nourished part of the population grows faster, and the worse nourished part reaches its final height later.

In order to measure height variation and inequality, different methods have been used. Soltow (1992) for instance, calculated Gini coefficients of heights.[9] Since most of the height variation was caused by natural variation, the differences between 19th century and 20th century Gini coefficients were relatively small. As Gini coefficients are typically used to measure the distribution of income or wealth, i.e. variables whose variation changes much more over time, these small changes of Gini coefficients of heights might give an inaccurate impression.

The other possibilities are standard deviations and coefficients of variation (CV). Anthropologists have found that standard deviations typically increase with average heights, while coefficients of variation do not display this behaviour to a significant extent - if CVs are related to average height at all, they increase only very slightly with height.[10] Bogin (1991), in accordance with Sokol and Rohlf (1969), concludes that for measuring height variability "the CV is an appropriate statistic, since it minimizes the effect of differences between samples in mean height, ... when comparing differences in the variability of height ..."[11] Hence, coefficient of variation is used throughout this paper as an index of inequality. The height difference (in cm) between the lower class and the combination of the middle and (very small) upper class is also considered.

This methodology produces accurate results only if the geographical units are of similar size and the age of individuals are the same.[12] In early nineteenth century Bavaria, as in most European countries of the time, males grew considerably between the age of 19 and 21, and the adolescent growth spurt took place much later than today.[13] For example, in the 1965 height standard of Dutch people, the maximum standard deviation of heights is reached at the early adolescent growth spurt of age 14.5 (s.d. 8.9 cm, van Wieringen. 1972, p. 52). The standard deviation remains high up to age 16, and declines down to 6.7 cm at ages 20 and 25. As the CV is standard deviation divided by average height, the CV for younger ages of growing boys is much higher. Therefore, ages are not mixed in our study. For the Dutch grown-ups born in 1965, the CV is about 3.75, similar to those of Bavarians in the early 19th century, even if those were on average some 12 cm shorter than the average Dutch male of 1965 (177.7 cm at age 25). However, the Dutch height variation data are available only at the national level, so that some regional variation is probably included. Therefore, the measured variation is probably higher than the "natural" variation.[14] For

Bavarian (fully grown) 19-year-olds of today, regional data are available for 12 districts for birth years 1971 to 1975.[15] The average height is 179 cm; the CV is lower (between 3.6 and 3.7) than in the Netherlands, probably because of the regional decomposition, close to the lowest values of the 21-year-old of our early 19th century sample of Bavarians, even though the regional level of those 19th century Bavarians was even lower. Regression analysis of data available for 12 districts for 5 years suggests that for contemporary Bavarians, no relationship exists between CV and average height:[16]

CV = 4,4 -   0,00 * height
(0.28) (0.86)

R^2=0.00, N=60, F=0,03 (0.86), p-values in parentheses.

Therefore, the CV can be considered as a measure relatively independent of average height. The available evidence suggests that the "natural" value for grown-ups without much regional or economic variation should be close to 3.6.

2. Data sources

The main data source used in this study are the individual records of conscripts. Beginning with the birth cohort of 1797, all men aged 19 were measured and medically examined. For the birth cohorts between 1802 and 1814, only a few records have survived. By the time they are available again for the birth cohorts of 1815, the age was changed to 21 and remained so until 1839.[17] The conscription lists report health, height, name, district of birth and district of conscription, birth year, occupation of the conscript and of his father (or mother, if she was unmarried or widowed).[18] Therefore, Bavarian conscript lists are a nearly complete census of young men at a fixed age.[19]

From about 15,000 individual measurements stemming from 15 districts of Bavaria, coefficients of variation were calculated, aggregated by six 5-year-birth-periods.[20] The sample was subdivided into a cross-section of those born between 1797 and 1801, because these conscripts were younger, and a panel data set of those born between 1815 and 1839 (age 21). To minimize sampling error, only coefficients of variation based on more than 60 individual measurements were used.[21]

3. The relationship between height variation and economic development

As a measure for 'level of economic development' the share of non-agricultural occupations of the conscripts' fathers is used. Even if better indicators of economic development, such as GDP per capita, are not available on a regional basis, our indicator can be justified by the finding of Orsagh that it is highly correlated with aggregate income.[22]

A scatterplot of CV and the share of non-agricultural occupations shows a positive relationship for the earlier sample of 19-year-olds (Figure 4, correlation coefficient 0.57, p-value 0.032). The regression line in figure 4 and 5 has been fitted with a quadratic term to allow for some nonlinearity ($y=a+bx+cx^2$). This yields a higher R^2, because there are both maximum and minimum of attainable heights, and therefore there exists a theoretical maximum of height variation.[23]

As an alternative to the continuous variable '% of non-agricultural occupations', we can classify the districts into three types: Agricultural districts, early-industrial districts, and towns.[24] Most of the Bavarian districts were dominated by agriculture. The fathers of most conscripts were active in the agricultural sector, ranging from 60% to 70% per district. Only one of the districts in the 1797-1801 sample was early industrial; the economic structure of the region around Nuremberg was dominated by metal and glass manufacturing, reflected by a share of nearly 50% handicrafts and workers. The two towns in the sample had almost no agricultural population: Munich and Landshut. Among the five cases with the highest CV are found the two towns and the early-industrial district. Even within the agricultural districts, a relationship between the sectoral structure and the CV can be seen, although there are only a few cases.

The second subsample contains the birth cohorts of 1815-1839 (Figure 5, 21-year-olds). Seventy-one observations represent fifteen districts of Bavaria.[25] Again, the positive relationship between the CV of heights and the share of non-agricultural occupations is apparent (Correlation Coefficient: 0,50, p-value: 0.000).[26] The variation in the town is larger than the variation in agricultural districts. This is the case in every five-year cohort. The CVs of the five early-industrial districts are higher than those for agricultural districts, but are not as high as in the towns. This subsample includes five different early industrial districts. In addition to Nuremberg (rural district); Friedberg, a district of clockmakers; the salt-mining district of Reichenhall; and the textile districts of Frankental and Kaiserslautern are included.

Unfortunately, data on individuals are available for only two towns in the earlier sample and for five time periods for one town in the later sample. Whether the urban results are representative can, however, be judged by comparing them to the published conscription statistics (Table 2). These aggregated statistics give hints about similarly high CVs in other towns. The published data are divided into three categories: Short conscripts (less than 155.6 cm), medium (155.6-175.1 cm), and tall (greater than 175.1 cm). Table 2 shows the percentages of conscripts falling in these categories for towns and rural areas in four major Bavarian regions ('Regierungsbezirke').[27] In each of the four major regions, the medium group was smaller in towns compared with rural areas. This finding supports the notion that greater inequality of urban heights was a wide-spread phenomenon.

Did nutritional inequality rise in the early 19th century? It is obvious that CV increased between 1815 and 1819 and between 1835 and 1839 (Table 1). In a regression on CV, with the share of non-agricultural occupations and birth years ('time') as independent variables, the time variable is significant (Column 3 and 4 of table 3), so this change in the CV was not caused by composition effects. It is important to note that the share of non-agricultural occupations did not increase in Bavaria during this time.[28] It makes no difference whether the city of Munich is included (U/R) or not (R); including it affects only the slope of the function between the share of non-agricultural population and the CV. If the time trend is included in the equation, the estimated influence of this variable does not change much, although the adjusted R^2 is slightly higher with both independent variables.

The coefficient of time looks small, but we have to keep in mind that most of height variation is naturally caused. An increase in CV of 0.15 over the whole time period is not negligible. If we compare CV changes over time and CV differences across regions, we note that the average CV of early industrial districts is 0.20 higher, and that of the town 0.40, than that of agricultural ones (Table 4). Therefore, the magnitude of change in CV over time was about as large as the cross-sectional difference in CV at the beginning of the period. We can conclude that the time trend towards inequality and the difference of height variation between regions are statistically as well as economically significant.

4. Comparison of height variation and between-group differences

Did greater differences in income cause the larger CV in the towns and the more industrialized regions, and the time trend towards inequality? The extremely rich data set on Bavarian heights enables us to examine parental occupations as a proxy for income. Our previous studies showed that the parents' occupation had a larger impact on the nutritional status of the recruit than his own occupation. This is not astonishing since heights are heavily influenced by the nutritional situation in the first months in infancy.

In the last two columns of table 3, regressions of the height difference between the lower class and the middle/upper class on the share of non-agricultural population and the time trend are given. Both the differences across regions and those over time correspond to the regressions with CV as the dependent variable (Table 3, columns 1-4): (a) Every five years, the between-group difference increases by 0.21 cm. (b) The influence of the share of non-agricultural occupations on between-groups differences in height is also significant. A one percent change equals 0.0432 cm increase in the non-urban case. Taking this coefficient, we can estimate the differences between the non-urban extremes of 20% and 50% share of non-agricultural occupations to be about 1.2 cm. On average, the between-group difference in agricultural districts is 0.8 cm, in early industrial districts 1.6 cm, and in the town 2.3 cm (Table 4).

To examine the relationship between CV and between-group difference directly, we can look at the correlation coefficients between the two variables. For the cross-section of 15 districts in table 4, the correlation coefficient is as high as 0.50 (P=0.060), while calculated for all 71 time-space-observations, it is somewhat lower (0.33, P=0.005). For the earlier cross-section of conscripts born between 1797 and 1801, the correlation is also high (0.51, P=0.064). This means that the relationship between BGD and the variation in heights is generally quite close.

Was the higher variation in heights in more industrial and urban places caused by immigration? We would expect the CV to rise, if immigration is strong, as more individuals of extreme height might enter a town or an industrial district, that might have had medium stature before. From the rural areas of outmigration, perhaps the tallest individuals might migrate, this would reduce the variation in theory. However, the empirical results do not confirm this consideration (Table 5). [29]

5. Winners and losers

Which social groups gained in height, which lost? If one compares the earliest and the last birth cohort of the later sample, the three groups with the highest average height stay more or less at the same level (Figure 6, Table 6): The middle and upper class, the farmers with big plots, and the master craftsmen. On the other hand, agricultural lower class occupations declined on average 0.4 cm, but not significantly (always at the 10% level of significance). The strongest (and significant) decline in net nutritional status experienced the unskilled industrial occupations (-1.7 cm), and semi-skilled craftsmen (-0.8 cm). Tradesmen also declined in height, although this was a heterogenous group. Interestingly, the only group with a significant height increase were farmers with medium plots (although from a low initial level). In addition, their share of the population also increased. This makes sense considering Bavaria's increasing specialization in agriculture: In the early 19th century, rich farmers kept their high nutritional status, while farmers with medium-sized plots converged somewhat. The underlying economic mechanism was probably increasing returns to land in an agricultural country, while the semi-skilled and unskilled industrial activities yielded far lower returns. The latter occupational groups had much more limited possibilities to nourish their children with protein-rich food, while the group that benefitted from increasing returns to land had better possibilities. This is consistent with declining real wages of labourers between the 1820s and mid-century (Goemmel. 1978) and a modest increase in agricultural production per capita in Bavaria (Boehm. 1996).

The Williamson (1985) hypothesis of unbalanced technological change favoring skilled occupations in England during this time period is confirmed in the Bavarian case. The height trend of (skilled) white collar employees and master craftsmen diverges from those of semi-skilled craftsmen and especially unskilled industrial workers. However, the Bavarian data suggest that self-employed farmers also improved their relative position, as their higher living standard contributed much more to inequality in an agricultural country such as Bavaria.

6. Impact on the individual´s utility

One could argue that the future height of one's children is not an element of a household head´s utility function. How much, then, did it matter to parents in the poorer segments of society that their children's quality of nutrition declined over the time period 1815-19 to 1835-39? While height or even the quality of nutrition[30] of one's children might not be part of the utility function, the life expectancy of children certainly is – especially in a world with a very low level of old age insurance. Costa (1993) reported a strong link between height and mortality risk, and she and Fogel (1994) found the same relationship between body mass index (weight divided height squared) and mortality.

For a cross-sectional sample of 16 countries it has recently been shown that the correlation between GDP per capita and mean height was relatively low during the 19th century (as was the correlation between GDP and life expectancy), but the relationship between mean height and life expectancy was strong.[31] Around 1860 and 1900, one additional centimeter of mean height meant 1.8 additional years of life expectancy. This result was recently confirmed in a study of Italian regions.[32] Therefore, the children of the unskilled industrial group lost more than 3 years of life expectancy between 1815-19 and 1835-39. That meant a major loss of welfare not only for them, but also for those of their parents who became dependent on their children's income. On the other hand, farmer families with medium sized plots gained about 1.5 years in life expectancy, while sons of richer farmers and skilled craftmen may have gained modestly.

7. Conclusion

Anthropometric variation has been used to measure inquality in nutritional status, one of the important components of the standard of living, in early nineteenth-century Bavaria. All of the hypotheses that were posed at the beginning of this paper were confirmed:

1. A positive relationship existed between nutritional inequality and the share of non-agricultural occupations at the district level; nutritional inequality was also related to early industrial activity in rural districts.

2. Nutritional inequality increased between 1815 and 1839. This is additional support for Kuznets' (1955) hypothesis of increasing inequality during the early stages of industrialization.
3. Both the higher inequality in the economically more developed regions and the rising inequality over time appear to have been caused by between-group differences between social classes, especially increasing factor returns to land and declining returns to unskilled labor.
4. This height decline of industrial lower classes probably influenced the average height stagnation or decline in Bavaria and other European countries in the early 19th century.

Table 1. Heights and variation in height in Bavaria

Birth cohort	Height	Standard deviation	CV	% non-agric. population
1815-19*	166.3	6.1	3.68	40.2
1820-24**	166.3	6.2	3.71	40.3
1825-29**	166.1	6.2	3.76	42.7
1830-34**	166.2	6.3	3.78	40.4
1835-39**	165.9	6.3	3.83	41.5
1937, city	173.4	6.4	3.71	
1937, rural	171.8	6.4	3.72	
1955	176.1	6.4	3.63	
1965	178.0	6.5	3.65	

* 11 Districts available; ** 15 Districts available.
Sources: *Munich State Archive*, RA 27231-28366; *Amberg State Archive*, BA Hemau 761-786, BA Sulzbach 1644-1652, LG Hemau 1207-1226, LG Sulzbach 1125-1148; *Nuernberg State Archive*, BA Nuernberg; *Bayerisches Kriegsarchiv*, Abt. Musterung/Ergaenzung, Bd. 92-94; *Speyer State Archive*, G 7 Militaria.; For 1937: Harbeck (1959, pp. 321-323); For 1955/65: friendly communication of the Institut fuer Wehrmedizinalstatistik und Berichtswesen.

Table 2. Urban-rural height distributions in 4 "Regierungsbezirken" (large districts) of Bavaria, birth cohorts of 1830s (in percent)

	below 155.6 cm		Between Extremes		greater 175.1 cm	
	Rural	Urban	Rural	Urban	Rural	Urban
Major region						
Upper Franc.	5.0	6.0	87.6	84.5	7.4	9.5
Middle Franc.	5.5	8.2	88.8	86.3	5.7	5.5
Swabia	4.4	6.0	85.7	84.4	9.9	9.6
Lower Bav.	3.3	3.3	87.7	83.6	9.0	13.1

Source: Bavaria (1860-66)

Table 3. Weighted Least Square Regression of CV and between-group difference (BGD). 1815-39 sample.

Dep. Variable:	CV	CV	CV	CV	BGD	BGD
Sample:	U/R	R	U/R	R	U/R	R
% non-agric.	0.82	1.33	0.82	1.26	2.96	4.27
population * 100	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)
Time			0.03	0.03	0.21	0.21
			(0.07)	(0.08)	(0.02)	(0.03)
Constant	3.42	3.23	3.32	3.15	-0.70	-1.20
	(0.00)	(0.00)	(0.00)	(0.00)	(0.14)	(0.09)
adj. Rsq.	0.22	0.18	0.24	0.21	0.18	0.14
F-Stat.	20.22	15.44	12.15	9.60	8.49	6.47
N Observ.	71	66	71	66	71	66

Notes and abbreviations: Constants refer to CV or BGD in a hypothetical district, where the share of agricultural occupations would be zero. The cases are weighted by sample size, because a few cases contain much more than the minimum sample size. P-values in parentheses.
U/R: urban and rural; R: only rural; BGD: between-group difference in cm between a) lower class and b) upper/middle class occupation of father. Time is 1 for 1815-19, 5 for 1835-39. Source: See table 1.

Table 4. Regional differences in the 1815-39 sample.

District	Observ.	Std.dev.	CV	% non-agric.	BGD	Height
Toelz	514	5.8	3.40	28.0	0.8	170.2
Miesbach	587	6.1	3.65	29.2	1.5	168.3
Moosburg	1088	6.1	3.70	30.6	-0.4	164.5
Speyer	737	6.1	3.66	31.2	0.3	165.3
Wasserburg	656	6.0	3.58	33.4	1.3	167.5
Brueckenau	908	6.3	3.79	35.4	1.2	165.6
Bruck	788	6.2	3.72	35.6	0.8	166.0
Neustadt	862	6.0	3.61	37.1	1.4	164.7
Frankental*	682	6.3	3.78	41.4	1.1	166.2
Friedberg*	1449	6.2	3.78	41.9	1.6	164.7
Bergzabern	1321	6.3	3.85	43.9	0.6	164.3
Kaiserslautern*	919	6.5	3.94	45.2	1.4	165.5
Reichenhall*	679	6.5	3.90	46.9	2.2	166.8
Nuernberg*	1614	6.5	3.91	47.2	1.8	165.0
Munich (town)	610	6.8	4.06	87.2	2.3	167.1
Average early industrial		6.4	3.86	44.5	1.5	165.6
Average agricultural		6.1	3.66	33.8	0.9	166.3

Abbreviations:
BGD: between-group difference in cm between a) lower class and b) upper/middle class occupation of father.
* early industrial, as known from other sources. Bergzabern cannot be called an early industrial district, although doing so would support the argument. Source: See table 1.

Table 5. Differences between Migrants and Non-Migrants in the 1815-39 sample.

District	Observ.			Std.dev.		Height	
	Non-migr.	all	%migr.	non-migr.	all	non-m.	all
Toelz	514	539	4,6	5.8	5,8	170.2	170,1
Miesbach	587	623	5,8	6.1	6,3	168.3	168,2
Moosburg	1088	1176	7,5	6.1	6,0	164.5	164,5
Speyer	737	756	2,5	6,1	6,1	165,3	165,3
Wasserburg	656	717	8,5	6.0	6,0	167.5	167,4
Brueckenau	908	926	1,9	6.3	6,3	165.6	165,7
Bruck	788	888	11,3	6.2	6,1	166.0	165,9
Neustadt	862	865	0,4	6,0	6,0	164,6	164,7
Frankental*	682	693	1,6	6,2	6,3	166,1	166,1
Friedberg*	1449	1618	10,4	6.2	6,2	164.7	164,7
Bergzabern	1321	1334	1,0	6.3	6,3	164.3	164,3
Kaisersl.*	919	961	4,4	6.5	6,4	165.5	165,5
Reichenh.*	679	723	6,1	6.5	6,6	166.8	166,9
Nuernb.*	1614	1737	7,1	6.5	6,4	165.0	165,0
Munich	610	741	17,7	6.8	6,8	167.1	167,1

Abbreviations:
* early industrial, as known from other sources.
non-m., non-migr.: non-migrant, birth district=mustering district
Source: See table 1.

Table 6: Winners and Losers: Their Height and Share in Population

	1815-19		1835-39	
	Height	%sample	Height	%sample
Middle/U.c.	167.8	7.0	167.2	6.1
Big farm.	166.7	24.1	167.1	21.5
Master	166.5	2.4	167.1	2.5
Med.farm.	164.6	9.0	165.5	13.2
Trade	166.6	3.5	165.3	3.7
Craft.	165.7	22.0	164.9	20.6
Unsk.	166.3	11.7	164.6	12.6
Agr.lab	165.0	20.4	164.6	19.9

Abbreviations:
Middle/U.c. - Middle & upper class, except farmers, skilled indistrial occupations and trades; **Big farm. -** Farmer, big plot; **Master -** Master craftsmen, artisan; **Med.farm -** Farmer, medium-sized plot; **Trade -** tradesmen; **Craft. -** (semi-skilled) craftsmen; **Unsk.** -Unskilled industrial worker; **Agr.lab. -** Unskilled agricultural laborer.
1815-19 and 1835-39: 11 districts included.
Source: See table 1.

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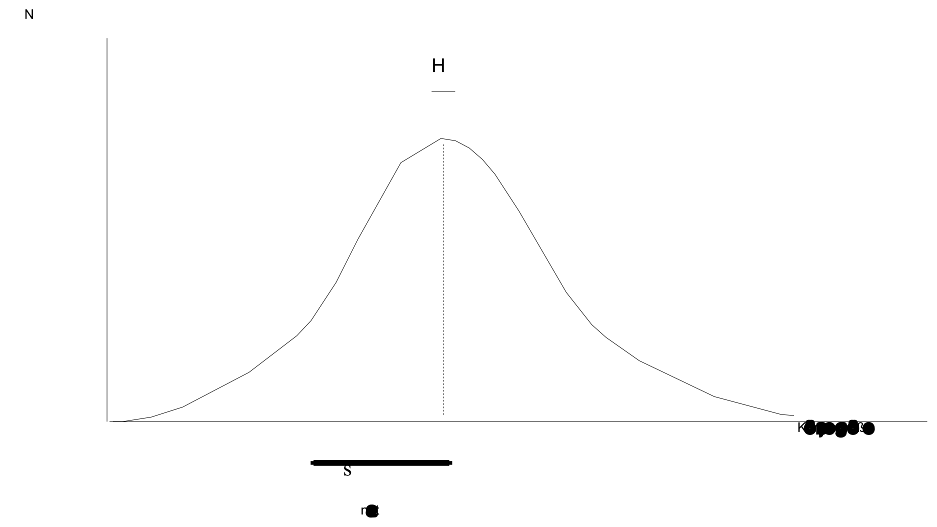

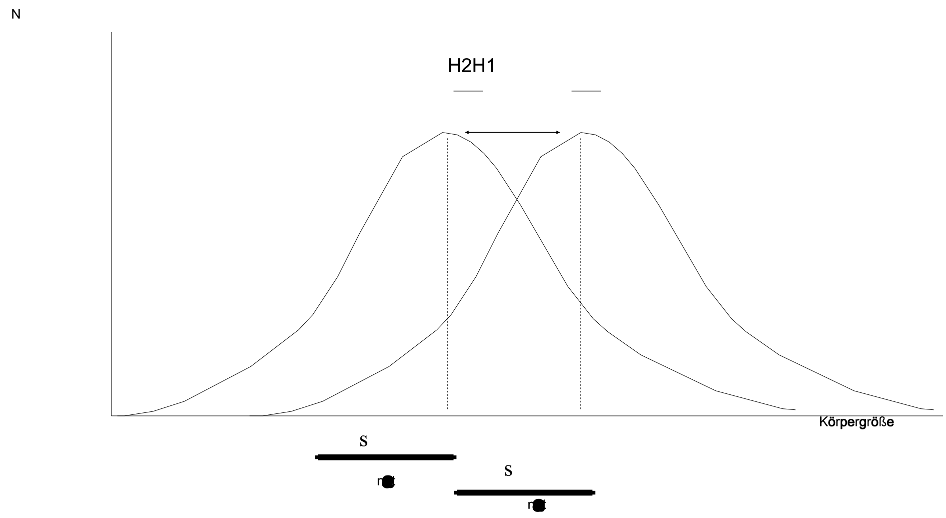

Figure1

%ofthe
population

Endnotes

[1] Williamson (1985); Williamson and Lindert (1980); Dumke (1988); Soltow (1992); see also the studies on Sweden, Austria, Belgium and Australia in Brenner/Kaelble/Thomas. (1991).

[2] See for example Feinstein's (1988) criticism of Williamson's conclusions. Van Zanden (1995) tends to extend backwards the Kuznets curve into the early modern era. He argues that inequality always increases with economic progress, while periods of contraction tend to have the opposite effect. Jackson (1994) looks at the distribution of life expectancy, as Lindert (1991) suggested.

[3] By using average height by age for pupils of the Karlsschule in Stuttgart to compare nutritional levels with social status differences in two time periods of the late 18th century, Komlos (1990) showed that nutritional status became increasingly unequal during these years. Steckel (1994) compared the between group differences of different samples for inequality trends in the U.S. Soltow (1992) calculated gini coefficients of heights.

[4] Horlings and Smits (1997), Drukker and Tassenaar (1995), Komlos (1993 and 1996), Steckel (1994), Williamson and Lindert (1980), Sandberg and Steckel (1988), Joerberg (1991).

[5] Social group is defined as follows: (a) Lower class are made up of day laborers, cottagers, handicrafts without special skills, workers, servants, and other lower class occupations. (b) In contrast, the middle and upper classes consist of medium or rich farmers, master craftsmen and handicrafts with special skills, tradesmen, officials, noblemen, professionals and other middle and upper class occupations.

[6] The joint distribution can be bimodal, if the between-group difference is large enough.

[7] Urban-rural differences are not available for these birth cohorts.

[8] Schmitt and Harrison (1988), Eveleth and Tanner (1990, p. 199).

[9] He found that inequality was declining between 1918 and 1976-80, which supports the findings in this paper. In most of his calculations, Soltow worked with national averages. This might be problematic, if interregional variation played a role.

[10] Schmitt and Harrison (1988, p. 358) compared variances (=squared standard deviations) and CVs of 23 tall, affluent populations and 57 non-affluent, short populations that were studied in the Annals of Human Biology and Human Biology between 1974 and 1987, and found that neither between women nor between men were the differences in CV significant, while the differences between variances were significant for men. These modern CVs were between 3.6 (for non-affluent populations) and 3.8 (for affluent males), again being quite similar to the Bavarian data of the early 19th century. It is important to note that their category of “affluence“ is very broad, a more detailed comparison with economic data might yield other results.

[11] Bogin (1991), p. 288.

[12] The results were checked by calculating standard deviations, and the results were found to be the same. .

[13] Danish recruits grew about 1.3 cm growth between ages 19 and 21 (Mackeprang 1907, p. 156).

[14] Although the Netherlands might have otherwise served as an example of very low "economic" variation.

[15] Thanks to Vincent Tassenaar for informing me about modern Dutch heights, to Barry Bogin for the discussions and hints about modern height variation, and to the "Institut für Wehrmedizinalstatistik und Berichtswesen" of Germany, who kindly provided me the data for contemporary Bavaria.

[16] The same insignificant results turn out if one includes a time variable for the five mustering years:

CV =	-19.7 -	0.02 * height +	0.01 * year
	(0.26)	(0.48)	(0.16)

R squared=0.03; N=60; F=1,0 (0.37); p-values in parentheses; "years" range from 1990 to 1994.

[17] The conscripts were chosen by lot from those eligible. Those who could afford it could buy substitutes to perform military service, and the sons of noblemen had the privilege of entering the cadet corps, but first they were recorded and measured, see *Regierungsblatt* (1830, pp. 441-607). For the sources, see table 1.

[18] Only a few groups were recorded but not examined. Their share (between 0 and 3%) was too small to bias the results. The following groups were not measured: (a) volunteer soldiers already serving in the army; (b) those who disappeared illegally; (c) priests who had already taken orders. Percentages of the three groups were extremely low, and they belonged to different social strata. Military volunteers might have been a bit taller than the average because of the minimum height requirement, although this minimum requirement was extremely low (155.6 cm). Priests also were probably taller, because their parents tended to belong to the middle- and upper-classes. In contrast, missing recruits were born mostly in the lower social classes, as the occupations of their parents recorded in the lists suggest. 'Districts' (Landgerichte, Polizeikommissariate) are the smallest administrative unit above the municipal level. These units had 18,000 inhabitants on average in 1844.

[19] This is a major advantage for anthropometric research, compared with sources available in Bavaria before 1800 and in many other countries, in which a volunteer army selected avaiblable men of the desired characteristics. The latter types of samples require large numbers of measured soldiers to deal with the problem of truncated distributions. For a few birth years, the results of the conscription process were published in contemporary statistics, see table 2.

[20] The sample containing the heights of conscripts who were born earlier has CVs on 14 districts.

[21] With the exception of Landshut-Town (only 37 individuals), which was one of the few towns, see fig. 4. The restriction to units of more than 60 individuals is a conservative one. Human biologists usually calculate CVs even for units with only 25 measurements of individuals, see Schmitt and Harrison (1988, p. 353). Extreme heights (less than 145 cm, more than 185 cm) and the heights of migrants were excluded.

[22] Orsagh (1968, p. 282). calculated the R^2 to be 0.96 in a regression of regional income 1907 on employment share. Frank (1993, p. 14-16) confirmed his regressions, albeit using a modified specification.

[23] The six agricultural districts with a low CV of less than 4.0 are not concentrated in any single region.

[24] A district is called 'early-industrial', if there is evidence from other sources that it produced non-agricultural commodities in large amounts for sale in non-local markets. The definition of 'town' is a legal one (with status of 'unmittelbare Städte'), but nearly all of those had more than 5000 inhabitants in 1840. 'Agricultural' districts are those districts that did not meet the criteria for the afore-mentioned two types.

[25] For the first birth group alone, four districts were not available. Including only 11 districts does not change the results.

[26] The lower level of CVs compared with the earlier sample might be caused by the fact that these conscripts were measured at age 21. At this age, a lower percentage of conscripts was still growing.

[27] Bavaria was divided into eight 'Regierungsbezirke'. Height statistics were published for four of them.

[28] The regression of this variable on time yields:

%non-agric. occup. =	40.3 +	0.25 * time
	(0.00)	(0.85)

R^2=0.00, N=71, F=0.04 (0.85), p-values in parentheses.

[29] Fortunately, we have information on both the birth and mustering place of the conscripts, and excluded all migrants from the previous analysis. However, it would not have made a significant difference, if we would have included the migrants.

[30] As demonstrated in Craig and Weiss (1998).

[31] Baten and Komlos (1998). Murray (1997) reported a weaker relationship on the individual level among middle class students at Amherst.

[32] Kahrs (1998) found that for 21 Italian regions, the correlation was strong in 1885 and 1955, weak in 1970 and vanished in 1985.