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Nutrition and Economic Development in Bavaria, 1730-1880

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Chapter 1. Introduction: The "Early-Industrial Growth Puzzle" in Bavaria

1.1 "Nutrition" and "economic development"

As recently as one or two generations ago, economic historians might not have seen much connection between the concepts of "nutrition" and "economic development"; indeed, the two concepts might have been felt to be mutually exclusive. When conceptualizing the processes of economic development, historians thought first and foremost of industrialization. Most important among their concerns were such factors as technological change, capital accumulation, and financial innovation. Even today, economic development is all too often equated with the expansion of industrial activity. Nutrition, on the other hand, was either the province of historians of nutrition, or a topic in the literature on contemporary development economics.[1] The idea that malnutrition was a constraint on economic development was generally accepted for the less developed countries of today. Until recently, however, it was rarely considered that undernutrition could have also been an important factor in the industrial revolution.[2]

More recently, however, the links between nutrition and economic development have been fully recognized in a historical context. Undernutrition can, indeed, be a limiting factor in the economic development of a region or a country, because the

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[1] This is somewhat of an overstatement and is not intended to minimize the achievements of nutrition history cf., e.g. H. J. Teuteberg /G. Wiegelmann (1972), U. Dirlmeier / G. Fouquet (1993).

[2] J. Komlos (1993 d and 1989 b). In popular writing, this branch of research was briefly presented in R. Usher (1996). Development economist Amartya Sen has used the "Life Expectancy" Indicator to evaluate the biological components of living standards, Introduction to A. Sen (1993). also World Health Organisation (1980, 1986). John Komlos (2000a).

productivity of labor, or, indeed, the very survival of the labor force itself depended upon it.[3]

Nutrition, moreover, was very closely related to living standards in the past, insofar as a very large share of GNP was made up of agricultural output for most places most of the time. Hence, nutrition correlated highly with well being. Recent studies of nutrition at the onset of modern economic growth documented an inverse relationship between per capita income and nutritional status.[4] Known as the “early-industrial growth puzzle“, this phenomenon appears to be a hitherto unknown cost of industrialization. This monograph will examine these complex issues within the geographic confines of Bavaria and document the history of nutritional status in the eighteenth and nineteenth centuries there using the methods developed in the anthropometric history literature. In the final chapter we discuss the influence of nutritional status on subsequent economic development.

The concept "economic development" is understood as the long-term tendency for per-capita incomes to grow, as either the share of the population working in the non-agricultural sectors increase, and/or as the integration of markets proceeds apace. Thus, the economy of a country or region could still develop even without the rapid growth of the industrial sector, provided the region specialized in agricultural production, exported food in exchange for manufactured goods, and thereby captured gains based upon its comparative advantage and specialization.[5]

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[3] A. Sorkin (1994); G. Kennedy /M. Garcia (1994). J. Komlos/M. Artzrouni (1990).

[4] cf. the overview by J. Komlos (1987a)

[5] The concept "nutrition" will be further defined in this section. It is interesting that the relevant reference works offer no definition of "economic development" other than in terms of the problem of less developed countries (LDCs). In the introduction of his work "Development Economics" Clive

1.2 The measurement of nutritional status and economic development

To increase our understanding of the connection between nutrition and economic development we collected and analyzed demographic, economic, and anthropometric data pertaining to Bavaria and the Palatinate over a century and a half (from 1730 to 1880).[6] We keep in mind that there were considerable regional differences in this period as the timing of the integration of markets and the rate at which it proceeded varied considerably even within the confines of Southern Germany. Hence, to the extent possible, we examine developments in as much geographic detail as the data allow.

To begin with, we calculate conventional measures of the standard of living, paying special attention to the real wages of the lower classes. As there are often large measurement errors in these estimates, we corroborate them using agricultural production data.[7] We then compare these results with independent estimates of the nutritional status of the population.[8]

How can the quality and quantity of nutrition in the 18th and 19th centuries be measured? After all, officials seldom registered such an everyday matter as nutritional intake, almost never differentiated it sufficiently on the basis of region and social class. In short, records on historical diets are rather rare. The historical anthropometric

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Bell says, for example that even classical economists mainly worked on the concept economic development, but does not go any further into this. He looks instead in detail at the connection between industrialisation and development, on the one hand and international trade and development, on the other. Cf. C. Bell (1987).

[6] For the territorial boundaries at each particular point in time. These changed considerably, especially in the period around 1800.

[7] Cf., e.g., Gerhard's criticism of calculations of real wages and wages measured in rye.

[8] On the concept of the biological standard of living, cf. J. Komlos (1993d), p. 4

method solves this information problem by making use of the biological relationship between nutritional intake and human height. The quantity of calories and protein that a person consumes in the period between gestation and adulthood has a positive effect on his/her height. Illnesses and workload intensity, particularly during adolescence have a negative impact on final height as the organism uses the food consumed for these purposes rather for growth. In a sense, the remaining net nutrition can be regarded as an index of the biological standard of living. In what follows, the terms "net nutrition" and "nutritional status" are often used synonymously, the term "nutrition", on the other hand, stands for the "intake of nutrients" or "gross nutrition".

Food intake between birth to about three years of age is of the utmost importance for the determination of final height. The intake of nutrients during puberty is also very important, as is the mother’s nutritional status during pregnancy.[9] The genetic growth potential, a significant influence on terminal height, must, in any case, be taken into account. First, there is a natural height distribution even within a homogeneously nourished population, so that large enough samples are always necessary for an accurate calculation of average height. Secondly, the traditional anthropological viewpoint suggests that different countries or world regions have different genetic height potential which do not depend directly on environmental factors. Yet, some studies in the USA certainly showed that no significant height differences can be established between the descendants of European and African immigrants with the same diet.[10] Nevertheless, we still know too little about the effect

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[9] Of course, height depends on many other factors which cannot be discussed in detail in this book. See J. Tanner (1978); B. Bogin (1988b), p.126-159; J. Komlos (1994a).

[10] The descendants of Asian immigrants, however, were not as tall as those of European descent even when they were much taller than the people in their countries of origin. See T. Cuff (1995), p.5.

of genetic growth potential on the height-by-age profile of a population. Thus, the genetic composition of the samples studied should remain homogenous.[11] This presents no problem in the case of Bavaria, because immigration of genetically distinct populations was quantitatively insignificant during the period under study.[12]

The relationship between living standards and physical stature did not allude 19th-century observers. The Bavarian physician, Joseph Wolfsteiner, for example, pointed out in 1860, that height could serve as an indicator of living standard and life expectancy:

> *"With reference to the human being, it can be demonstrated that his height falls when general conditions are detrimental to his prosperity, whether these conditions have their roots in physical or in social relationships. (...) People who are taller achieve a higher average life expectancy".*[13]

Wolfsteiner regarded not only environmental, but also socio-economic circumstances as determinants of height, although he did not propose the exact nature of the relationship among the various factors. It is, however, noteworthy, that he was well aware of the connection between height and life expectancy, a relationship that has been proven by recent clinical research.[14] Numerous other 19th-century scientists,

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[11] We regard the genetic potential as a "disturbance variable", because we are not interested in this variable in itself, but because we want to be able to leave it out of the calculation.

[12] Moreover, a significant proportion of the younger anthropologists thinks that there is no difference in the genetic height maximum among most of the world's populations, simply a limited chance of inheriting the height maximum within one to two generations. Studies have shown, for example, that, as a result of better nourishment, mayan children evacuated from Guatemala during the civil war there grew roughly 50 cm taller than their contemporaries in Guatemala did, and that they had growth characteristics similar to those of American children, cf. B. Bogin (1995), p.64. Still, Bogin thinks that some populations which developed in isolation, such as the Pygmies, do have genetic maxima.

[13] cf. Bavaria, Vol.1 (1860), p.445

[14] cf. R. Fogel (1994), p. 374. For criticism of this, see J. Riley (1994), p. 485-492.

including Quetelet and Villermé also investigated the socio-economic correlates of adult heights.[15]

Social differences in height in today's industrial societies are rather small. Nonetheless, they do exist, for instance, in the United States, where income inequality is relatively large. Scandinavian studies in the 1970s were the first to report no significant differences in height among social groups.[16] For less developed countries, however, such differences are still large enough to be used as an indicator of welfare differences across social groups.[17]

1.3. The determinants of nutritional status

Anthropometric history has been a productive branch of economic history for about a quarter century. A wide range of studies have been undertaken especially for the United States and for Great Britain. For Germany, on the other hand, there have been only two studies published hitherto, both pertaining to Wurttemberg, in southwestern Germany.[18] Sophia Twarog's work examines nutritional status between 1850 and the turn of the century,[19] while John Komlos investigates pupils of the Hohe

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15 cf. the special issue "Historische Anthropometrie," of the Jahrbuch für Wirtschaftsgeschichte, 2000, no. 1; J. Komlos / J. Baten (1998b); J. Komlos / T. Cuff (eds.) (1998); J. Komlos (1994c); J. Komlos (1995a); J. Komlos (1991).

16 cf. J. M. Tanner (1978), p.154-155.

17 cf., e.g., J. Strauss/T. Duncan (1997); A. B. Deolaliker (1988), p.406-13; E. Kennedy/M. Garcia (1994), p.183. For the period from the 1960s to the 1980s, Tanner and Eveleth found social differences within the range of 6 to 10 cm between well-to-do and poor eight-year-olds in Jamaica, Nigeria, Costa Rica, Guatemala, and India. Hardly any differences could be seen in Norway, Sweden, and Japan; in Great Britain and the USA, differences were slight, but obvious. Cf. P. H. Eveleth/J. M. Tanner (1990), p.199.

18 J. Komlos (1996a); p. Twarog (1993).

19 In any case, there are, in my opinion, problems with this study, because the three estimation procedures that are used produce different results, and this difference is not discussed. The problem might lie in the composition of the sample, Twarog, for example, had a disproportionate percentage of "one-year-volunteers" in the sample. Although these man made up less than 2% of the soldiers in the

Karlschule in Stuttgart born between 1753-1776. The longer-run trends in the development of nutritional status not only in Germany, but even in southern Germany between 1730 and 1880 are, therefore, a terra incognita of the scholarly world, and this is precisely the focus of the present investigation.

Our goal is more ambitious than merely to fill a hiatus in the anthropometric history of southern Germany. We want to learn more about trends in living standards of the population of Bavaria, and in a regionally more finely disaggregated manner than has been possible up till now. We would also like to make a contribution to the methodology of anthropometric history by comparing the trends and cross-sectional patterns in height to extant economic variables in a statistically rigorous way in order to gain insights into the processes of modernization in Bavaria at the threshold of the industrial age.

To some extent, this attempt is inspired by the slightly critical remarks made in a 1995 review of a volume of essays on anthropometric history:

> *"I was impressed by the boldness of the speculation about cause of changes in height rather than it's safety. I associate economists with models of horrific complexity but the approach in this book was generally descriptive and even simple statistical testing is usually omitted. The caution used in applying complex analysis was probably better founded than the boldness of the speculation. ... I found this*

Army, this social elite was about one quarter of Twarog's infantry sample. This group voluntarily financed its equipment and provisioning, and must be predominantly members of the small non-peasant middle and upper strata. The modal value of this elite group was, e.g., in 1860-64, about 5 cm higher than the modal value of the conscripts, cf.S.Twarog (1993), p. 272. Further estimation problems result from using the Quantile Bend Estimator, whose applicability demands a very regular normal distribution on the upper tail. RSMLE-estimation is problematic, too, if the truncation point is very close to the mean. Cf. the criticism in J. Baten/M. Heintel (1995).

book rather like those books in which paleontologists start with a few fragments of dinosaur skeleton and end by describing in vivid detail the appearance of the complete animal. I am intrigued and dazzled by their ingenuity but not entirely convinced".[20]

An important aim of this work is to convince this anonymous reviewer, and possibly other skeptics as well, of the statistical rigor of anthropometric history by, for example, exploring the correlation between height and real wages. Two lines of path-breaking analysis influenced the conception of my research on Bavaria. First, in 1983 Richard Steckel found a close connection between per capita income and average height in 15 countries in the second half of the 20th century. In this sample, the more prosperous was a society, the taller were its inhabitants.[21]

Another line of inquiry, whose focus was two centuries earlier, provided a surprising contrast to the one noted above. John Komlos analyzed military data from the 18th-century Habsburg Monarchy and found a greater average height in precisely those regions that were economically less developed, and hence had a lower per capita income. He explained his finding with a model in which subsistence peasants, who were not yet integrated into a market economy, consumed all their food output themselves. Because of high transaction, transportation and information costs, it did not pay for them to exchange their produce for manufactured goods. While peasants

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[20] Review by J. K. (abbreviation not revealed) in Public Health 109 (1995), p.30

[21] This result was also found by Floud for a panel of 64 observations from European countries for the period from about 1880 to 1980, and confirmed by a time-series study of Brinkman et al., see H. J. Brinkman/J. W. Drukker/B. Slot (1988); for criticism of that result, see C. A. Mandemakers/J. L. Van Zanden (1993); a confirmation of that result, on the other hand, can be found in J. W. Drukker/M. Van Meerten (1995). Recently, the first mentioned research team has obtained the same result for less developed countries, see Cf. H.-J. Brinkman/J. W. Drukker/B. Slot (1997).

who had been integrated into the market might have had a higher real income, and could consume more industrial goods, they did so by trading away a large part of the nutrition supply of their families. As a consequence, their children consumed less protein, and were shorter than those of the subsistence peasantry.

Building upon these two findings, this book explores the relationship among such variables as real income, wages, relative prices, nutritional status, and physical stature in Bavaria of the 18th and 19th centuries. We pay particular attention to regional patterns and temporal developments of both conventional living standards as well as anthropometric indexes constructed on the basis of more than 100,000 dusty (and hitherto unused) records extracted from military and penitentiary archives. We hope thereby, that the results will be sufficiently valuable to inspire other regional studies for other parts of Germany and beyond.

1.4. Structure of the work

We start out by surveying the economic characteristics of Bavaria and the Palatinate. The following two chapters examine the trends in nutritional status over time and their determinants. The examination of the available independent variables follow in the 18th century (Chapter 3) and the 19th century (Chapter 4).

The relationship between climate, agricultural production, real wages and the anthroprometrical indexes of nutritional status is also explored. Climate is considered as an independent variable, insofar as it had a major influence on agricultural production in the pre- and early-industrial era as well as on the human organism itself through the basal metabolic rate. Given the state of agricultural technology, cold and wet years could result in enormous harvest failures which caused real wages to plummet. Additional variables considered include mortality, the distribution and variability of income, food prices, and the intensity of physical labor which are all related to the well-being of the human biological organism, and affected the height of the population, particularly those of the lower segments of the society. We also compare developments in Southern Germany with contemporaneous changes in England, the most industrialized country of the time.

Chapters 5 and 6 are devoted to the analysis of regional differences in nutritional status using extant cross sectional evidence. Luckily, contemporary statisticians and the military authorities collected information on the heights of approximately 1.1 million conscripts, aggregated to the level of around 179 regions in Bavaria and the Palatinate at three distinct time periods. Numerous economic variables are calculated for these 179 regions – various agricultural products; the share of the non-agricultural population, real wages, as well as the degree of proximity to a large city.

Our estimates indicate that nutritional status was especially high in thinly settled regions with high per capita milk production, and that it was less favorable in regions developing a proto-industrial sector, and in grain growing districts. We discuss, furthermore, the extent to which the high nutritional status was brought about by the local production of animal protein, or the propitious disease environment.

Chapter 7 analyzes the social distribution of the nutrient consumption, and uses anthropometric indexes to test Simon Kuznets' hypothesis, according to which social inequality increased significantly at the onset of modern economic growth, becoming more egalitarian much later. Finally, the last chapter looks at further developments in the late-19th century using cross-country analysis. We discuss the possible relevance of nutritional status for subsequent economic development.

Chapter 2: An Overview of the Economic and Demographic Developments in Bavaria – an International and Interregional Comparison 1750-1850

Before we start with the anthropometric analysis, we present an overview of the economic and demographic developments in Bavaria of the 18th and 19th centuries in an international comparative framework. To the extent sources permit, our spatial unit of analysis pertains to the boundaries of the Kingdom of Bavaria that existed in the 19th century. We are especially interested in such issues as the structure of production, external trade, population density, infant mortality, and real wages.[1] We first consider regional differences within Bavaria.

2.1 The economic and demographic variables

We selected six variables which previous research has shown to be significant determinants of nutritional status and physical stature. The structure of production is an important factor, because at the early stages of the industrial revolution proto-industrial areas generally had to import agricultural products which meant that the price of food tended to be higher there than in areas which specialized in agricultural production. This was the case, because of the relatively high cost of transportation of bulky products prior to the transportation revolution associated with the coming of the railroads.[2]

1 For the economic history of Bavaria in this period, see W. Zorn (1975); W. Zorn (1962). For demographic developments, see the regional study by W. R. Lee (1977a).

2 J. Komlos (1994a), p. 95-99.

Ever since Malthus' famous treatise, population density and population growth have been seen as major determinants of the per-capita availability of nutrients. Yet, Ester Boserup, Julian Simon, and John Komlos hypothesized that demographic growth also had positive effects on economic growth in some historical epochs.[4] Gomez-Mendoza and Perez-Moreda have found a close correlation between infant mortality and nutritional status in early-20th century Spain.[5] However, the biologist Noel Cameron has argued that in contemporary developing societies between the first and fifth years of life mortality is determined primarily by nutritional intake, while infant mortality was influenced more by medical, cultural, and perhaps even by genetic factors.[6] The correlation between real wages and net nutrition was the original motivation for anthropometric research.[7]

2.2 The structure of production

In the early 19th century, Bavaria was, in the main, an agricultural country.[8] Because of the comparative advantages provided by the Alps, the number of cattle per capita was high compared to those prevailing in other countries. In the 1850s there were 0.6 cattle per capita in Bavaria, but only 0.4 in France, in Hungary, in Austria, as well as in the German Tariff Confederation (*Zollverein*) as a whole (see table 2.1).[9]

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4 J. Komlos (1994a), p. 189-198.

5 Gomez-Mendoza/V. Perez-Moreda (1995), p.89. also R. Spree (1995).

6 N. Cameron (1997).

7 See the overview by J. Komlos (1997b).

8 W. Zorn (1975); K. Bosl (1988), pp. 22-39; Karl-Heinz Preißer presents a slightly modified view of the question of Bavaria's state of development. K.-H. Preißer (1993).

9 W.G. Hoffmann (1965); M. Böhm (1995); B. R. Mitchell (1975);

Because productivity in Bavaria's livestock economy was not lower than that of other countries, per capita output of animal proteins was probably higher than elsewhere.[10] Bavarian grain production was also not below that of other parts of Europe. However, the proportion of the population engaged in the secondary sector was, however, lower than in other West-European countries.[11] While in Great Britain half of the labor force was engaged in industry or trade as early as the 1850s, in Bavaria, in contrast, the comparable figure was about a quarter (see table 2.2).[12] The percentage of the population working in agriculture in Bavaria was higher than in France, Austria, or Germany as a whole. Of the countries cited as examples in the table, only Hungary was more specialized in agriculture than Bavaria.

As a consequence of the restructuring of the map of Europe during the Napoleonic Wars and the Treaty of Vienna, Bavaria was enlarged to include a number of previously independent territories which were at different stages of economic development. Upper Franconia, lying in the north east, was a proto-industrial mountainous region, similar in structure to the neighboring Saxon and Bohemian areas. Thus, north eastern Bavaria had a high proportion of industrial labor force (Map 3.1). Metal-working trades and textile plants flourished in the big cities of Middle Franconia and Swabia.

Although the rest of Bavaria was primarily agricultural, there were substantial regional differences in agricultural structure: milk and beef production along the

10 Boehm, for example, estimates a milk yield of about 1000 liters per capita per year around 1840, and Bittermann estimates a yield of 800 to 1150 liters (1800 - 1861) for Germany as a whole. M. Böhm (1995), p. 260; E. Bittermann (1956), pp. 118-121.

11 Bavarian industrial density might have actually decreased in the early 19th century. For its level in the 18th century E. Schremmer (1970).

southern border contrasted with grain growing and pig raising along the Danube and the upper Main River (Map 3.2 a, Map 3.2 b, Map 3.3). Wine, pork and grain were produced along the lower Main, and in the Palatinate along the Rhine, and by the 1810s a new product appeared in rather large quantities: the life-saving potato (Map 3.4). These substantial regional differences enable us to obtain interesting cross-sectional results on the effect of structure of agricultural production on nutritional status.

2.3 Transportation and foreign trade

Before the railway age, the possibilities for the transportation of bulky goods were more limited in Bavaria than in other parts of Europe. Water transport was the only cost-efficient way of moving goods long distances, but the only navigable rivers in Bavaria were the Main and the Rhine in the north west, and the Danube in the southern half of the country. However, the Danube flowed in the wrong direction from an economic perspective, i.e., from west to east. This was disadvantageous for trade in agricultural goods, because the countries downstream of the Danube were themselves agricultural surplus regions: the flow of trade in food traditionally was in an east-west direction.[13] Consequently, the grain and wine surpluses of the Palatinate and of Main-Franconia were sent to the districts along the Rhine, while there was little trade in bulky goods in the entire south and north east of the kingdom. The grain surplus of the South was mainly exported to Switzerland and Württemberg by road, but this was very

12 The higher share of industry in Great Britain probably only explains a small part of this difference.

13 M. Böhm (1995), p. 335.

expensive, hence of negligible magnitude.[14] All of Bavaria's net exports of agricultural products amounted to only about 2% of rye output, and about 10% of that of wheat.

The total commercialized share of grain production (i.e., including internal trade) is estimated to have been about 20% for the early 19th century, the remaining 80% was subsistence production. Trade in cattle and butter fat was larger, though.[15] According to statistics available for the late-18th century only for upper and lower Bavaria, grain and salt were the main exports items, each composing about a quarter of the total value of internationally traded goods.[16] Grain exports were about 60% of Bavarian exports of the early 1820s, but this may be misleading, insofar as the 18th century figures also include exports to grain-importing Swabia which later became part of Bavaria.[17] Hence, 19th century figures no longer include trade with Swabia.

One can nonetheless, infer from the trade figures that, in the 18th century, the foreign trade of southern Bavaria was concentrated in the export of primary commodities, and not of protoindustrial goods. The relatively high proportion of people working in Bavarian agriculture were producing predominantly for the domestic market, and numerous human capital intensive luxury products were imported.[18] In contrast, in the parts of Franconia that later became northern Bavaria, protoindustrial woven goods and the famous so-called “Nuremberg wares" (predominantly metal products) were produced in very large quantities for export even

14 M. Böhm (1995), p. 332.

15 Bavaria, Vol.1 (1860), pp. 439-443.

16 E. Schremmer, 1966, pp. 242-3

17 However, the data might also be interpreted so as to imply that exports of grain did not increase by much in the intervening period. E.g. Augsburg, one of the largest German cities of the early modern era. M. Böhm (1995), pp. 331-2.

18 I. Rudhart (1825)

in early modern times, as were textile products of Augsburg and in some of the smaller cities of Swabia and Franconia.[19] There were no major changes between the late-18th and early-19th centuries in the wine exports from the Palatinate and lower Franconia, or in the export of grain from the Würzburg area. Production of these goods was determined by the comparative advantages of these regions derived from climatic and geographical factors.[20]

2.4 Population growth

The 18th century

The growth of population in the 18th century has been accurately estimated only for upper and lower Bavaria, the upper Palatinate, and the Palatinate (see tab 2.3).[23] The growth of population in Bavaria and the upper Palatinate was, compared with the other European countries, well below average. The population of the Palatinate grew from about 0.22 million in 1750 to 0.34 million by 1795 – a growth rate of about one per cent per annum.[21] Thus, the population of the Palatinate was among the fastest growing in Europe.[22] The economic conditions on the Rhine made it possible for many

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19 For weaving in eastern upper Franconia, K. Schmid (1923); for industrial activity in Nürnberg, R. Gömmel (1978); E. Wiest (1968).

20 For wine production in the Palatinate, J. Bassermann-Jordan (1923); for the grain in the Würzburg region: G. Angerpointner (1994).

23 For Swabia and Franconia, no estimates are available yet.

21 Growth, however, was probably somewhat higher between 1720 and 1750, and somewhat slower between 1750 and 1772 - the losses of the Thirty Years War had not been made up completely until about 1730.

22 In England and Bohemia, the flourishing secondary sector, where there were constant or increasing returns to scale, provided many new employment opportunities. In Ireland and the Palatinate, however, the growth was caused by the growth of agricultural production, made possible by the combination of a good, moderately warm climate and good transport connections to the centers of industry and trade in England and the Netherlands. This agricultural foundation was supplemented in northern Ireland, as in the Palatinate, by the beginnings of proto-industrialization. for the pre-1800 textile industry of the Palatinate, W. Freitag (1963).

regions to attain a high population density.[24] The proximity of the Danube, however, was not such a great advantage for Bavaria, because one could not use it to transport goods to the early urban-industrial centers of northwestern Europe.[23] Another factor limiting trade was the worsening climate of the late 18th century in both upper and lower Bavaria, especially obvious in the regions around the Alps, to be discussed in greater detail in the next chapter.[24]

The 19th century

Population growth remained slow in Bavaria even in the 19th century when demographic expansion accelerated in many parts of Europe. Between 1816 and 1864, its population grew by 32.4%, while the average for Germany as a whole was 58.6% (see table 2.4). In the early 19th century the fastest growing regions in the German-speaking world were those that produced grain for northwestern Europe: the Baltic provinces of Prussia. Annual rates of population growth reached 1.65% in West Prussia, 1.57% in Pomerania and 1.44% in East Prussia. Population growth in the industrial regions in the Rhineland and Westphalia did not peak until the late-19th

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24 In periods of crisis and pressure, those regions were the first that experienced large-scale emigration.

23 W. R. Lee (1979), p. 154, found that Bavaria and Württemberg took little part in international trade. For the 19th century, net grain exports are estimated at about 10%. M. Böhm (1995); W. Zorn (1962).

24 On the other hand, I consider the traditional argument, that the inheritance laws caused low population growth in old Bavaria and the upper Palatinate and high population growth in the Palatinate, to be insufficient. The inheritance laws were probably endogenously determined. Because the Palatinate was more highly commercialized, an inheritance system could evolve that was more favorable to demographic and economic expansion. In the southeastern part of what later became Bavaria, however, the laws in existence at the end of the 18th century were a result of the limited economic opportunities. Nonetheless, the population could have grown through massive urbanization, if the economics and geography of trade had permitted it, as was, e.g., the case in Bohemia, where entail was also widespread.

century.[25] Of the 33 regions of Germany only six had slower population growth than Bavaria – among these were Bavaria's western neighbors, Württemberg and Hohenzollern.[26] Austria-Hungary as a whole, as well as the Alpine districts bordering Bavaria to the south (Upper Austria, Vorarlberg, Tirol, and Carinthia) also showed a similar tendency towards slow population growth. but higher growth rates were reached in the more industrially developed provinces of Bohemia and Lower Austria.[27] Thus, for the late 18th and early 19th centuries, the entire region of southeastern Germany and Alpine Austria (with the exception of Lower Austria) can be regarded as a demographic unit, characterized by low population growth.

2.5 Infant mortality in the 18th and 19th centuries

The low population growth rate in Bavaria went hand in hand with very high infant mortality rates. In the 1830s, Bavarian rates were markedly higher than those in all other countries of Europe (see table 2.5). Only the figures for Saxony came even close to the Bavarian rates. North Germany, like northern and western Europe in general, had already achieved much lower infant mortality rates by 1830. There were substantial variations at the district level as well (see table 2.6). The highest infant mortality figures were in the Massenhausen district of Bavaria (column 2) and in a district in southern Württemberg (column 1).[28]

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25 See also H. Kiesewetter (1987).

26 W. R. Lee (1979), p. 178

27 H. Helczmanovszki (1979), p. 63.

28 In the table, membership of a religious denomination is given. The historical demographer Imhof has argued that parents of the different religions treated their children differently, and that Calvinist protestants, in particular, felt a stronger responsibility for their children's survival. A. E. Imhof (1985), pp. 84-90. Thus, according to Imhof, family planning was practised earlier in protestant regions, like, e.g., in 17th-century Geneva and less children meant more food available per child. The three studies found, in fact, that infant mortality was highest in catholic districts. However, most catholic districts

For some districts we were able to estimate the infant mortality rates for the years 1809-1815 and 1862-68 (Map 3.6). The blanks represent districts for which data were unavailable. Infant-mortality was extremely high, often as high as an unimaginable 40%, particularly in the southeastern part of the country.[30] In the north, by contrast, far fewer children died in their first year of life (this was also true in the predominantly catholic northwest). The high infant mortality rate also decreased in the Bavarian Forest in the southeast, and in a thin strip of land along the Alps.

There are contemporary calculations for infant mortality for the years 1862-68 which has many parallels with the earlier period (Map 3.7). Surprisingly, average infant mortality did not decrease at all, as indicated by the legend. Infant mortality was still low in the North. We also have data for the northeast for this period, also showing particularly low infant mortality rates. Again, the Bavarian Forest and the strip along the Alps in the southeast have lower infant mortality than the districts in the south center. A substantial change was that the district with the highest infant mortality rate (of over 40%) shifted westward into the Swabian administration district.[31] The

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lay in the south of Germany, so that this result may be influenced by a mixture of religious and geographical factors. The fact that, in the one study of a protestant village in the South of Germany, the infant mortality figures were between the catholic and protestant averages for Germany as a whole favors this argument.

30 The study of W. R. Lee (1977a) also comes from this region. Knodel (1988) studied Swabian villages from the Southwest.

31 Breast-feeding patterns are said to be the chief determinant of differences in infant mortality within Bavaria. This, in fact, explains the North-South contrast and the better conditions that prevailed in the Bavarian Forest, because a higher proportion of women in these districts breast-fed their infants, while infants in the south and southwest were fed with a flour paste. Because this paste was low in protein and lacked other important nutrients, it was a poor substitute for mother's milk. A cogent explanation for the existence of this type of quasi-infanticide in the south, has not been proposed. Governmental efforts to change this behavior were unsuccessful for a long time. W. R. Lee (1979), p. 155. The shift of the extreme mortality districts westward, and the slightly lower infant mortality rates in the extreme south are also puzzling. This shift westward could, of course, have been influenced by changes in the nutritional situation. In Chapter 5 we show that it became increasingly easier to transport animal

relationship between infant mortality rates and nutritional status will be investigated in chapter 5.

2.6 Real Wages

We examine the real wages in Bavaria, in order to enable us to sketch the broad outlines of conventionally measured purchasing power. On the basis of data for urban construction workers we can surmise that in the 1850s real wages in Germany were only half of those prevailing in the U.S.A., clearly below British levels, and just as clearly above those obtained in France, Holland, and Scandinavia (see table 2.7).

Regional estimates of real wages in Germany have not been calculated because of the lack of regional price indexes. We circumvent this problem by using the price of rye, available for some Bavarian cities, as the price deflator, and thus calculate how many kilograms of rye a laborer (skilled and unskilled) could buy with his daily wage (see table 2.8). We find that these urban quasi-real wages of laborers did vary substantially across the urban landscape, because factor mobility was limited in this period and real wages depended on local supply and demand conditions. Not surprisingly, the purchasing power of journeyman and artisans varied far less, because construction workers were geographically far more flexible – they were actually required by the guilds to undertake years of travel. Purchasing power of unskilled day laborers in the two Saxon cities, especially in Leipzig, near the proto-industrial districts, was very low. The oversupply of labor there, brought about by the depression in the cottage industry in the early-19th century, put downward pressure on real wages

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protein previously could only be consumed within the western Bavarian-Swabian districts by the local population.

in that region.[32] The port cities of Germany's northwest, in contrast, had the highest real wages for unskilled labor in this period.[33] The labor market was much more open there to international influences. Sailors could always sign on Dutch and English ships. In addition, urban industrial development, was most robust in the north west in this period, increasing the demand for labor, thereby increasing real wages.[34] Even within Prussia, the purchasing power of rural wages was higher in the west than in the districts in the east, lying near Saxony. Prussian rye wages were even lower in the regions in the far Northeast. South Germany was in the middle of the two extremes and urban real wages in Bavaria were neither especially high nor especially low.

If we look at rural real wages within Bavaria (again, measured by the ability to purchase rye), we also see a region with lower purchasing power in the north east bordering on Saxony, which had a similar proto-industrial economic structure (Map 3.8).[35] Real wages were high towards the north west, around Würzburg on the middle Main, and in some regions in the south. Within the Palatinate, real wages were higher in the eastern districts on the Rhine than in the western districts.[36]

2.7 Summary

Taken together, these economic and demographic indicators describe a predominantly agricultural country, whose population was, despite moderate prosperity, growing slowly and had not yet entered the demographic transition. To be

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32 D. Saalfeld (1970), p. 88.

33 This has been also shown for Hamburg's twin city, Altona. D. Saalfeld (1970), p. 84.

34 In the case of Altona higher rental costs must, of course, be estimated, but not, however, in the cases of Emden and the cities inSaxony.

35 For the estimation of real wages, see Appendix A.

sure, there was very little increase in population in the entire Alpine area, to which southern Bavaria belongs. This pattern ought not be ascribed to the dominance of agriculture in Bavaria, insofar as other agricultural countries, such as Ireland, Norway and the Baltic provinces of Prussia in the 19th century, experienced a much more rapid demographic expansion.[37] Furthermore, Bavaria had probably the highest infant mortality rate anywhere in Europe and its overseas offshoots. Though there were substantial variation within Bavaria itself, this, too, was a sign of a pre-modern demographic regime.

All in all, the river system of the kingdom was not particularly propitious for trade, and the lack of canals left most of her regions rather isolated from the main European trading centers, there were nonetheless regions on the Rhine and the lower Main River that were able to carry on a brisk trade in agricultural goods, mostly wine and grain, with international ports. Population density was substantially higher in those regions than in the proto-industrial weaving districts of the north east. Infant mortality, too, was lowest in the north. Thus, we see considerable regional variation in the level of economic and demographic development within Bavaria itself. In fact, at the threshold of the modern era, the Bavarian pattern mirrored the European variation in miniature, with an industrializing and commercially active part in the north and a

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36 In the Alps region and in the Bavarian Forest, where people were relatively tall, real wages were only at average levels.

37 It is unclear why demographic growth was relatively slow in Bavaria. Population growth even in such an agricultural country as Hungary was stronger in the 18th century. The most frequently cited causes for Hungarian population growth are the low population density under the Ottoman rule and the new settlement that followed the end of that rule. Komlos considers the estimates of population growth for the 18th century to be rather unreliable. Nonetheless, Hungarian population, despite immigration, grew at a rate lower than that of the Bohemian population. (Bohemia 1754-90: +46%; Hungary 1754-87: +39%). J. Komlos (1994a, pp. 58-59). A theory of population growth is, however, outside of the purview of this volume.

largely subsistence agriculture in the south. We shall pay special attention to these regional differences in our analysis of the anthropometric patterns in the following chapters.

Chapter 3: Climate, Grain Production and Nutritional Status in the 18th Century

3.1 Research questions and data (18th century)

Was Malthus right in arguing that population growth tends to outpace the growth of food supply? Technological progress in the 19th century did free Europe from the laws he proposed, but declining nutritional status in the late 18th century might well validate his arguments for his own lifetime.[25] Wrigley and Schofield suggested that Malthus' theory based on diminishing returns to labor, was applicable to the English economy until the very moment of the publication of his treatise in 1798.[26] Komlos argued that declining trends in nutritional status after the middle of the 18th century were caused by such strong population pressure that the threat of a Malthusian crisis was evident in spite positive 'Boserupian' effects.[27] This argument is strengthened by the fact that in North America, where land was abundantly available, such a Malthusian threat did not appear in the 18th century.[28] Moreover, densely populated areas such as Northern Bohemia and Lower Austria had lower nutritional status, and lower average heights than Galicia or Hungary.[29]

In studies on twentieth-century famines in less developed countries, two major influences come to mind: over-population (in relation to capital stock and resources),

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25 T. R. Malthus (1798/1976); the contrary view in E. Boserup (1981).

26 E. A. Wrigley/R. S. Schofield (1981).

27 J. Komlos (1998); J. Komlos (1999).

28 J. Komlos (2001).

29 The relationship between height and nutritional status is described in detail in J. M. Tanner (1990); J. Komlos (1994a); R. W. Fogel (1984); T. Cuff (1995), p. 5; J. Komlos (1994b), p. 213/4, and will not be discussed here. See also Komlos (1985a and b).

climatic conditions, political dislocations (China, Soviet Union) and the occurrence of natural catastrophes. Did climate also determine famine and welfare in the European past? Long time series on Central European climatic history have been derived in recent years, making it possible to compare these data sets with trends in nutritional status.[30] We shall argue below that milder winters from the 1730s to the early 1750s influenced nutritional status positively, while the cold winters between the late 1750s and early 1770s had a distinctively negative impact.[31]

In order to broaden our knowledge of anthropometric history, estimates of physical stature of conscripts in southern Germany in the 18th century are presented (Bavaria, Palatinate, and Upper Palatinate), and compared with those prevailing in other parts of Europe. 5,882 measurements of soldiers born in the densely populated Palatinate in southwestern Germany are analyzed, as are 15,842 records of soldiers from southeastern Germany: from upper and lower Bavaria (that we will call "Bavaria" in the following), and Upper Palatinate.[32] Climatically, the Palatinate in the south west was, and is, much warmer than the southeastern regions. If the argument of the climatic impact on nutritional status is correct, better nutritional circumstances would be expected for the Palatinate in the late-18th century than for the other regions under consideration. We should also expect nutritional status to have improved during

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30 C. Pfister (1988), pp. 38-39; R. Glaser (1991).

31 I am assuming that when the availability of food declined, the intra-household distribution between children and adults remained either stable, or fewer resources were given to the dependent children, and that the reverse was true for periods of increasing food availability. For similar considerations for 19th-century French parental consumption decisions, see D. Weir (1993).

32 'Upper and Lower Bavaria' will be referred to as 'Bavaria' in the following. Other characteristics of the three regions are very high per capita milk production in southern Bavaria, and low values for the same in the Upper Palatinate and the Palatinate.

the warm 1730s, especially in Bavaria (Upper/Lower), where the climatic conditions were otherwise rather cold.

Height is a measure of net nutritional status, and therefore is also affected by changes in the disease environment and physical exertion. Climate may also have had a direct influence on heights, for example, if colder winters meant that more calories were needed to maintain body temperature. This effect is discussed in section 5. The argument will be advanced below that, in 18th-century southern Germany, climatic conditions – via agricultural production shocks - were an important factor in determining net nutritional status.

The height data for Bavaria and the Palatinate

The height data are derived from military records compiled between 1760 and 1787 (referred to in the following as the "earlier sample") and between 1805 and 1811 ("later sample", see table 3.1). They are records of the armies of Bavaria and Palatinate, which were combined in 1778.[33] For the period between 1787 and 1805, only some scattered data are extant in the Bavarian War Archive, but are insufficient for meaningful analysis.[34] Because of this hiatus, the two samples will be analyzed separately at first. The recruitment system in the two armies was similar even before unification. The troops consisted of volunteers and conscripts ('Landfahnen') (about 50%-50%); the latter were chosen by local authorities from the peasant and artisan

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33 Until 1778, the territory of upper Palatinate was divided between Palatinate and Bavaria.

34 Most of these records were probably destroyed during World War II. Only a few lists of the Palatinate survive, but they were not representative enough for the territory under consideration. Later, the Palatinate became part of the French Republic, and regions were structured differently than either before or thereafter, see J. Kermann (year not given).

populations.[35] Officers were typically of upper class origin, while the non-commissioned officers came from a broad social spectrum, but predominantly from the urban middle classes.

Until 1788, minimum height requirement (MHR) was extremely high – 167.7 cm for infantry, 170.2 cm for the elite troops, the so-called 'Leibsoldaten' and 'grenadiers (grenade throwers) in the Palatinate, and 175.1 cm for grenadiers in Bavaria.[36] In order to explore the extent to which this MHR was actually applied, we estimate the truncation point using kernel density estimator which finds the steepest slope of the smoothed height distribution.[37] This estimation technique showed that the extremely high minimum height requirement was not applied strictly. For adult infantry of Bavaria (23 to 50 years) the actual truncation point was estimated at 165.2 cm and not at 167.8 cm for the early sample.

As the elite army categories were overrepresented in the data for earlier birth cohorts, dummy variables were assigned to these units in order to avoid biases. The officers were taller because their social origin was higher, and so, too, were the non-commissioned officers, medical and logistic personnel. The 1760-87 sample contains information on soldiers born between 1725 and 1769. The younger soldiers are overrepresented in the later birth cohorts, as most of the sample was recorded in the late 1770s and 1780s. There were very few soldiers aged 23-50 among the 1765-69 birth cohort. The estimated trend in adult height must, therefore, end with the cohort

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35 O. Bezzel (1925, 1930, p. 99, 1933).

36 As the cavalry also had an upper height limits, and the artillery selected their recruits according to their skill levels, this sample was restricted to the other three army categories.

37 I am indebted to Markus Heintel for creating this procedure, documented in J. Baten/M. Heintel (1995), and M. Heintel (1996).

born in the early 1760s. Only for the younger soldiers can the trend be extended until 1765-69.

The second sample, recorded during the Napoleonic wars, consists of 4,596 soldiers from Bavaria and its regional components, and is thus comparable to Upper and Lower Bavaria only (i.e. one of the three regions in the earlier sample). The recruitment process was changed radically in 1799 and 1805, so that potential soldiers were primarily conscripted into the military, not volunteers. The minimum height requirement was lowered considerably to 162.4 cm (62 "Rhenish inches"), so there are few missing cases to the left of the MHR among the birth cohorts of the 1770s and 1780s (see appendix Figure B. 1). After these preliminary statistical considerations, we can examine the trend in physical stature.

Height trends in southern Germany, 1725-65

Two methods are used to estimate trends and regional differences – the Komlos & Kim method (K&K) and the 'reduced sample maximum likelihood estimator' (RSMLE).[38] With the former method, the height distribution of every birth cohort is truncated at the highest MHR applied during the period considered. The simple mean of the reduced sample is then calculated either over time or across regions. This mean is a constant function of the 'true' mean of the underlying height distribution, assuming that the variance did not change dramatically.[39] The second method enables us to

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[38] The K&K method was proposed by J. Komlos/J. H. Kim (1990); RSMLE was first applied to height studies by J. Trussell/K. Wachter (1984).

[39] The advantage of the K&K method is its robustness. In contrast, the Quantile Bend Estimator, which was often used in prior studies is very sensitive to small violations of the normality assumption, see J. Baten/M. Heintel (1995).

regress height on exogenous variables, such as dummy variables for age, but it only yields reliable results if the truncation point is far enough below the mean.[40] A simulation study by Mokyr and O'Grada (1996) yielded favorable results even when the truncation point was close to the mean, but this is not the case if there is significant rounding to the nearest inch or half inch. The Bavarian data of the earlier sample is not rounded significantly. This is fortunate, because the truncation point is relatively close to the mean. The second sample does have substantial rounding, but the difference between the mean and the truncation point is more than an inch. Nevertheless, it is necessary to compare the two estimators. A reliable height trend can only be confirmed if results estimated with both methods yield similar results.

The RSMLE method shows an upward trend in all three regions between the birth cohorts of 1725-29 and 1750-54, and a downward trend thereafter (see appendix table B.1, Figure 3.1). Bavaria had the tallest soldiers during the 1730s, while among the cohorts born after 1745 those from the Palatinate were the tallest. The decline in Palatinate heights of about 1.4 cm between 1750/54 and 1765/69 was rather modest, compared to the decrease in Bavarian heights of 2.7 cm. Excluding the elite army categories from the estimation confirms the ordinal regional differences (see appendix table B.2).[41] The K&K method generally confirms these results – heights increased

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40 Ibid.

41 "Ordinal", because the decline was strongest in Bavaria and weakest in Palatinate. The same centimeter estimates cannot be expected because of the way the categories were selected. For Upper Palatinate, the number of cases is too small to make this control estimation if the elite categories are excluded. The weighting of the army categories was done in terms of their shares in the army (in Bavaria: 59% non-elite, 23% Leib, 18% Grenadiers, in Palatinate and upper Palatinate: 68%, 16%, 16%). It could be argued that the non-elite soldiers were more typical of the underlying population than the mix of the three categories. In addition to estimating the the non-elite soldiers separately, a simple sensitivity analysis was done, increasing the non-elite weights by 10%. This did not change the results to any visible extent.

until mid-century and declined thereafter (see fig. 3.2, 3.3, 3.4). Because this method does not take covariants into account, the sample is divided into the two elite categories on the one hand, and the ordinary soldiers on the other.[42] Every birth cohort for Bavaria contains more than 30 individuals, even for the "Leibsoldaten" with the least number of observations. As we would expect from army regulations, the difference in height between the elite and the ordinary soldiers was greatest in Bavaria.[43]

Height trends, 1770-94

The heights of the birth cohorts 1770-74 to 1790-94 can be estimated with the K&K and RSMLE method using the later sample of Bavarian recruits (see appendix table B.3).[44] Most of the height distribution lies above the minimum height requirement of 162.4 cm (see appendix fig. B.1). Heights were very low, especially in the first birth cohort. This result is not particularly surprising as the Bavarians experienced a severe famine in 1771/72. In the following birth cohorts, heights recovered somewhat. The K&K and the RSMLE estimates corroborate one another for the different army categories and age groups for which enough measurements are available (see fig. 3.5 and 3.6). There was a bifurcation by army category. Only height

42 The number of cases for "Leibsoldaten" would be too small for some of the birth groups.

43 This height difference between elite soldiers and the ordinary soldiers might be a military response to the extreme regional differences in nutritional status in Bavaria. In the mountaineous region of southern Bavaria, people were relatively tall because their supply of animal protein from milk was sufficient (see section below), in northern Bavaria near the Danube river, the nutritional standard was much lower, see J. Baten (1998).

44 In this case, the stated and the estimated minimum height requirements are identical (162.4 cm).

of ordinary soldiers declined temporarily between 1775/79 and 1780/84, contrary to the main trend.[45]

To what extent can the estimated height in the two recruitment periods be compared? Changing the recruitment system from a volunteer to a conscript army can imply substantial selection biases, insofar as changes in labor market conditions can have an impact on the supply of the "quality" recruits.[46] As a consequence, anthropometric historians prefer, to the extent possible, to confirm the results obtained on the basis of military samples from civilian height data. In the case of 18th century England and the Habsburg Monarchy, height of students measured in orphanages, charitable institutions and military schools served this purpose.[47] However, no comparable source has yet been found for Bavaria and the Palatinate, so we are not able to corroborate our results with other sources. Hence, we must discuss the possible impact that changes in the recruitment process and in labor market conditions between the earlier and later sample could have had on our estimates.

As already mentioned, the earlier sample consists of approximately equal shares of volunteers and conscripts. The latter typically came from the rural lower classes and were selected by the local authorities. These had an incentive to select from the poorest segments of the society, who were most likely to become a financial burden on the community at some time in the future. However, as the recruiting system was

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45 Interestingly, their heights also fell between 1765/69 and 1770/74. The earlier birth group was included only in the K&K estimate.

46 See, for example, J. Mokyr and C. O'Grada's (1996) general critique of height analysis based on volunteer armies. Physical anthropologists have found that even the heights of the subpopulation "US basketball players" are normally distributed, so normality tests alone do not reject the hypothesis of selection bias.

47 Floud et al. (1982, 1990) and Komlos (1994a, pp. 75-79).

ultimately controlled by the Bavarian government, the recruits had to be tall and healthy enough to fulfill their military service. In general, these recruits probably had a lower nutritional status than the average for the population at large. The other half of the army, the volunteers, obviously had lower opportunity costs than first born sons of farmers (who would inherit the farm), master craftsmen or other urban middle classes, as otherwise they would not have joined the army. Their limited earning prospects must have meant that they were drawn from the class of simple craftsmen, landless peasants and those farmers' sons who would not inherit the land. Within this group, no negative selection for height is to be expected, as the volunteers received bounties proportional to their height, and the recruiting officers used these to ensure that the recruits were as healthy as possible.

Accordingly, the earlier sample is probably composed of a disadvantaged group that was probably shorter than average, and one which was probably pretty close to the average. The later sample was structured by different rules, but the outcome turns out to have been pretty similar. After the recruitment reforms of 1799/1805, a restricted form of general conscription was introduced. A much larger part of the population was conscripted than with the earlier sample. The urban middle classes were excluded (they were non-commissioned officers in the army) as were the first sons of farmers, if they were the only male descendants. The residual classes are again simple craftsmen, non-inheriting sons of farmers, and the rural and urban lower classes.

The social composition suggests that the two series for Bavaria can be compared without prejudice to the outcome. Our height estimates for the two samples for the contiguous periods, 1765-69 and 1770-74, also suggest that the two samples might well be spliced together. The declining trend that started in the earlier sample simply seems to have continued through the birth cohorts of 1770-74. Since this was a famine period, the decline in height is quite plausible. An important argument against a significant role for the modified recruitment process is that the downward trend in heights found in the earlier sample, was for soldiers who were recruited entirely under the old system.

Was the decline in heights between 1750-54 and 1770-74 caused by labor market conditions? According to Mokyr and O'Grada's (1996) model, falling real wages would be expected to increase the willingness of the better fed part of the population to join the army, as their opportunity costs would fall. Real wages declined during this period due to climatic problems in food production, so that this selection bias would have caused heights to increase, not decline. Another factor that might have introduced a bias into the earlier sample might be the occurrence of wars. During major conflicts, people who have the choice prefer not to volunteer for armies, and the recruiting officers pay higher wages and premiums and accept lower "quality" recruits. However, Bavaria was not directly involved in military conflicts during 1760-87. In the Seven Years War Bavaria was neutral, and the short War of Bavarian Succession was fought primarily between Prussia and Austria-Hungary.[48] So we would not expect that wars introduced biases into our height samples. In sum, the soldiers in our sample are quite representative of the lower segments of Bavarian society, and the two

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48 The Bavarian succession was only the cause of the war. Although Bavaria was not directly involved in the conflicts, the fear of war could have had an effect on recruitment. A negative selection of the first birth groups, i.e. lower heights than 'normal' would then be expected, which would support the argument of this paper. A dummy variable for "recruitment 1760-63" cannot be included in in the regressions, as this would lead to substantial multicollinearity with the time dummy "birth group 1730-34".

samples are most likely comparable to one another. We can, therefore, accept the estimated trends as being unbiased estimates of the nutritional status of the Bavarian population. According to these results, nutritional status rose until mid-century only to decline substantially until the famine of the early 1770s. It rose slowly thereafter, reaching just barely the mid-century peak again by the turn of the 19th century.

3.2. Comparison of height trends with real wages, grain and potato production

The original working hypothesis of anthropometric research involved a close correlation between physical stature and conventional measures of the standard of living, such as real wages or real per capita income. In the course of the research it appeared that this connection did not always hold up, depending on the degree of commercialization of the society. The two variables were found to have drifted apart, for example, in both England and the USA between the 1820s and 1840s.[49] In the following section, the height-real wage relationship will be investigated for 18th-century Bavaria. We deflate nominal wages by an index of rye prices, because a representative consumer price index is unavailable for Bavaria. In addition, in order to corroborate our findings, we also compare height trends with potato and grain production trends.

The real wages and grain/potato production in Bavaria in the 18th century

Until the very end of the 18th century nominal wages were more-or-less constant; they tended to be sticky.[50] Yet, during the Napoleonic Wars - from about

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49 J. Komlos (1997)

50 H.-J. Gerhard (1984), p. 55.

1795 until 1815 – nominal wages did rise, only to remain at the 1815 level until the early 1850s.[51] Thus, the variation in real wages was caused mostly by changes in prices.[52]

We also consider trends in rye production on the basis of tithe lists.[53] Tithe series have been compiled for two regions in southern Germany, Wertheim and Kuehlsheim.[54] We are taking the geometric average of those two series, as they are

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51 In North Germany, too, the wage rate hardly ever varied, apart from the period of the Seven Years' War (1756-63), in which nominal wages were somewhat higher. Cf. H.-J. Gerhard (1984a), p.56.

The increase in nominal wages in the period around 1800 appears to have differed greatly from region to region. For Göttingen hod-carriers and apprentice bricklayers, nominal wages around 1815 were about 10% higher than around 1795; in Bremen, they rose by 40-50%. According to Elsas, apprentice bricklayers' wages in Munich rose by about 25%; according to Gerhard, they actually doubled. The latter data are, however, biased by the inclusion of different kinds of activities (e.g., workers of different skill levels). In Figure 4.5, nominal wage increases after 1795 are based on Elsas's calculations, which correspond to the mean for Goettingen and Bremen. Cf. H-J. Gerhard (1984): M. Elsas (1936), p. 733.However, we know little of the dynamics of unemployment, which averaged 40 to 50 days annually for construction artisans in the 18th century. In addition, there were at least to 60 or 70 Sundays and feast days a year, cf. ibid.

52 The calculation of real wages by dividing nominal wages by grain prices rests on the basis of the following assumptions:
1. Over time, underemployment remained relatively constant. Therefore, changes in the nominal wage rate reflected changes in the actual nominal wages.
2. The prices of other foodstuffs and firewood are, given the substitution effect, correlated with the price of rye. Even if higher valued foodstuffs (i.e., meat) had a higher price elasticity of demand, the correlation of the index values was nonetheless high. Even wood production had opportunity costs. If rye rose in price, forests were more intensively cleared and used for food production, and labor inputs were reallocated. We know this from forestry discussion about the fear of a wood shortage in the 18th century (cf. J. Radkau (1989), p. 92). Therefore, even the price of wood also tended to follow the price of rye.
3. The prices for other expenditures (rent, clothing, other goods) changed so little, and their proportion of the total household budget in Bavaria was so small, that they did not substantially influence total living costs. Cf. also the section at the end of the chapter.

Gerhard has some doubt about the dominance of the food items in the total budget, based on a Hamburg household budget, which attributes greater weight to the cost of fuel. One can easily imagine that, in the largest cities of wood-poor north Germany, the relative price of wood was especially high. Cf. H.-J. Gerhard (1984). On the significance of rye prices, cf. W. Abel (1966); T. Bengtsson (1995).

53 On the methodology and problems, cf. E. Le Roy Ladurie and J. Goy (1982), pp. 24-26;

C. Pfister (1988), pp. 65-69. A connection between tithe yields, rye prices and winter temperatures is also shown by W. Bauernfeind and U. Woitek (1996).

54 Those regions are situated a few kilometers west of the later northwestern boundary of Bavaria, thus exactly between (Upper/Lower) Bavaria, upper Palatinate, and the Palatinate. I thank Rüdiger Glaser, Würzburg, for these series, published in graphical form in R. Glaser (1991), p. 155. Because the territory of Wertheim was larger than that of Kuehlsheim, a weighted average, with the ratio 3:1,

closely correlated. The yields pertain to a district, hence are not per capita values. To arrive at per capita values, we assume that the population of those districts grew at the same rate as the Bavarian population, at 0.32% per annum.[55]

The estimates show a very close relationship between the trend of real wages and grain production until 1770-74, a time of severe famine. According to historians of nutrition, this famine brought about a breakthrough in the diffusion of potato production (see fig. 3.7).[56] Although it had already begun to be cultivated, it was only then that it suddenly gained major importance.[57] Exactly the same chronology is found in the Swiss canton of Bern. After the potato spread there, population began to grow well beyond the level per-capita grain production alone would have allowed.[58] What was the contribution of the potato to demographic expansion in Germany? For Bavaria's north eastern neighbour, Saxony, the contribution of the potato to food production, can actually be quantified for a few selected years (see table 3.2). According to these data, potato production made only a slight contribution to nutrition before 1772, even though it was occasionally cultivated by parish priests and large estate owners.[59] Only after the famine of 1771/72 did the potato become, as in Bavaria or Switzerland,[60] enormously popular.[61] We can estimate the share of the potato in

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was calculated from both series. The two series move are highly correlated, the one of (colder) Kuehlsheim is, however, somewhat more sensitive to climatic change.

55 Calculated from population estimates for 1700 and 1800 by M. Rauh (1996).

56 H. J. Teuteberg/G. Wiegelmann (1986), p. 93-134; C. F. W. Dieterici (1838), p. 262.

57 M. Boehm (1995), p. 361, and the studies cited there.

58 C. Pfister (1995), p. 177.

59 U. Schirmer (1996), p. 51.

60 For Switzerland, there are two regional studies which deal with the contribution of potato cultivation around 1760: one gives a share of 7% for all root crops (thus, inter alia, potatoes and turnips); the other considers the share of root crops too small to quantify. Cf. C. Pfister (1995), pp. 191/192, who refers to the unpublished results of Frey and Stampfli.

total food production in Saxony and Bavaria in 1809/10. In Bavaria, about 156 kg of rye, wheat, and spelt, were produced per capita compared to 132 kg of potatoes.[62] In caloric terms, therefore, the contribution of the potato was substantial, indeed, about 17% of the total, i.e. about the same as in Saxony (22%). In 1800, the potato contributed only 12% of calorie intake in Bavaria.[63] Therefore, the available information suggests that the chronology of potato cultivation in Bavaria was similar to that in Saxony, although the extent of cultivation was somewhat smaller. In the light of contemporary reports on the sudden spread of the potato after the famine of 1771/2, and the availability of comparative data for Saxony, we augment our tithe series for rye by the estimated potato output in Bavaria. We assume that the output was 2% of grain production between 1750 and 1770 and extrapolate this amount linearly until it reaches 12% in 1800 and 14% in 1810. The estimated series is closely correlated with real wages (see fig. 3.7). Only in the last five-year periods after 1795 was the real wage slightly below the value that would have been expected from the production estimates.[64] Real wages declined strongly between 1750 and 1770, this was

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61 In the northern districts of what later became the Kingdom of Bavaria, substantially more potatoes were cultivated than in Saxony; in the southern regions, less, cf. J. Baten (1998),

G. Angerpointer (1994). In the south, more labor and capital were probably invested in livestock raising and grain growing. Unfortunately there have been no studies of tithe yields for southern Bavaria; a less sharp decline in these would be expected than in those regions that enthusiastically converted to potatoes.

62 Without the Palatinate. A unit weight of grain contains some 300% more calories than the same unit weight of potatoes, see C. F. W. Dieterici (1838); G. Angerpointer (1994).

63 For 1800, Boehm estimates the contribution of grain to total calorie production at 67%, that of the potato at 9%, for a total of 76%. (This refers to total production when only grain and potatoes are considered the share of the potato is 12%). The remaining 24% of total calorie production consists of milk (19%) and meat (5%). Cf. M. Boehm (1995), p. 91.

64 Here one of the series could be inaccurate because of the influence of the war.

phenomenon in most countries of Europe. Even quite remote countries such as Turkey experienced this decline, as Pamuk recently estimated.[65]

Comparison of real wages, grain production and height trends

Although there is a general agreement between the trends of adult heights and real wages, there are also a few differences (See fig. 3.7 and 3.8).[66] Aside from the catastrophic harvests of 1740/41, both wage and production figures were, before the mid-eighteenth century, generally above average, while heights rose first, reaching their peak in 1750-54. The decline from 1750-54 to 1770-74 is common to all three series. In this period, heights fell by about 3 cm, well below the level of 1735-39. Grain production per capita diminished by about 20% and, in the short term, real wages fell even more sharply. After 1770, heights in Bavaria recovered somewhat, as grain cultivation was supplemented in the densely populated regions by potato production. Real wages also recovered, because the price of rye, which caused them to change, was pushed downward by the new nutritional alternative of the potato.

3.3. Climate and nutritional status

The relationship between climate and food production is of course very complex. Generally, climatic extremes are problematic for agriculture, both in terms of temperature and humidity. Monthly timing is very important – how warm and wet was it during the months of the winter grain harvest, summer grain sowing and haymaking? Threshold and interaction effects are also important, for example, if the temperature in May rose over 8°C and this was combined with late snowfall.

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65 Pamuk (1999), figure 7.

66 According to our previous reasoning, the earlier and later height samples were spliced together.

We first construct a simplified model of the relationship between climate and agricultural production. We consider the climatic determinants of animal protein production that played an often underestimated role in the nutritional experience of early modern societies. Winter temperature is especially relevant to this kind of agricultural production in Central, Eastern and Northern Europe. Pfister has isolated four criteria that influenced the production of animal protein significantly in early modern Europe:[67]

1. The length of time the pastures were snow covered.

2. The time grass started growing in spring (meadow grasses start to grow in spring when the temperature reaches 8°C), and the time it stopped growing in autumn.

3. When the grain harvest was completed in autumn.

4. The humidity of the haymaking season in summer.

The duration of snow coverage, which depends on both temperature and humidity, is decisive for the productivity of the cows, because the cows were taken from the barns in March in good years, and could graze in the meadows. In bad years, on the other hand, dry cattle feed often ran out before the grass began to grow again in April or May. In these years, either the cows were slaughtered or their ability to produce milk capacity fell.[68]

In autumn, the cattle were taken back to the barns as soon as the temperature reached 5°C. As long as the cattle were outside no dry feed was needed, so it could be

67 For the following, see C. Pfister (1988), pp. 38-39; R. Glaser (1991).

68 A Swiss peasant rule says: 'Hungry cows give milk again – frozen ones never do' ('Erhungerte Milch kommt wieder, erfrorene aber nicht mehr.') cited after C. Pfister (1988), pp. 38.

retained for the winter. The last factor, the date of the grain harvest, relates to the customs of early modern European agriculture. After the harvest, the villagers were allowed to take their cattle to the fields to graze. If the grain harvest was later than normal – typically the result of low temperatures in April to June – this benefit was smaller. These four variables which influence animal protein production (both dairy products and beef) tended to be negatively correlated with winter temperature. The colder the winters, and the longer the period of cold winters, the more difficult it was to maintain the cattle stock. Obviously, a single hard winter (as in 1740) following a good year for hay production did not by itself affect the cattle stock as seriously as a series of cold years.

The fourth influence on the amount and quality of hay (the most important dry feed) was how humid the summer was. If the summer was extremely rainy, the farmers had to wait for a dry period before haymaking could begin. If they waited too long, however, the quality of the hay was poor, because there were not enough nutrients in the plants. If it started raining after the hay had been mown, the water washed out the nutrients. Fortunately for the parsimony of our model, winter temperature and humidity are correlated.[69]

Cold winters and short growing seasons also had a negative impact on grain harvests.[70] In addition, in colder winters rye tended to develop poisonous ergot.[71] Grain

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69 R. Glaser (1991). For now the residual of regressing temperature on humidity must be left to the error term of the relationship between winter temperature and gross nutritional standard. Humidity – and the variability of both factors – might well have played an independent role, but we are starting here with the most parsimonous model.

70 However, the manure provided by the animals, another decisive input for grain production, should not be forgotten.

71 M.K. Matossian (1984); J. Komlos (1994a), p. 170.

production, however, was sensitive to many other factors, including humidity during the harvest (July/August) and the sowing months for winter grain (September/October), drought, and hail. As the last two factors were not correlated with winter temperatures, the quantities of calories and vegetable protein available were not necessarily correlated with animal protein production. Thus, substitution effects could buffer extreme cases of underproduction of either animal protein or grain.

There are many sources for grain production for the history of nutrition, but animal protein, particularly milk, production is poorly documented. Grain production was very important for urban populations, while meat was often regarded as a luxury. Milk, on the other hand, played an extremely important role in rural nutrition, but the amount produced was not recorded, because the peasants did not have to pay taxes on milk, and there was nowhere else milk output could have been recorded.[72] As climate influenced milk and meat production, using climatic data might give us a clue to animal protein production in early modern Europe.

The connection between climate and food production has been investigated for an earlier period. Between the second and the last third of the sixteenth century, average spring temperature in Switzerland declined by 0.8°C, and average humidity in summer increased by 20 per cent. Pfister has argued that milk production practically collapsed during this period. As the quantity of dry feed fell and the grazing seasons became shorter, he estimated milk output to have fallen by more than 50% (in the range of 55-193 million liters annually). For a population of 900,000 this meant a loss

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72 H.J. Teuteberg and G. Wiegelmann (1986), p. 170.

of between 61 and 214 liters per capita. Grain production also declined by some 10 to 15 percent.[73] Even if these margins of error are quite large, the effect of climatic deterioration on milk production appears to have been more dramatic than on grain production. Agriculture in Switzerland, Iceland, and Southern Bavaria were probably particularly strongly affected by climatic conditions because of their dependence on dairy products, but other European countries north of the Alps also suffered from the worsening climate over the long run.[74] For example, Jan de Vries found a correlation between cold winters and rye prices in the Netherlands, and Patrick Galloway demonstrated the effects of temperature on population growth world-wide, especially in the cold 14th and 17th centuries.[75] In the 18th century, the cow population of some documented regions of Northern Germany experienced a dramatic decline (see fig. 3.11).

What was the weather like in Malthus' time? As there are no temperature series for Bavaria before 1781, estimates for Switzerland serve as a proxy (see fig. 3.9). In general, winter temperatures were rising up to 1745-49, followed by a dramatic downturn until 1755-59. Winters remained cold until they began to rise again in the late 1780s. When this time series is compared with the estimates for food production, real wages and heights, time lags become important.[76] In good years, stocks of cattle and grain increased and these enabled the population to maintain its nutritional status

73 C. Pfister (1988a or b), pp. 84-95. For cattle in Austria, compare R. Sandgruber (1978).

74 There was a very strong correlation between hay yields and winter temperatures in Iceland in the 20th century (1901-1975). P. Bergthorsson (1985), pp. 113-123. Eckstein, Schultz and Wolpin (1982), p. 28, find a relationship between Swedish yields and winter temperatures 1756-1869, while autumn, summer and spring temperatures do not indicate this correlation. For excellent overviews of this topic, see P. Galloway (1986, 1994).

75 Jan de Vries (1980), p. 25; P. Galloway (1986), p. 7.

76 Thanks to Robert Whaples for this important idea.

through a series of adverse years. In bad years, the cattle stock was gradually slaughtered and additional protein (in meat) was made available for consumption. However, when climate became favourable again, it took some time to build up cattle stocks, especially in regions where markets were not very well integrated. In the following analysis, we assume that the average of winter temperatures in the current and the past five-year-period had an impact on nutritional status. This time lag makes sense in terms of protein production, as cows typically live for five to ten years, and only about 12% live longer. The same is true for oxen, which, as the main draught animals in southern Germany, were an important item in the capital stock of the grain producing farmer.

The trend in winter temperatures and heights is similar (see fig. 3.10). The warm winters between the 1730s and the early 1750s (even with the exceptionally cold year of 1740) enabled Bavarian farmers to increase their cattle stock and grain production which, in turn, had a positive effect on height. The cold years after the mid-century had a negative effect on heights, although the effect of the extremely cold famine year 1771/72 is not evident because the surrounding years were relatively warm.

Thereafter, the relationship is less close. As noted above, the famine promoted the spread of the potato. Although the temperatures rose only slowly, so that shortages remained, the technological innovation of potato production changed the nature of food supply. This indicates that there could be solutions to the problems of shortages that dampened the impact of climatic factors on the agricultural sector.

Unfortunately, a production series of milk and meat for southern Germany cannot be estimated. We cannot directly assess the climatic impact on protein production. W. Abel (1966) concluded from several studies that Germans ate much less meat in the late 18th century than they had previously. This can be supported by data from northern German regions on declining numbers of cows per capita (cf. Figure 3.11).

3.4 Country and Regional Comparisons

Comparison of the three regions in South Germany

Another possibility for investigating the connection between climate and net nutritional status is provided by the different climatic conditions in the three regions. There is sufficient anthropometric data for such a comparison in the earlier height sample. The Palatinate was the warmest of these regions and Bavaria the coldest[77] and in terms of climate the upper Palatinate[78] was between the two extremes. We would expect, therefore, that when the climate improved before the mid-century, Bavaria would have the highest nutritional status and that this effect would be less marked in the somewhat warmer Palatinate. The trend in heights actually does show this relationship (see fig. 3.1). In the relatively warm period, men were taller in cooler Bavaria than in the warm, but densely settled, Palatinate. The reverse was true in the colder phase after 1750-54: heights in cold Bavaria underwent a substantial decline, while the colder winter temperatures in the Palatinate did not have such a strong effect on heights. These differing reactions indicate how important the changes in climate

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77 Viebahn (1858).

78 It included the Palatinate-Neuburg districts on the Danube.

were for nutritional status, and how much stronger this effect was in colder regions than in warmer ones.

Comparison with Great Britain and Austria-Hungary

How do these trends in height compare with other European countries? They are very similar. The estimated trend for five regions of the Habsburg monarchy is rising until the 1740s, after this the trend is reversed (see fig. 3.12). The trend is also downwards in three regions in the United Kingdom, after the middle of the 18th century (see fig. 3.13), although the fall seems to have started later than in Austria-Hungary, especially in England.[79] Using core density modal estimation techniques Heintel and Baten confirmed the declining trend among poor boys in a charitable institution in London.[80] In Sweden, heights increased until the 1740s, declined until the 1780s, and then began to rise again.[81] An especially large increase in heights was experienced in this cold northern country during the warmer period between the 1800s and the 1820s.[82]

The continental climate in Austria-Hungary was similar to that of Switzerland and Bavaria but the maritime climate of the British Isles was different. In England, the relative mildness of the winters is reinforced by the effect of the Gulf Stream. From

79 J. Komlos (1993a and 1993b, 1999) recalculated the heights in the data set made by and described in R. Floud/K. Wachter/A. Gregory (1990); R. Floud/K. Wachter (1982), p. 432; J. Komlos (1999).

80 M. Heintel/J. Baten (1998).

81 The new estimates in M. Heintel, L.G. Sandberg and R.H. Steckel (1998) are more reliable than the older ones in L.G. Sandberg and R.H. Steckel (1987), p. 104. For example, the strange upward blip in the 1770s completely disappeared in the RSMLE and K&K estimates of the Swedish volunteer data set, and the trend looks extremely similar to the height trend in southern German regions.

82 M. Heintel, L. G. Sandberg and R. H. Steckel (1998)

1781 to 1850 January temperatures in central England were therefore about 4°C warmer than in Munich and 2°C warmer than in De Bilt in the Netherlands (see fig. 3.14). Temperature variability in England was also substantially smaller, as can be easily seen by comparing maxima and minima. The warming trend up to the 1730s also favored better harvests in England and real wages clearly rose (see fig. 3.15).[83] Real wages began to fall again after the 1730s when temperatures fell once more and this decline continued with minor interruptions until the turn of the century. Declining real wages also led to a decline in heights in 18th century England. In contrast to southern Germany, English heights did not recover at the century's end, but kept falling in the 1800-09 decade. In sum, the following can be concluded with regard to England: 1) An influence of winter cold on real wages is evident, but it is much weaker than in southern Germany or Austria-Hungary (see fig. 3.16).[84] 2) There was a relatively close correlation between real wages and heights in England during the seven decades after the 1740s for which data are available. 3) A direct influence of climate on the decline in heights after the 1740s in England is far less obvious. The 1790s, especially, were relatively warm (see fig. 3.15) but heights were nearly at their lowest level. The French wars probably contributed to low real wages around the turn of the century. Britain also suffered from the missing imports from the Baltic, as the

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83 J. Komlos (1994a), p. 166-175. The temperatures for England are contemporary measurements from a single source and the temperature data for Switzerland are estimated by a much more comprehensive proxy approach, see Pfister (1988) for details.

84 The residual in a regression (if the sample size of only 16 time periods were not so small) would be much larger. A certain influence can be found even if the extreme five-year period 1735-39 is excluded.

climate was harsh in the grain producing areas of Prussia and Poland around 1800 (see fig. 3.17).[85]

3.5 Other factors influencing gross and net nutritional status

In addition to the consumption of food, other factors such as disease environment, physical exertion of children, direct claims of winter cold on the caloric consumption, and the relative price of food might have also contributed to changes in heights.[86] These factors are more difficult to measure because less systematic evidence

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85 During Napoleon's Continental Blockade alternative transportation routes, e.g. across Archangelsk, made the grain supply more expensive. Additional factors which help explain the weak relationship between winter temperature and height might include changing trading patterns in foodstuffs. While the grain markets of the north European coastal countries were integrated by the 18th century. When the climate worsened after the 1740s, England changed from being an exporter of food to being a net importer. From the mid-18th century onwards, England paid for its food imports with the income from its industrial exports. Because sea transport was inexpensive, the country could be supplied with grain from the Baltic Sea area and with livestock products from Ireland. In a study of the correlation between climate and nutritional status in Great Britain, therefore, the climate in the Baltic area, and not just that of England and Ireland, is important. We would expect that this would be reflected in English real wages, because when the climate worsened in grain-producing regions, the cost of living in England rose. In fact, data on the freezing of the Baltic Sea show that, from the beginning of the 1750s to the turn of the century, the Baltic area was becoming cooler (see fig. 3.17). The most extensive freezing of the Baltic Sea took place around 1800, when both heights and real wages in England reached their lowest point. After the catastrophic 1790s and 1800s, the freezing of the Baltic declined until the 1820s, and both real wages and heights recovered in England. If not only the effect of the domestic climate of England, but also the effect of the winter temperatures in the grain supplying countries is included, then a negative influence of winter cold on heights becomes evident even in the country that was the most developed industrially at the time. A similar case could be made for the Netherlands. Irish deliveries of foodstuffs to England are not considered separately, because Ireland's climate was similar to that of England. B. Mironov (1985); J. Komlos (1994), p. 177. Food imports to England were small (1.4%) in relation to total food production in the 1770s and 1780s. By the 1800s, they had risen to 6.2%, cf. Deane and Cole (1962), p. 65. The low estimates of the early decades do not mean that the imports were unimportant. The large cities, in particular, depended to much larger extent on food imports. The freezing index for the Baltic was calculated by Koslowski and Glaser (1995, p. 84/85) by arranging the data on ice volume from 13 coastal stations in an ordinal pattern of seven categories.

86 For a group of French regions between 1840 and 1911, D. Weir (1993) found both a positive influence of real wages and a negative influence of mortality rates as proxy for disease environment. In addition, the changes in the intrahousehold distribution of resources between adults and children, which was approximated by fertility rates, turned out to be very important. Attempts to prove that the disease variable is the most important one for the explanation of English height trends is problematic. H. – J. Voth and T. Leunig (1996) for example, selected only those three groups of boys that supported

is available. In addition, there are synergistic effects inasmuch as worsening nutrition also increases the probability of the spread of many diseases. Hence, we would need not only a morbidity indicator, but a “residual indicator” from which the effect of nutrition on morbidity was eliminated. As there is little hope of constructing such an indicator, most studies use infant, child, and overall mortality rates to proxy the disease environment, and control for real income. Is it possible that the disease environment worsened sufficiently to have had an independent effect on the decline in heights between mid century and the 1770s in south Germany (in addition to the effect of the food shortages induced by climate changes and by population growth)? If we assume that mortality is a proxy for the disease environment, the answer is probably not. Imhof found no obvious trend in life expectancy at ages 0, 1, or 20 in Germany between 1740 and 1790[87], and between 1750 and 1770 he found a small increase in life expectancy at all ages.[88] Lee confirmed these results, finding that infant mortality remained unchanged between the 1750s and 1770s at about 36 percent.[89] Thus, the available evidence on mortality suggests that the height trends in 18th century south Germany were not caused by nutrition-independent changes in the disease environment.

The second factor, physical exertion, is even more difficult to measure. Hans-Joachim Voth assumed that the abolition of several Catholic holidays in Austria-

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their argument and disregarded the eight other groups that did not support it, cf. M. Heintel/J. Baten (1998).

87 Thereafter it improved markedly until the climatically favorable 1820s.

88 For males, remaining life expectancy improved between 1750 to 1770 (a) at age 0 from 35.7 to 38.0 (b) at age 1 from 41.8 to 46.3 (c) at age 20 from 36.3 to 40.2. See A. Imhof (1994), pp. 379-411.

89 His study is confined to a few Bavarian villages (Hofmark Massenhausen) in the 18th century. This average does not reflect short-term effects - for example, in the famine of 1771/72 mortality was much higher than normal. W. R. Lee (1979), p. 186.

Hungary was a sign of increasing work load, also for children and young adults whose heights might have been reduced by exertion.[90] How many additional calories did it cost the already badly nourished children to work in the fields, or at the weaving looms, on those extra days in the year? One possibility is that they would have worked less intensively, keeping the energy expenditures at a more or less constant level. Robert Fogel estimated that, in France around 1790, 20% of the population were not able to do more than three hours of light work per day, and the inputs he used for this calculation were similar in southern Germany and Austria-Hungary in the 1760s and 1770s. At that level of consumption, the amount of calories spent on work must have been more strongly determined by the amount of calories consumed. When harvests were good and milk production was higher, the population was able to work more, and when nourishment was poor even governmental regulation would not make the workers in the fields, or their children, work more than was physically possible. This view is supported by the fact that in the 19th century the length of the working day was longest in the 1860s and early 1870s, when the heights, real wages and food production were much higher than in the five earlier decades.[91] With the current stage of research, the hypothesis that the disease environment or physical exertion contributed to the cycles in height cannot be rejected, but there is no evidence supporting their (independent) role for the 18th century.[92]

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90 H. – J. Voth (1995, 1996). J. Komlos and A. Ritschl (1995), on the other hand, argue that the abolition of Catholic holidays in Austria-Hungary cannot explain the decline of heights in 18th century Protestant Sweden.

91 To return to the disease factor, infant mortality also reached its long-term peak in German history during this period. See J. Baten (1998).

92 The disease factor might have played a role in the decline of British and US lower class heights between the 1820s and the 1840s, but it was more a reinforcement mechanism and not independent of

A direct influence of climatic factors on the growth of children (independent of its effect on food production) cannot be ruled out either. According to this argument, with constant nutrient intake, people in northern Europe or in the Bavarian Alps would have been shorter than people living in warmer areas, but this was certainly not true in the 18th or 19th centuries.[93]

The relative price of food did not play a role in the 18th century, as other goods's prices rose stronger during the critical period (see table 3.3).

3.6 Conclusion

At the time Malthus published his *Essay on the Principles of Population* in 1798, the relatively well-nourished Englishmen born in the 1730s were already 70 years old. Their younger contemporaries were considerably shorter in stature and less healthy, especially those born in large towns and in densely populated areas. As the relationship between average height and nutritional status was known to some people in the 18th century, this decrease in heights might have reinforced Malthus' pessimistic view of population growth.

The inference was drawn on the basis of the evidence that the deterioration in the European climate beginning in the late 1750s contributed to a general decline in nutritional status. Before this period, heights tended to be stable or increasing, and the climate was also favorable. There was a causal chain leading from colder winters to

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nutritional factors. Shifts towards a diet of less protein and more starches are also possible explanations, see J. Komlos (1987); R. Floud/ K. Wachter/A. Gregory (1990), J. Baten (1998).

93 On the other hand, one could imagine that the "tax" for diseases in colder areas would be lower, as many diseases spread faster with warmer temperatures, and that this would offset the effect of the cold climate in northern Europe or mountainous areas. However, if this were true, it would also apply to explaining the development of heights over time.

lower grain and protein production. These factors determined real wages and finally people's heights and this was only slightly modified in central Europe by the new production technology of potato growing. Where there were divergences from the trend – as during the warm 1730s in otherwise cold Bavaria – there were similar divergences in the height series.

Population growth certainly reduced available food per capita (especially of animal protein) because of diminishing returns to labor, as Malthus argued. In a regional cross-section of heights in Bavaria, we find – similarly to the case of Austria-Hungary – that densely populated areas tended to have lower net nutritional status.[94] Population growth was one of the two burdens in already densely populated Europe, given the available stock of human and physical capital, resources and livestock. Climatic conditions was the other.

94 See J. Baten (1998).

Chapter 4: Determinants of Net Nutrition, 1820-1880

4.1 Research questions on 19th century heights

The aim of this chapter is to identify the most important determinants of net nutrition in Bavaria in the early 19th century, measured in terms of heights of men and of women, for information starts becoming available on female physical stature after the turn of the century. We start by considering the original working hypothesis of the anthropometric research program, and ask whether the development of average heights over time was influenced by real wages (since these determined the ability to buy food). Additional influences to be considered include the disease environment, the effect of the workload on the human organism during the growing years, the distribution of income, the relative prices of industrial goods and food with a high animal protein content, the changes in income, and population growth.

We argue in this chapter that there was a positive influence of real wages on the height of the lower class population of Bavaria. This result is contrary to those obtained for England and the USA, where heights decreased from the 1820s to the mid-19th century, although real wages were increasing at the time (see fig. 4.2). We will therefore consider variables that might explain the different development in Bavaria in comparison with the Anglosaxon countries.

Although we have only one real wage series for all of Bavaria, this series reflects common trends within Bavaria. Nominal wages were sticky in the early 19th century, and the cost of living changed mainly because of grain price fluctuations (that were highly correlated with other food prices). The grain price developed very similar across regions (see fig. 4.1).

In the last chapter we found a close relationship between climate (especially winter cold) and real wages. Although is not the main focus of this chapter, we find that for 19th century Bavaria, this relationship becomes less close, but is still visible (see fig. 4.3).

4.2 Data sources on 19th century heights

Three anthropometric data sources are analysed in this and the following chapters – individual records of conscripts, published conscription statistics, and samples of female and male prisoners.

1. Individual conscript lists. Starting at the later stages of the Napoleonic wars, all young men were measured and medically examined in Bavaria.[95] Although there was a minimum height requirement, all 21-year-old males were first measured, except very few volunteer soldiers, emigrants and priests.[96] A large number of conscription lists are available for the birth cohorts between 1815 and 1849. These lists report health, height, name, district of birth, district of conscription, birth year, and occupation of the conscript and that of his father (or mother, if she was unmarried or

95 This is a major advantage for anthropometric research, compared to the sources available in Bavaria before 1805/12 and in many other countries, in which a volunteer army selected available men with the desired characteristics. The latter types of sample require large numbers of measured soldiers to deal with the problem of truncated distributions.

96 The conscripts were chosen by lot from those eligible. Those who could afford it could buy substitutes to do the military service, and the sons of noblemen had the privilege of entering the cadet corps, however, they, too, were recorded and measured, see *Regierungsblatt für das Königreich Bayern*, München 1830, pp. 441-607. For the sources, see Table 5.1.

widowed).[97] Unfortunately, there are gaps in the archives for the proto-industrial weaving districts, the potato region, and the industrially developed towns, i.e., Augsburg and Nuremberg. This source will be employed in all following chapters.

2. Conscription statistics at the district level. Gaps in the archival lists can be bridged to a certain extent by the published conscription statistics, which are available for the birth cohorts 1809 to 1835.[98] These aggregate statistics report (a) the number of conscripts from a certain year and district, (b) the percentage rejected because of short stature, and (c) the percentage rejected because of illness. Average height is not recorded, but as we know that heights are normally distributed, we estimate average height as a function of the percentage of those subjects rejected because they were too short.[99] Those statistics will be used mainly in chapter 5 and 6.

3. Female Convicts in Wasserburg jail and male convicts in Kaisheim jail. Sources on female heights are extremely scarce in the period considered. However, as

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97 A few groups were recorded but not examined. Their share (between 0 and 3%) was too small to bias the result. The following groups were not measured: a) volunteer soldiers already serving in the army b) those who disappeared illegally; c) priests who had taken orders. Percentages of the three groups were extremely low, and they belonged to different social strata. Military volunteers might have been a little bit taller than the average because of the minimum height requirement, although this minimum requirement was extremely low (155.6 cm). Priests were also probably taller, because their parents tended to belong to the middle and upper classes. By contrast, missing recruits were mostly born in the lower social classes, as the occupations of their parents recorded in the lists suggest.

98 But not for lower Franconia up to 1819. They were published in a contemporary statistical journal, see Beiträge zur Statistik des Königreichs Bayern III (1954), VIII (1859).

99 Certainly, there are disadvantages in the conscription statistics, compared with the individual archival lists. Occupations were not recorded, and the statistics did not go beyond the birth year 1835 on an annual basis. In addition, the counting method changed between the birth years 1830 and 1831. From 1809 to 1830 only those conscripts were counted in the category "unfit for height reasons" who were shorter than 155,6 cm and also so weak that the recruitment physicians would not expect an increase of their heights up to the minimum requirement until the following year. Recruits with these two characteristics are called "definitely unfit for height reasons". Their percentage ranged between about 1 and 3 percent in upper Bavaria. From 1831 to 1835, all recruits shorter than 155.6 cm were counted as "unfit" in the statistics, about 3 to 6 percent in Upper Bavaria. Although we can assume a correlation between the recruits "unfit because too short and weak" and those "unfit because too short", the development between the birth years 1830 and 1831 is not interpretable.

a perfect correlation with male heights cannot be assumed, it is important to investigate female heights. For Bavaria, the registers from the Wasserburg prison is available and contains 1,402 cases of females born between 1820 and 1849 aged 22 to 49.[100] Women criminals were measured so that "wanted" circulars could be published if they escaped.[101] As 92% of these women came from the lower class, the results reflect the lower class situation. In addition, we located a very similar source on male heights that were recorded in the prison of Kaisheim.

4.3 Social composition and height patterns

Social composition of prisoner inmates in Bavaria

The two samples of male and female prisoners in Bavaria are suitable for a comparison between height trends and the development of real wages, because relatively long time series without structural breaks can be constructed from yearly averages.[102] The social stratum is probably comparable with that of British data on prisoners.[103] Like the latter, the Bavarian prisoners also did not necessarily come from a "criminal class of the population", as some of their contemporaries surmised, but

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100 Since people's height starts to decline after age 50, the maximum age was applied. There were very few women younger than 22, hence age dummy variables are not used, but the younger and older women are discarded from the sample. This leaves 1329 women for the analysis.

101 Nicholas und Steckel argued successfully against the assumption of a separate "criminal class".

S. Nicholas/R. H. Steckel, (1991), pp. 942-944. Other sources for female heights are descriptions of runaway Afro-American slaves and indentured servants, and infirmary records. J. Komlos (1993).

102 J. Baten/J. Murray (1996). In contrast to the military samples used in chapters 5 and 7, which cover a shorter time span.

103 Cf. P. Johnson/S. Nicholas (1994); P. Johnson/S. Nicholas (1995); P. Riggs (1994). A further possible comparison would be with a sample of prisoners from the USA. Cf. J. Komlos/P. Coclanis (1996).

were more or less typical members of the less prosperous strata of the society who were convicted often of some minor offenses such as common theft.[104] In the Wasserburg prison, whose inmates are about to be scrutinized, thefts and related crimes were 72% of all offences.[105] The occupational distribution suggests that both among men and women about 9% of the inmates had middle or upper class occupations.

To what extent did male prison inmates represent a negative selection in terms of height even within the lower stratum? To settle this question, we can compare the male convicts with a sample of 21-year-old conscripts. The latter sample has a similar regional composition, but is available only for a short time period.[106] The sample is, with few exceptions, representative of the entire population of this age group.

The average height of the 21-year-old conscripts among the birth cohort of the 1820s was 165.6 cm (see table 4.1).[107] In contrast, adult male prison inmates from the lower strata were 167.3 cm tall in the same period.[108] The difference of 1.7 cm in favor of the prisoners is explained partly by the residual growth expected for the 21-year-old men, estimated at 0.4 cm for the late 19th century but probably much during the early 19th century.[109] Nonetheless, the astonishing fact remains that prison inmates were at

104 S. Nicholas/R. Steckel (1991), pp. 943-944.

105 J. Baten/J. Murray (1996).

106 This sample was used, therefore, only for the cross-sectional analyses in chapter 5 and the investigation of inequality in chapter 7.

107 In these cases we can do ordinary least square regressions because there were no minimum height requirements enforced.

109 This could have been even higher for the early 19th century, because the nutritional situation was worse. Cf. E. P. Mackeprang (1907). In the early 19th century, the nutritional situation was worse than in the late 19th century and people thus grew more slowly. The worse the situation, the later the phases of growth take place.

least as tall as, or even taller than, the 21-year-old population of the same social strata.[110]

The difference between English soldiers and prisoners was also small, though in that case the advantage was in favor of the soldiers. Mokyr and O'Grada found that English East India Company soldiers born mostly in the 1820s were 168.5 cm tall on average.[111] At about the same period the height of a sample of English criminals was 167.4 cm, 1.1 cm shorter than the soldiers.[112] According to their occupations, they, too, came mainly from the lower strata.[113] However, the British soldiers were volunteers, while the Bavarian conscripts were representative for the whole male population. Thus, both the Bavarian and the English samples indicate, that the heights of the members of the lower segments of the society were almost the same in the military and prison samples.[114]

It must be remembered, however, that even if the Bavarian inmates were generally from the lower classes, they were not randomly selected from the same. Rather, some groups were over-represented. The census of 1882 can be used as a

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110 Three possible explanations come to mind: First, growth after the 21st year of life might have been even greater in this population, so some of the difference in height would have been eliminated by the time the soldiers had reached their ultimate height. Second, for the prisoners we do not have data on the occupation of the parents which would be a better indicator of the nutritional status they experienced during their childhood and youth than their own occupation in adulthood. Some of the "day-laborers and "servants" among the prisoners might well have been the sons of better off peasants, who were able to provide better nourishment to their children than many other urban occupations with comparable social standing. Third, perhaps there was some selectivity into criminality that predestined the taller members of the lower strata to break the law, perhaps because of their physical strength. (I thank John Komlos for this hint).

111 This is a weighted average of the data presented by J. Mokyr/C. O'Grada (1996), p. 156. The workers among them, who can be said to be representative of the lower strata, were about one centimeter shorter. Comparison is between workers mustered in 1841-45 with the total sample of those mustered in 1841/42, ibid., p. 159.

112 Birth decade of the 1820s, cf. P. Johnson/S. Nicholas (1995), p. 479.

113 Ibid., p. 474.

gauge of the social/occupational distribution of the Bavarian population 14 years of age and older.[115] The comparison indicates that the share of the primary sector among both men and women inmates is very similar to its share of the population as a whole (see appendix tables B.4 and B.5). If all day laborers in the sample were assigned to the primary sector, this category would become over-represented, but only slightly. In the prison sample, however, the social stratum of farmers is far less frequently represented than its share in the population: 36% of men and 42% of women in the population belonged to this stratum. However, there are many more male and female farm workers and servants in the sample than one would expect if they were randomly selected. Clothing/laundry workers and domestic servants are over-represented among the women and the occupational groups food/beverages, clothing/laundry and building/construction are over-represented among the men. Among both genders, public officials and independent professionals are underrepresented.

Obviously, low income groups are over-represented among the inmates – for men these included the crafts which declined substantially in the 19th century, such as cobblers and tailors, for women these included occupations such as seamstresses. A small income made it less probable that the offender could avoid a prison sentence by paying a fine. Moreover, the temptation among poor people was greater to engage in illegal activity during the hard times in the 19th century than among well off people or the self-sufficient peasants. Harsher sentences were also more likely for poor people because the judges, too, thought that poverty increased the probability of crime. On the

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114 Englishmen born in the 1820s were a half centimeter taller than Bavarians.

115 J. Baten / J. Murray (2000). Pensioners and school children were excluded. School children were not found in prisons, juvenile offenders were placed in separate institutions, e.g. the '*Arresthaus*' in Speyer.

other hand, male and female farm workers and servants of both sexes had easier access to wealthy households, and thus had greater opportunities for stealing.

The social composition of the prison sample and that of the soldiers of the 18th century are very similar. Farm workers and servants were mostly children of poorer people or second and third children of peasants. We have encountered these groups in the 18th century military. In contrast, the farm owners themselves and their first-born sons were hardly ever conscripted, and they rarely joined the army voluntarily. The poorer artisan population is a major section of both the prison and the military samples. In both cases, journeymen and non-guild craftsmen are over-represented and master craftsmen with special skills, civil servants, and independent professionals, are underrepresented.

The physical stature of male and female prisoner inmates in Bavaria

We first examine the development of height by five-year cohorts (see fig. 4.4). The heights of female prison inmates declined from the early 1820s to 1835-39 and they were still clearly below those of the initial period in 1840-44. A sharp increase in height can be seen in the early 1860s, afterwards heights declined slightly once more, but remained above the level of 1820-59. Up to 1855-59, male heights declined slowly but steadily (see fig. 4.5). The tendency of real wages to decline up to 1855-59 is reflected in both height series – female heights declined earlier and male heights later. For women, heights rose again in the 1860s and there was a short-term setback during the five-year period 1870-74, that witnessed the Franco-Prussian war and the depression of 1873.

It was not until the end of the period under discussion that male height rose again. A direct comparison of female heights and real wages shows a remarkably close correlation (see fig. 4.6). In the five-year period 1835-39, women were somewhat shorter than would be expected from the real wages, while in 1860-64 – and to some extent in the five-year periods before and after - they were somewhat taller than expected. Among men the relationship is much less clear (see fig. 4.7). The five-year period 1865-69 is completely out of keeping with the rest of the data, the men were considerably shorter then than would be expected from real wage data.

The correlation between height and real wages is substantially smaller among the men than among women, as we can see from the lower R^2. This can be attributed to the smaller number of cases in the sample among males or it could indicate that the response of male heights to changes in real wages was less elastic. One possible explanation why this might have been the case involves distribution of resources within the household. When real wages declined, girls might have been given less food as parents had lower income expectations for their daughters than for their sons, and therefore could expect less support from them in their own old age. When food prices were relatively low (as, e.g. in the 1860s), however, children of both sexes could be better fed. In these good years, parents did not see a need to discriminate against female children to ensure support in their old age. The temporal growth pattern would also support this explanation, insofar as female heights began to decline earlier than male heights.

These observations also agree with research on excess female mortality (EFM).[116] A negative correlation between EFM and the development of real wages, which has been found for Germany in the 18th and early 19th century, indicates that, in times of high food prices, fewer resources (clothing, etc., as well as food) were given to female children than to male children.

So far, we considered aggregated five-year averages that made it possible to base a single observation unit on a larger number of individual cases. But this implies that short-term movements in food prices are not taken into account. Now we regress the log of annual height (males and females separately) on log of real wages, controlling for a trend and obtain the following relationship:

Log Female Heights = 4.67 + 0.020 * Log of Real Wages + 0.02 * Birth Year

(0.00) (0.00) (0.00)

R^2 = 0.31; N = 59 years[117]; Durbin-Watson = 1.57.

Log Male Heights =5.12 + 0.017 * Log of Real Wages + 0.01 * Birth Year

(0.00) (0.02) (0.51)

R^2 = 0.09; N = 60 years; Durbin-Watson = 1.72 (no autocorrelation)

Notes: p-values in brackets. In the regression of female heights, the year 1876 was excluded, because it is an outlier. It is more than threee standard deviations from the mean. The real wage was averaged over the first three years after birth for each individual.[118]

116 Cf. S. Klasen (1998).

117 If 1876 is included, R^2 falls to 0.29. The coefficients and their level of significance remain nearly unchanged. Omitting the time trend does not make the real wage variable insignificant. (adjusting for autocorrelation does not change the result).

118 Cf. J. M. Tanner (1990), p. 131.

These regressions indicate that there was a relationship between real wages of the parents during the first three years after the birth of their child and the final height of their children.[119] Among men, the explanatory share, R^2, of the independent variable is again smaller, but the influence of real wages is still statistically significant.[120] The coefficient is also economically significant. Among women, a ten percent rise in real wages means a 0.2 percent increase in height, or about 0.3 cm. Consider two years, one of which height was one standard deviation above, and the other one standard deviation below, the mean. The difference in wages between the two years is about 30%. According to the above estimate, height of females in the year with low wages was about 0.9 cm below that of the year with high real wages. The difference among the men was the same order of magnitude, because the coefficients were almost identical.

4.4 Comparison with Great Britain

As has mentioned above, the correlation between height and wages in Bavaria turns out to be positive, contrary to that found for Great Britain for the same time

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[119] The high R^2 in the regression of female heights is not caused by trend correlation. Although there was an upward trend in female heights, a trend hypothesis for the real wage series is rejected at the usual level of significance.

[120] There is no unit root in any of the series

Series	ADF Test Stat.	Critical Value (5%, MacKinnon-Table)
Women-	3.86	-3.49
Men	-4.05	-3.49
Real Wages	-4.00	-3.49

A unit root is found in a time series, if the current observation is mainly determined by the previous observations, e.g., if the time series follows a random walk. This concept can be explained by imagining a drunken man on his way home. He staggers from side to side as he walks, the direction and length of his deviations from his basic direction are unplanned and randomly determined. If the series were to follow such a random walk, the probability that agreements between the different series would be by chance and that "spurious regressions" would mask the true relationship would be higher.

period. The English height series show that: (1) As in Bavaria, the height of male and female criminals decreased in the 1840s (the series ends in 1850);[121] (2) for women of Scottish and Irish origin in two prisons in Glasgow there was a continuous decline in heights from the 1800s to the 1840s;[122] (3) for men in the same prison, on the other hand, the lowest point was reached in the 1830s and heights rose again in the 1840s,[123] (4) there was, almost without exception, a decline in heights in military samples of English, Irish, and Scottish men between the 1820s and the 1840s.[124]

However, real wages rose in England by 14% from the 1820s to the middle of the nineteenth century, according to Lindert and Williamson's or Mitchell's estimates. However, more recently estimates by Feinstein show convincingly that if factors such as unemployment are taken into account, real earnings appear to have been rather stable in these decades.[125] In any case, the influence of real wages on English heights, was contrary to expectations. Why is the correlation between height and real wages so different in Britain and in Bavaria (where real wages fell by 17% in the same time period)?

A bivariate relationship, such as the one investigated above, implicitly assumes that all other factors that could have influenced nutritional status remained unchanged or were correlated with independent variables. According to the generally accepted model, these factors are: (1) the disease environment; (2) the burden of the work load

121 P. Johnson/S. Nicholas (1994).

122 P. Riggs (1994), p. 71.

123 Ibid.

124 For this time period, the estimates of Floud/Wachter/Gregory and the newer estimates of Komlos are in agreement.

125 Lindert and Williamson (1983); Feinstein (1998); for the following Figure, we use the estimates in E. A. Wrigley/R. Schofield (1981), p. 642-644.

on the human body during the years of growth; (3) the distribution of income; (4) the relative prices of industrial goods (relative to food);[126] (5) the variance of incomes, to name only the major variables of interest.

An additional factor might well be the price of meat and dairy products relative to all other food items, because animal proteins are especially important for the growth of the human organism. At a time of relatively high food prices low income families are obviously going to substitute away from meat products and consume mainly food from plants.

Unfortunately, no direct regression estimates for all factors is possible. Three of the variables are strongly correlated with one another and this results in multicollinearity. This comes about because grain prices influence both the relative price series and the real wage series. However, we can regress both relative price series separately, to obtain:

Log Female Height =	4.8 +	0.00*LogRPL +	0.01 * Time
	(0.00)	(0.55)	(0.01)

R^2 = 0.12; N = 60; D.W. = 1.48

Log Female Heights =	4.8 +	0.00 * LogRPF +	0.01 * Time
	(0.00)	(0.78)	(0.14)

R^2 = 0.12; N = 60; D.W. = 1.45

Note: P-Values in brackets.

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126 Really, "all other goods". Because the majority of these goods were industrial goods, the term "industrial goods" is used in the following pages for stylistic reasons.

LogRPL = Log of relative prices of livestock products (relative to plant products)

LogRPL = Log price of food products (weights: 60% plant, 40% livestock) relative to industrial goods

These results indicate that the relative price of nutrients is not directly correlated with the height of females, as was the real wage index. In the following sections we compare the effect of various influences on physical stature in both Bavaria and England in order to attempt to ascertain which factors might account for the decline in heights in England at a time of rising wages.

The disease environment

The effect of the disease environment on physical stature is not easy to analyze because of the high correlation with nutritional status. That is to say, a decline in nutrition brought with it an increased susceptibility to sickness and epidemics. The disease environment can, of course, deteriorate independently of nutrition, e.g., through massive urbanization, which occurred in a far more pronounced form in England than in Bavaria. Yet, a change in the disease environment cannot be approximated by any unequivocal indicator. The crude death rate (CDR), which is correlated with the alternative variable infant mortality,[127] can give an impression of basic trends but it itself is also influenced by nutrition.[128]

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127 P. Huck (1995). For regions with cottage industry, Huck finds a substantially worse development of mortality (CDR and infant mortality) than for in England as a whole. This accords with the decline in the height of cottage industry workers in the weaving region of Bavaria. cf. Chapter 5.

128 The CDR can also be affected by changes in the age structure, but that did not change dramatically in the short run during our time frame, hence probably does not affect our analysis. For Germany, cf. A. E. Imhof (1994); W. R. Lee (1977a); P. Marschalck (1984); J .E. Knodel (1988).

In England the CDR (five-year averages) changed appreciably only once between 1831-35 and 1866-70 – it rose by just under 0.2 % in the five year period 1846-50 (see fig. 4.8). The 1840s was the decade of the terrible famine in Ireland, and there were also frequent complaints about the transport of food from Ireland to England, it seems more than likely that there were food shortages in at least parts of the Island. Compared to that of Bavaria, however, the crude death rate in England was very low. The Bavarian CDR was also stable until 1865-69, it fell only in 1846-50 by less than 0.1 %.

Work load of the young

We next examine the hypothesis that an increase in real wages failed to bring about an increase in physical stature in England, because the youth entered the labor force earlier, or worked longer hours and more intensely up to the middle of the century. The increase in the work load would have to have been far greater than in Bavaria to explain the differences in development.

Unfortunately it is not possible to quantify labor intensity in the form of a time series. However, previous research shows that, in Bavaria, the work load of the population rose in the early 19th century. For example, the total labor inputs in the agricultural sector in Bavaria is estimated to have increased by a quarter to a third between 1800 and 1870, while the number of persons employed in agriculture increased only by about 15%.[129] The increase of work intensity and the prolongation of working hours together may therefore have been about 10% to 18%.

The increase in labor intensity in Bavaria was brought about by the growth of animal husbandry, the increase in barn-feeding, and the increasing spread of the cultivation of potatoes and other root crops. Child and female labor were also engaged in these activities.[130] The number of holidays was reduced, the working day was lengthened and intensified. The spread of labor-saving technologies – in agriculture, the threshing machine was the earliest and most important one – did not begin until the 1860s, and diffused only gradually from the large estates to the small farms on which the great majority of the two million Bavarians engaged in agriculture were employed.[131] Neither this factor nor the increased use of draft oxen could reduce the increase in the intensity of labor very much.[132]

Given the increase in work intensity and working hours in agriculture of about 10 to 18 percent, it seems unlikely that the intensity of labor could have risen much more sharply in England than in Bavaria, certainly not enough to have caused the difference in the correlation between wages and heights. This conclusion must, however, remain provisional and it is to be hoped that further research will bring more precise data to bear on this issue.

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129 M. Böhm (1995), pp. 429 and 425. For the crafts, the number of working hours, at least, did not increase, cf. U. Puschner (1988) p. 92. Clark believes that the English work loads did not increase at all, cf. G. Clark (1991), p. 458.

130 M. Böhm (1995); as an example for the 18th century, cf. also J. Komlos/A. Ritschl (1995).

131 M. Böhm (1995), p. 427. In 1860, there were only 483 threshing machines in Bavaria, by 1882, the number had to risen to 4428 steam threshing machines and 13060 hand and horse drawn threshing machines.

132 M. Böhm (1995), p. 428.

Income distribution

One could argue that changes in the distribution of income is not likely to have affected the height series, inasmuch as many samples have been dominated by members of the lower social classes, including our prison samples. Macroeconomic distributional effects should not distort the time series in any way. It is conceivable, however, that, even within the lower strata, income was redistributed in some way, and the empirical evidence does point in that direction. In both England and Germany trends in income distribution indicate a common trend towards inequality, even within the lower strata.[133]

It was not until 1870 that the turning point of the Kuznets inverse U-curve was reached in England. For Germany, this did not occur until about 1890. In the absence of appropriate studies, we shall assume that values for Germany as a whole also hold for Bavaria. A sample of property distributions from military conscription lists in four Bavarian districts on the left bank of the Rhine (i.e., in the Palatinate) indicates that this assumption is plausible, because these data also show a trend towards inequality in property ownership (see fig. 4.9). This is confirmed by the trends of inequality in resource distribution (cf. Chapter 7). Thus, the difference between the development in real wages and height in England and in Bavaria probably cannot be explained by differences in the trends in inequality, as the Bavarian development was similarly characterized by growing inequality.

Relative prices of food and industrial goods

Consumers select their market basket of goods according to their consumption preferences and the relative prices of the goods, with a given budget constraint. If the relative prices of industrial goods decline, it is likely that, ceteris paribus, the consumer will buy less food and more industrial goods.[134] Could this factor have made English nutrition so much worse as to outweigh the effect of wages on height by the middle of the nineteenth century? A glance at price data shows that relative prices of industrial goods did not fall as much in 19th-century England as they did in 19th-century Germany (see fig. 4.10).[135] The price decline in England had already taken place before 1820, as can be seen from the example of textiles (see table 4.2).

Between 1820 and 1850, the relative price of textiles in England, which had declined so considerably from 1770 to 1820, hardly changed at all. Whereas the price of cotton textiles did indeed decline considerably, the diminution in the price of other textiles – woolens and linens - was much smaller. Nevertheless, because the "total index of all consumer goods and services" for 1820 to 1850 is influenced also by declining grain prices, the relative price of all textiles did not fall during this period. Although this variable obviously possesses some explanatory power for the USA, it cannot explain the difference between England and Bavaria in the height-real wage relationship.[136]

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133 J. G. Williamson (1985); R. Dumke (1991).

134 Komlos (1985).

135 We shall assume that average relative prices for Germany as a whole also hold good for Bavaria, an assumption which is especially plausible after the creation of the Zollverein in 1833/34.

136 On the USA cf. J. Komlos (1987).

This result is astonishing, since there were very large increases in productivity in England's industrial sector in the 19th century. It should be kept in mind, however, that, because of changes in trade policy, particularly the abolition of the Corn Laws, and the expansion of import resulting from them, the prices of foodstuffs had fallen considerably.

Variability of income

In the pre-industrial era, it might reasonably be expected that fluctuations in real wages from year to year were greater in a more developed country, with more pronounced business cycles, than in an agrarian country such as Bavaria. Yet, the data we have indicate that this was not the case (see table 4.3). During the entire period, the variability of real wages in England was actually less than in Bavaria. Moreover, the increase in the coefficient of variation between the 1820s and the 1850s was 66% in Bavaria, but only 38% in England. In this context, however, no quantitative assertions about unemployment can be made. Mobility of labor was far greater in the English labor market and it is, therefore, rather unlikely that unemployment was higher in England than in Bavaria.[137]

The relative prices of animal proteins compared to vegetable products

The relative prices of meat and dairy products rich in protein and plant products moved in different directions in England and Germany (see fig. 4.11). In England they

[137] For geographical mobility in England, cf. for example, S. Nicholas/P. R. Shergold (1987). In Bavaria, the percentage of migrants was generally below 10%, cf. H. Decker (1994).

were about 30% higher in 1850 than in 1820, whereas in Germany they were about 30% lower. This might have slightly reduced the decline in Bavarian height caused by the real wage slump. The major reason for the difference between Bavaria and England lies in the fact that the abolition of the corn laws in England in 1845 brought about a decline in the price of grain almost to the Central-European level, while animal protein products increased in price. This is astonishing, because we would expect that, if real income increased, the poorer strata would consume food that was higher in quality, and thus richer in animal proteins. But available data suggest that English lower-class parents increased their share of the cheaper grain and reduced meat and milk consumption so they could use their additional real wages to acquire more other consumption goods. The complaints by social reformers, that workers in the industrial regions spent their money on 'superfluous' goods like coffee, alcohol, clocks, etc., are well-known.

The decline in the consumption of foods containing animal proteins can also be shown from household budgets. Sara Horrell analyzed the English lower classes in the 19th century and determined the share of expenditures for various categories of goods (see table 4.4).[138] The two periods 1830-39 and 1840-54 were times when English heights clearly declined. In these periods, the share of the total family budget spent on grain rose significantly, and the share spent on textiles rose by 11.1%. The share of expenses for the two items that contained animal protein, however, declined.

If we consider that the price of foods containing animal proteins had risen in absolute terms, it is obvious that these households would have bought even smaller

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138 S. Horrell (1996).

quantities of these foods, especially as Horrell found a decline in total expenditures from £ 62.7 to £ 58.4. This means that the increase in the relative price of animal proteins might explain why English heights declined at a time when real wages were stagnating.

4.5 Summary: The results and their relationship to population growth

For Bavaria, we found a positive correlation between real wages and average height of male and female prison inmates, who came almost exclusively from the lower social strata. The correlation is higher for women than among men.

Previous anthropometric historical research on industrially developed countries had not found such a positive correlation in the first half of the nineteenth century. We therefore examined what factors might have contributed to the differences in the English experience. Because, for methodological reasons, a multivariate time series analysis was not possible, we investigated the most important factors which influenced average height in order to ascertain whether the development of these factors might have been less favorable in England than in Bavaria from the 1820s to the 1840s. This was clearly the case as far as the relative prices of animal products are concerned and the pattern of change over time also corresponded with the decline of heights in England. Given the present state of research only a crude estimate could be given for the intensity of labor. According to that estimate, it is unlikely that the labor intensity increased more sharply in England than in Bavaria. The same is true for the distribution of income and wealth. Crude mortality was increasing in England in 1846-50, though it was still at a much lower level than in Bavaria. The time pattern of the CDR, however, agrees less with the height series than with the time series of relative prices of animal protein. The downward trend in height, which could already be seen in the early 1840s, was not evident in mortality data. If we consider the fact that mortality is influenced substantially not only by the disease environment, but also by nutritional status, the following causal chain is more plausible. In England the 'Early Industrial Growth Puzzle', as the divergence over time between the trend of real wages and of heights has recently been called,[139] was most strongly influenced by rising relative prices of animal proteins. This increase did not have any effect on English mortality rates until the 1840s. One cause of the rise in the relative price of animal proteins was the abolition of the Corn Laws in 1845, and another was the fact that providing the large English food-importing economy with animal protein products was substantially more expensive than providing it with grain. Milk products spoil more easily than plant products, and live animals are more expensive to transport than plant products.

Population growth and increasing urbanization resulted in a rise in the relative price of animal products up to mid century and the willingness of English consumers to pay for animal proteins was insufficient to make it worthwhile increasing such imports very much. English grain imports, however, meant that England was better protected from the famines of the 1840s than was the case in Bavaria and the other German states. The effect of urbanization on the relative price of animal protein is, in any case, not found in all early industrial countries. In the USA, where there was, in any case, 'early industrialization' only in very few regions, the relative price of animal protein products did not rise relative to that of grain. There the rise of food prices in

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139 J. Komlos (1998).

general relative to the prices of industrial goods caused the mid-19th century decline in height. Further examples are needed to test the hypothesis that the influence found here was important only in food-importing economies before animal products could be transported easily, and that did not begin in earnest until after the mid-19th century.

Chapter 5: Protein Supply and Nutritional Status in Early Nineteenth Century Bavaria

Nearly all previous anthropometric studies have pointed to the importance of regional height differences. In this chapter, we compare anthropometric evidence with production estimates of different food products, and other economic variables at the regional level. To this end, Bavaria is divided into 179 regional units, whose population averaged 14,000 (in 1844). This micro-level analysis enables us to analyze the influence of the local supply of different food products and other economic variables on the nutritional status of the population.

Compared to other countries, Bavaria had a larger number of cattle per capita. In 1852/53, there were 0.57 cattle per capita in Bavaria. while in France (1852), Hungary (1857), and Germany as a whole (1857) there were only about 0.34 cattle per capita, and in Austria (1851) there were 0.42.[140] Moreover, Bavaria's grain production was not much lower than in other European countries, while the industrial sector was relatively unimportant. Only 23% of the population of Bavaria was employed in industry, in contrast to 48% of the British population.[141]

Between 1803 and 1816 Bavaria consisted of many small territories with different economic structures. Upper Franconia in the northeast and parts of Swabia were regions with large proto-industrial sectors, as large relative to the population as in Saxony or Bohemia. Textile factories and metal manufacturing were prospering in the towns of middle Franconia and Swabia. The rest of Bavaria was dominated by

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140 W. G. Hoffmann (1965); M. Böhm, (1994); B. R. Mitchell, (1975); R. Sandgruber (1978); B. Bolognese-Leuchtenmüller, (1978); M. Lévy-Leboyer/ F. Bourgoignon (1990).

141 Ibid.

agriculture.[142] Nevertheless, different soils, transport facilities, and population densities implied different production structures. Milk and beef production in the southern and eastern mountain regions contrasted with grain and pork production along the Danube and Main Rivers. In the lower Main region and in the Palatinate, quite a lot of potatoes were produced as well as pork, grain and wine, and this was also true of the proto-industrial region in the northeast. These regional differences make a study of the influence of regional production structures on nutritional status interesting. This analysis should also contribute to our general understanding of the relationship between nutritional status and economic development at the early phase of industrialization.

In the following section we postulate a typology of economic regions based on nutritional flows and the degree to which the markets were integrated. The second section discusses anthropometric sources available for testing this typology. Section three analyzes the anthropometric patterns across the regional types.

5.1 A typology of regions

Compared with today's standards, nutrition in Bavaria in the early nineteenth century was characterized by a shortage of protein and fat, while the supply of carbohydrates was better than in the 18th century. Basic food consisted of grain, milk,

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142 K. Bosl (1985), pp. 22-39). For a revised view of Bavaria's industrial development: K. H. Preisser (1993).

vegetables (e.g., cabbages), potatoes, clarified butter and meat.[143] Scarce proteins could be obtained from milk and meat, even though meat was rather expensive.[144]

In addition to productive capacity, the degree of market integration and transport costs were very important for the nutritional differences between certain types of regions. The following nutritional typology at the regional level takes into account some special characteristics of Bavaria in the early nineteenth century.[145] Six types of regions can be distinguished:

1. Towns:[146] Bavarian towns can be subdivided into industrial and administrative towns, but their common feature with regard to nutrition is the large influx of meat and grain. Beef cattle sent to such towns as Munich made a large contribution to the protein supply of the urban population. As early as the 1810s, 8,000 beef cattle with a slaughter weight of about 650 kg were driven to markets annually. However, the absence of cooling systems meant that milk and dairy products were difficult to transport. Based on the assumption that the maximum distance sour milk could be transported was 40-55 km, the milk supply in Munich and Augsburg was about 60 liters per capita in 1840 and only 40 liters in Nuremberg.[147] Given that one liter of sour milk contained about 30g of protein, and 1 kg of meat (average quality)

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143 Clarified butter was an important additional source of fat, especially in towns.

144 Cheese played a minor role, except for soft cheese (Topfenkäse) produced in the milk regions which could not be transported. Data on hard cheese, which could be transported, was not found in any of the statistics.

145 The definition of "region" is based on Sidney Pollard`s argument that economic regions have a center, but no clearly defined borders. S. Pollard (1994), pp. 57-63.

146 Twenty nine towns with 5,000-92,000 inhabitants in 1840 were administered directly by the Bavarian gouvernment.

147 Beiträge zur Statistik des Königreiches Bayern (1855). This seems to be a general feature of pre-industrial times, because refrigeration was not available and land was scarce close to towns. For

about 170g, Munich's protein supply from meat was 5.5 times higher than from milk.[148]

The unfavorable disease environment in the early nineteenth century was a major influence on net nutrition in the towns and their surroundings. Urban hygienic conditions were worse than rural ones, especially up to the last third of the century.

2. The areas surrounding the larger towns were well integrated with urban markets[149] and the farmers were able to sell their milk, fruit and vegetables there. Because growing fruit and vegetables was labor intensive, the work loads of the agricultural laborers were higher than in the regions where the markets were less integrated. Yet, their real wages were also higher because the value of their product was greater. Relative to their work load and the disease environment, however, the nutrition of the people in these areas was generally poorer, and contained less protein than in the towns. The non-agricultural goods available in the towns probably tempted the farmers to forego consuming some milk.[150]

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example, only 54 liters of milk per capita were transported to Vienna in 1830. R. Sandgruber (1982), p. 161.

148 Beck, Rainer (1986), p. 252.

149 Defined as districts surrounding towns. See also definitions in Table 5.1.

150 For example, at the beginning of the century a senior official of the Bavarian government wrote about the district Wolfratshausen, close to Munich: *"They spend a lot on clothing: silver clocks and women in silk dresses can be seen everywhere"*. (*"Dort wird viel auf die Kleider verwendet; man sieht überall silberne Uhren und die Weibsleute in seidenen Kleidern"*). Hazzi, J.v. (1804), vol. 3.1, p. 194. Similar descriptions exist also for milk regions, but there "luxurious clothing" did not contrast with poor nutrition. In contrast, the biological standard of living as he describes it, sounds poor: *"Heights are low in this area, many persons become crippled due to heavy work loads at early ages (...) Bread is always of low quality, meat is consumed nowhere. In the upper part [with better nutrition, J.B.], noodles with clarified butter is a common food". ("Die Menschen sind hier klein, durch zu frühe Anstrengung verkrüppelt (...) Das Brot ist durchgängig schlecht; nirgends ißt man Fleisch, in der obern Gegend sind die Schmalznudeln eine gewöhnlich Speise"*).Ibid., p. 193/4.

3. Milk and beef cattle producing areas (hereafter called milk regions). The high average per capita stock of cattle in Bavaria was the result of the large numbers of cows in the milk regions in the Alps and its foothills where the population density was low. The cattle density in the Rhoen/Hassberg area in the north of Lower Franconia was also higher than in the surrounding areas (Map 3.2 b).[151] Milk production is highly correlated with beef production – the correlation coefficient is 0.85. The cattle were sold in the urban markets but the milk was used to produce clarified butter and sour milk. The former was sold in towns but the latter was consumed locally as its price was extremely low.[152] Even our lower-bound estimate for milk production gives an annual figure of more than 400 liters per capita in the milk regions. Since plenty of sour milk was available in these regions, even the lower classes could afford to consume it, and consequently had higher nutritional standard than elsewhere.[153]

4. Grain and pig producing regions ("rye districts"). Most of Bavaria produced rye, wheat and pigs. Bavaria exported about 10% of the wheat it produced.[154] The grain producing regions were on the plains of the Main, Inn and Danube and thus more favorably placed with regard to the availability of river transportation than the

151 Estimates of milk production in 1840 are based on the number of cows multiplied by a lower-bound estimate of their annual milk yield of 800 liters, which takes into account some production losses.

152 In hereditary contracts, meat and clarified butter are always defined in exact measures, while - if sour milk is recorded at all - it was only mentioned in terms of "enough". R. Beck (1986), p. 147.

153 Clarified butter was an important item of commerce, sold to urban and even non-urban consumers. In contrast, hard cheese is never mentioned in contemporary accounts and statistics, with the exception of the Zollverein statistics. For 1841, the latter report 12 gram cheese export and 182 gram cheese import per capita annually between Bavaria and countries outside of the Zollverein (Austria, including Bohemia, and Switzerland). Even if these figures are doubled, because probably there was trade with western and northern neighbors as well, the amount of traded cheese must have been insignificant. G. Seuffert (1857), p. 428-9. After mid-century, hard cheese production began to spread from the western Alpine region toward east and north.

154 Böhm, Max (1994), p. 380.

milk regions. Transport costs of grain and pork were, therefore, lower, and it is likely that the farmers in these regions sold a high percentage of their production. Whether this implied a lower nutritional status will be considered later.

5. Agricultural regions with significant potato production ("potato regions"). Potato growing spread slowly from the northwest and northeast of Bavaria southward. It did not reach southern Bavaria until mid century, except in the areas near the towns. Contemporary sources frequently describe potatoes as being extremely unpopular in the southern part of the country.[155] Potato regions exported almost none of the potatoes grown there: instead they used them for their own consumption and to feed pigs.[156] Typically, these regions had a large increase in population, as did had the weaving districts discussed below.

6. Proto-industrial "weaving districts". Potatoes were also produced in the proto-industrial areas. The weaving regions in the northeast were infertile, mountainous areas with a dense and still growing population.[157] Agricultural production apart from potatoes was extremely low. The main product was cotton cloth, which provided most of the income of this region. A few agricultural goods could be imported, but contemporary sources describe the low level of real income. *"Their wage is inexplicably low and their lot sometimes miserable"*, wrote the economist and government official Ignatz Rudhart in 1827.[158] In contrast to English factory

155 Even in 1860 many farmers from mountainous regions were proud of not having eaten a single potato in their lives. Bavaria 1865, p. 442.

156 Bavaria 1866, p. 209.

157 Beiträge zur Statistik des Königreichs Bayern (1855).

158 *"Ihr Arbeitslohn ist unbegreiflich niedrig und ihr Loos bisweilen kümmerlich"*, I. Rudhart (1827), Bd. II, p. 62.

production, the Bavarian cottage weavers were extremely backward. They could compete only by reducing labor costs to extremely low levels and by having women and children participate in production. Heavy work loads for children and pregnant women was another reason for the low biological standard of living in these regions, frequently mentioned by contemporaries.[159]

5.2 Cross-sectional analysis of regional differences

Determinants of the rejection rate (because too short) in rural districts

In order to investigate spatial patterns in nutritional status, three cross-sectional regressions are discussed, for the periods 1809-19, 1820-29 and 1831-35. The towns are analyzed separately in the following. The dependent variable of the regressions is the rate of rejection because the minimum height requirement of 155.6 cm was not met. This is shown in Map 5.1. We assume that regional genetic height differences were unimportant within Bavaria. This seems reasonable, as there are almost no regional height differences today.[160] Possible influences of regional differences on

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159 The primary reason was poor nutrition. A government physician described one typical example, the district of Naila, in 1860: "Concerning the architecture of their bodies, the weavers, who form an important part of the population, are somewhat special. In most cases their thorax is narrow and flat, their muscles underdeveloped. (...) Nutrition [in the whole district, J.B.] is characterised by large quantities [of potatoes, J.B.], while proteins are lacking". German original: *"In Beziehung auf die Architektur des Körpers zeichnen sich besonders die Weber aus, welche ein bedeutendes Kontingent der Einwohnerschaft ausmachen. Sie haben in der Regel einen engen, flachen Brustbau, die Bildung der Muskeln ist in ihrer körperlichen Formation zurückgetreten. (...) In Beziehung auf die Kost wird [im gesamten Distrikt] durch die Masse ersetzt, was durch den Mangel an proteinreichen Nahrungsmitteln abgeht"*. Physikatsbericht des Landgerichts Naila, Bavarian State Library, sign. cgm 6874.

160 The Institute for Military Medical Statistics and Reports sent us today's heights by regions. The differences between regions were lower than 0.3 cm for the conscription period of 1990-94, if we aggregate them in a similar way to the historical evidence:

'milk regions'	179.1 cm
'rye regions'	178.9 cm
'weaving regions'	179.2 cm

nutritional status are entered as independent variables in the regression (see table 5.1). Because agricultural data are available for all 179 Bavarian districts, production estimates for milk, grain and potatoes are used as continuous variables in the regression. Other independent variables include such dummy variables as "area near town" or "weaving district".[161] The use of the production statistics as explanatory variables is based on two assumptions.

(1) It is assumed that in regions where an agricultural good was produced, the local population was better supplied with this good than were other areas. This is especially true if the transport costs of this good were high in relation to its value per weight.[162]

(2) It is assumed that the regional structure of production changed little during the period considered. Typical 1810 milk and cattle regions produced predominantly the same goods in 1840, even if output increased (correlation between milk production in 1810 and 1840 is +0.87 at the district level). In rye and weaving districts and areas near towns the structure of output also remained much the same. The only fundamental change in the production structure was the spread of potato growing, which started in the northwest and northeast and moved slowly southward. Data on potato output are

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'potato regions' 179.2 cm

To compare historical heights with the data of our time, we have to assume that immigration after WW II affected all regions similarly. This is a reasonable assumption, since this was the policy of the government of the Federal Republic of Germany at that time. The emigration of the mid-nineteenth century did not change regional height patterns, as can be see from the maps of J. Ranke (1881).

161 The weaver dummy variable had to be introduced into the regression because statistics on the number of weavers are unavailable at the district level. This dummy variable pertains to the 11 narrowly defined regions in the Northeast.

162 Examples are milk (no transport over more than 50 km) and potatoes (low price per weight). This local-supply effect was less valid for beef cattle, bacon or grain because their value per transportation cost was higher than that for potatoes. The local supply effect was also measured by L. Craig / T. Weiss (1998)and M. Haines (1998).

available for 1810 and 1853. To minimize the regional variation, the average production over two years was calculated for each region.[163]

The regression equations look very similar for all three time periods – the milk production variable always has a highly significant negative effect on rejection rates and average height is thus positively influenced. We estimated that a one percent change in the rejection rate meant a 0.8 cm change in average height.[164] Therefore, conscripts from regions with milk production one standard deviation above the average were 0.8 cm taller than conscripts from regions with milk production one standard deviation below average. The one standard deviation difference amounted to about 206 liter per capita per annum.

In weaving districts the rejection rates were above average. This finding seems to confirm the scattered references to the low biological standard of living of weavers. Rye production, in contrast, increased the rejection rates very little, it was significant only for the birth cohorts between 1809 and 1819. It is important to note that rye production did not have a positive effect on heights, possibly because the protein yield was too low compared to the high work loads in grain production, and because a high

163 Even before potato growing was introduced, there was one common characteristic of those regions that later grew potatoes – population was dense in relation to agricultural acreage. This provided incentives for producing potatoes despite their unpopular taste, because if labor was cheap the land productivity for this crop was high. For this reason, more inhabitants per acre could get basic sustenance.

164 Provided we assume that the rejection rates were between 0 and 6%. Using the individual conscription lists, this could be estimated by calculating the average height and the share of conscripts, who were shorter than 155.6 cm, by district and five-year-birth period:

Height (in cm)=	-0.8 * rejection rate (in %) +	169.3 cm
p-values:	(0.00)	(0.00)
adj. R2: 0.52; F-Stat:	69.3; N of Cases: 63	

share of nutrients was "exported" (delivered to towns). In contrast, potato production invariably had a negative influence on heights as it always increased the rejection rates.[165] The estimated height disadvantage for the birth group 1831-35 is 0.5 cm. As mentioned in section one, potato growing areas were poor ones where rapid population growth created a Malthusian situation. The variable "area near town" had an increasing effect on rejection rates in the third period, at a time when the otherwise significant variable 'share of those rejected for disease reasons' is insignificant. In contrast, the variable "rye wages of day-laborers" had almost no influence on heights, it only lowered the adjusted R square values.

Because of the changes in statistical procedures between periods 2 and 3 mentioned above, no inter-temporal comparison between these periods is possible. Between the 1810s and the 1820s, the influence of both milk production and the weaving variable became larger.

In sum, the regional analysis shows the following results:

1) milk production had a positive influence on physical stature.

2) in proto-industrial weaving districts, nutritional status was low.

3) nutritional status declined in weaving districts, at a time when the positive influence of milk production on nutritional status increased.

4) the nutritional status of the birth cohorts 1831-35 (measured in 1852-56) was low in areas near towns.

If the rejection-rate were higher, the coefficient decreases. For the conscripts of the Grand Duchy of Baden born between 1820 and 1840, for example, a one percent change in rejection rate was brought about by only a 0.5 cm change in average heights (calculations on the data from Ammon, O., 1899.)

5) rye production and the wages of day-laborers had no significant effect on heights

6) the rejection rate on account of illness had a negative effect on heights in the first two regressions.

Determinants of the rejection rates (for being too short) in towns

Three separate regressions are calculated in order to explore the influences of the rejection rates of urban conscripts (see table 5.2). Milk production around towns had a positive influence on heights again, though significantly so only for periods 1 and 3. The estimated difference between well and poorly supplied towns is 1.6 cm for 1831-35. It is possible that when food prices were low in the 1820s, more meat could be purchased so that towns were less dependent on buying milk from the areas immediately surrounding them.[166] The percentage of officials and professionals, and of people living in their households, is a proxy for the administrative towns. The percentage of officials always influenced rejection rates negatively and significantly (estimated difference in heights: 1.9 cm for 1831-35). Differences in our proxy for disease environment are never significant, a finding which could, of course, be caused by small number of observations

Examination of determinants using data on individual conscripts.

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165 The coefficients for the early period remain nearly the same regardless if potato production figures for 1810 or 1853 are entered in the regression.

166 For food prices, see G. Seuffert (1857), p. 124.

These findings on the influence of regional differences will be counter-checked using individual samples of military conscripts and female criminals. Unfortunately, the military lists from weaving, potato districts, and from industrial towns are not extant. However, four other types of region can be examined. Munich is taken to represent a typical urban administrative center, and data from the alpine slopes are representative of men living in the milk region. Data on "areas near towns" come from districts around Munich and Augsburg, and rye regions include districts from the Danube area.

Table 5.3 provides information on heights by types of region. The rural districts are sorted by height. Recruits from milk regions such as Toelz were fully 5.7 cm taller than those from rye regions such as Moosburg. All of the four districts from the Alpine milk region stand at the top of the table, the large amounts of protein produced were to a large extent consumed within this region (whereas some of Moosburg’s protein – a meat producing district close to the Danube river – might have been “exported” to the towns). The areas near town (indicated by names in italics) are among the districts with lower average height. In contrast, urban heights were relatively high in Bvaria.

The first regression in table 5.4 shows that the protein availability in the district had a systematic and economically significant influence also on individual height. Caloric production by itself had even a negative impact: Bavaria’s main grain production areas exported a high share of their nutrients, and work load was high in those regions. On the other hand, real wages were also comparatively high in those grain areas close to the Danube and Main river. In order to control for the development over time, we are using two sets of variables, because we deal with heights of still-growing individuals here. A new methodology was recently suggested that is confirmed by these results[167]: Birth year dummies have small and insignificant coefficients. In contrast, the “real wage over time” reflects the income situation in the years directly preceding measurement and has a statistically and economically meaningful impact on heights. In column 2 and 3 we considered the robustness of the coefficients by making small changes in the model. The result speaks for a great robustness, only the early industrial district loses its detrimental impact if the local food production is not controlled for.[168]

Nutritional status of women in the different regions.

The sample of 1,402 female inmates in the correctional institution at Wasserburg makes it possible to pose similar questions for the nutritional status of women. However, the composition this sample is different from that of the conscripts. Judged on the basis of the occupational information, 92 percent of women were of the lower class, which makes a finer distinction in height between occupations not very sensible. These women, therefore, cannot be considered as a representative cross section of the population as a whole although they do provide some information about the situation of the lower classes.[169]

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[167] J. Baten (2000b).

[168] In addition, we are using the Schneeweiss method in column 2 to deal with multicollineariy between the two nutrient production variable, sweeping out the impact of calory production on all the other variables. We find that the protein variable remains robust, see H. Schneeweiss (1990), p. 141-3.

[169] For a closer analysis, see Baten/Murray (2000).

For the analysis of regions, the regressions in table 5.5 show similar results to that found for the sample of recruits. The variable for animal protein has a large and positive coefficient.[170] The disadvantage of women born in either an area near town or in a calory producing rye region is clearly visible. Urban dwellers appear to have discriminated stronger against girls, as the coefficient is negative, while the coefficient in the regression of male heights was positive or insignificant. In addition, illegitimate birth was a strong determinant of (lower) female height.[171] In sum, data at the individual level for both men and women confirm the nutritional advantage of the milk region and the nutritional disadvantage of the areas around towns, the grain producing and early industrial regions.

As almost all of the female inmates have reached their final height, we are using birth cohort dummies to control for changes over time in these regressions. Female heights have declined between the early 1820s and the late 1830s by 1.6 cm.

Some differences of minor importance are:

- the birth cohorts of the 1830s and 1840s contain higher numbers than that of the recruits, while the numbers for the decades prior to that are lower.

- information on occupation does not refer to the more relevant concept of the occupation of the parents, but to the occupation of the women themselves or those of their husbands. For the latter case, the sources, for instance, contain entries such as "blacksmith", and it is not likely that the woman herself worked in that occupation.

- almost 31% of women were born out of wedlock, while for the recruits only about 6% were illegitimate. This is partially explained by the fact that most women in this sample belonged to the lower class. Couples of the lower class were not allowed to marry if they could not prove they could afford to maintain a family. See K.-J. Matz (1980), p. 153. In addition, in the case of the women, the variable "illegitimate" refers to the status at birth, while for the recruits it refers to their status at age 21. Some children born out of wedlock were given legitimate status later on. The mortality rate of children born out of wedlock, too, was significantly higher than that of legitimate children.

- the female sample is regionally somewhat more widespread, e.g. it contains some women from the industrially more developed towns.

170 It is not possible to differentiate precisely between "town" and "areas near towns" for all women. This is because, in some cases, the birth district can be confusing. If there is an entry for "Munich", it can mean both the town itself and the rural districts around Munich. Only if the areas around towns districts have different names from the town itself, were they attributed to the areas around towns.

5.3 Conclusion

This case study of the Kingdom of Bavaria has shown that a predominantly agricultural country with low export rates of protein-rich foods could achieve comparatively high nutritional status in the early-nineteenth century. Nevertheless, a closer look at the regional structure of production in 179 Bavarian districts revealed important systematic geographic differences.

Areas near towns had a relatively low nutritional status. A large percentage of the protein-rich food produced in these regions was sold in urban markets. Net nutrition was also poor in the weaving and potato regions in early nineteenth century Bavaria, both of which were densely populated.[172] Cattle transport permitted a relatively high nutritional status in Bavarian towns, especially in administrative centers. Inhabitants of Munich, for example, did not suffer from the nutritional disadvantages of the inhabitants of rural non-milk regions. This differs from evidence from American, English, Swedish and Japanese towns of the same period, where "urban penalty" referred not only to disease environment, but also to the biological standard of living.[173]

The most important result of this study is the measurable influence of milk production on nutritional status. All anthropometric evidence points to the fact that inhabitants of regions that specialized in cattle farming achieved higher nutritional

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[171] See Baten/Murray (1997).

[172] Evidence about these last two regions is based on a single source only, the conscript statistics, while several sources were used to investigate differences between the other regions mentioned in this chapter.

[173] Many anthropometric historians have observed height disadvantages for urban inhabitants: J. Komlos (1992); R. A. Margo/ R. H. Steckel (1983), p. 169; T. Shay (1994), pp. 41-43; L. G. Sandberg/R. H. Steckel (1987), pp. 101-110.

status than their contemporaries in grain producing or other areas. The variable "milk production per capita" explains a lot of the variation in rejection rates among regions. The reason for this is the lack of refrigeration which prohibited the transportation of milk over great distances until the late nineteenth century.[174] Hence, farmers produced (besides meat) clarified butter and sour milk, the first of which could be transported easily. Even when real income was low in some of the "milk regions", the low relative price of sour milk made a protein-rich diet possible for the regional population in the early modern period.

174 In addition, hard cheese production was unknown in these "milk regions".

Chapter 6: Milk production, Disease Environment and Real Wages as Factors of Influence in Seven Major Regions of Bavaria

We found in the previous chapter that the influence of milk production on nutritional status was substantial, particularly so in the regions around the lower Alps. On account of the fact that the milk regions were not densely populated, one could argue that height advantage in these areas was caused primarily by the propitious epidemiological environment, instead of the high per capita output of milk.[175] Because of their secluded lifestyle, the inhabitants of the mountains might have suffered less from both endemic and epidemic diseases (see map 7.1). Hence, in this chapter we examine the influence of milk production in these regions separately.[176] The assumption is that within these larger regions themselves the disease environment was more-or-less homogenous. If we still find that per capita milk production had a significant influence on physical stature within these regions, then our finding in Chapter 5, of the beneficial impact of local milk production would be corroborated.[177]

Another possible weakness of the previous chapter needing further elaboration is the simultaneous influence of milk production and of rye wages on physical stature. No influence of real wages on height was found in the total cross-section of 179 districts if milk production was taken into account. Yet, if milk production was ignored, there was a slight, but significant, negative influence of real wages on the

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175 I thank Bernard Harris and John Komlos for this useful suggestion. The dangers of bad milk are, however, emphasized by P. J. Atkins (1992).

176 A further investigation of the market integration of milk production is found in M. Kopsidis (1993).

177 See also Craig/Weiss (1998); Haines (1998).

rejection rate (for height reasons), as we would expect.[178] This indicates that there might be a slight degree of multicollinearity between wages and milk production, even though there was only a weak correlation between rye wages and milk output (0.32, p=0.00). Hence, the second aim of this chapter is to explore further the possible influences of rye wages on height within the seven major sub-regions of Bavaria. That is to say, in the previous chapter, we analyzed all 179 districts together, while in this chapter we restrict our analysis to 7 large sub-regions which are rather homogenous in terms of economic structure.

6.1 Classification of the seven large regions in Bavaria

Besides the larger mountain regions, which are considered as a separate unit of analysis, the other major regions are mainly formed by the boundaries of the Bavarian government districts:[179] (Map 6.1)

1) the Bavarian forest and the upper Palatinate (in the east)

2) southern upper Bavaria/Allgaeu with a more favorable disease environment

3) the eastern Danube district/western upper Palatinate

4) middle Franconia

5) upper Franconia

6) northern Swabia/western Danube

7) lower Franconia/Palatinate

178 The proportion of variance in the rejection rate that was explained was, however, extremely small (R^2= 0.03).

179 The Palatinate was combined with lower Franconia because otherwise the number of cases would have been too low, and the boundaries of some regions were slightly rounded off.

Insofar as a direct indicator for the disease environment is not available, we assume that the epidemiological environment is unfavorable where there were many chances of becoming infected. That is to say, where population or infrastructure density was high. This was especially the case in the towns and on the main roads in the early 19th century. Southern upper Bavaria/Allgaeu and Bavarian Forest/Upper Palatinate Forest had the smallest percentage of their total surface area covered by streets and roads (see table 6.1).[180] If waterways were included in the calculation, the contrast would be even more obvious as districts 3, 6 and 7 were connected by the Danube, Lech, Main, and other rivers. On this basis we presume that the disease environment was less favorable in sub-regions 3-7.

In addition, the lower temperatures in the mountain districts further hindered the development of pathogens although the mountain dwellers often suffered from iodine deficiencies, and the cold weather in winter meant that people needed more calories to maintain body temperatures.

6.2 The Influence of milk production and rye wages in the seven regions

6.2.1 Milk production

The coefficients in the seven regressions indicate that milk production per capita had a robust positive influence on height (see table 6.3). Milk production had a significant negative influence on the rejection rate in six of the seven regions, and the size of the impact is in a similar range as with the district-level regressions (Chapter 5). Only in middle Franconia, the most urban and industrialized region, do we find no measurable influence of milk production on the human organism, perhaps because

180 Beiträge VII (1875)

there was some early interregional trade in this relatively rich (in purchasing power), but protein-poor region.

Interestingly, we find that the smaller are the coefficients of milk production, the greater was milk production per capita. An additional 100 liters of milk production reduced the rejection rate by 2,3% in lower Franconia and in Upper Franconia by 2,0%. The same effect in southern upper Bavaria / Allgäu, which was well supplied with milk, caused the rejection rate to be only about 0,5% lower.

In contrast to the influence of local milk production on the biological standard of living (cf. the previous Chapter) we find that the impact of the disease environment as measured by population density does not have a significant effect at the regional level (see table 6.4). Similarly, the correlation with the variable "rejection rate for being sick or weak" had the expected positive sign and was significant in only two major regions (see table 6.5). This was the case in upper Franconia and in lower Franconia / Palatinate, both regions with the lowest per capita milk production, and thus the lowest provision of animal protein. In the Bavarian and upper Palatinate Forest, a negative correlation can be ascertained.[181] Hence, the argument that the disease environment had a more potent influence on the biological welfare of the recruits than milk production is not supported by the evidence at the regional level. Milk output has a systematic and significant impact on height and health even within the epidemiologically homogenous regional level, while population density does not.

[181] This requires further analysis

The influence of rye wages in the seven large regions

In contrast, the influence of rye wages is evident for the birth cohorts 1831-35 in only two regions: middle and lower Franconia (see table 6.6). In Middle Franconia, where milk production did not have a significant impact on rejection rates the coefficient of determination R^2 is highest. In this region, an additional purchasing power of 1 kg rye per daily wage reduced the rejection rate by 1%; thereby (according to the estimate in Chapter 5), increasing height by about 0.8 cm. In Upper Franconia, the region with the highest proportion of non-agricultural population, the influence of rye wages is likewise significant, and the coefficient of the same order of magnitude. To be sure, we also ascertained a high explanatory power for milk production for this low-wage region. In the other five regions, the coefficient of determination is hardly different from zero. If any influence of real wages on height existed at all in this earlier era, then it was in the two regions with the most highly developed industry.[182]

6.3 Comparison with Prussia

A parallel study of Prussia, the largest state in 19th-century Germany, corroborates the impression that wages were more important in the more industrially developed parts of the country, while milk production was more important in the less developed parts of the country. For Prussia, we can compare its more highly developed western part with the less developed eastern one.[183] Negative correlations between

182 This is supported by contemporary observations on meat consumption, reported by M. Bergmeier. Cf. M. Bergmeier (1990), p. 328. Cf. also H. J. Teuteberg (1994).

183 Cf. J. Baten (1996); For the construction of real wages, see J. Baten (1997a). For these observations we assume that regional differences in per capita milk production and in real wages did not change fundamentally. In the case of milk production, this conclusion can be corroborated by a high correlation with per capita cattle numbers between 1816 and 1861; in the case of wages, the

milk production and the rejection rate are found in the eastern (and more heavily agricultural) part of the country for two points in time. In the more developed western part of the country, however, real wages are correlated negatively with the rejection rate. The correlations between the proportion disqualified because of their height (rejection rate) and wages and per capita milk production in 1831 and 1854 are given in Table 6.7.[184]

Moreover, for Prussia as a whole we find a decline (in absolute value) in the correlation between the rejection rate and milk production over time. In 1831, the correlation coefficient was -0.67 (p=0.00); in the 1854 measurement, it was -0.53 (p=0.00). The correlation coefficient of wages and the rejection rate, however, hardly changed at all (1831: -0.40, p=0.05; 1854: -0.42, p=0.03).The observation that per capita milk production played a greater role in the less developed regions of Bavaria, and rye wages played a greater role in the more industrially developed and urbanized districts, is thus corroborated with the results for Prussia.

An investigation of West Point Cadets born in the first two-thirds of the 19th century in the USA also shows that milk production had an identifiable, and slightly positive, influence on net nutrition (t-value =1.6; p-value about 0.10).[185] In the highly developed USA, with its relatively high real wages, the quantity of milk that was available locally per capita was no longer as decisive as it was in the less developed regions of Bavaria or Prussia; the transportation system in the USA was already better

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widespread stability of regional differences from 1850 to 1900 can be used to indicate that no sudden change took place even before this period.

184 No correlation between real wages and per capita milk production can be found either for Prussia as a whole (correlation coefficient: 0.12, p=0.56), its western part (-0.05, p=0.88), or its eastern part (-0.61, p=0.03).

developed, and there were more other sources of protein available per capita (such as meat).

Nevertheless, the nutritional advantage of the milk regions gradually declined even within Bavaria, as is evident from the heights of women from the lower social classes (see table 6.7). All of the significant regional coefficients diminish in the second regression, which is based on the second half of the 19th century. The nutritional advantage decreases most clearly for southern Swabia, where high-fat cheese was produced far more intensively than elsewhere.[186]

The switch from producing butterfat and sour milk to producing high-fat cheese in one of the Bavarian milk regions meant that the milk proteins were becoming transportable. They could now be brought to the markets of the industrially developed cities, where they made an improvement in the nutritional status of the inhabitants. Of course, urban hygienic situation also improved in the late 19th century. In the twentieth century, the height of city dwellers increased even if they lived a long way away from milk regions (like, for example, in the industrial cities of middle Franconia). The fact that this did not yet show up in the heights of lower-class Munich women in the table 6.7 can be attributed to distribution effects that worked to the detriment of these women.[187] These aspects of food distribution will be discussed in greater detail in Chapter 7.

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185 Cf. J. Komlos (1996b), p. 211, footnote 28.

186 K.Lindner (1955) describes this process – though as a success story (because of the rise in income as "conventionally" measured).

187 For social stratification in industrial cities, cf. S. Fassl (1988); C. Grimm/R. A. Müller (1985).

6.4 Summary

Increases in interregional trade in food gradually reduced the influence of the locally produced dairy products on the health and growth of the human organism. Animal proteins that could be transported (cattle, high-fat cheese) became more and more important over time in the industrially developed districts (seen cross-sectionally). This development in the late 19th and early 20th centuries represents a kind of "missing link" between the lower net nutrition in the more developed regions of the Habsburg Monarchy, found by Komlos, and the close correlation between per capita GNP and height in the second half of the 20th century, reported by Steckel.[188] In this section we were able to describe the transition between these two systems for Bavaria.

At the same time, we were able to show, by examining separately the seven sub-regions of Bavaria, that even within these economically and epidemiologically rather homogeneous regions per capita milk production had an influence on nutritional status. This finding argues in favor of the notion that the influence of milk production was not merely a proxy for the background disease environment with which it might have been correlated.

188 J. Komlos (1994a); R. H. Steckel (1983). For the expansion of the market for foodstuffs in Bavaria, cf. C. Borcherdt (1960), p.38/39.

Chapter 7: Economic Development and the Distribution of Nutritional Resources in Bavaria, 1797-1839

Simon Kuznets (1955) asserted that income inequality traces a ∩-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. As this change in income distribution is very important both socially and politically in the contemporary world, economic historians have since then pupblished studies on long term trends in inequality in several countries.[189]

The trend toward greater equality in the developed countries in the twentieth century until very recently is now widely accepted, but the concept of widening income gaps in the previous century is still under discussion.[190] It is especially difficult to estimate real incomes or living standards for different social groups before the middle of the 19th century. Peter Lindert pointed out that most income statistics refer to wage earners, but that we know very little about those whose income came from self-employment and property (Lindert (1991), p. 215). Wealth distributions give us important information about these groups, but the income distribution cannot be derived from them very accurately. In predominantly agricultural countries with medium sized land holdings, well over half the population was self-employed without regular income. However, using anthropometric indicators the nutritional status can be

189 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).

190 See, for example, Feinstein's (1988) criticism of Williamson's conclusions. Van Zanden (1995) tends to extend the Kuznets curve backwards 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.

measured for all social groups if such evidence is available. Since human height is determined by net nutrition, the distribution of heights in a population could be used as a proxy for the distribution of nutrients.[191]

This chapter focuses on the following issues.

1. Can Kuznets' findings on income distribution be observed in a cross sectional analysis of height distributions? Was nutritional inequality higher in regions with a relatively large industrial sector than in regions still dominated by agriculture?

2. Was nutritional inequality in Bavaria increasing in the early nineteenth century, with the onset of modern economic growth?

3. Do the different measures of this new approach point in the same direction?

4. Is it possible to explain the occasional divergent 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 found 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 led 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,

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191 By using average height by age for pupils of the Karlsschule in Stuttgart to compare nutritional levels with social status differences in the late 18th century, Komlos (1990) showed that nutritional status became increasingly unequal during these years. Steckel (1994) compared the between group

including increasing inequality of income, which Steckel (1995) has found to be associated with shorter stature in the 20th century. Soltow (1992) argued that inequality did not increase in the US before the Civil War, but, in the Dutch, British and Swedish cases, increasing inequality might have been a major reason for declining heights.[192] Because of this controversy, and because of the potential importance of rising inequality to solving the antebellum puzzle, we examine the distribution of nutritional resources in early-19th century Bavaria.

This is possible to do, because, in contrast to most recruitment systems of the time, in Bavaria nearly all men were measured for the military, including the son of the finance minister as well as the son of the seamstress.[193] The calculations of height variation in this chapter are based on the measurements of approximately 15,000 Bavarian conscripts.

It could be argued that early-19th century Bavaria is not a particularly good case for examining the validity of Kuznets' law. In fact, Bavaria was a "lagging region" in terms of industrialization within Germany (Tipton (1976), Orsagh (1968)). The industrial and service sectors did not increase their share of the labor force in the early 19th century as much as they did in Westphalia, the Rhineland, and Saxony. The share of the non-agricultural sector in total labor force was 28% in Bavaria in 1849, below the German average of 41%. Its level of per-capita national product was only

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differences of different samples for inequality trends in the USA. Soltow (1992) calculated Gini coefficients of heights.

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

193 Social group is defined as follows: (a) Lower class is made up of day laborers, cottagers, artisans without special skills, workers, servants, and other lower class occupations. (b) 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.

77% of the German average (Frank (1994)). Nonetheless, some regions within Bavaria were fairly well industrialized (parts of the Palatinate, Swabia, middle and upper Franconia), even though as a whole it was still mainly agricultural. In addition, there is a large margin of error in the GDP estimates for the early 19th century. This is important, because in Bavaria the agricultural products that increased most rapidly were those that are usually not included in GDP estimates, such as milk output consumed in the farmers' own households (Boehm (1996)).

7.1 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 the effect of work load and the incidence of diseases during the growth years. Two factors influence the variation in heights – human biology and the environment. Heights of adults are approximately normally distributed, and this is nature's contribution. In order to consider the environmental contribution theoretically, let us consider two economies A and B. In economy A, the distribution of nutritional resources is perfectly equal, while in B the distribution is unequal (see fig 7.1 and 7.2). Since in A only natural variation (s_{nat}) plays a role, the variation is lower than in B. In economy B, there are two groups with heights in group 1 being 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 in B has a larger variation.[194]

How much does the variation in 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 and a mean of 171.8 cm (see table 7.1). 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.[195]

Human biologists and anthropologists have analyzed the relationship between height variation and economic development for the late 20th century. In figure 7.3, height differences between seven and a half year old boys from poor and rich families are shown for developed and less developed countries. In India, the most extreme case, the class differential is about 10 cm. If the two groups are large enough to influence the overall variation in the country, the variation would be expected to be larger in the less developed countries.[196] 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)). In the same geographic region, the variation coefficient of heights of poor children in urban Guatemala was much larger than among the 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 the variation coefficient of height in the well-off strata in Guatemala city 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

194 The joint distribution can be bimodal if the between-group difference is large enough.

195 Urban-rural differences are not available for these birth cohorts.

196 Schmitt and Harrison (1988), Eveleth and Tanner (1990, p. 199).

members of the population grow faster and the worse nourished members reach their final height later.

Different methods have been used to measure height variation and inequality. Soltow (1992), for instance, calculated the Gini coefficients of heights.[197] 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 in Gini coefficients of heights might give a distorted picture.

The other possibilities are standard deviations and variation coefficients (CV). Anthropologists have found that standard deviations typically increase with average heights, while coefficients of variation do not display this behavior to any significant extent. If variation coefficients are related to average height at all, they increase only very slightly as height increases.[198] Bogin (1991), in line with Sokol and Rohlf (1969), concludes that, for measuring height variability, "the variation coefficient is an appropriate statistic, since it minimizes the effect of differences between samples in mean height, ... when comparing differences in the variability of height ...".[199] Hence,

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

198 Schmitt and Harrison (1988, p. 358) compared variances (squared standard deviations) and variation coefficients 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 the differences in the variation coefficient were not significant either between women or between men, while the differences between variances were significant for men. These modern variation coefficients 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, and a more detailed comparison with economic data might yield other results.

199 Bogin (1991), p. 288.

coefficient of variation is used throughout this chapter as the index of inequality. The height difference (in cm) between the lower class and the combination of the middle and the (very small) upper class is also considered.

This methodology produces accurate results only if the geographical units are of similar size and the individuals are the same age.[200] In early nineteenth century Bavaria, as in most European countries of the time, males grew substantially between the age of 19 and 21, and the adolescent growth spurt took place much later than today.[201] For example, in the 1965 Dutch height standard, the maximum standard deviation of heights is reached at the early adolescent growth spurt at age 14.5 (standard deviation 8.9 cm, van Wieringen (1972), p. 52). The standard deviation remains high up to age 16, and declines to 6.7 cm at ages 20 and 25. As the variation coefficient is the standard deviation divided by average height, the variation coefficient for younger ages of growing boys is much higher. Ages are therefore not mixed in our study. For the Dutch adults born in 1965, the variation coefficient is about 3.75, similar to those of Bavarians in the early 19th century, even though these 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 likely. Therefore, the measured variation is probably higher than the "natural" variation.[202] For Bavarian (fully grown) 19-year-olds of today, regional data are available for 12 districts for birth years 1971 to

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

201 Danish recruits grew about 1.3 cm between ages 19 and 21 (Mackeprang 1907, p. 156).

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

1975.[203] The average height is 179 cm; the variation coefficient is slightly lower (between 3.6 and 3.7) than in the Netherlands, perhaps because of the regional decomposition, and is close to the lowest values of the 21-year olds in our early-19th century sample of Bavarians, even though the regional values of those 19th century Bavarians were even lower. Regression analysis of data available for 12 districts of Bavaria (1990-94) suggests that, for contemporary Bavarians, no relationship exists between variation coefficient and average height:[204]

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 variation coefficient can be considered as a measure which is relatively independent of average height. The available evidence suggests that the "natural" value for adults without much regional or economic variation should be close to 3.6.

7.2. Data sources

The main data source used in this chapter is 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

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203 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.

204 The same insignificant results turn out if a time variable for the five mustering years is included:

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.

age was changed to 21 and remained so until 1839.[205] 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).[206] Bavarian conscript lists are therefore a nearly complete census of young men at a fixed age.[207]

Variation coefficients were calculated, aggregated by six 5 year birth-periods, from about 15,000 individual measurements from 15 districts of Bavaria.[208] 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 variation coefficients based on more than 60 individual measurements were used.[209]

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205 The conscripts were chosen by lot from those eligible. Those who could afford it could pay substitutes to do the military service for them, 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 6.1.

206 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 their vows. 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, even if this was extremely low (155.6 cm). Priests also were probably taller, because their parents tended to belong to the middle- and upper-classes. By contrast, missing recruits were mostly born 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.

207 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 available men of the desired characteristics. The latter types of samples require large numbers of measured soldiers to adjut for the truncated distributions. The results of the conscription process for a few birth years were published in contemporary statistics, see Table 6.2.

208 The sample containing the heights of conscripts who were born earlier has variation coefficients on 14 districts.

209 With the exception of Landshut Town (only 37 individuals), which was one of the few towns. The restriction to units of more than 60 individuals is a conservative one. Human biologists usually calculate variation coefficients even for units with only 25 measurements of individuals, see Schmitt

7.3. The relationship between height variation and economic development

The share of non-agricultural occupations of the conscripts' father is used as a measure for the level of economic development. Although better indicators of economic development, such as GDP per capita, are not available on a regional basis, our indicator can be justified by Orsagh's finding that it is highly correlated with aggregate income.[210]

A scatter diagram of the variation coefficient and the share of non-agricultural occupations shows a positive relationship for the earlier sample of 19-year-olds (see fig. 7.4, correlation coefficient 0.57, p-value 0.032). The regression line in figures 7.4 and 7.5 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 attainable heights, and therefore there is a theoretical maximum of height variation.[211]

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.[212] Most of the Bavarian districts were dominated by agriculture. The fathers of most conscripts worked in the agricultural sector in these districts, from 60% to 70%. Only one of the districts in the 1797-1801 sample can be considered as

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and Harrison (1988, p. 353). Extreme heights (less than 145 cm, more than 185 cm) and the heights of migrants were excluded.

210 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.

211 The six agricultural districts with a low variation coefficient of less than 4.0 are not concentrated in any single region.

212 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 previously mentioned two types.

early industrial. The economic structure of the region around Nuremberg was dominated by metal and glass manufacturing, as evinced by a share of nearly 50% handicrafts and workers in the labor force. The two towns in the sample, Munich and Landshut, had almost no agricultural population. The two towns and the early industrial district are among the five cases with the highest variation coefficient. Even within the agricultural districts, a relationship between the sectoral structure and the variation coefficient can be seen, although there are only a few cases.

The second subsample contains the birth cohorts of 1815-1839 (see fig. 7.5, 21-year-olds). There are seventy one observations from fifteen districts of Bavaria.[213] Again, the positive relationship between the CV of heights and the share of non-agricultural occupations is evident (Correlation Coefficient: 0.50, p-value: 0.000).[214] The variation in the town is larger than the variation in agricultural districts. This is the case in every five-year cohort. The variation coefficients of the five early industrial districts are higher than those of the agricultural districts, but not as high as in the towns. This subsample includes five different early industrial districts. These are Nuremberg (rural district surrounding Nuremberg), Friedberg, a clockmakers district, the salt mining district of Reichenhall, and the textile districts of Frankental and Kaiserslautern.

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

213 Four districts were not available for the first birth group alone. Including only 11 districts does not change the results.

214 The lower level of variation coefficients 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.

urban results are representative can, however, be judged by comparing them to the published conscription statistics (see table 7.2). These aggregated statistics give hints about similarly high variation coefficients 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 (more than 175.1 cm). Table 7.2 shows the percentages of conscripts in these categories for towns and rural areas in four major regions ('Regierungsbezirke').[215] In each of these regions, the medium group was smaller in towns than in rural areas. This finding supports the idea that greater inequality in urban heights was actually a widespread phenomenon.

Did nutritional inequality rise in the early 19th century? We find that the variation coefficient increased between 1815 and 1819 and between 1835 and 1839 (see table 7.1). In a regression on the variation coefficient, with the share of non-agricultural occupations and birth years ('time') as independent variables, the time variable is significant (Columns 3 and 4 of Table 7.3), so this change in the variation coefficient 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 period.[216] It makes no difference whether the city of Munich is included (U/R – for urban and rural) or not (R – for rural), as including it only affects the slope of the function between the share of non-agricultural population and the variation coefficient. If the time trend is included

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

216 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.

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 appears to be small, but we have to keep in mind that most of height variation is naturally caused. An increase in the variation coefficient of 0.15 over the whole time period is by no means negligible. The average variation coefficient of early industrial districts is 0.20 higher, and that of the town 0.40 higher, than that of agricultural ones (see table 7.4). Therefore, the magnitude of change in the variation coefficient over time was about as large as the cross-sectional difference in the variation coefficient at the beginning of the period. We conclude that the time trend towards inequality and the difference in height variation between regions are both statistically and economically significant.

7.4. Comparison of height variation and between-group differences

Did greater differences in income cause the larger variation coefficient in towns and the more industrialized regions as well as the time trend towards inequality? The 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 surprising as heights are heavily influenced by the nutritional situation in the first months in infancy.

In the last two columns of Table 7.3, 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 the variation coefficient as the dependent variable (see table 7.3, columns 1-4).

(a) Every five years, the between-group difference increased 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 (see table 7.4).

To examine the relationship between variation coefficient and between-group difference directly, we can compute the correlation coefficients for the two variables. For the cross-section of 15 districts in table 7.4, the correlation coefficient is as high as 0.50 (P=0.060), while it is somewhat lower (0.33, P=0.005) when calculated for all 71 time-space observations. 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 areas caused by immigration? If there is a lot of immigration, we would expect the variation coefficient to rise, as more individuals of extreme height might enter a town or an industrial district, thus distorting its existing distribution. If the tallest individuals are the ones who leave the rural areas, then the variation coefficent would be reduced there. However, the empirical results do not confirm this hypothetical pattern.[217]

7.5. Winners and losers

Which social groups gained in height, which lost? If the earliest and the last birth cohort of the later sample are compared, the three tallest groups stay more or less at the same level (see fig. 7.6, Table 7.5). These are the middle and the upper class, the farmers with large acreage's, and the master craftsmen. Agricultural lower class occupations, on the other hand, declined on average 0.4 cm, but not significantly so (at the 10% level of significance). The unskilled industrial occupations (-1.7 cm), and semi-skilled craftsmen (-0.8 cm) experienced the strongest (and most marked) decline in net nutritional status. Tradesmen, a heterogeneous group, also declined in height. Interestingly, the only group with a significant height increase were farmers with medium sized farms (although from a low initial level), and their share of the population also increased. This makes sense, given Bavaria's increasing specialization in agriculture. In the early 19th century, the rich farmers' nutritional status remained high, while that of farmers with medium-sized farms converged somewhat. The underlying economic mechanism was probably increasing returns to land in an agricultural country, while the semi-skilled and unskilled industrial activities had far lower returns. The latter occupational groups had far more limited opportunities to give their children protein-rich food, while the group that benefited from increasing returns to land had better opportunities. This is consistent with declining real wages of

217 Saee J. Baten (2000a). Fortunately, we have information on both the birth and mustering place of the conscripts, and excluded all migrants from the previous analysis. However, if we had included the migrants it would not have made a significant difference.

labourers between the 1820s and mid-century (Goemmel (1978)) and a modest increase in agricultural production per capita in Bavaria (Boehm (1996)).

Williamson's (1985) hypothesis that unbalanced technological change favored skilled occupations in England in this period is confirmed in the case of Bavaria. 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, and their higher living standard resulted in greater inequality in an agricultural country such as Bavaria.

7.6. Impact on the individual´s utility

It could be argued that the future height of their children is not an element of the utility function of the heads of the households. How much, then, did it matter to parents in the poorer segments of society that the quality of their children’s nutrition declined over the period 1815-19 to 1835-39? While height or even the quality of children's nutrition[218] might not be part of the utility function, the life expectancy of children certainly was – especially in a world where there was little insurance for old age. 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.

It has recently been shown for a cross-sectional sample of 16 countries 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.[219] 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.[220] Therefore, the children of the Bavarian unskilled industrial group probably 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 farms gained about 1.5 years in life expectancy, while sons of richer farmers and skilled craftsmen may have had modest gains.

7.7. Conclusion

Anthropometric variation has been used to measure inequality 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 chapter were confirmed.

1. We found, on the basis of height distributions, that the distribution of nutritional resources was becoming more skewed at the early stages of modern economic growth in early-19th century Bavaria, just as Kuznets has suggested.
2. We also found that nutritional inequality was consistently higher in regions with a relatively large industrial sector than in regions still dominated by agriculture; nutritional inequality was also related to early industrial activity in rural districts.

218 As demonstrated in Craig and Weiss (1998).

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

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 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.

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

Chapter 8: Prospects – The Effects of Different Nutritional Standards in the "First Phase of Globalization" (1870-1914)

8.1 The influence of nutrition on productivity

We noted in the introduction that there are two opposing causal linkages between nutritional status and the conventionally measured standard of living.

(1) On the one hand, a higher level of prosperity makes it possible to reach a more favorable nutritional status by favoring a diet that is richer in animal protein. In the previous chapters, a considerable portion of the difference in height was explained by such factors as income, social class, proximity to nutrient production, and relative prices.

(2) On the other hand, the causal relationship can be in the other direction as well. Insufficient nutrition puts limits on economic productivity, and, therefore, on the standard of living.

Identifying the causal direction in interacting causal chains like these is fundamentally difficult, if neither of the factors is "more clearly exogenous" than the other. Anthropometric researchers consider that, over the long run the influence of income on height is the stronger than the other way around. For the periods considered here, the main influence was on the physical growth of children and young people. For interregional comparisons identifying the direction of causation is, indeed, difficult. In the previous chapter we found that the local nutritional advantage of higher protein production was partly exogenous. In the case of milk, this advantage was the result of the fact that at the time milk could not be transported over long distances, so that its relative price was low thereby exerting a positive influence on consumption and on nutrition. In what follows I shall look at the last period when milk still had a strongly exogenous effect in Europe, that is, the late 19th century. An attempt is made to discover whether there was any influence of protein deficiency on economic development. This chapter has deliberately been entitled "Prospects" because although it does not claim to clear up all questions in this area, it does suggest future lines of research in this intellectually stimulating field.

In the literature of development economics, the connection made between protein deficiency undernutrition and retarded economic development is almost a commonplace.[221] A connection between protein deficiency and lessened physical and mental capacity has also been found in anthropology and psychology.[222]

The period from the late 19th century to the First World War has been called the First Age of Globalization, in analogy to the second phase of globalization in the 1990s.[223] In Europe, and in those countries settled by Europeans, technological innovations were diffused much more freely than previously, a diffusion that was facilitated by the transport revolution of the preceding period. The "new" branches of industry (the electrical industry, chemistry, and new branches of engineering) required their employees not only to be educated, but also efficient and flexible. In these new growth industries, local deposits of mineral resources were a less important success

221 Cf. J. Strauss/D. Thomas (1997); A. B. Declaliker (1988).

222 For the relationship between nutrition and economic productivity, cf. A. Sorkin (1994); E. Kennedy (1994).

factor than in the preceding period, when local availability of coal and iron ore had constituted an overwhelming advantage. The efficiency of the individual worker was more significant for economic growth than it had ever been previously. The decisive factor in economic growth was whether these technologies could be employed to produce goods that could compete in the world market.[224] Did the countries with a high per capita protein production at the start of the period (and, correspondingly, higher average stature) also attain a high rate of economic growth in that period?

8.2 Empirical Analysis

The close correlation between protein production and height can be seen in the scatter diagram of cattle per capita versus height (see fig. 8.1). In the 19th century, herds of cattle consisted overwhelmingly of milk cows (e.g., up to almost three-quarters in Bavaria) so that these figures are even more valid for milk production than for meat production.[225] The values show a very strong correlation between heights and cattle per capita, and the diagram includes all countries for which data for the birth cohorts of around 1860 were available. There are, at present, no figures for average height available for Germany as a whole for the period considered, and three states or territories (Bavaria, Wuerttemberg, Holstein) were therefore chosen. From later data,

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223 In a weaker form, this is true for the entire post World War II era as well, even though East-West antagonism and the interventionist economic policies of many countries prevented globalization from becoming more widespread in some areas.

224 cf. J. Brown (1995).

225 This can be confirmed by the fact that most young bulls were slaughtered early, and only the few breeding animals necessary to reproduce the herd were kept. Protein production in the Mediterranean area (including Greece/Croatia) was probably more heavily dependent on goats than in Germany. To my knowledge internationally comparable figures on per capita goat milk are still a desideratum for research.

disaggregated on a regional basis, we can conclude that the average for Germany as a whole probably was about midway between those of Holstein and Bavaria.[226]

The data for England vary greatly in quality, since England did not have any universal conscription during this period.[227] Data for Spain and Portugal stem from the 1840s. Up to the birth cohorts of the 1890s Spanish heights increased by only about 0.4 centimeters.[228] Most heights are based on 21-year-old conscripts and in almost all cases represent a broad cross-section on the population.[229] Data for somewhat older or younger people have been standardized for age 21, using Mackeprang's method.[230]

The economic growth in this period 1870-1913 was very fast in the USA and Canada, above average in the Scandinavian countries, Germany, and Austria (Cisleithania), and slow in Italy and Portugal. There was little growth (though, of

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226 Cf. D. Evert (1908). This is in agreement with the RSMLE - estimates for Württemberg in the 1860s, cf. S. Twarog (1993).

227 P. Johnson/S. Nicholas (1995) have estimated English heights in the 1850s at 165 cm. (Mainly from the lower class, because an estimate based on a sample of criminals found average heights of 164.6 cm for 21-year-olds). The middle and upper classes were about 1 cm taller. An anthropological study in the 1880s found 173 cm (at age 21: 172.6 cm). Fogel's data would mean a height of 168.4 cm for 21-year-olds (probably derived from Floud). The value that I have chosen is a rather high modal estimate of army heights, according to the histogram in J. Komlos (1993a) for the 1820s, minus a decrease of about 0.6%, which he has estimated for the period between the 1820s and the 1850s. It lies between the estimate of Johnson/Nicholas and that of Fogel.

228 Cf. S. Coll (1997). Per capita cattle figures for Portugal are an extrapolation, under the assumption that the cattle stock grew in the same proportion as in Spain. In 1925 the Portuguese had 72% of the number of cattle per capita of Spain. Here, further work could be done.

229 Except for Canada and possibly England. Canadian height figures are based on the heights of the Mounted Police. In England, there is data for the Army.

230 For the late 19th century, he estimated that, compared with 21-year-olds

- 19-year-olds grew another 1.3 cm
- 20-year-olds grew another 0.5 cm
- 22-year-olds grew about another 0.3 cm, and
- 23-year-olds grew about another 0.4 cm.

He found between the 23rd and 24th years of life to be less than a millimeter . In total, 19-year-olds thus grew 1.7 cm. Cf. E.Ph. Mackeprang (1907), p. 156

course, from a high level) in Belgium, Great Britain, and the Netherlands (see fig. 8.2). If these growth data are compared with data for the nutritional situation, an influence of nutrition becomes evident, assuming that there is no other variable that influences both height and economic growth. We will discuss this assumption below.

The objection could be raised that the low stature of the Mediterranean people and the high stature of the northern Europeans and North Americans could be genetically determined. On the other hand, the fact that heights around 1860 can be explained so well in terms of the production of protein at the time leads me to believe that the genetic influence on heights in Europe has been overemphasized.[231] The dramatic changes between countries support this view: Western and Northern Europeans are now taller than Americans, especially the Dutch rose from almost the shortest Europeans in th 1840s to the tallest in the world of today.[232] Even in the industrial cities of northern Italy, migrants from southern Italy have clearly shown increases in height in the second generation, compared with southern Italians who did not migrate.[233] This is also the case for Japanese emigrants to the United States.[234] A residual difference could have been caused by different nutritional habits. There is an inertia in the way food is prepared in individual countries and regions, even though the economic need to use certain kinds of food has disappeared in particular countries during the 20th century. Are the differences in the countries of origin less strong today? Today we can no longer speak about low-protein consumption in the Mediterranean

231 Martorell and Habicht, for example, explain the heights of peoples from all regions of the world on the basis of economic, and not biological, factors, because the upper strata have approximately equal average heights. Cf. R. Martorell/J.P. Habicht(1986).

232 Cf. T. Cuff (1995).

233 Cf. M-C. Chamla (1964).

countries. For example, in the 1980s, Spaniards (more precisely from the town of Bilbao) were taller than Belgians, French, and Hungarians, and only slightly shorter than Americans (see table 8.1).[235] Italians on average were actually two centimeters taller than Spaniards. The Dutch were taller than the Scandinavians, who are taller than the other Europeans. On the other hand, Norway, for example, even today has the highest share of dairy products in its diet in the world, and one of the world's highest per capita national products.[17]

This discussion is based only on the countries of the so-called Atlantic convergence club where the circumstances prevailing at the time of the first period of globalization made it possible to transfer technologies easily among countries. In addition, the new branches of production made it increasingly possible to substitute human capital for the missing endowments of physical capital and natural resources. In that period, the negative influence of market integration on nutritional status of an earlier period could well have developed into the positive relationship between per capita income and height found by Steckel and Brinkman/Drukker/Slot.[236] At the start of the period, no relationship between the heights and per capita gross domestic product (GDP) can be found. It was not only the Norwegians, Swedes, and Irish who were clearly taller than their per capita GDP would lead us to expect – the same is also true of the Germans, Danes, and Austrians, whose countries converged strongly in GDP between 1870 and 1913.

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234 Cf. T. Cuff (1995).

235 Cf. S. Coll/G. Quiraga (unpublished); S. Coll (1997).

17 On inequality, cf. J. Komlos (1997a); R.H. Steckel (1983).

236 R.H. Steckel (1983); H.J. Brinkman/J.W. Drukker/B. Slot (1997).

One of the favourite variables of growth studies on the late 19th century globalization period is literacy. Literacy is a proxy for human capital, and this variable could have freed "impoverished sophisticates" such as Sweden from a disequilibrium situation of low per capita income. In table 8.2 we directly test this variable (that is itself heavily influenced by protein malnutrition) against height, our proxy for the quality of nutrition. We find that literacy loses its significance once malnutrition is controlled for (table 8.2, col. 1). The goodness of fit measure is surprisingly large, suggesting that more than half of growth variation can be explained by height alone. An obvious objection is the question about the direction of causality. Did lower protein malnutrition cause productivity growth, or did higher productivity cause higher incomes and, ceteris paribs, better nutrition? Granger causality tests have been developed to analyse which variables systematically precede which other variables, if both directions of causality are plausible theoretically. While we have no times series and cannot perform the Granger causality test directly, we can test in our cross-section whether height has an additional impact on GDP per capita once GDP in the previous period is controlled for, and whether GDP has an additional impact on height once height in the previous period is controlled for. We find that height has indeed an additional impact on real income per capita, while the opposite is not the case, caused by the lack of milk transport possibilities around mid-century (table 8.2, column 2 and 3).

We restrict our hypothesis to phases of globalization that allow relatively free technology transfer. In addition, a *condition sine qua non* for the influence of nutritional status on economic growth is a sufficient level of urbanization. Rural regions and countries with high nutritional status are not capable to develop human capital intensive industries, because urban agglomeration externalities are missing.

Some objections to this approach should be discussed that related to Japan and Russia, two countries that were not members of the Atlantic economy as defined by O'Rourke and Williamson (2000). If we had included Japan in the data set it would have been an outlier. Although we still do not know much about Japanese heights in the 19th century, however, 20-year-old conscripts born in 1872 were on average 156.1 cm tall, much below European standards.[237] Japanese heights subsequently began to increase rapidly, - at a rate of 0.93 cm per decade for the following 40 years. In the late 1940s and 50s the Americans introduced into Japan a more markedly "western" diet, which also included milk. Japanese heights then increased unprecedentedly, thus showing that the small stature had been caused largely by the lack of (milk) protein in their diet.[238] Contrary to the conventional wisdom, fish had not played a major role in Japanese nutrition.[239]

At the same time, it should be kept in mind that Japan did not have an above average growth in GDP until the 1950s and 1960s. The growth rate in the period between 1870 and 1913 is estimated at 1.4% per year, at a time when the annual growth in gross domestic product in the USA was 1.8%; in Canada, 2.3%; and in Germany, 1.6%[240]. Japanese GDP grew "only" as fast as the European average, and this at a level that was, in both 1870 and 1913, still far less than half of Germany's. In

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237 T. Shay (1994), p.201.

238 G. Honda (1996).

239 G. Honda (1996).

240 Maddison (1991).

1913 per capita GDP was US $2606 (in 1985 prices) in Germany; by the same year, Japan had reached only US $1114.[241] As late as 1950, Japan's per capita GDP was far below that of the countries in Maddison's 16-country sample.[242]

A second country whose pre 1913 economic growth has been sometimes overestimated is Russia. The cause of the overestimate is the meteoric rise (albeit from very low level) of Russian industrial production, even though the industrial sector made up only a small part of the Russian economy. If we look at the Russian economy, including agriculture, as a whole, then the Russian growth figures are in the upper middle range for European countries. Maddison estimates the growth of GDP between 1900 and 1913 at 1.5% per year; the growth of national income between 1875 and 1913 is also estimated by Mironov at 1.5%.

Although we have no very precise estimates for Russia and Japan, they are not major exceptions to the general relationship discussed above. In this period, Japan's per capita income was far lower than that of the countries considered, and its growth rate was only average. Japan did not achieve a world record for the growth rate of GDP until the 1950s and 1960s when nutrition was much better. Russia's growth rate (1870-1913), for which estimates are not of equal quality, was slightly above average and its heights were slightly below average. If we look at this relationship for regions within countries, the above relationship can be provisionally confirmed by a few examples.[243] Of course, when we make regional comparisons we must also assume that urbanization had probably reached a threshold level as 19th century industrialization

241 For Germany, cf. also R. Fremdling (1991).

242 A. Maddison (1991), pp. 24/25 and pp.195-242.

243 For the German regions, cf. H. Frank (1994).

was to a large extent an urban phenomenon. In England, for example, the north industrialized faster than the rest of the country, as the north did too in Spain and Italy, and the west in Prussia. All these regions, had a better supply of protein and a higher degree of urbanization than the other regions in these countries. But Italy's urban South did not grow and neither did protein-rich rural Schleswig-Holstein, or even Bavaria's South (two regions without sufficient urbanization).[244]

244 For the protein supply in regions in England and Italy, cf. J. Baten (1976b); for Spain, A. Gomez-Mendoza/V. Perez-Moreda (1995).

Chapter 9: Conclusion and Prospects for Further Research

We summarize below the salient results of our investigation into the nutritional status of Bavarians during the second half of the 18th and the first half of the 19th centuries. We have used an anthropometric approach to quantify how well the population ate relative to the demands on the nutrients. This enables us to gain a perspective on the ability of the human organism to thrive in its socio-economic and epidemiological environment. This opens up a new window to the historical past which has up to now largely eluded us. Our focus was to understand how the human organism was influenced by economic processes during these times of major socio-economic transformation. We conclude by suggesting some further lines of inquiry which follow from our analysis.

9.1 Secular Trends in Height and their Determinants

Our study is based on military and prison registers which pertain, in the main, to the lower social classes. Many of these were day-laborers and unskilled artisans, but we were able to enhance our sample for a brief time period (1815 and 1839), to include a sample of the entire population of 21-year-old young men. We could thereby obtain a representative statistical portray of the Bavarian male population and compare them with the previously mentioned sources. We found that the average height of the conscripts and that of the prison inmates were quite comparable as long as we took account of differences in occupation or social composition. The prisoners actually tended to be somewhat taller. We were also fortunate to find some height records for female inmates of the Wasserburg prison near Munich – which are quite rare for the period under consideration.

At the beginning of the period for which data are extant heights were increasing in Bavaria as well as in the Palatinate. This was the case from the 1730s to the early 1750s. Thereafter, heights began to decline, as in other parts of Europe, indicating an incipient nutritional crisis that lasted well into the late 1770s. Though the crisis was reversed, and never fully materialized as in prior centuries, the previous high nutritional status was not reached again until the early 1820s. Heights then remained stable, except in some areas as in southeastern Bavaria, and among the lower social strata, among whom heights declined right up to the middle of the 19th century. There was no clear improvement in the general nutritional situation, including the lower classes until the 1860s. The continuous increase in heights in the 20th century should, therefore, not be projected back into the two preceding centuries. The anthropometric history of prior centuries can be characterized not by secular trends as much as by periodic cycles in nutritional status.

In order to investigate the socio-economic determinants of net nutrition, we considered the impact of climate, of per capita output of various foodstuffs, and of real wages on the nutritional status of the population. We analyzed the relationship of these variables both cross-sectionally and longitudinally for both sexes, and with different geographic units of Bavaria and the Palatinate. In one section we sidetracked to compare the Bavarian patterns to those of Prussia. We considered urban-rural differences as well as the spatial distribution of nutritional resources. We showed that, from the 1730s to the early 1750s, central Europe had mild temperatures while in the following two decades temperatures fell by about 0.6 degrees Celsius.[245] From the late

[245] Altogether, the 18th century was a cold period, when temperatures were always below those of the period between 1900-1960. This has been shown for Switzerland; cf. C. Pfister (1988a).

1750s onwards, therefore, the growing season was shorter, and per capita production of foodstuffs declined. This inference could be confirmed on the basis of actual tithe statistics. The rise in the price of grain, like that of all other types of food, caused a fall in real wages in Bavaria in this period, as in all other parts of Europe. Not until potato cultivation was intensified, from the 1770s onwards, was it possible for food consumption to be stabilized, though at a relatively low level, i.e., still below that of the 1750s. At the beginning of the 1820s, and then again in the 1860s, Bavarian winters were mild; between these two periods, however, they were much colder. These results for Southern Germany were compared with Austria-Hungary, where the climate pattern was similar, as well as with England where it was different.

Overall, many parallels can be found between the trends in net nutrition in Bavaria and that in other countries. The 18th-century decline in height also occurred in all regions of the Habsburg Monarchy, in Great Britain, in France and in Sweden.[246] Like Bavaria, Sweden, Denmark, the Netherlands, Great Britain and the USA all experienced falling nutritional status from the 1820s to the 1840s (cf. Chapter 4). However, no decline or stagnation in the 19th century was found for France. Weir attributes this finding to the early decline of fertility there.[247] The positive correlation between real wages and changes in height, which has been found in this study for 19th-century Bavaria (and which probably also existed in Sweden, Denmark and the Netherlands), was not found for Great Britain and the USA. There heights decreased in the 1830s and 1840s at a time when real wages were either stagnating or improving. Komlos attributed the divergence between real wages and heights in the USA to the

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246 J. Komlos (1993a and 1994a); .L. G. Sandberg/R. H. Steckel (1987).

247 D. Weir (1993)

special conditions prevailing in a frontier economy. On the one hand, the amount of land per capita in the American economy was very large and, on the other hand, in some densely populated areas population growth was so enormous that it raised the prices of foodstuffs relative to industrial products significantly. The sharpest decline in heights in the USA was among farmers. The proportion of the food that they sold to the cities increased, because, as a result of market integration, they were able to buy other goods, especially industrial products. In this period, the prices of foodstuff rose relative to those of other goods. Therefore the farmers, and to a lesser extent other Americans as well, tolerated a certain decline in the quality of their children's nutrition (e.g. less animal protein) in order to be able to buy more other goods. Even in the 1840s, however, the level of nutrition in the USA was well above European standards.

In England, whose per capita supply of protein and limited per capita land area were similar to those of Bavaria, there was also a divergence between real wages and heights. Up to the 1830s, these two variables had developed in parallel in England too.[248] In the 1830s and 1840s, Great Britain experienced the highest rates of increase in industrial production in its history and the peak of its wave of urbanization. It was argued above that the divergence between the trend in the "biological" standard of living and the trend in the "conventionally defined" standard of living in England in this period was dictated primarily by the problems of a foodstuff importing economy at a time when population was growing rapidly and transport technology was inadequate. In the 1830s and 1840s, it was far more difficult to import animal proteins - and to produce them at home - than it was to import vegetable foodstuffs, which

248 Cf. Heintel/J. Baten (1997)

could be transported at lower cost. This affected the prices of animal protein relative to vegetable foods, which resulted in the diet of the English lower strata becoming partly vegetarian. People preferred to spend additional real wages on industrial goods and luxury foods, such as coffee and sugar, because these produced subjectively greater utility than buying milk or meat for children. Although these preferences also existed in Bavaria, which was far poorer than England, for most of the lower strata in Bavaria around the middle of the 19th century, their effect was less than the huge losses in purchasing power due to a decline in real wages.

Another task of the final chapter is to show how the results could be significant in other contexts. We can begin for example, by discussing the history of economic thought. Previously, history of economic thought of the 18th and early 19th centuries has studied the writings and biographies of the important economic theorists and the legal texts relating to economic policy with a small amount of background information. If, however, we look at the new series on the changes in the standard of nutrition, some intellectual currents of the time appear in a new light.

Late 18th-century German economic theory, for example, followed the ideas of the Physiocrats, who considered agriculture and primary production to be more important than industrial production. This intellectual focus has often been held responsible for the fact that economic development in 18th century German was less dynamic than in England. When the devastating effect of the reduction in per capita foodstuff production on heights in the second half of the 18th century is considered, however, this strong emphasis on agriculture becomes less surprising. It was perhaps precisely this background of massive nutritional problems that made rapid industrialization seem too risky to the late 18^{th} century and early 19^{th} century observer. Similarly, Malthus' ideas in England around 1800 might have been influenced by the reduction in per capita production in foodstuffs that occurred at that time, including countries from which food was imported into England.

And it is surely no accident that around the middle of the 19^{th} century, when heights, which had increased in the 1820s, again became stable, and in some places actually fell, Malthusianism was more favorably received in Germany.[249] It was not until the 1860s, when nutritional indicators were favorable, that economic liberalism prevailed in Germany, as can be seen from the introduction of freedom of occupational choice (in contrast to the medieval guild system of restricted entry) in most German states.

9.2 The regional cross sectional patterns

In explaining trends in height, the focus was on changes over time in the availability of foodstuffs and less emphasis was placed on the two other determinants of physical stature – the disease environment and the workload of young people. These factors have been discussed in greater detail for the 19^{th} century in chapter 4. Generally, however, it seems that in the 18^{th} and 19^{th} centuries gross nutrition had a much greater influence on net nutrition than the claims on those nutrients posed by the other two variables. The results of the analysis of regional cross sectional patterns supported this argument.

For some regions a high local per capita production of milk proved to be a substantial advantage. This factor had a significant positive influence on height in all the regressions and similar patterns were found in both Prussia and the USA.[250] In other countries as well, the much better supply of milk in regions with greater average heights (e.g., the west and north of England in the early 19th century, the north of Italy in the late 19th century[251]) indicate that the connection between local milk production is related directly to local milk consumption and the height of the local population. This was a frequently occurring phenomenon at least up to the 1860s and 1870s. From then on, it gradually became possible to use railroads to transport milk to districts where there was no local milk production.[252] Then the availability of refrigeration accelerated the process by which nutritional status in urban areas could improve relative to rural ones.

This result is also important because, up to now, economic historians have paid less attention to milk production than to that of meat possibly because it was primarily consumed in rural areas. Meat was more important in the nutrition of the city dwellers in the past, and it could also be recorded better by the tax assessors. This is an example of a new perspective, which could not have been undertaken without the methods of anthropometric history, because other sources for the rural nutritional situation in the past were scattered and random, and hence unable to provide much in the way of systematic evidence.

Another important point in relation to the regional cross sectional pattern is that the nutritional situation in administrative cities was generally more favorable. In

249 Cf. K.-T. Metz (1980)

250 Cf. J. Baten (1996b). For the USA cf. J. Komlos (1996b); L. Craig/J. H. Weiss (1997)

251 Cf. J. Baten (1997b)

252 On the USA cf. J. Komlos (1996b); L. Craig/J. H. Weiss (1997)

industrial cities there was a higher proportion of men unfit for military service because they were not tall enough. This is mainly due to an income effect, because in the early nineteenth century administrative cities had a large number of officials and self-employed professionals whose incomes were high. In industrial cities there were many poor artisans and workers, and only relatively few entrepreneurs and prosperous master craftsmen.[253] Inhabitants of administrative centers in Bavaria such as Munich, Bamberg or Bayreuth, therefore, could afford to purchase more meat.

On the other hand, the proxy indicator for the disease environment, the proportion of men disqualified for military service because they were too sick or too weak, also had a slight negative influence on height in the cross-section of the regions in Bavaria. It could also be argued that disease environment was more important than gross nutrition because, in regions with higher milk production, the population was generally spread more thinly so that the disease environment was also more favorable. Yet, in northern Italy and western Prussia both the supply of milk and the average stature were higher, even though these regions were more densely populated. Moreover, we examined seven major regions of Bavaria in chapter 6 with rather homogeneous disease environment, and considered the mountainous regions with lower population density separately. In six of the seven regions, local production of milk retained its significant influence on physical stature so that it was probably not the favorable disease environment that was the cause of the higher stature. The proxy indicators for the disease environment were also tested in these seven major regions. The result was that the variable of being disqualified for being too sick or too weak for

253 H.-J. Gerhard (1984a)

military service had a significant influence on height with the expected sign in only two regions. Moreover, these two regions (upper Franconia and lower Franconia/Palatinate) had the poorest supply of milk in the seven major regions. In none of the major regions did the other indicator (population density) give any statistically significant results. These weak effects might also be due to the synergistic effects between nutrition and illness.

A more detailed investigation of the social distribution of nutritional resources was possible for the early 19th century, a period in which stagnation, or even decline, in heights was contrasted with overall economic growth in some countries. To consider this problem we used two anthropometric methods: (1) the "traditional" method of comparing differences in stature among social strata, and (2) a new approach that uses the coefficients of variation of the heights and compares them with the standard deviation. The further the mean height of the better nourished part of the population diverges from that of the worst nourished part of the population, the greater does the variation in heights become. The development of this method offers one advantage for similarly homogeneous samples from other countries and other periods: we do not have to code the social strata first in order to examine the increase or decrease in inequality.[254]

This analysis showed that the inequality of nutritional status between the social strata actually increased in the early 19th century, and that it was greater in those regions that were less agricultural and more developed industrially. This finding is also important for investigating samples from other countries, in which the worse nourished

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254 It is assumed, of course, that all individuals in a district have an equal chance of being represented in the sample, and that the sample is homogeneous with respect to age.

part of the population is strongly overrepresented (samples from volunteer armies or prison records in the UK for example). Because only the lower range of the height distribution in these samples is considered, there is a danger that the negative influence of industrialization and urban disamenities on the population as a whole will be overestimated.[255].

In the last chapter, we examined the relationship between nutritional status and economic development in the late-19th century and considered the direction of causation during the so-called "First Era of Globalization" (after Jeffrey Williamson). This period was characterized by greater mobility in the factor markets than in previous periods. Moreover, in the pre-World War I era, the international exchange of goods had fewer restraints than in the decades that followed it. By comparing the nutritional status around 1860 with the growth of gross domestic product per capita between 1870 and 1914, we were able to show that the influence of the former on the latter could have been at least conceivable. A scarcity of proteins might have prevented some countries from participating in the economic expansion of the period, while economies in which the labor force was better nourished (e.g. in Scandinavia) grew more rapidly. On the other hand, many southern European countries (Spain, Portugal and Southern Italy) did not enjoy rapid growth in gross national product until

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255 We can also ask, whether the estimates by which the proportion rejected on account of their being too short (rejection rate) was converted into average height of the population (in cm) in chapter 5 was accurate. In the small sample, however, which contains both average height and rejection rate (and on which we based our estimate of the relationship), we found both districts that were more agricultural and districts that were less agricultural. Therefore, the conversion formula has already taken this effect into account. Only for districts in which the relationship might have had a completely different dimension (e.g., the weaver districts, for which we do not have any average height and rejection rate figures) is there a possibility that average height might be slightly underestimated on the basis of rejection rate. Unfortunately, this question cannot be answered conclusively on the basis of the Bavarian data until more data for individuals from those regions are found; cf. Chapter 5. The 19th century literature on the city/country issue has been discussed systematically in P. Sorokin (1932).

the second half of the 20th century.[256] The relationship observed here will have to be verified or falsified by more exact studies. If these provisional results are confirmed in the future, anthropometric history will acquire an additional important function, because the strategic importance of nutrition as a factor in economic growth would gain in significance. Its importance might be shown, for example, in present day Russia, where the net nutrition of children has deteriorated rapidly in recent years, or in China, where from the 1970s onward (i.e. in the lifetime of people who are economically active today) net nutrition clearly improved.[257] No less important, however, is that anthropometric history helps us to achieve a better understanding of the great economic miracle, how so many countries that were extremely poor in the 18th century came to enjoy the high level of prosperity of the 21st century.

256 There were some reflections on this subject in the 19th century. When speaking in favor of the law limiting child labor to 10 hours, the English parliamentarian Lord Macaulay gave an exaggerated and rather crude stereotype of the Germans. Defenders of the 12-hour day had objected that, in German industrial centers, children worked as long as 17 hours and sometimes so strenuously that «not one in a thousand can be found who has reached the height required for induction into the army». Macaulay replied: «Gentleman! Thinking of such a competition makes me laugh. If we are ever forced to give up our first place among the trading nations, we are not going to lose it to a race of degenerated dwarfs, but to a nation that is exceptionally strong in mind and body». E. Engel (1856), p. 81.

257 For Russia, cf. T. M. Mroz/B. M. Popkin (1995); for China, S. Morgan (1997). For an archeologist’s viewpoint on the connection between the biological standard of living and economic development, cf. M. N. Cohen (1989).

Appendix A: Estimating Regional Rural Rye Prices and Real Wages in Bavaria

In order to analyze the relationship between wages and the standard of living in rural regions, an attempt is made to estimate real wages using the prices of rye as the price deflator. We call this the rye-wage method (i.e., the purchasing power of nominal wages in terms of rye) and use it for regional cross-sectional analysis. While we know quite a lot about nominal wages from contemporary statistics, we know less about regional differences in the cost of living; hence, the latter will be discussed more intensively here.[258]

What made up the market basket of goods of a lower-stratum household in Bavaria? We estimated that in 1818 and 1849 the (urban) building workers of Nuremberg spent 70% and 65% of their income on food respectively, about half of it for bread (see table A.1).[259] The other half of the food budget was composed of expenditures in equal part of: meat, milk, beer and (somewhat less) potatoes. The remaining 30-35% of living costs were spent on clothing (8%), rent (9%) and fuel (6%) besides lighting, furniture, and utensils. In the rural districts the prices for rent and food were probably lower than in the industrial city of Nuremberg. Because of the substitution possibilities, prices for other foodstuffs, such as vegetables or beer, were correlated with rye prices; this rule did not always apply to milk and meat only. When we estimate real wages in this way, we must disregard milk because, before the late

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258 The nominal wages of rural laborers for the 179 districts (1853) are found in Beiträge VII (1857). They are highly correlated with the (around 20% higher) day wages of 1863, and with servants' wages (correlation 0.56; level of significance: 0.00). Bonus payments in kind are included in the calculation uniformly.

259 Cf. R. Gömmel (1979).

19th century, there are not sufficiently good price data for milk. For this reason, milk has been mostly disregarded in other estimates of real wages as well. In chapter 5 we discussed in greater detail why, in general, there was only a shadow price for milk and not a market price. Quantitatively, meat played hardly any role at all in the diet of rural people.[260] We were able to take 84 local rye prices from the Montgelas statistics; [261] and these 84 price data came from all regions of Bavaria. In order to be able to estimate regional price levels, we have calculated for these price data mean values in the larger regions in which similar prices were demanded. The price levels obtained in this fashion correspond with the prices that would be expected in individual regions from their production and demand structure. It can be assumed that wherever the production of grain overshot demand prices were low, while in areas near large cities, or with a high density of non-agricultural population, increased demand led to higher prices.

260 Even in 1860, Felix Dahn confirms the notion of an almost completely lacto-vegetarian diet among the rural population of Upper Bavaria. "Characteristic for the diet of rural people throughout Upper Bavaria is the almost exclusive domination by flour, milk, and fat dishes, augmented by vegetables, and the limitation of the enjoyment of meat dishes to the five annual feast times: Shrove tide, Easter, Pentecost, the parish fair, and Christmas (...). Originally, the obvious reasons for this diet are probably to be seen in the fact that the peasant depended for his food on what his fields and his garden offered him. He can draw from the barn only current interest, milk, and everything that can be prepared from milk; the capital in the barn, the livestock itself, he requires in part for work in the fields, in part, because sales to the butcher in the city give him an indispensable source of income. Bavaria, Bd. I (1860), p.439.

261 Montgelas statistics : Bayerische Staatsbibliothek cgm 6854, Getreidehandel. What we are dealing with are the main prices for all sales and purchases that took place during the whole year in these grain markets. Cf. Geschichte der alteren bayerischen Statistik, Heft 77 der Beitr. z. Stat. d. Kgr. Bayern, published by Stat. Landesamt, Munich 1910, p. 174. A total of 72% of the price data come from the year 1809/10; some are also from 1811/12 (17%) and 1814/15 (11%). The 1811/12 prices are systematically somewhat higher: e.g., in Munich in 1809/10 the wheat price was Kr. 1025 per scheffel (167.9 kg); in 1811/12, on the other hand, it was Kr.1204, declining to Kr. 1085 in 1814/15. Because price increases were always greater in the city of Munich than in the smaller market towns, we deflated price data for 1811/12 by 10%; this agrees with price data for some districts for which prices for two years are available (e.g., Berchtesgaden/Reichenhall). Cf. G.K.L. Seuffert (1857), p. 123/4.

A detailed examination resulted in the following observations.

(1) Because of excess demand, prices were especially high in the southeastern district around the capital city of Munich, on the Swiss border (eastern Switzerland imported massive amounts of grain), and in the northeastern part of upper Franconia, where a large number of weavers were dependent on additional purchases of foodstuffs (see table A.2). In the Bavarian Forest and the upper Palatinate Forest, prices were especially low; in these two areas, the rural population, with its subsistence economy, purchased almost no additional grain.[262] Prices were also low in the grain-producing districts in the Danube Basin (especially around Staubing) and in Lower Franconia, around Würzburg/Aschaffenburg (see map 3.3). The other districts represent zones of transition. These price regions can be seen in map A.2.

We can test these grain price data, obtained for the years 1809 to 1815, using the multi-year averages obtained by Seuffert for 14 cities for the period 1815-55 (Map A.3). The highest prices are found near the Swiss border (where grain was imported), followed by Bayreuth in upper Franconia (near the weaver region), Munich, and Augsburg. The lowest prices were in grain-rich Straubing, followed by lower and middle Franconia (Würzburg/Nürnberg). The regional price differences of 1809-15 are confirmed by these urban prices. Price regions obviously arose on the basis of relative factor costs and relative yields. In rye-producing districts near the major rivers of the Danube and the Main, local rye prices were low. The lower was the rye production (including the region near the Alps), or the higher the excess demand (around Munich, the Swiss border, the weaver districts), the higher was the price.

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262 Cf. price data for the (very small) grain markets of Vohenstrauss and Cham.

Nominal daily wages show some correlation with grain prices (Map A.4): Daily wages were higher in both the district around Munich and the one near the Swiss border, while they were low in the Bavarian Forest, and also in upper Franconia where rye prices were high. Altogether, the correlation coefficient is 0.47; the level of significance, 0.001. Where grain prices were high, higher wages were paid to day workers, to compensate to a certain degree for the cost of living, and real wages were clearly lower in the "poor regions" of upper Franconia and Bavarian Forest/upper Palatinate Forest. Only in western lower Franconia do we find relatively high wages in a low price region (Map 3.9). Estimated real wages also correspond with what we know about agricultural labor migrations. As expected, harvest workers in the low wage regions (Bavarian Forest/upper Palatinate Forest, Fichtelgebirge, Ries, Rhön, Odenwald) migrated to the high wage regions around Würzburg, Straubing, Munich and Nuremberg.

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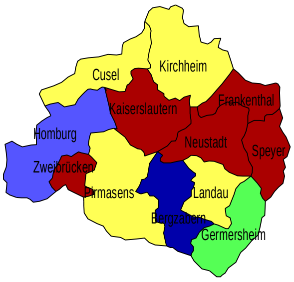
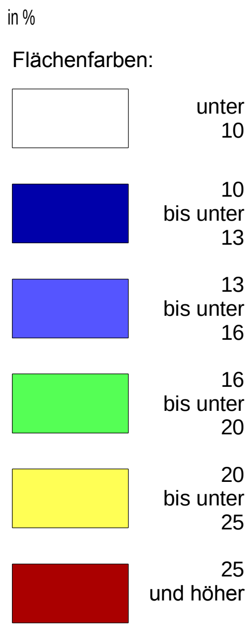
Joerg Baten

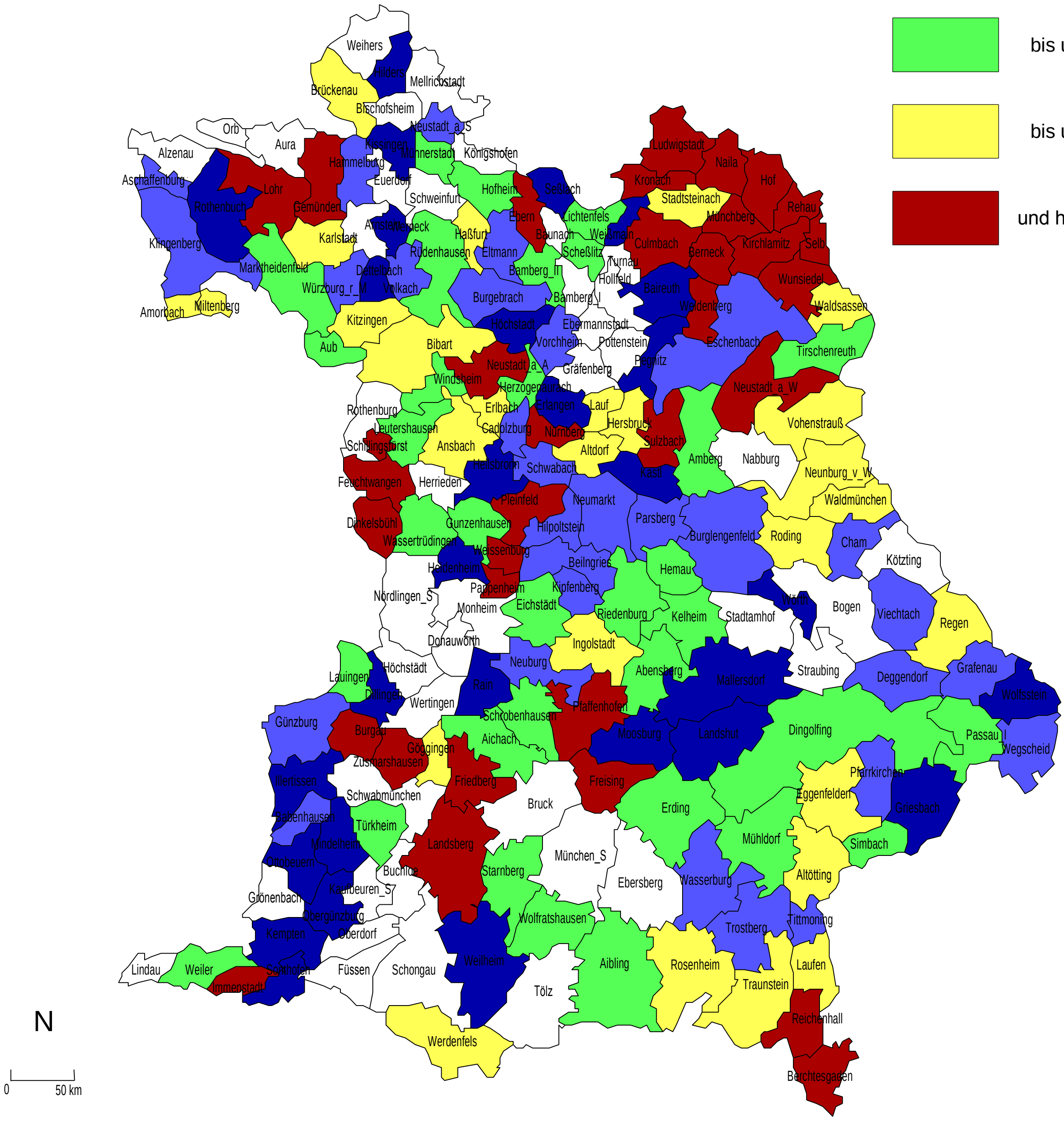
Nutrition and Economic Development in Bavaria, 1730-1880

Maps and Figures





Map 3.1: The share of non-agricultural ocupations
in rural districts



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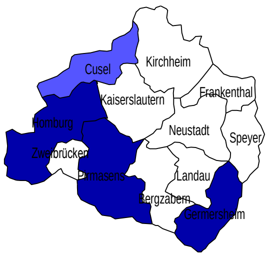
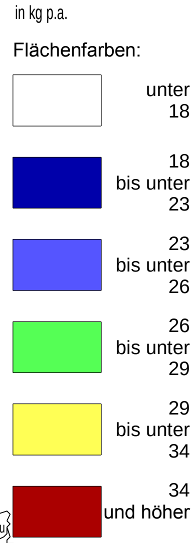
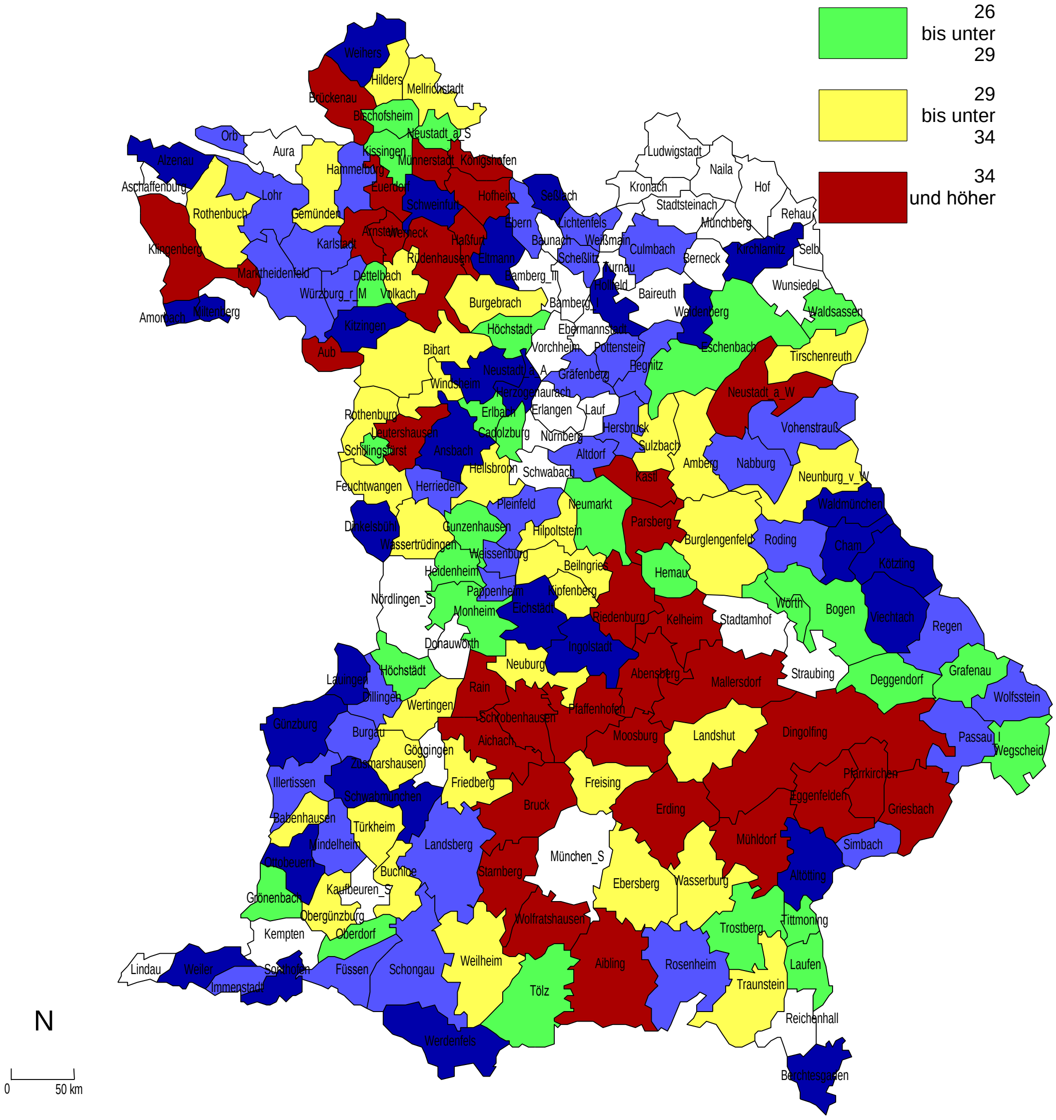


Map 3.2a: Meat production p.c. 1840
in rural districts





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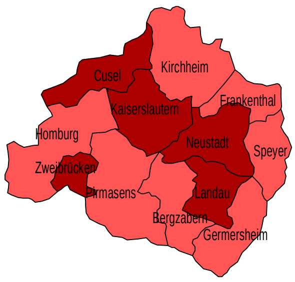
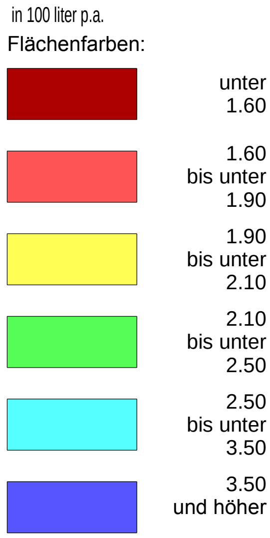
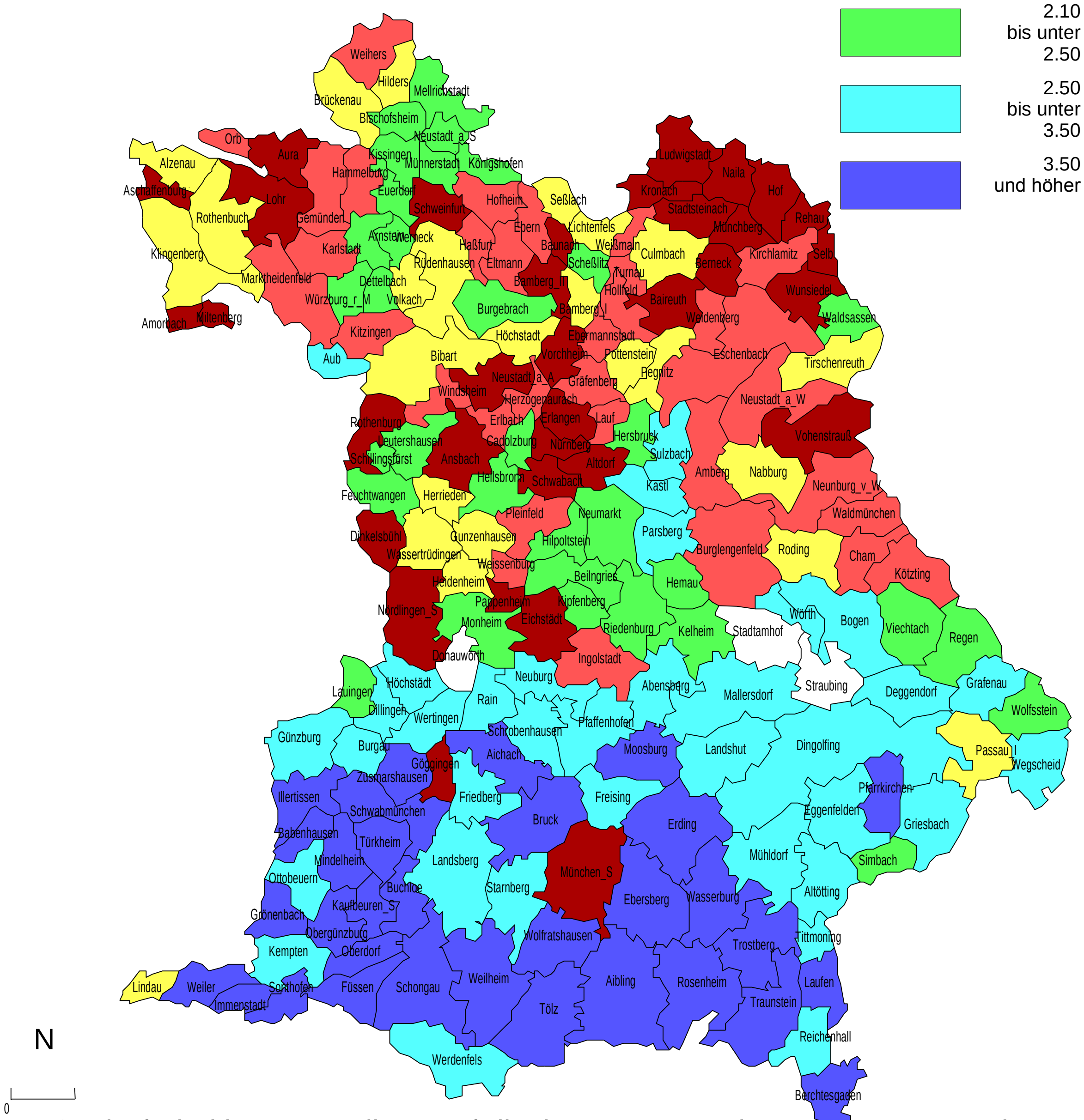
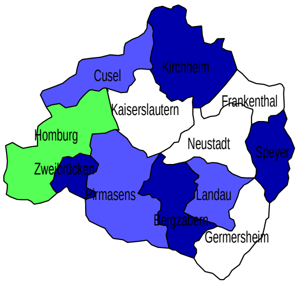




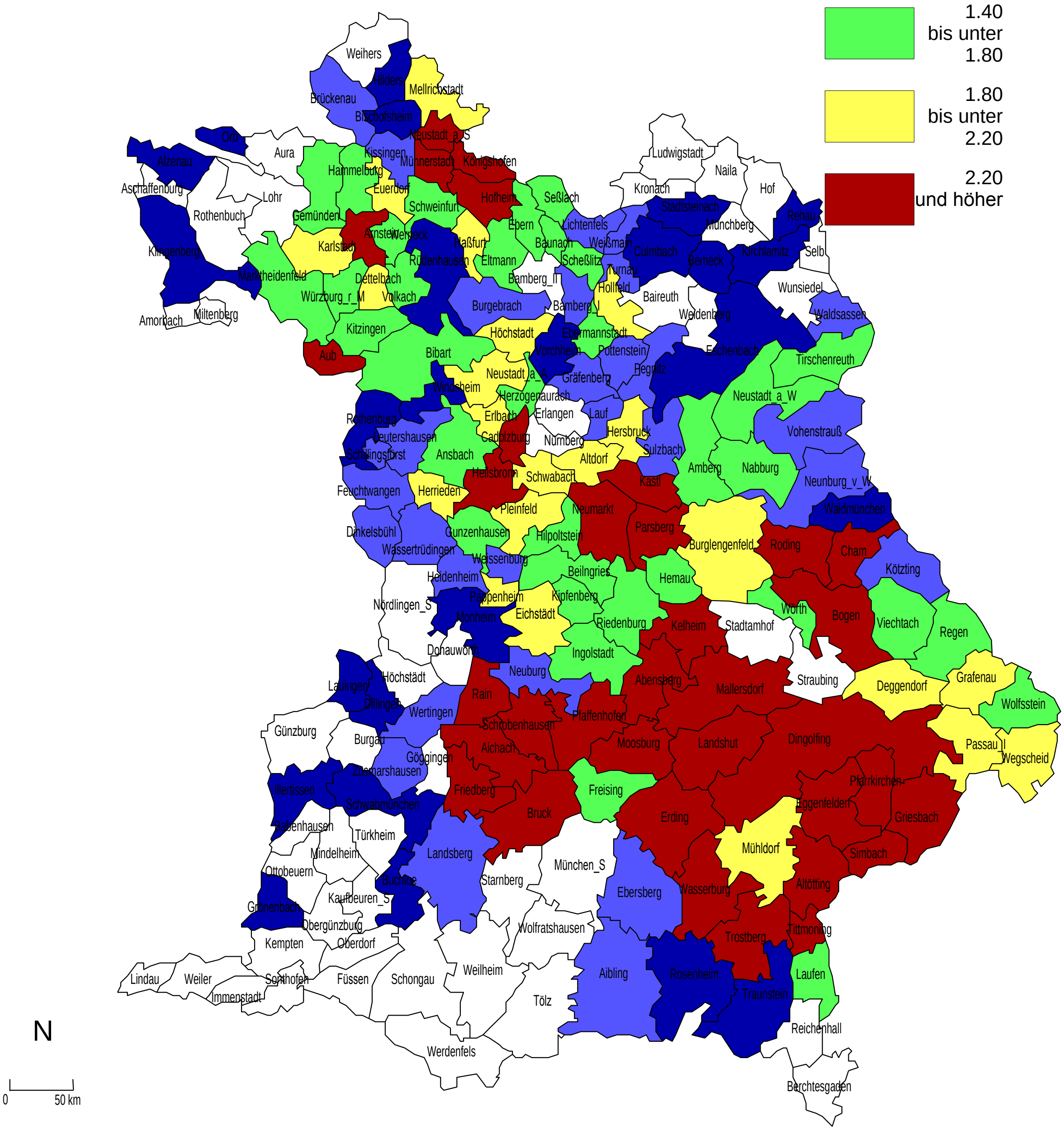
Map 3.2b: Milk production p.c. 1840



Towns included in surrounding rural districts. Aura: No data. Source: see tab. 5.1.



Map 3.3: Rye/Dinkel production p.c. 1853 in rural districts



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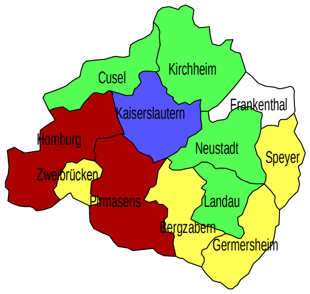
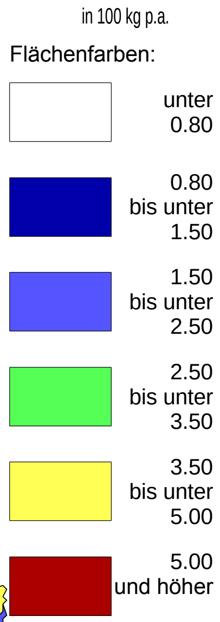
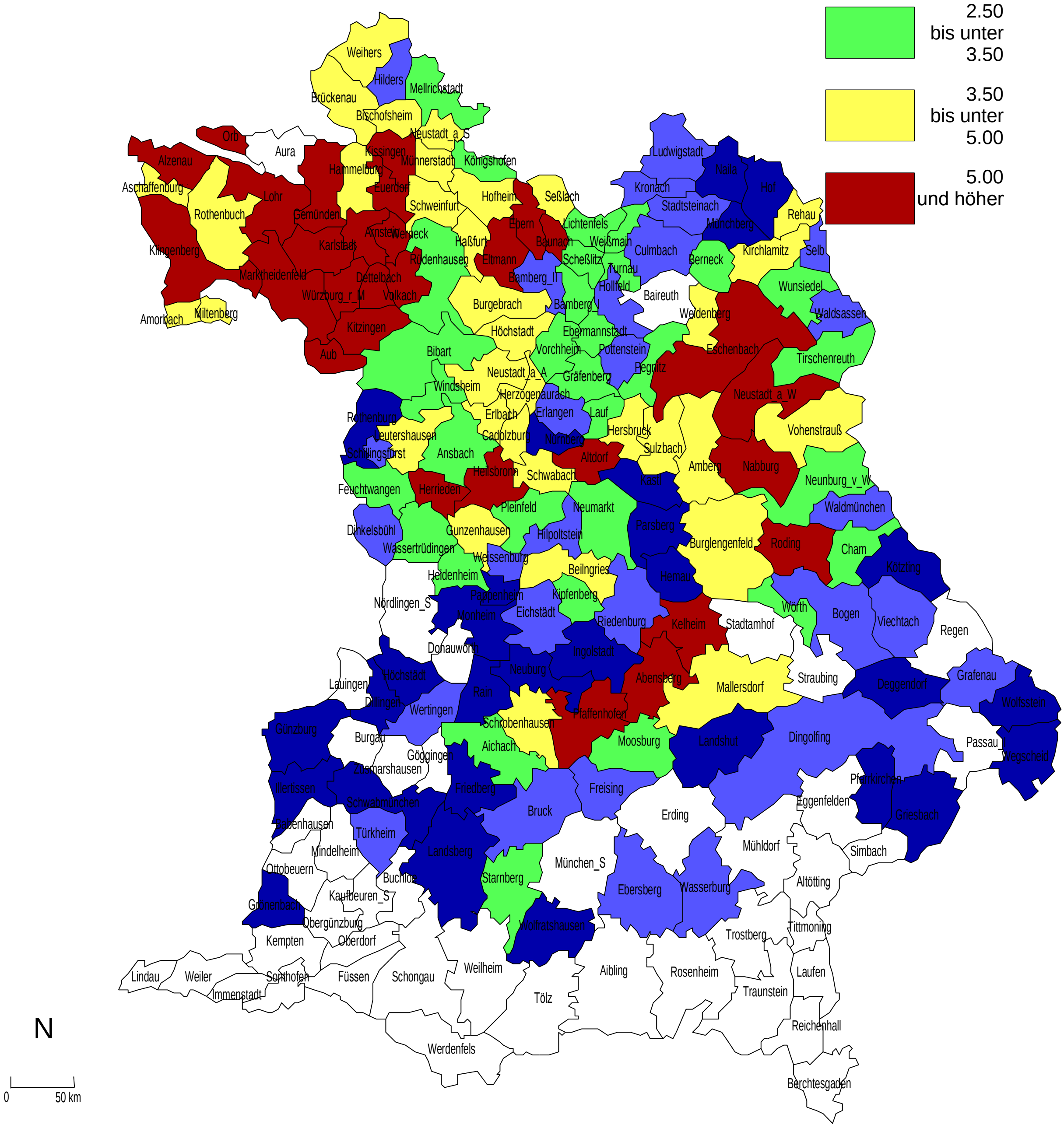


Map 3.4: Potato production p.c. 1853
in rural districts





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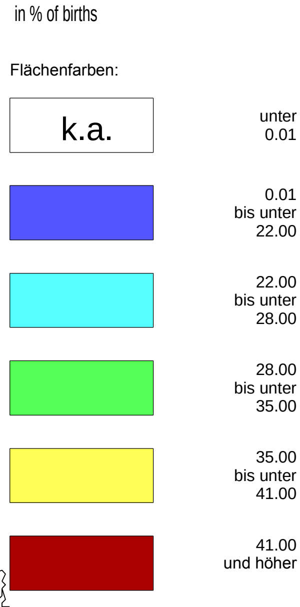
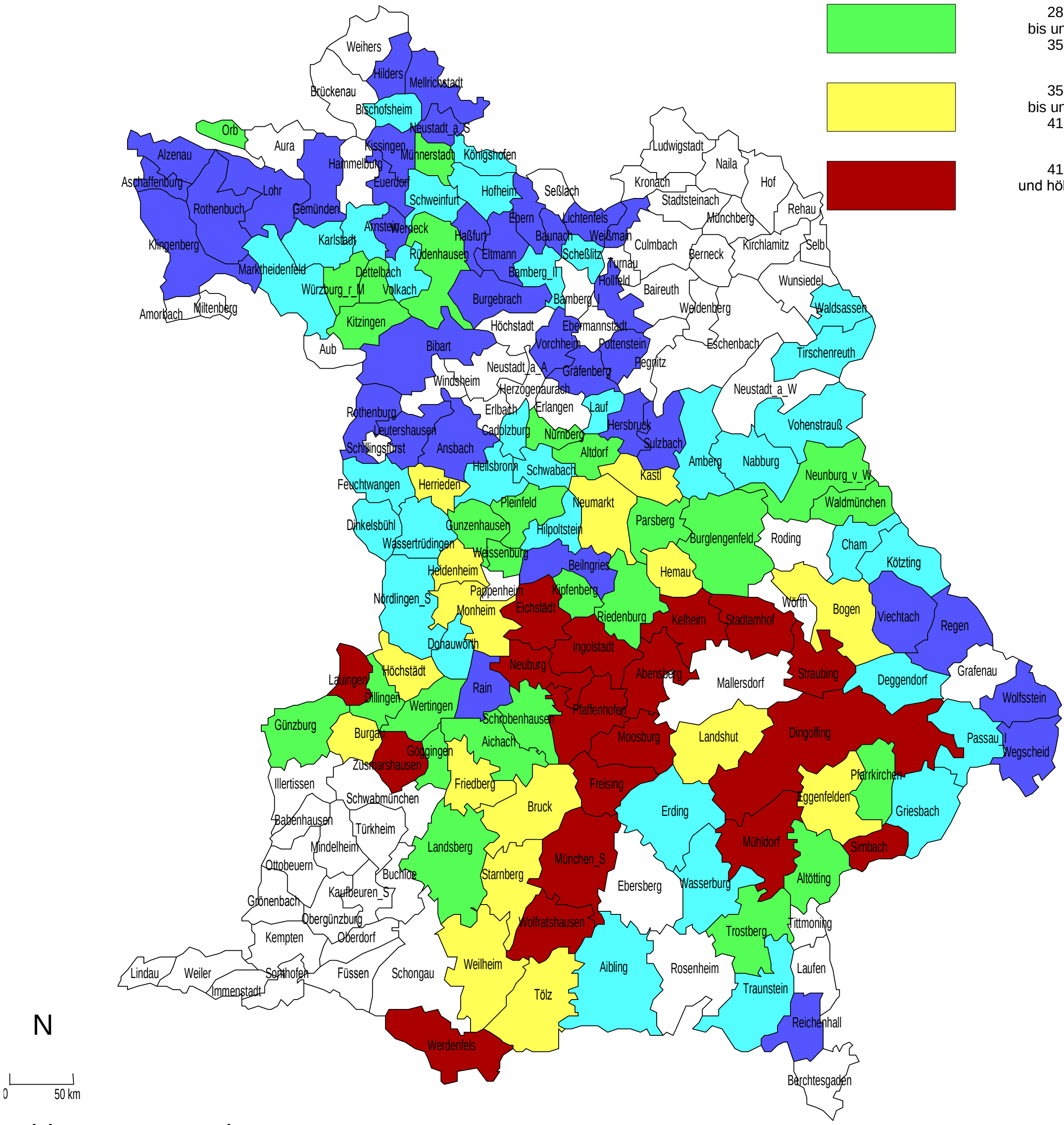
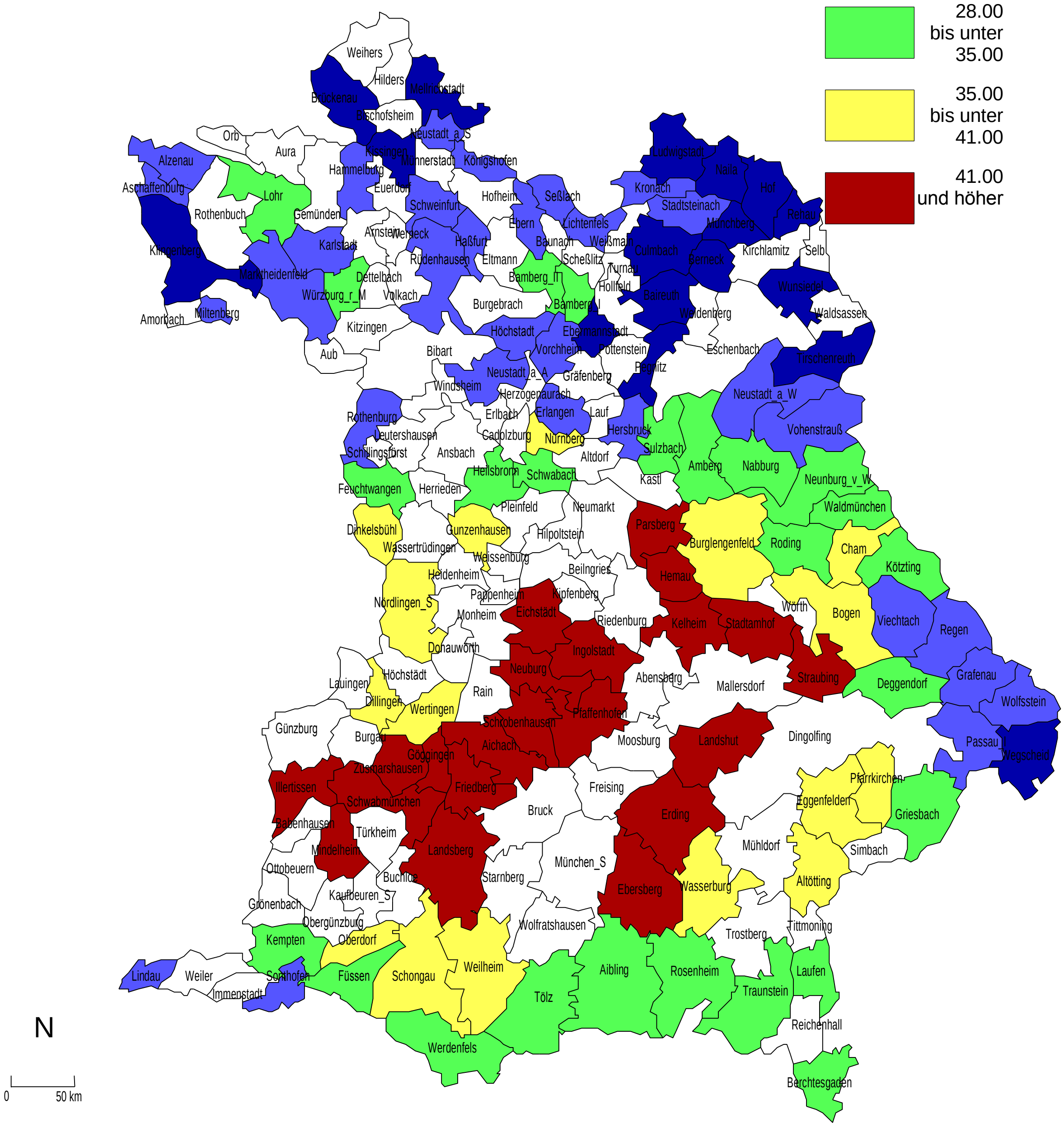
Map 3.6: Infant mortality 1809-15
in rural districts



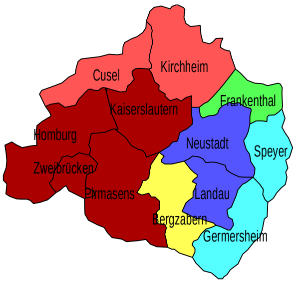


white areas: no data. source: see text.

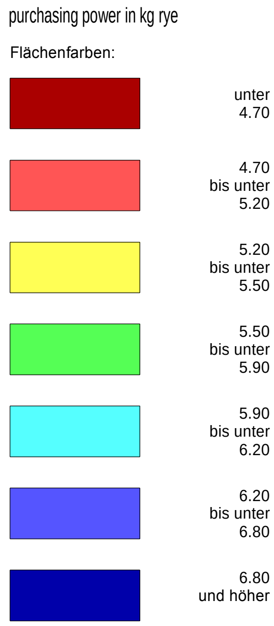
Map 3.7: Infant mortality 1862-68
in rural districts

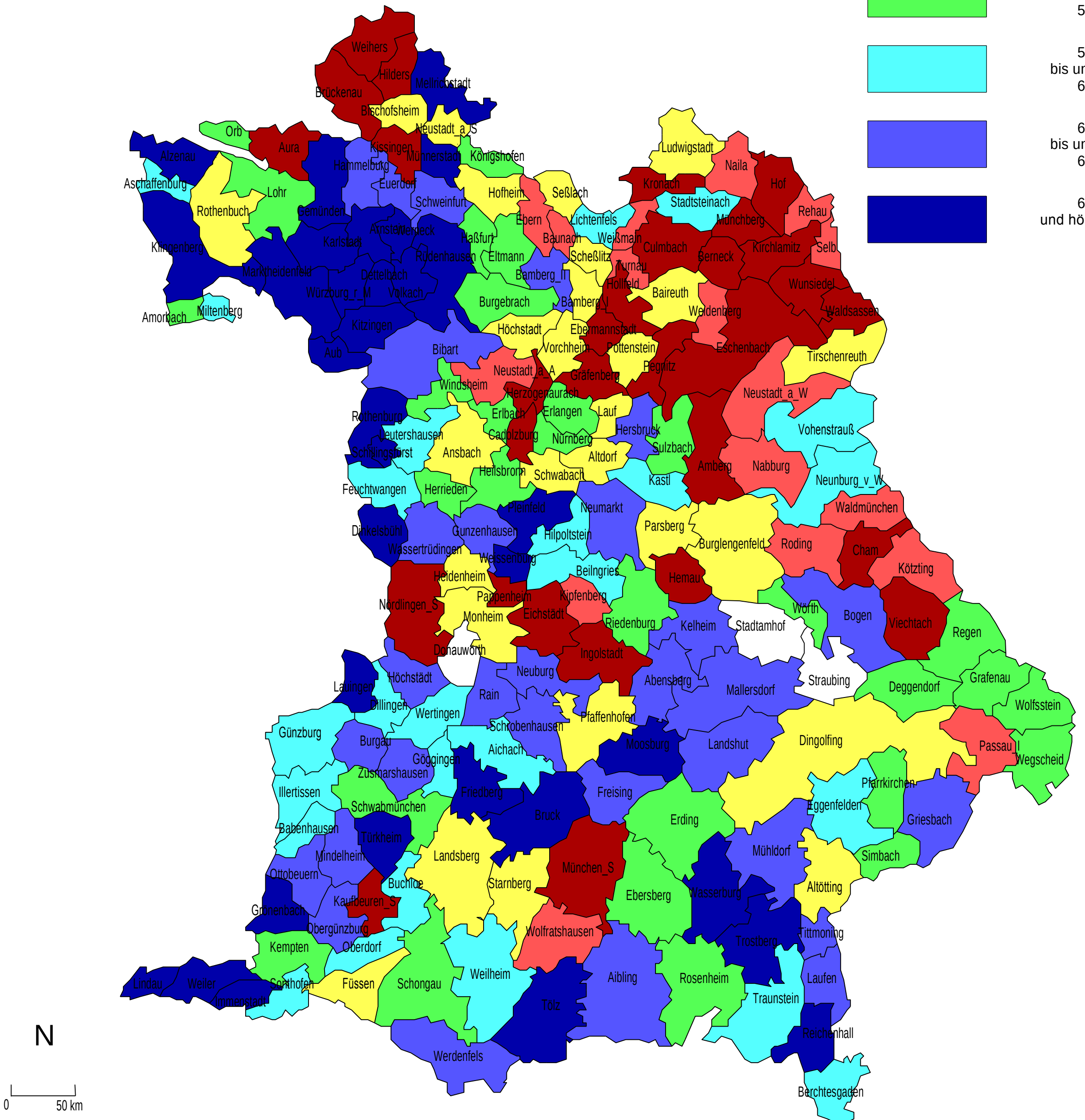


White areas: No data. Source: see Tab. 5.1.

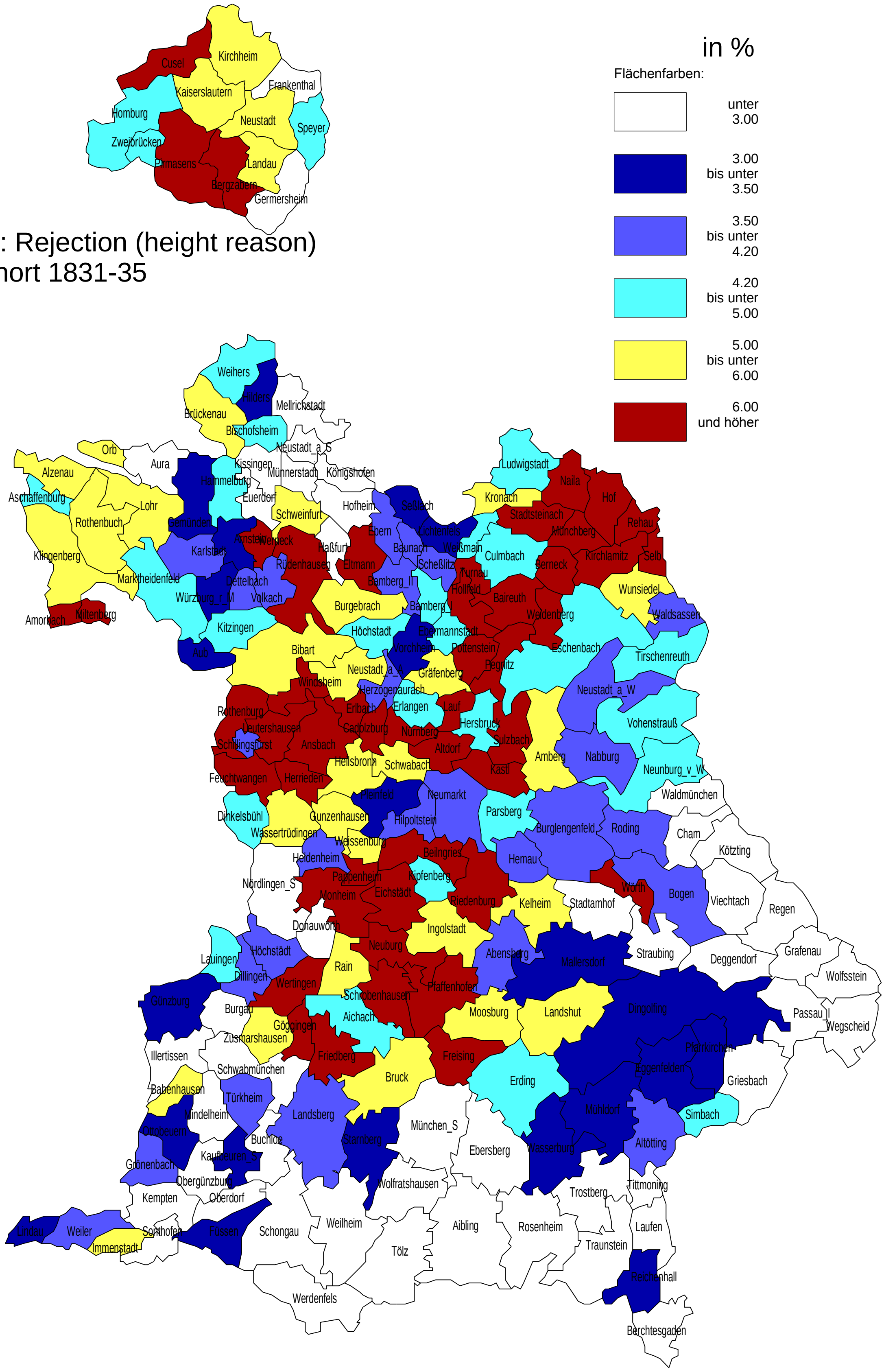


Map 3.9: Real wages (day labourers) 1853
in rural districts





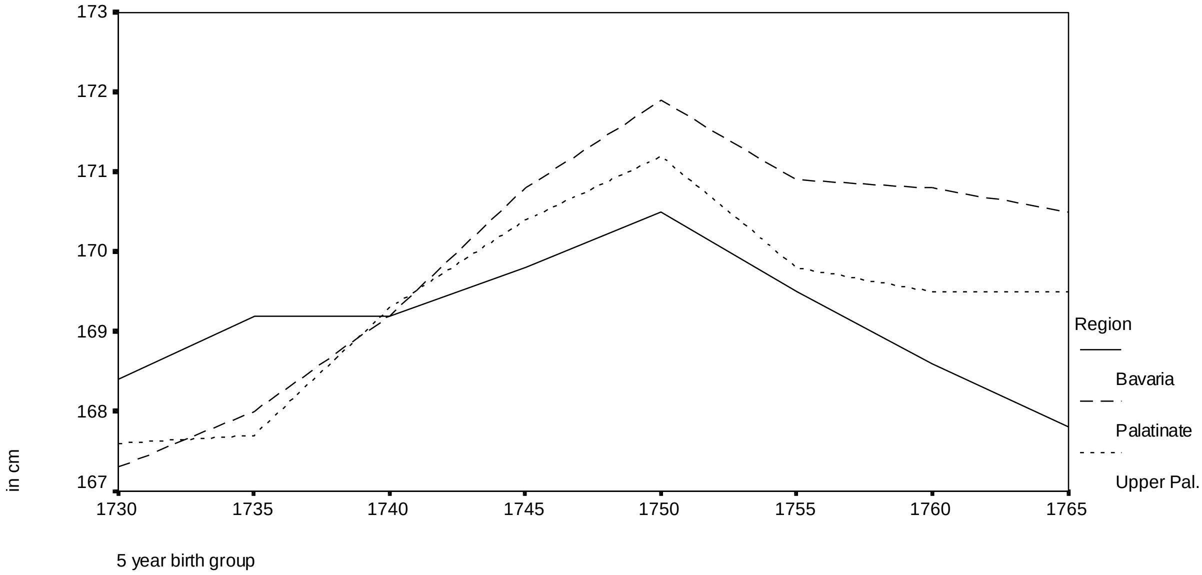
Aura (und towns): no data. Source: see tab. 5.1.



Map 5.1: Rejection (height reason)
Birth cohort 1831-35

Aura, Nördlingen: no data; source: see tab. 5.1

Fig. 3.1. Height development 1730/34-65/69, method RSMLE, all army soldiers



Source: see Table 3.1.

Fig. 3.2. Height development 1730/34-60/64, method K&K estimate, 'Leibsoldaten'

Souce:see Table 3.1.

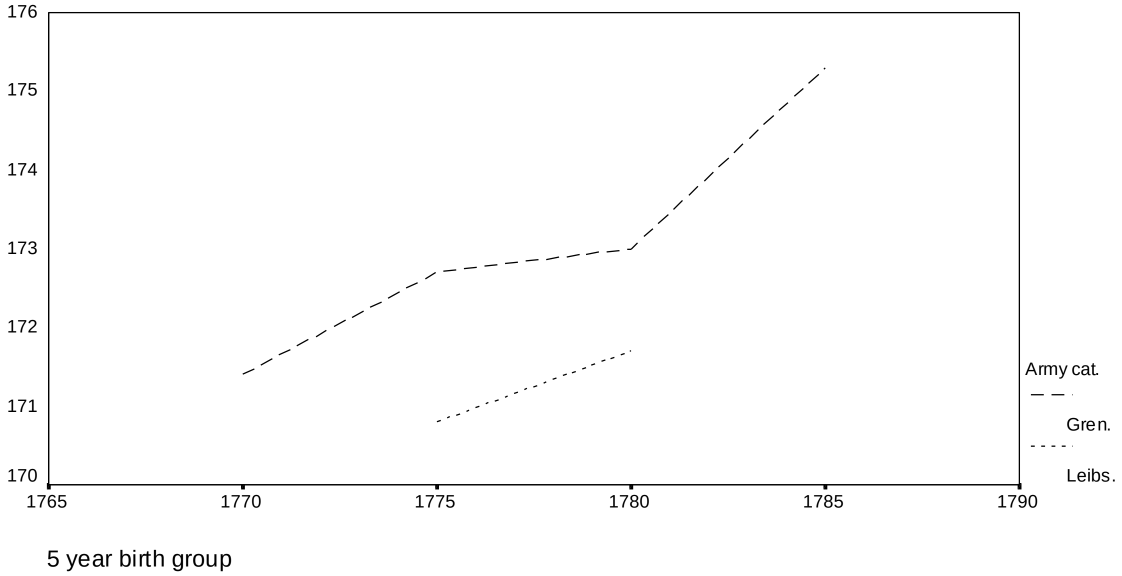
Fig. 3.3. Height development 1730/34-60/64, method K&K estimate, 'Grenadiers'

Source:see Table 3.1.

Fig. 3.4. Height development 1730/34-60/64, method K&K estimate, non-elite soldiers

Source:see Table 3.1.

Fig. 3.5. Height development 1765/69-1790/94, method K&K estimate by army category



Source:see Table 3.1.

Fig. 3.6. Height development 1730/34-65/69, method K&K estimate by age group, non-elite soldiers

Source:see Table 3.1.

Fig. 3.7. Real wage in Munich, grain and potato production p.c. (Tithe Werth./K.)

Source: see text and R. Glaser (1991).

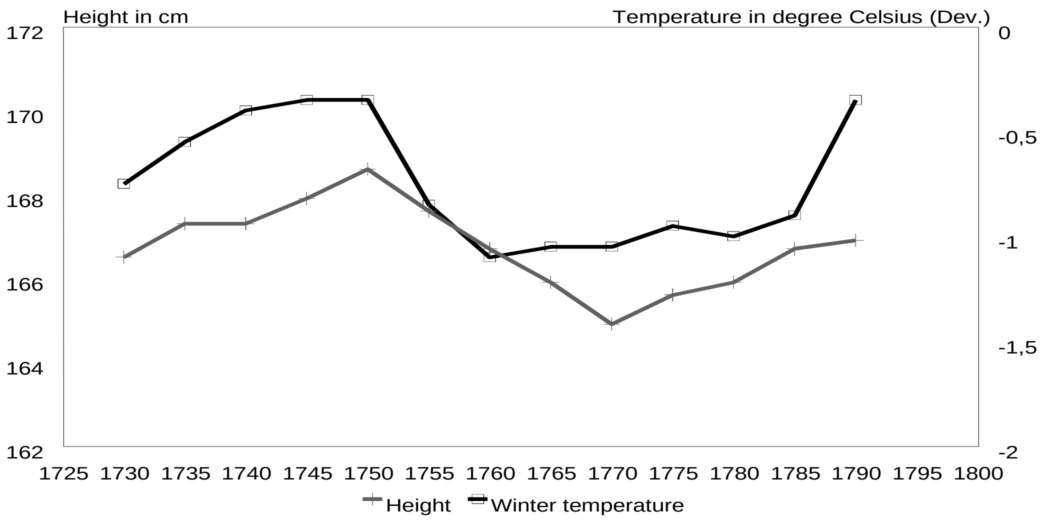
Fig. 3.8. Heights in Bavaria and grain/potato production per capita

Source:see text and Glaser (1991).

Fig. 3.9. Winter temperature in Switzerland (Pfister 1988a)

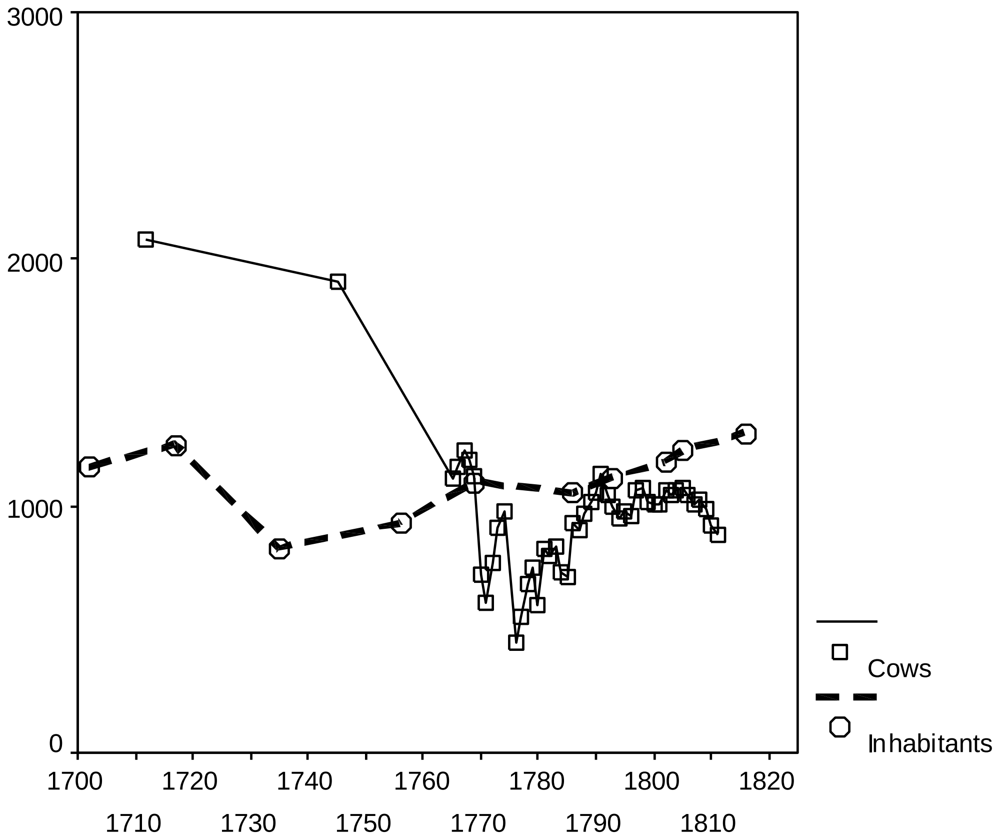
Source:see Table 3.1.

Fig. 3.10. Height in Bavaria and Swiss winter temperature



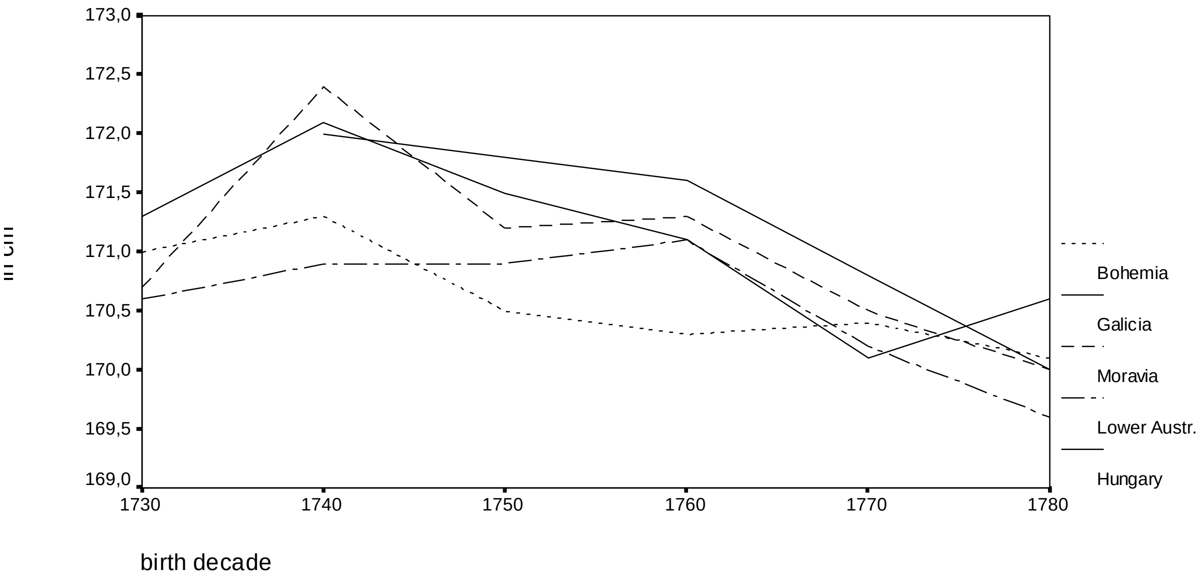
Source:see text and Table 3.1.

Fig. 3.11. Population and number of cows in a district near the North Sea (Stollhamm)



Source: W. Norden (1984).

Fig. 3.12. Heights of Habsburg soldiers, K&K estimates

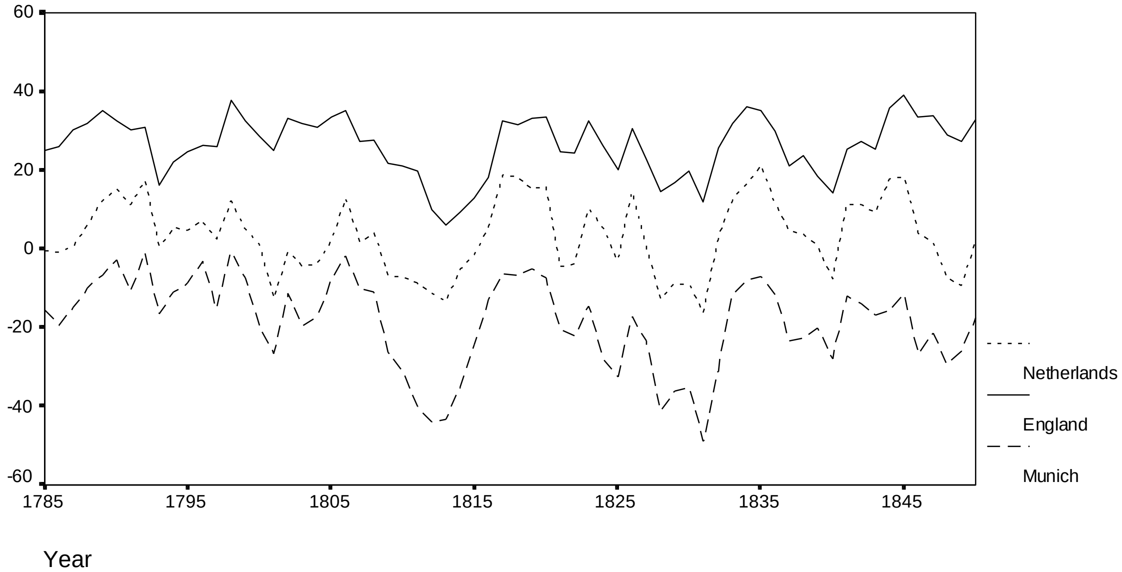


Source: Komlos (1994a).

Fig. 3.13. Heights of British soldiers, K&K estimates

Source: Komlos (1993a)-

Fig. 3.14. Temperature in January, 1785-1849; 10 year moving average

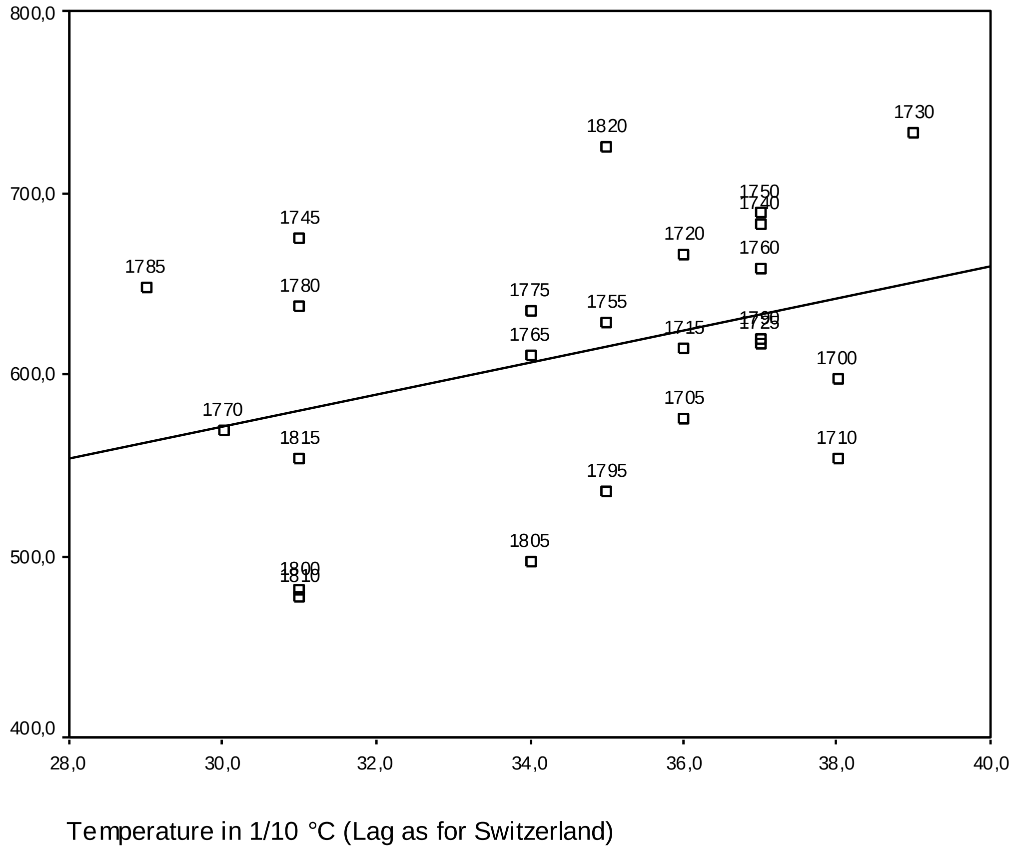


Source: friendly communication by R. Glaser.

Fig. 3.15. Real wages and winter temperature in England

Source: E.A. Wrigley/ R. Schofield (1981).

Fig. 3.16. Real wage and winter temperature in England (1735-39 omitted)



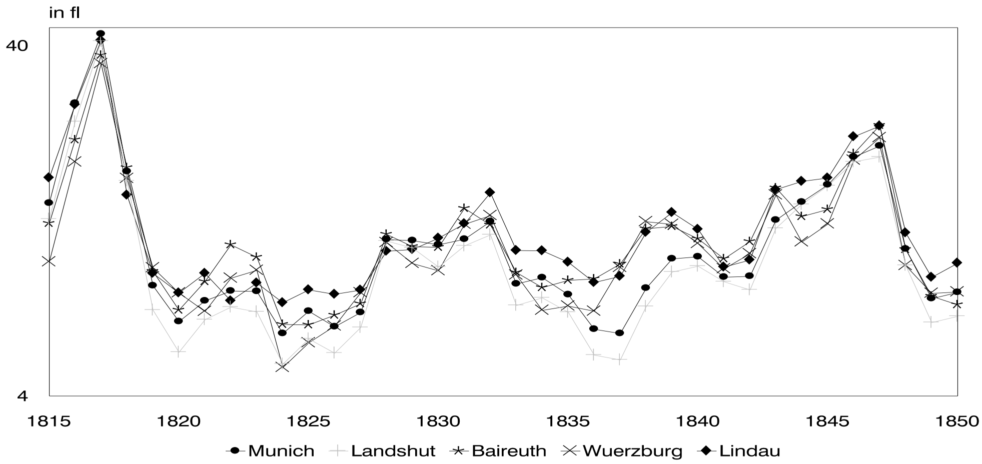
Source: see text and Fig. 3.13.

Fig. 3.17. Index of Baltic Sea Freezing

1901-60=0.4 degree Celsius. The higher the index, the stronger the freezing (and the colder).

Source: G. Koslowski/R. Glaser (1995).

Fig. 4.1. Rye prices in several Bavarian cities

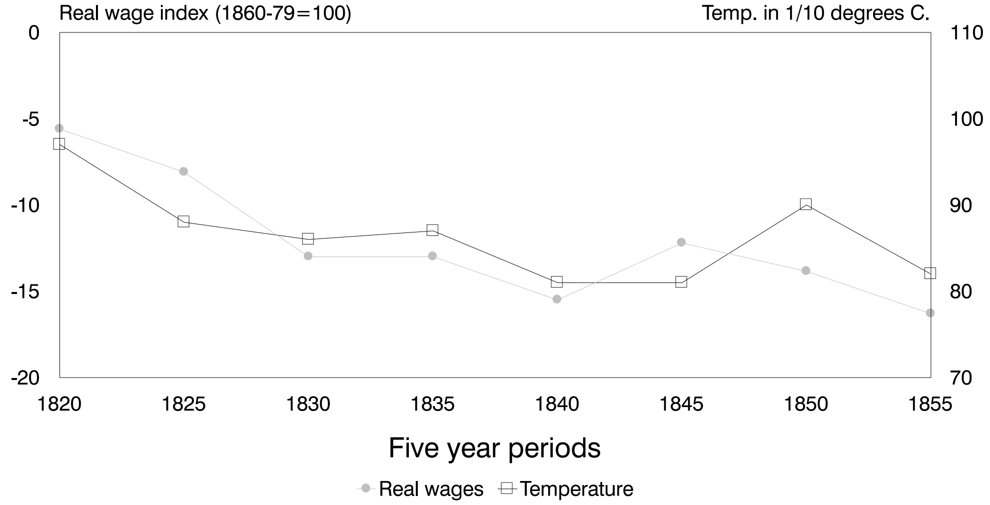


Source: G.K.L. Seuffert (1857).

Fig. 4.2. Cost of living and industrial wages in England

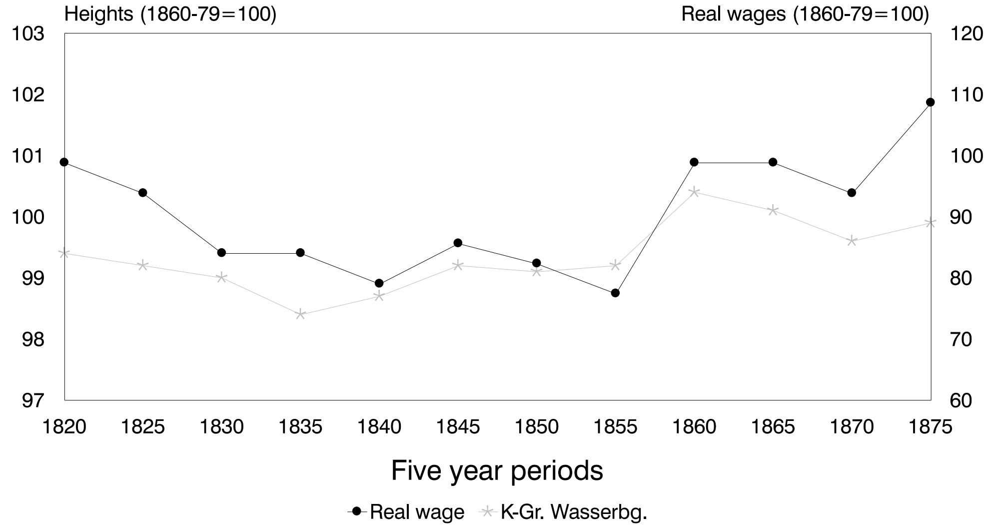
Source: B.R. Mitchell (1993).

Fig. 4.3. Real wage index and winter temperature in Munich



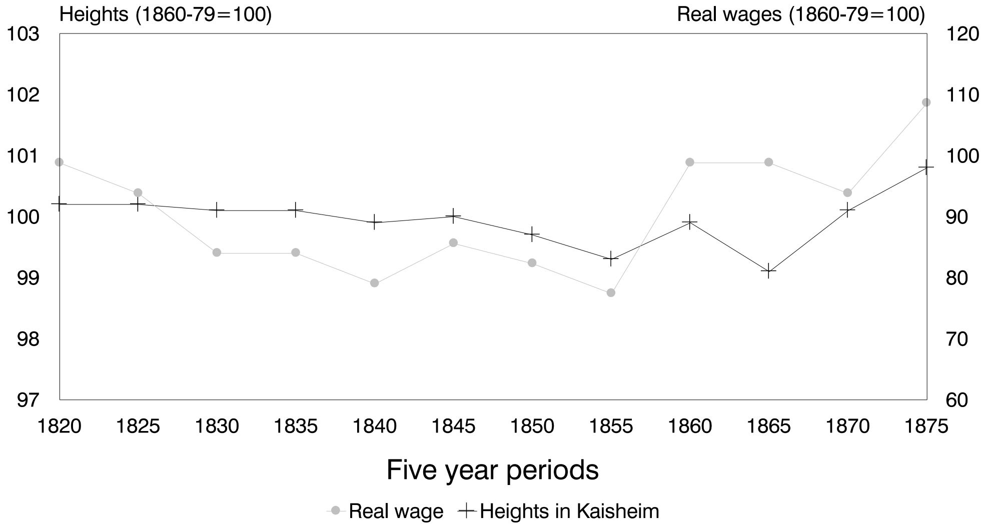
Winter temperature: average of the previous and current five year period.
Source: Friendly communication by Glaser/R. Gömmel (1978).

Fig. 4.4. Real wage index and female heights in Bavaria



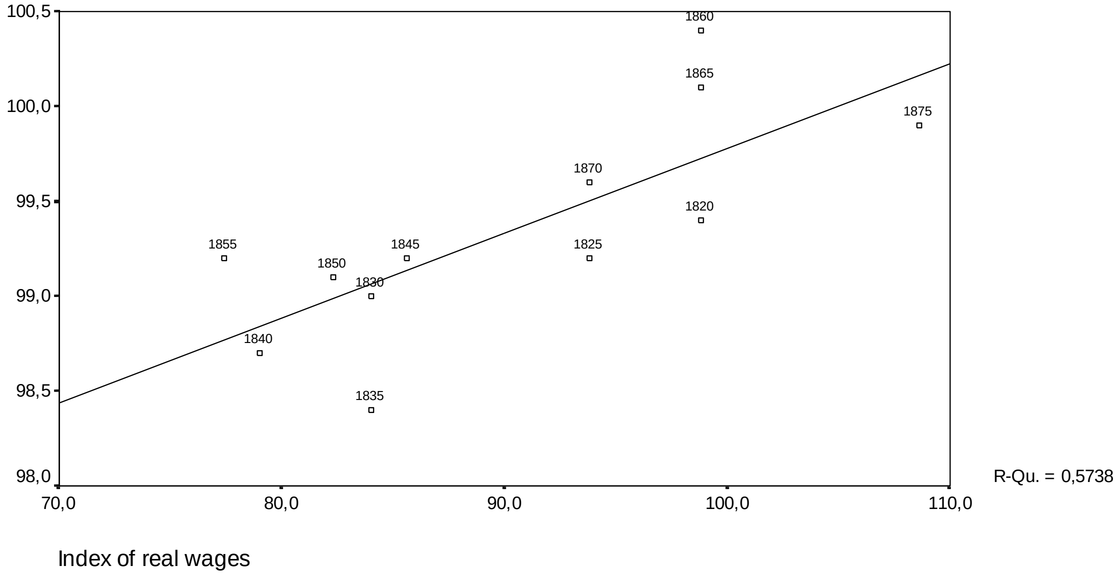
Source: see text and R. Gömmel (1978).

Fig. 4.5. Real wage index and male heights in Bavaria



Source: see text and R. Gömmel (1978).

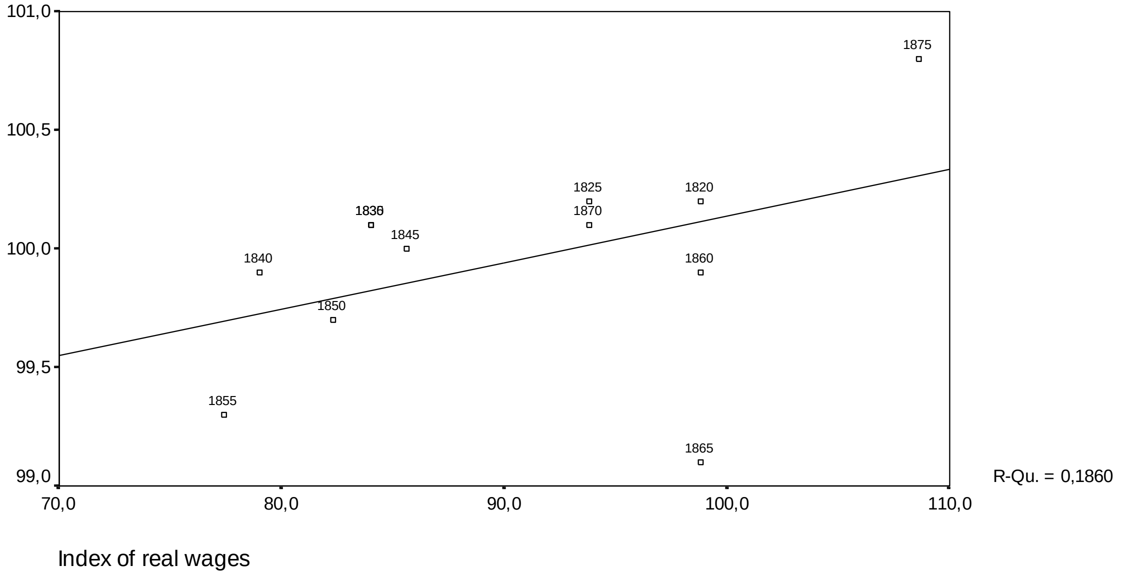
Fig. 4.6. Real wages and female heights in five year periods



Index 1860-79=100

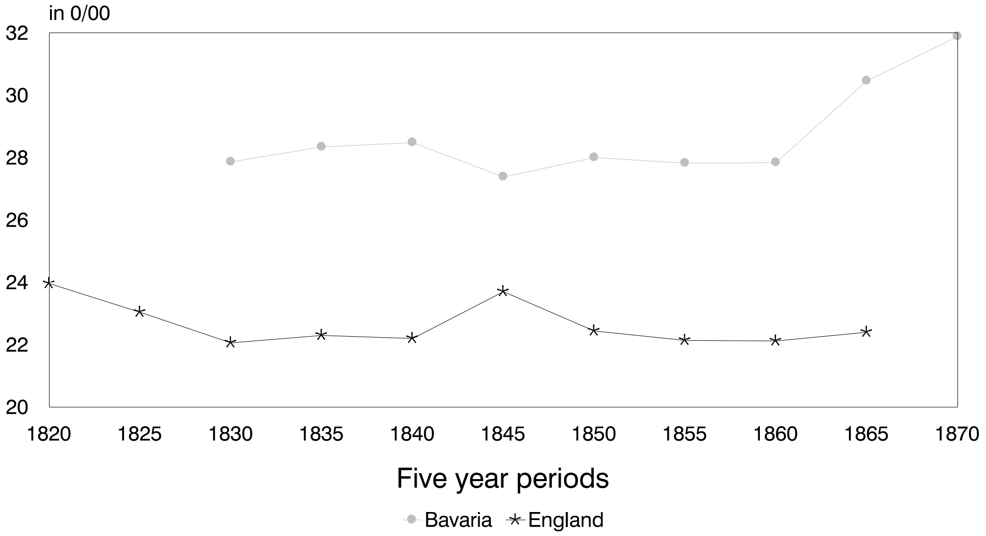
Source: see text and R. Gömmel (1978).

Fig. 4.7. Real wages and male heights in five year periods



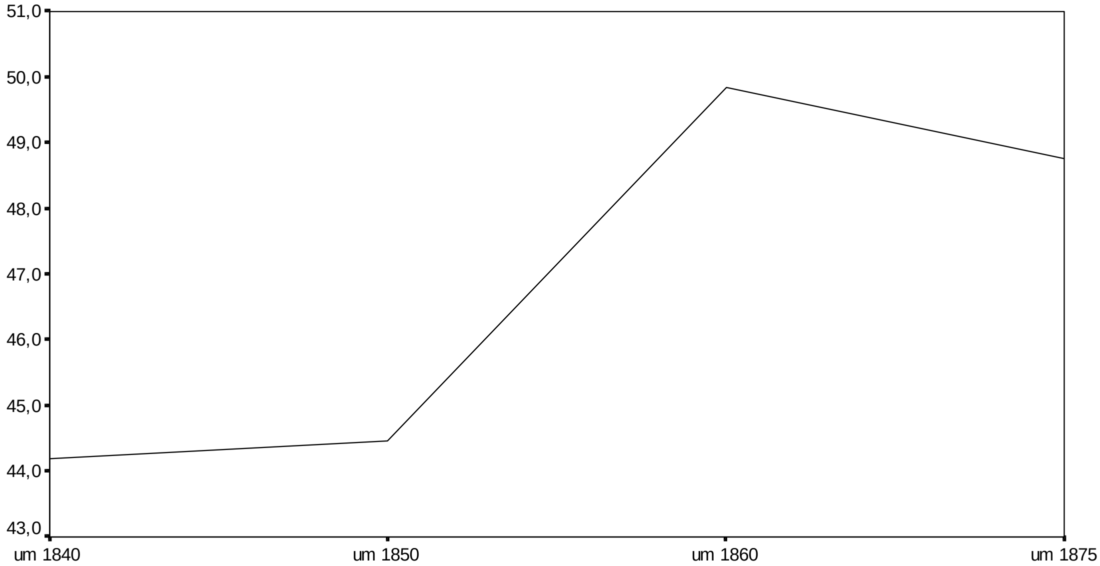
Inex 1860-79=100
Source: see text and R. Gömmel (1978).

Fig. 4.8. Crude death rates



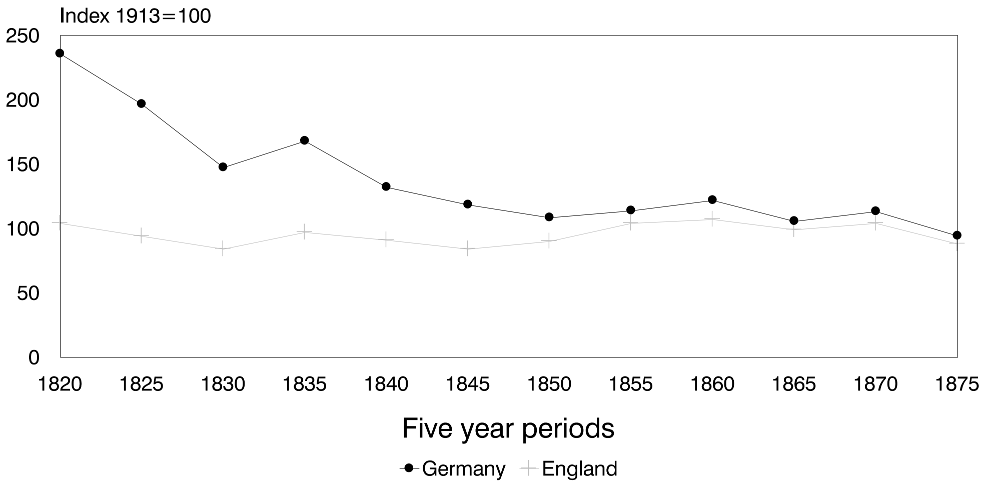
Source: E.A.Wrigley / R. Schofield (1981); W. Köllmann (1980).

Fig. 4.9. Trends in the distribution of wealth in four Palatinate regions



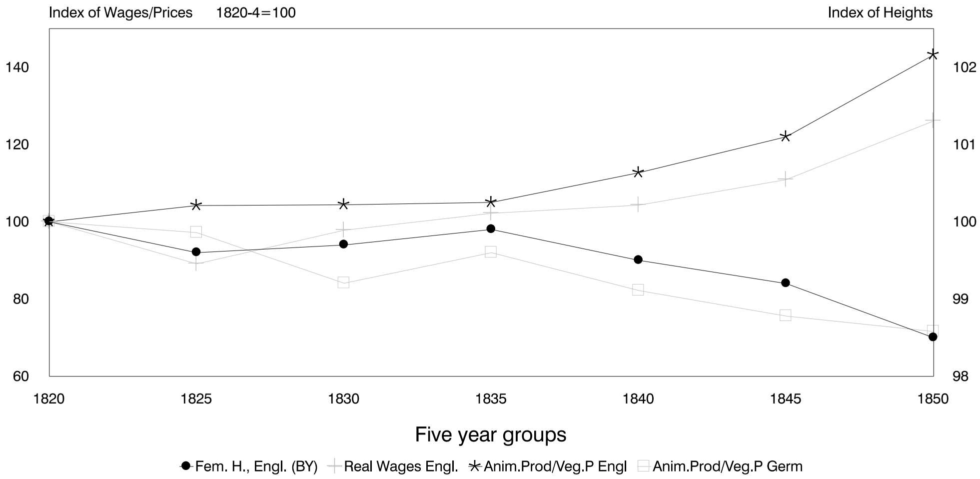
Source: See Table 4.1.

Fig. 4.10. Relative prices of industrial goods (divided by prices of starches)



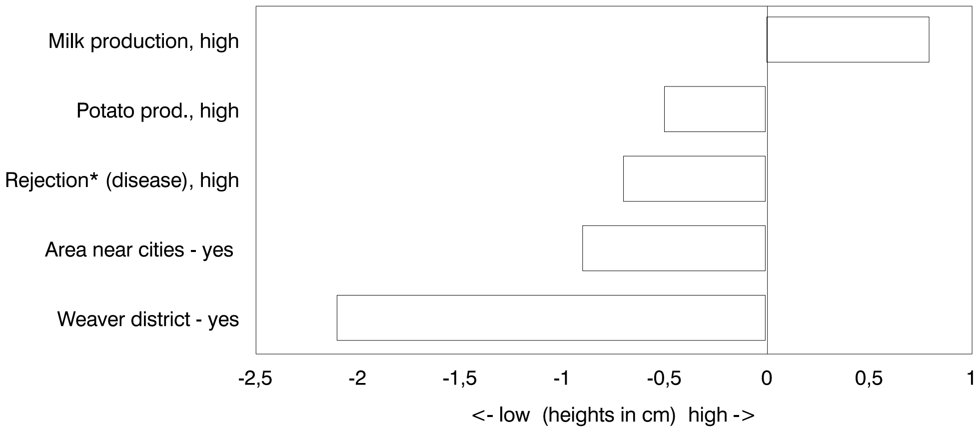
Source: A. Jacobs/ H. Richter (1935), B.R. Mitchell (1988).

Fig. 4.11. Relative prices for animal products, wages, and heights



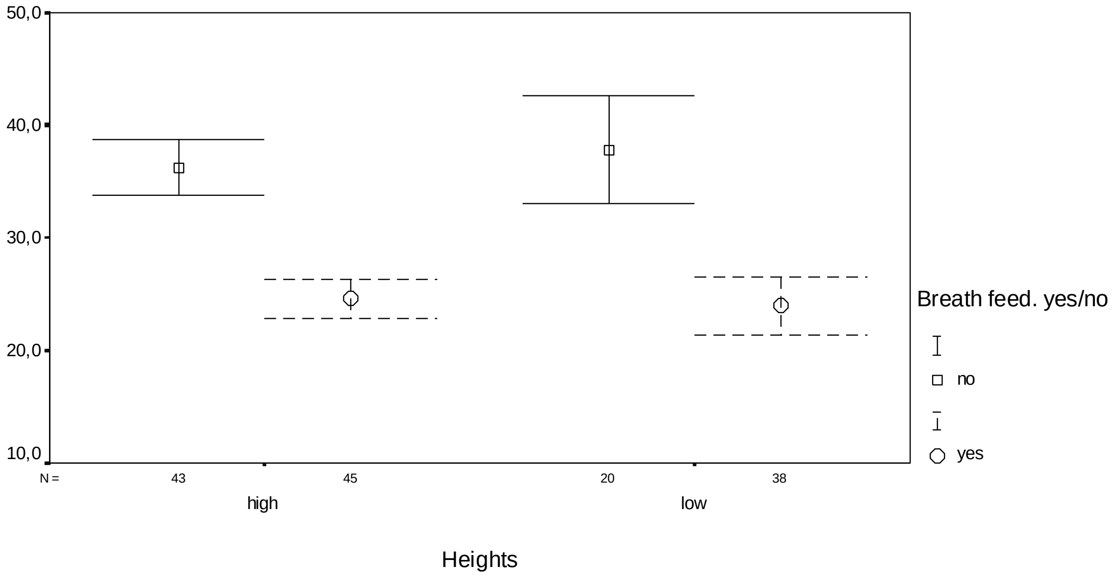
Source: P. Johnson/S. Nicholas (1995), A. Jacobs/ H. Richter (1935), B.R. Mitchell (1988).

Fig. 5.1. Estimated Influence of determinants from Table 5.1 on heights, birth Years 1831-35 (Average height: 165,4 cm)



High: Distance between two standard deviations of the exogenous variables; yes: Dummies; *1809-19.
Source: Table 5.1.

Fig. 5.2. Infant mortality by breath feeding behaviour and heights



Infant mortality of the year 1809/10.
Heights of 1831-35.
Source: see text.

Fig. 7.1. Joint distribution in economy A: perfect equality of nutritional status between groups

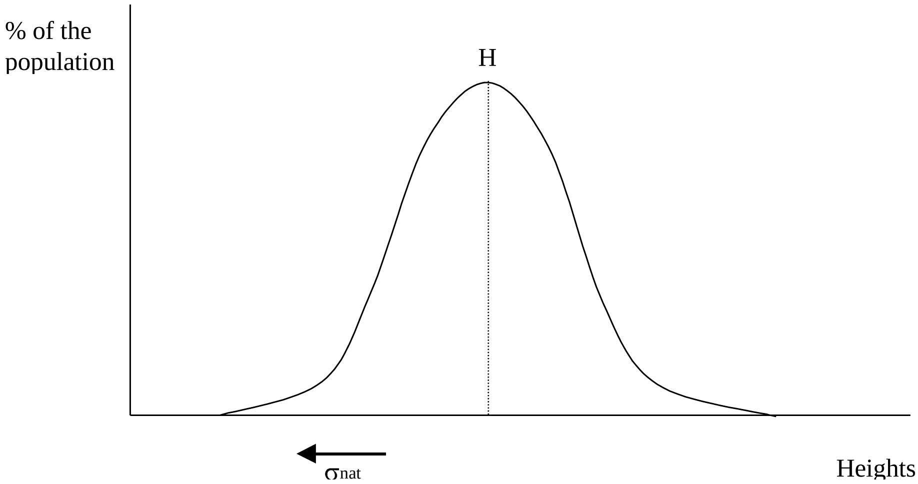


Fig. 7.2. Distribution by group in economy B: inequality of nutritional Status between group 1 & 2

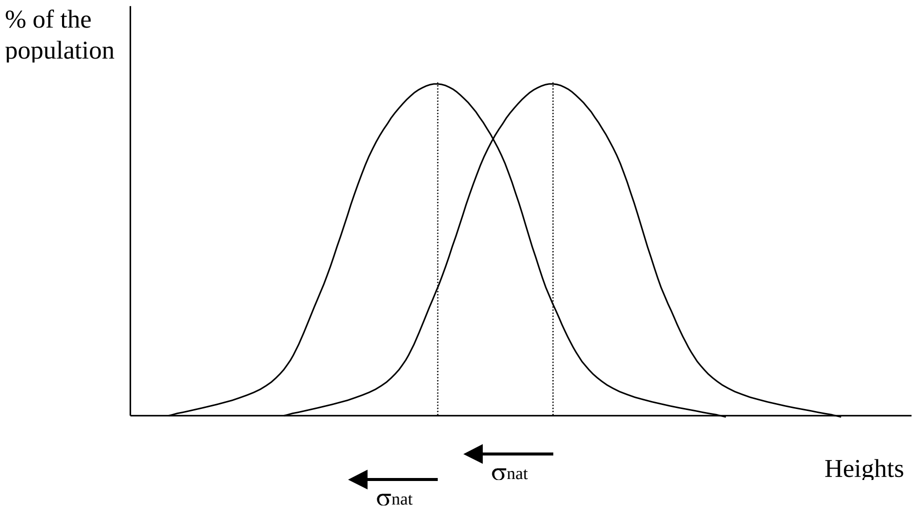
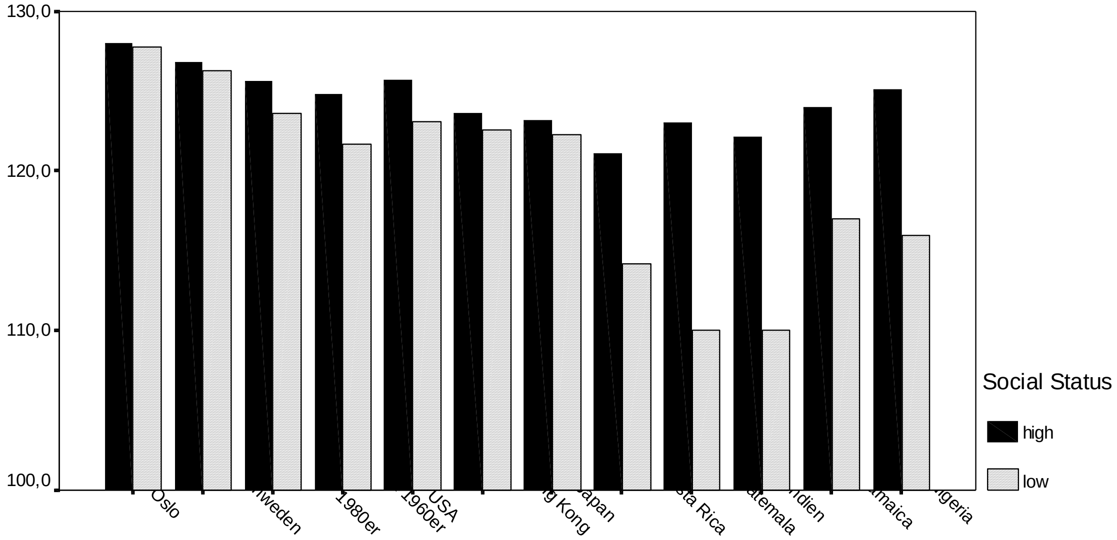
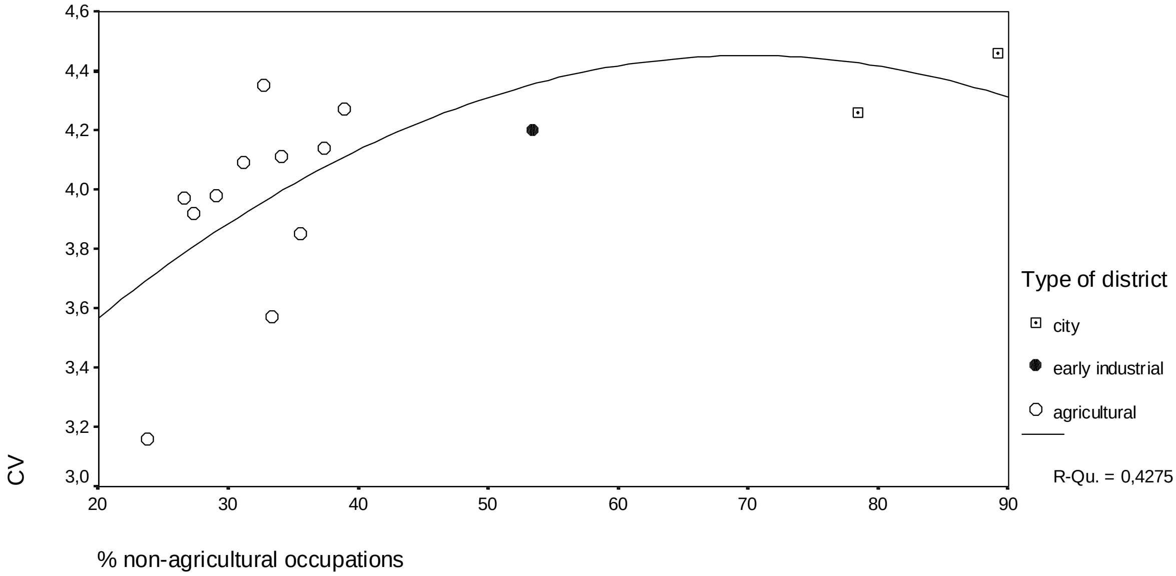


Fig. 7.3. Height of 7.5-year-old boys by socio-economic status in various populations, 1960s-80s



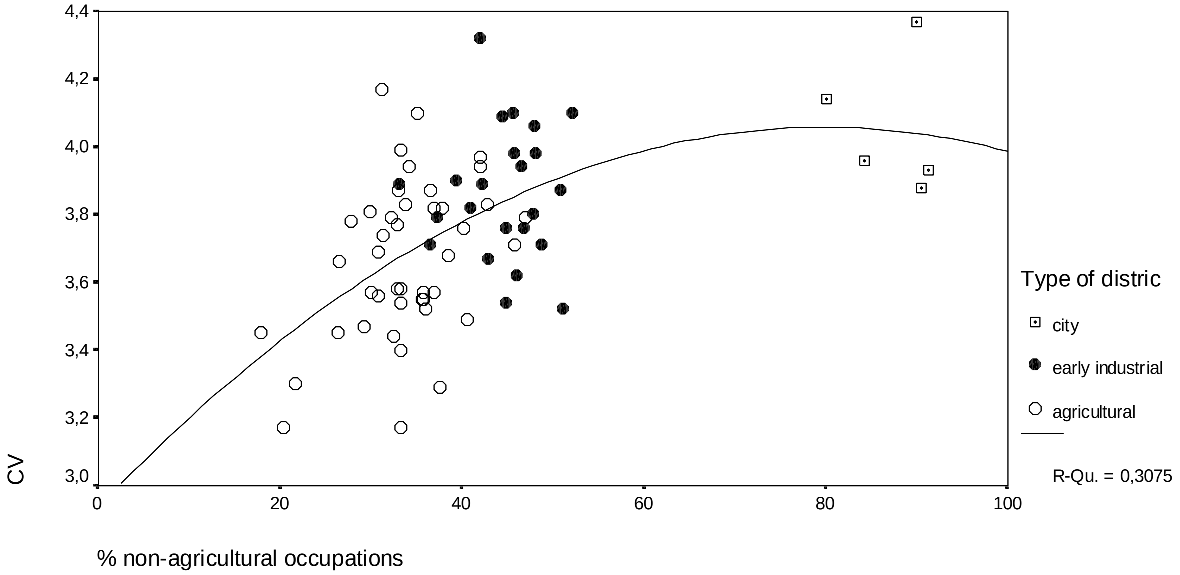
Source: Eveleth, Ph.B./Tanner, J.M. (1990), p. 199.

Fig. 7.4. Coefficient of Variation and Share of Non-agricultural Occupations, Birth year 1797-1801



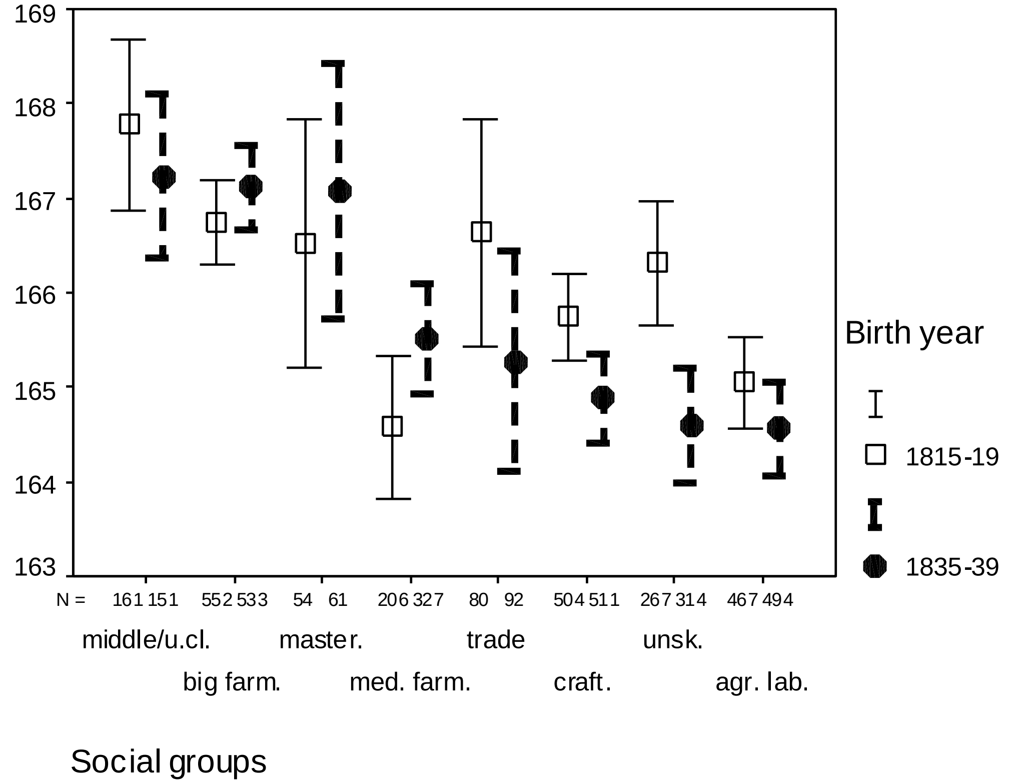
Source: see Tabel 4.1

Fig.7.5. Coefficient of Variation and Share of Non-agricultural Occupations, Birth year 1815-39



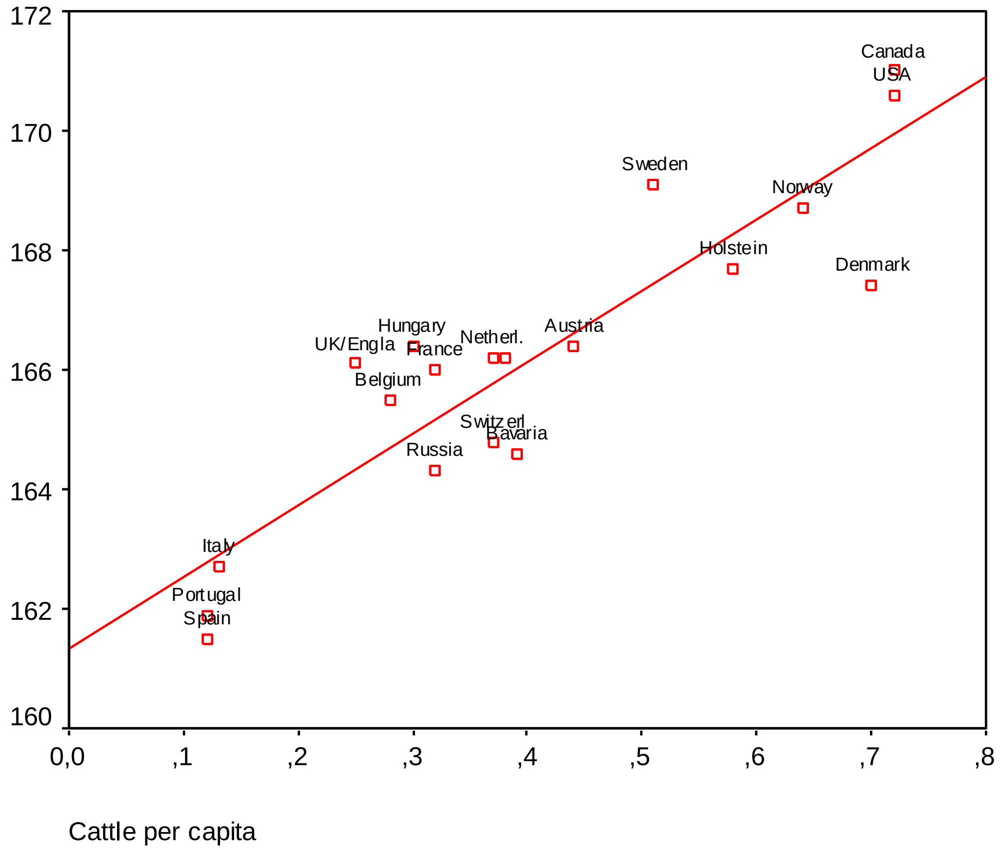
Source: see Tabel 4.1

Fig. 7.6. Winners and losers in height



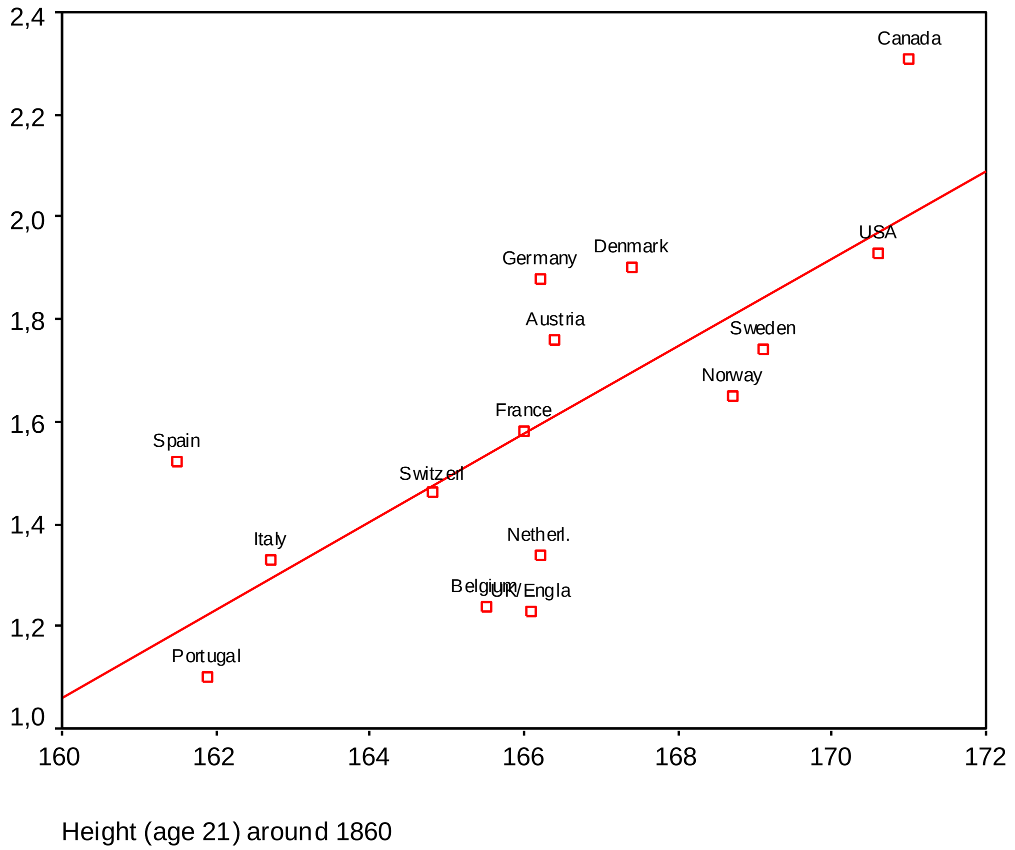
Abbreviations.: see table 7.5. 11 districts included

Fig. 8.1. Height and cattle density around 1860



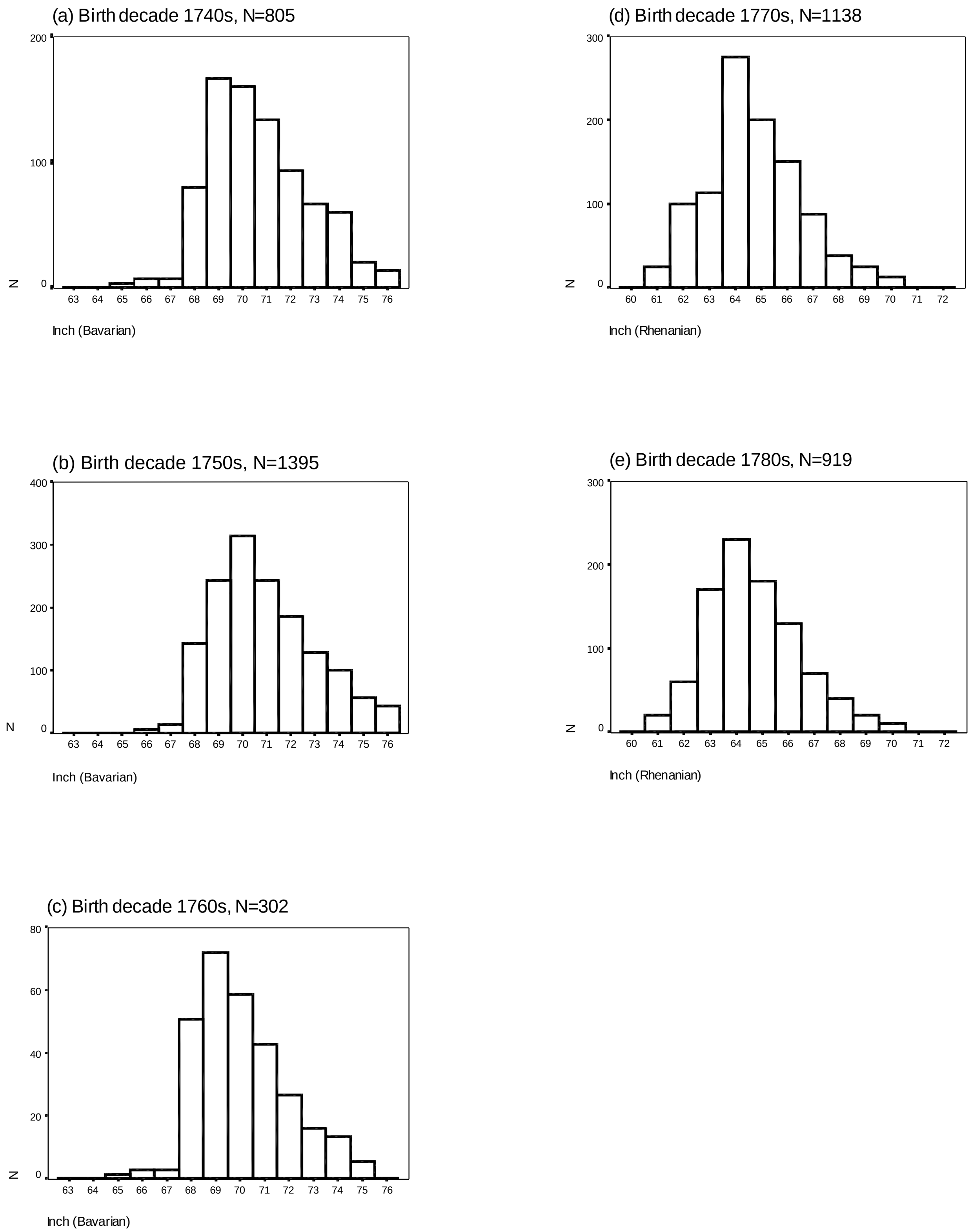
Sources: Mitchell (1983, 1993), Der Viehstand (1883); Baten/Komlos (1998).

Fig. 8.2. Height and real annual growth of GDP per worker-hour



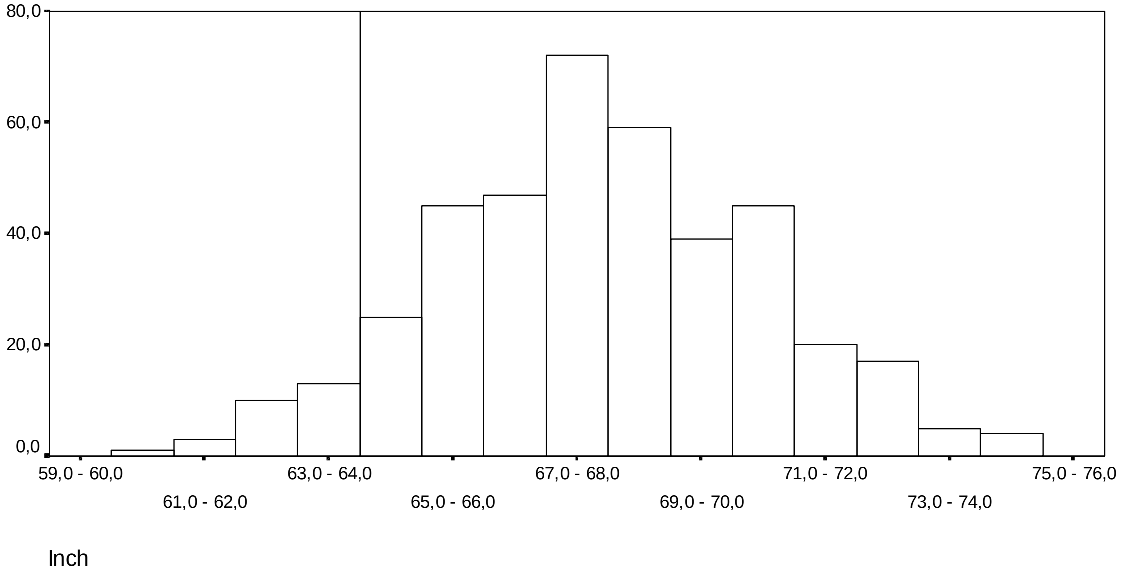
Source: A. Maddison (1991, 1994); C. Bardini et al. (1995); J. Baten / J. Komlos (1998).

Fig. B.1: Height distribution of Bavarian soldiers

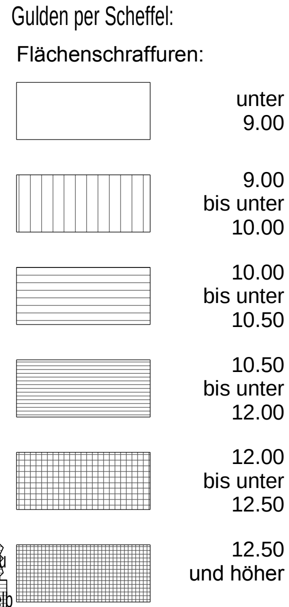


Source: see Table 3.1

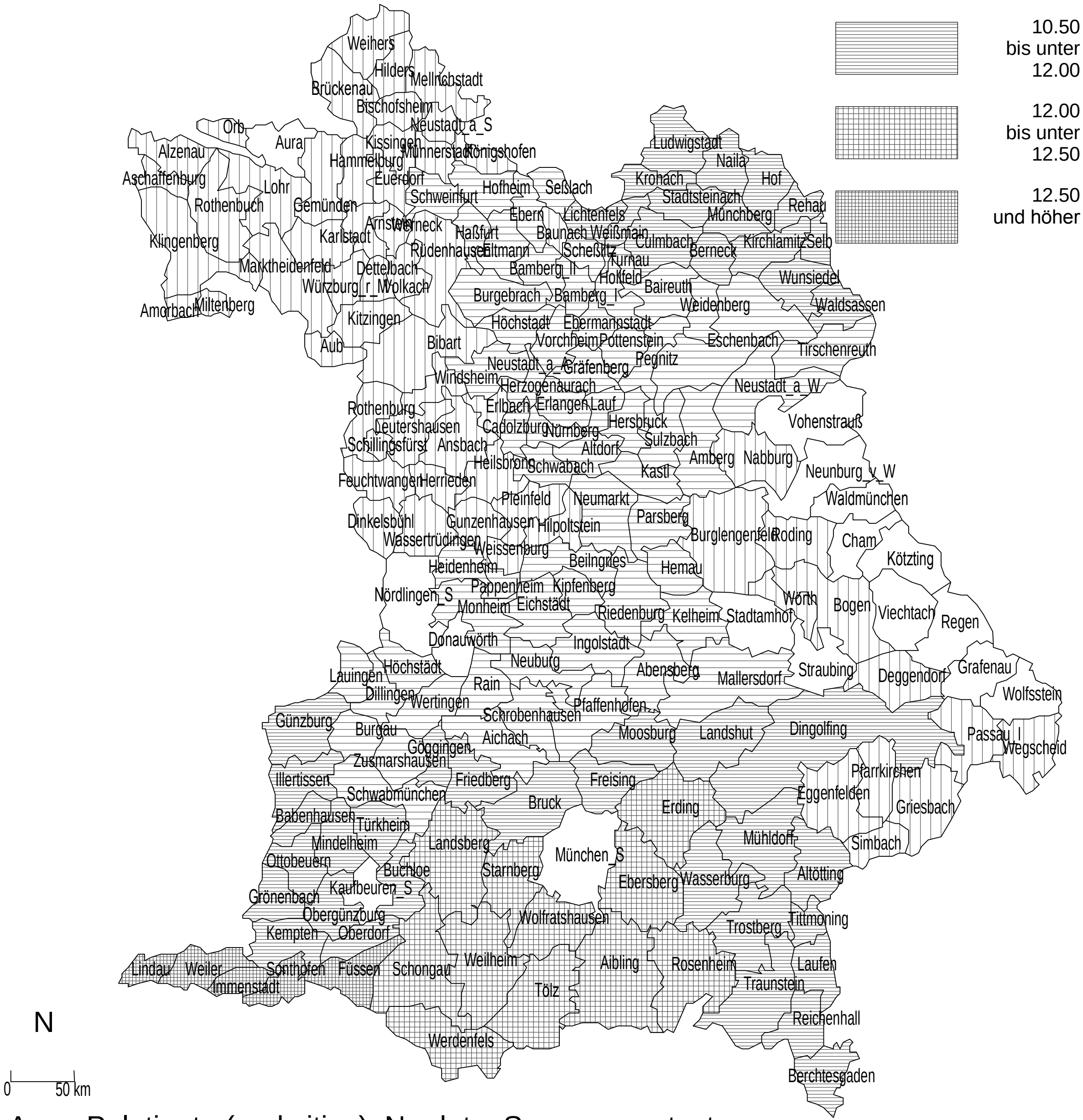
Fig. B.2. Distribution of Heights, Altdorf, Birth Decade 1830s



Source: see Table 4.1.

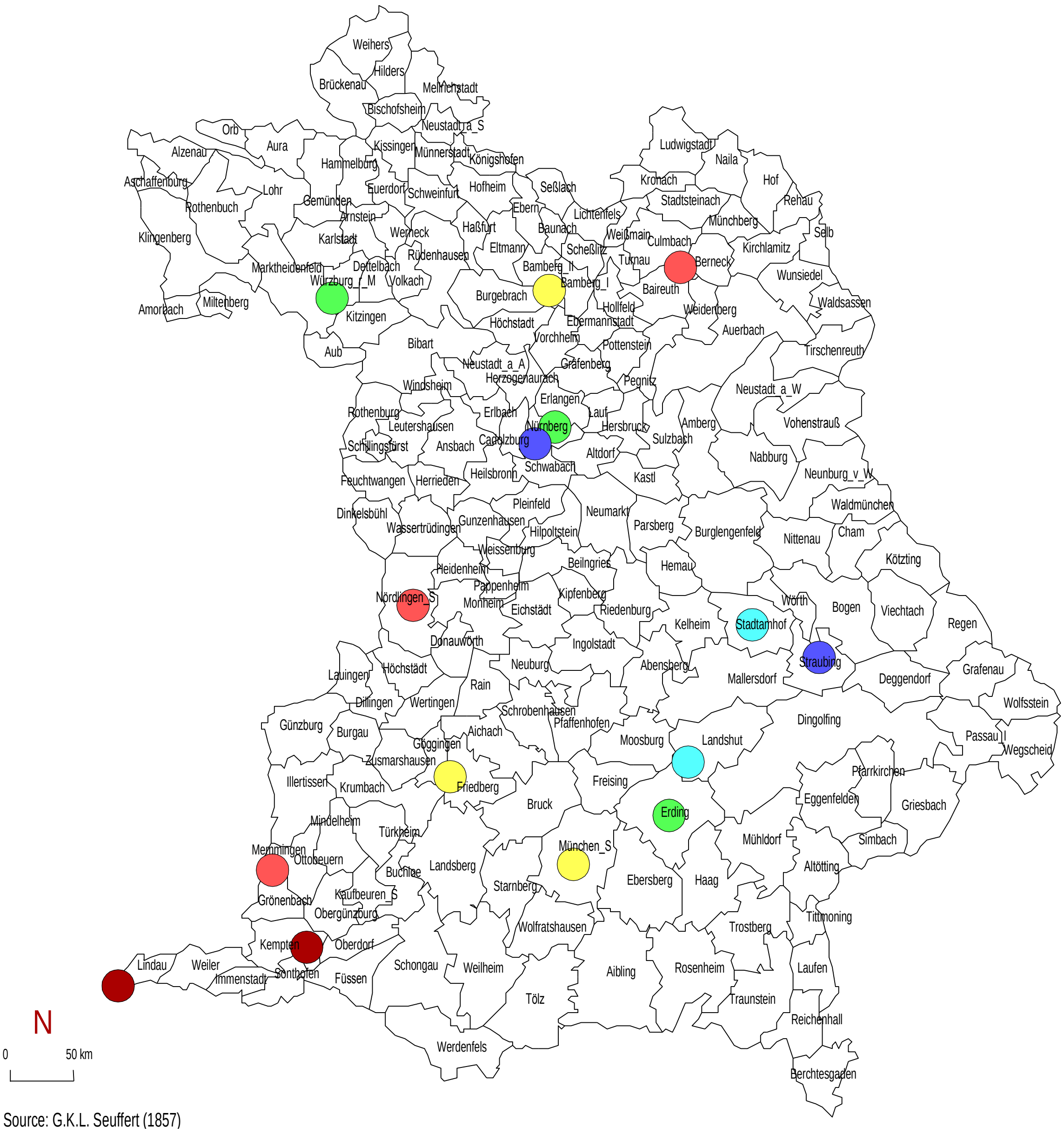


Map A.2: Rye price regions

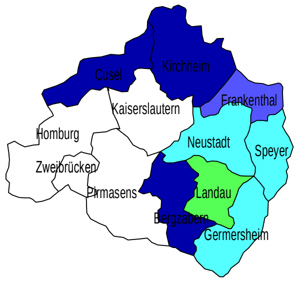


Aura, Palatinate (and cities): No data. Source: see text.

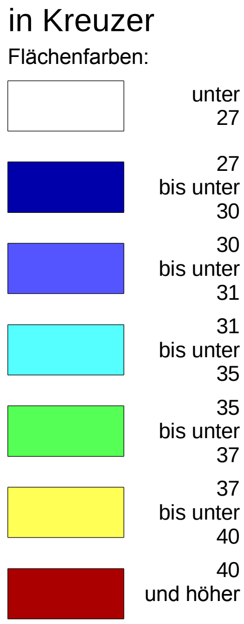
Map A.3: Rye prices, 1815-55

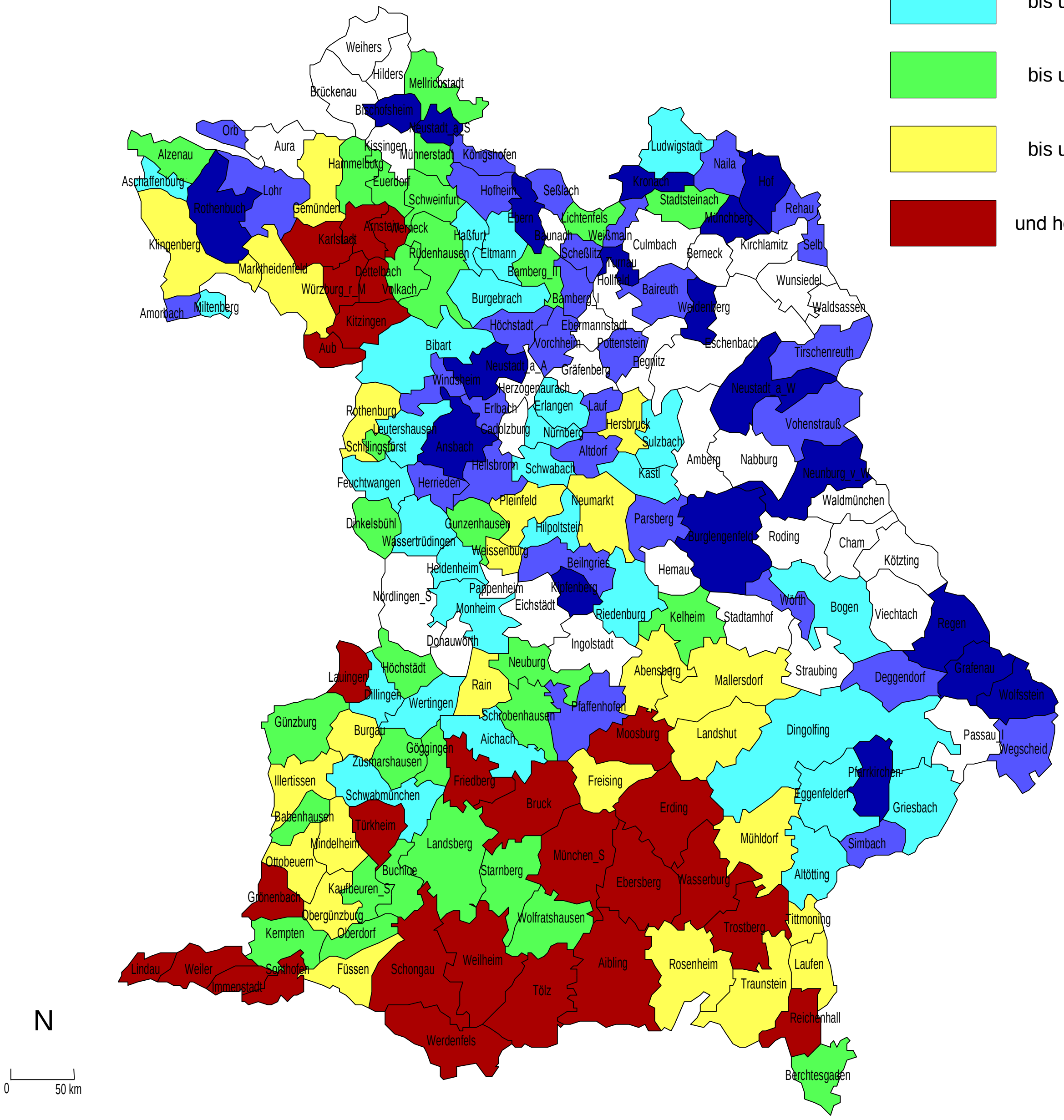


Source: G.K.L. Seuffert (1857)



Map A.4: Nominal wages of male agric. day labourers 1853





Aura, Nördlingen-/München-/Kaufbeuren-city: no data.

Joerg Baten

Nutrition and Economic Development in Bavaria, 1730-1880

Tables

Table 2.1. Selected Characteristics of Bavaria (agrarian production per capita)

country /Jahr	Population (in millions)	Grain Production (in kg p.c.)	Cattle p.c.	Hogs p.c.
France 1852	35.8	248	0.33	0.15
Hungary 1851	13.2	236	0.36 (1857)	0.34 (1857)
Austria 1850/51	17.8	133	0.42	0.12
Germany 1857	35.7	230	0.36 (1852)	0.13 (1852)
Bavaria 1853/4	4.5	236 (1863)	0.57	0.11

Grain production: wheat and rye.

Sources: W.G. Hoffmann (1965); M. Böhm (1995), p. 325 (gross value of grain); B.R. Mitchell (1993); R. Sandgruber (1978); B. Bolognese-Leuchtenmüller (1978); M. Lévy-Leboyer/F. Bourgoignon (1990); J. Toutain (1987).

Table 2.2. Population by Economic Sector (in %)

	Agrarian	Industrial*	Other	Total employment (millions)
France 1856	48	25	27	15.1
Great Britain 1851	22	48	30	9.4
Hungary 1857	80	9	11	4.0
Austria 1857	51	19	30	7.0
Germany 1852	56	26	18	14.8
Bavaria 1852**	68	23	9	4.5

* Including craftsmen.

** Not only the employed, but the population living from the respective sectors.

Sources: M. Lévy-Leboyer/F. Bourgoignon (1990); L. Katus (1970), p. 35-128; B.R. Mitchell (1993); W.G. Hoffmann (1965); Beiträge zur Stat. des Königreichs Bayern, Heft IV (1855); R. Sandgruber (1978).

Table 2.3. Population Growth in the 18th Century

Population (in millions) around	1700	1750	1760	1770	1790	1800	Growth rate (in %)
England	5.1	5.7				8.6	0.83 (1751-1801)
Ireland		3.2			4.7		1.04 (1754-1791)
Sweden		1.8				2.3	0.49 (1750-1800)
Germany**	17.5					22.0	0.46 (1750-1800)
France	19.7		21.8			27.3	0.59 (1762-1800)
Upper/Lower Bavaria	0.77	0.90				1.04*	0.32 (1750-1795)
Upper Palatinate	0.13	0.18				0.23	0.55 (1750-1795)
Palatinate	0.16			0.27		0.34	1.01 (1720-1795)
Lower Austria		0.93			1.27		0.68 (1750-1789)
Bohemia		1.97			2.87		0.95 (1750-1790)

* Including Innviertel, a region which was annexed by Austria in 1778.

** Including Bavaria.

Sources: England - E.A. Wrigley/R.S. Schofield (1981); Ireland - K.H. Connell (1950); France and Sweden - B.R. Mitchell (1993); Bavaria: M. Rauh (1988); Austria - J. Komlos (1994a), p. 58; Germany - C. Pfister (1994).

Table 2.4. Population Growth p. a. in Selected Regions

Regions With Rather High Growth Rates	Growth Rate	Regions With Rather Low Growth Rates	Growth Rate
Prussia	1.14	Bavaria	0.59
Saxony	1.41	Württemberg	0.45
Mecklenburg-Schwerin	1.27	Baden	0.75
Saxony-Anhalt	0.99	Hesse	0.78
Lower Austria	1.15	Upper Austria/Salzburg	0.25
Bohemia	0.93	Tyrol/Vorarlberg	0.38
		Carinthia/Krain	0.53
For comparison:			
England/Wales (1811-61)	1.37	Netherlands (1815-1859)	0.96
Norway (1815-65)	1.27	Italy (1811-61)	0.63
Scotland (1811-61)	1.06	France (1800-50)	0.45

Source: W.R. Lee (1979), p. 178; H. Helczmanovszki (1979), p. 64f. German regions: 1816-64, Austrian regions: 1818-57.

Table 2.5. Infant Mortality: Country Comparisons

	1820s	1830s
Bavaria (all regions)		29.5
Saxony		26.6
Netherlands	20.5	21.4
France	18.0	19.0
Prussia (all regions)	17.4	18.3
Denmark		14.6
England	15.0	15.0
England, industrialized areas*	16.5	17.2

Source: Bavaria, Saxony, Netherlands, Prussia, Denmark: W.R. Lee (1979), p. 186. England and France: in rounded percents, cf. J. Vallin (1990), p. 50.

* Nine industrialized local communities in northern England, 1819-1830 and 1831-36. Source: P.F. Huck (1995), p. 534.

Table 2.6. Infant Mortality in Selected German Local Communities by Confession and Region

Regions	1750er	1770er	1800er	1820er	1830er
1. Cath. SW	29.5		38.4		
2. Cath. SE	36.7	36.2	37.7	36.6	39.0
3. Cath. SW	26.7	31.2	35.8	26.6	35.8
4. Prot. SW	11.7	23.3	17.8	15.2	22.9
5. Prot. E	.	.	.	13.6	14.8
6. Prot. NW	15.6	15.5	13.8	7.7	13.2
7. Prot. Center	12.4	11.9	11.9	11.6	15.3

Communities:
1. Bernloch-Meidelstetten (Württemberg)
2. Massenhausen (Upper Bavaria)
3. Böhringen (Hohenzollern)
4. Hochdorf/Besenfeld/Göttelfingen (Black Forest)
5. Friedersdorf (district of Lauban, Liegnitz)
6. Mulsum (Administration district of Stade)
7. Burkhards/Kaulstoß (Upper Hesse)

Source: W.R. Lee (1979), p. 186.

Table 2.7. Real Wages in Urban Areas 1850-54

Country	Real Wage Index (Great Britain 1905=100)
USA	106
Great Britain	64
Germany	54
France	44
Netherlands	41
Sweden	23
Norway	22

Source: J. Williamson (1995). The effect of the purchasing power has been estimated by using the Purchasing-Power-Parity method..Williamson's figures for Germany are based on older studies by J. Kuczynski (1961), p. 246. Although these show a trend which differs from the more recent estimates by R. Gömmel (1978, 1979), they indicate a similar level for the early 1850s. We use Williamson's estimates because his results permit comparison between different countries due to the use of the Purchasing-Power-Parity-Adjustment - Method cf. J. Williamson (1995), p. 177-189.

Table 2.8. The Purchasing Power of Day Wages in Equivalents of Rye for Germany in the 1830s

City	Region	Purchasing Power of a summer day 's wage in kg of rye	
		Day laborers	Masons/carpenters (journeymen)*
Emden	NW	13.5	14.1
Munich	SE	10.3	16.8
Chemnitz	Eastern center	9.3	13.4
Leipzig	Eastern center	7.4	15.4

* Including "Meistergroschen" (fee for the master)

Source: D. Saalfeld (1970); Munich: H.-J. Gerhard (1984b); G.K.L. Seuffert (1857)

Table 3.1. *Sample Size of Earlier and Later Sample (Soldiers Recruited 1760-87 and 1805-11)*

	Upper/Lower Bavaria	Palatinate	Upper Palatinate
Earlier sample			
1725-29	186	121	109
1730-34	375	402	265
1735-39	570	575	379
1740-44	529	809	241
1745-49	673	600	383
1750-54	969	818	741
1755-59	984	934	935
1760-64	914	1000	1139
1765-69	386	623	646
Later sample	Upper/Lower Bavaria		
1770-74	261		
1775-79	844		
1780-84	1676		
1785-89	1166		
1790-94	649		

Source: Bayerisches Kriegsarchiv, Bestand AVI4d, (recruiting lists).

Table 3.2. *Comparing the Nutritional Value (in Calories) of Potatoes to Rye and Wheat in Saxony*

	Rye	Wheat	Pop.	R.+W.	Potato	Potato
	in 1000 l	in 1000 l	in 1000	l p.c.	in 1000	share in %
1755	103792	9152	884.5	127	15080	3
1772	136240	21632	859.6	185	79976	13
1792	203840	30160	984.4	238	141232	15
1800	191256	37856	1027.5	223	168064	18
1810	202800	35880	1027.5	227	207584	22

Source: R. Gross (1968), pp. 54/55. Note: The nutritional value of a liter (abbreviated "l") unit potatoes (in calories) is 25% , see C.F.W. Dieterici (1838), p. 262.

Table 3.3. Prices of Corn and Textile Products for Germany

Decade	Rye Prices	Drill (Frankfurt)	Linen(Frankfurt)	Linen (Leipzig)
1700	5.96	31.80	24.97	19.20
1710	6.94	25.20		
1720	5.78	24.90	17.83	
1730	6.12	25.20	28.35	18.02
1740	8.35	32.40	28.61	20.20
1750	5.84	53.25	33.64	19.20
1760	8.06	58.17	48.86	21.60
1770	11.13	62.70	45.88	23.92
1780	7.97	57.60	49.63	33.00
changes in %				
1730-80	+30%	+129%	+75%	+83%

Note: Rye prices: for Munich, in florin/bushel, source: G.K.L. Seuffert (1857).
drill: coarse textile, e.g. used for laborers cloths; prices for Frankfurt/Main, in dine/cubit,;
linen (Frankfurt/Main): used for shirts, in dine/cubit, source: M. Elsas (1940), p. 214f.
linen (Leipzig): used for lining; in dine/cubit; source: M. Elsas (1940), p. 346f.

Source: M. Elsas (1940), p. 502.

Table 4.1. Two Regressions. Determinants of Heights of (1) Male Convicts (Aged 22-50) and (2) 21-Year Old Conscripts from Upper Bavaria (Birth Groups 1815-49)

	(1)	(2)
Constant	167.3*	165.6*
Milk region	1.9*	2.7*
Town	-0.6	0.6*
Area near town	-1.1*	-0.8*
Upper/Middle classes	0.6	1.2*
Illegitimate birth	0.0	-0.2
Birth year		
1815-19		-0.1
1830-34	0.0	-0.2
1835-39	0.1	-0.3
1840-44	-0.2	0.4*
1845-49	0.1	
adj. R^2	0.00	0.04
F	1.2	55.8*
N	841	11555

Note: Constant refers to (1) an adult old convict, and (2) a 21-year-old conscript, who were both legitimately born in the 1820s, whose fathers had a lower class profession, and who were born neither in town nor in areas near towns nor in milk regions (per-capita-production of more than 400 liters, see chap. 6).

* significant on the 0,10-level.

Sources: (1) Staatsarchiv Augsburg, Bestand JVA Kaisheim; (2) Staatsarchive München, Amberg, Speyer, Nürnberg Würzburg.

Table 4.2. Price Changes in England, in Relation to the Average Price Index (all consumption goods)

1770=1,00	All foods	Bread	Meat	Butter/ Cheese	Textiles	Coal
1795	1.08	1.07	0.92	0.86	0.65	0.73
1820	1.02	1.00	1.20	0.88	0.57	0.77
1850	1.00	0.94	1.12	1.07	0.57	0.64

Source: G. Clark/M. Huberman/P. Lindert (1995), p. 233. "All foods" includes beer, sugar, and tea.

Table 4.3. Variability of Real Wages in Bavaria and England

Period	Coefficient of Variation		Standard Deviation	
	Bavaria	England	Bavaria	England
1820s	10.4	7.9	6.1	3.8
			(58.6)	(47.9)
1830s	7.6	7.6	3.9	3.8
			(51.1)	(49.8)
1840s	15.4	9.3	7.7	5.0
			(50.0)	(53.8)
1850s	17.3	9.5	8.4	5.2
			(48.6)	(54.8)
1860s	7.7	7.1	4.6	4.2
			(60.0)	(59.0)
1870s	9.0	6.9	5.5	4.5
			(61.1)	(64.8)
increase 1820-1850 (in %)	66	38		

Note: average of index figures in brackets. Bavaria: Index 1910-13=100; Source: R. Gömmel (1978). England: Index 1900=100, Source: B.R. Mitchell (1993).

Table 4.4. Changes in the Proportion of Expenses of English Lower Class Households

Share of Expenses	Changes between 1830/30 and 1840-54
carbohydrates/grain	+19%
meat/fish/eggs/fat	-19%
milk/butter/cheese	-8%
"remaining surplus" (including textiles)	-17.1%
Textiles only	+11.1%

Table 5.1. *Three Regressions. Determinants of Rejection Rates in Bavarian Rural Districts.*

Dependent variable:	(1)	(2)	(3)	
Rejection rate (in %)				
a) Reason:	Too Short and Weak	Too Short and Weak	Too Short	Standard Deviation
b) Birth years:	1809-19	1820-29	1831-35	
Explanatory variables:				
Milk production	-0.46*	-0.53*	-0.59*	1.03
	(0.00)	(0.00)	(0.00)	
Rye production	0.26*	0.00	0.01	0.87
	(0.01)	(0.98)	(0.97)	
Potato production	0.13*	0.11*	0.12#	1.85
	(0.09)	(0.02)	(0.14)	
Rejection because of disease	0.05*	0.03*	-0.00	12.20
	(0.00)	(0.00)	(0.99)	
Rye wages of day laborers	0.09	0.10	-0.05	0.97
	(0.40)	(0.24)	(0.73)	
Weaving district	0.97*	2.01*	2.90*	
	(0.00)	(0.00)	(0.00)	
Area near town	0.31	0.27	0.89*	
	(0.13)	(0.22)	(0.01)	
Constant	0.91	1.89*	5.84*	
	(0.16)	(0.00)	(0.00)	
Adj. R^2	0.46	0.48	0.29	
F	18.12*	24.18*	11.36*	
N	150	179	179	

Note: Constant refers to a district that is neither near a town, nor a weaving district, and where all continuous independent variables are zero. P-values in brackets.

" coefficient significant on the 10%-level.

coefficient significant on the 5%-level.

* coefficient significant on the 1%-level.

Sources on milk, rye, potato production, population, wages, rejection rates: Beiträge zur Statistik des Königreichs Bayern, Bd. 3 (1854), 6 (1855), 7 (1857), 8 (1859). Montgelasstatistik (Bayer. Staatsbibliothek cgm 6844-55, on mortality [not used] cgm 6847,4).

Table 5.2. Three Regressions: Determinants of Conscript Rejection Rates in 29 Bavarian Towns

Dependent variable: rejection rate(in %)	(1)	(2)	(3)
a) reason:	too short/ weak	too short/ weak	too short
b) birth years:	1809-19	1820-29	1831-35
Explanatory variables:			
Civil servants'/professionals ' households in %	-0.08*	-0.07#	-0.15*
	(0.00)	(0.02)	(0.00)
Milk production in the area near town	-0.54"	-0.27	-1.17#
	(0.06)	(0.28)	(0.03)
Rejection rate because of disease	0.03	0.02	0.01
	(0.25)	(0.33)	(0.94)
Constant	3.28#	3.31*	9.19*
	(0.01)	(0.00)	(0.00)
Adj. R^2	0.28	0.20	0.23
F	4.68*	3.27#	3.86#
N	29	29	29

Note: Constant refers to a hypothesized town where all explanatory variables are zero. P-values in brackets.

",#,*: significance levels see table 5.1.

"Milk production": See table 5.1; "area near town": see table 5.1.

" Civil servants'/professionals ' households ": Number of persons living in the households of civil servants and professionals in % of total population (in 1852).

Sources: Milk production, rejection rate, population structure, calculated according to: Beiträge zur Statistik.

Table 5.3. Infrastructure Variables and Local Food Production of those Districts for which Individual Data of 21-Year-Old Conscripts is Available

District	Height in cm	Share of non-agricultural population	Daily production of... Protein	kcal (total)	kcal (potatoes)
Tölz	170.2	7.0	43.5	294	13
Miesbach	168.3	19.2	39.6	1715	92
Wasserburg	167.5	14.3	34.0	3038	338
Reichenhall	166.8	*42.1*	26.0	1030	27
Frankental	166.2	*32.8*	14.3	1251	96
Bruck	166.0	8.4	40.5	3283	467
Hemau	165.7	19.8	19.7	1981	211
Brückenau	165.6	20.4	18.7	2009	778
Kaiserslautern	165.5	*30.2*	11.8	972	468
Speyer	165.3	25.7	14.6	1809	829
Nuremberg	165.0	*38.4*	3.8	966	265
Neustadt	164.7	25.6	13.8	1077	566
Friedberg	164.7	*30.1*	27.4	2137	190
Moosburg	164.5	10.9	33.9	3914	591
Altdorf	164.4	24.5	13.2	2486	969
Bergzabern	164.3	12.9	14.7	2044	944
Administration towns:			*Daily consumption (approx.)*		
München/Au	167.1	99.0	30.0	2000	500
Ingolstadt	166.1	83.8	30.0	2000	500

District names in italics refer to districts surrounding towns, figures in italics in column (3) refer to early industrial districts.

Column (3): share of non-agricultural population (December 1852). Source: Beiträge 4 (1853), G. Angerpointner (1994).

(4): Estimated production of animal protein (for the towns: estimated consumption) based on the estimated daily milk production in liters p.c. Algorithm: [Number of cows p.c. in 1840 x 650 l (annual output of a cow) : 365 (days)] x 30g (protein)/l (milk) + 25% of meat production (beef, pork) of the respective district, because most of the meat was exported to the towns. Source: Beiträge, Bd. 4 (1855).

(5): Estimated nutritional value (in kcal.) of grain and potatoes produced.) Grain and potato production of an average year per capita x 370 kcal/100g of grain, minus 25% because of wastage during grinding, therefore approx. 280 kcal/100g, + 70 kcal/ 100g of potatoes. The additional calories from milk products, meat and vegetables (approx. 30%) are not taken into account. Source: Beiträge 7 [1857]; R. Beck (1986), p 248.

Table 5.4. Three Regressions. Determinants of Heights of 21-Year-Old Conscripts in South Eastern Bavaria, Born Between 1815-44.

	(1)	(2)	(3)
Middle and upper classes	1.25*	1.25*	1.36*
Birth year			
1815-19	-0.20	-0.22	0.00
1825-29	-0.12	-0.12	-0.11
1830-34	-0.18	-0.18	-0.15
1835-39	-0.13	-0.13	-0.11
1840-44	-0.05	-0.05	0.16
Real wage (over time)	0.03*	0.03*	0.03*
Regional variables:			
Area near town	-0.31*	-0.35*	-0.69*
Town	0.05	0.07	0.72*
Early industrial district	-0.39*	-0.33*	0.01
Animal protein	1.10*	1.08*	
Calories	-1.00*		
Constant	163.53*	166.26*	164.12*
Adj. R^2	0.04	0.04	0.02
F	77.67*	77.75*	37.78*
N	21064	21064	21064

Note: The constant refers to a conscript whose father had a lower class profession, and who was born in a rural district between 1820 und 1824.

Sources See Table 5.1. The occupational coding scheme is based on P. Lundgreen/M. Kraul/K. Ditt (1988), p 321-350.

Definitions: "animal protein": daily production (in towns: consumption) in units of 10g; "calories": nutritional value of daily grain and potato production in units of 1000 kcal; "real wage": real wage index (1913=100) of the two years before conscription; "town", "area near town", "early industrial district": see Table 5.1 and 6.3.

* significance level 1%.

Table 5.5. Regressions: Determinants of Heights of Female Convicts

	(1)	(2)
Birth year		
1825-29	-0.54	-0.45
1830-34	-1.02	-1.01
1835-39	-1.73#	-1.64+
1840-44	-1.51+	-1.56+
1845-49	-0.20	-0.27
Illegitimate birth	-1.36*	-1.38*
Regional variables:		
Town	-0.75+	-0.79+
Area near town	-0.86#	-1.00*
Animal Protein	0.47#	
Calories	-0.51*	
Constant	157.01*	157.45*
Adj. R^2	0.04	0.03
F	6.23*	5.29*
N	1329	1329

Note: Constant refers to a female convict who was born legitimately in a rural district between 1820 and 1824. Women who were not born in Bavarian, or who were born in Franconia, in the Palatinate or in the Bavarian forest are excluded. Age 20-50.

Definitions: See Table 5.4. Significance levels: see Table 5.1.

"Illegitimate": Mother unmarried, but not widowed or divorced..

Source: see Table 5.3.

Table 6.1. Characteristics of the Seven Major Regions

Major region	Roads/surface	Real wages	Milk p.c.	Non-agricultural	Towns	Population density
1-Bavarian forest/ Upper Palatinate	1.5	5.2	2.1	17.1	2	16.8
2-Upper Bavaria-South /Allgäu	0.8	6.3	4.1	15.1	5	14.0
3-Danube-East	1.6	6.0	2.7	15.8	3	15.3
4-Middle Franconia	2.1	5.9	1.9	20.3	7	25.3
5-Upper Franconia	2.1	4.9	1.7	22.8	3	23.7
6-Swabia-North /Danube-West	1.7	6.0	2.9	18.5	6	19.4
7-Lower Franconia/Palatinate	1.9	6.1	1.8	16.9	3	26.4

Note:
Roads/surface = roads per total surface area (in %).
Real wages = rye wages: purchasing power (in kg of rye) of the wages of a male agricultural day labourer.
Milk p.c. = per-capita-milk production (in 100 l p.a.) (for the estimates, see chapter 6).
Non-agricultural = non-agricultural population (in %).
Source: See table 5.1.
Towns = number of towns.
Population density = density of the rural populations per square kilometre (in 1840).

Table 6.2. Coefficients of Correlation Between Rye Wages and per Capita Milk Production

Major Region	Correlation	P-value	N.
1-Bavarian forest/Upper Palatinate forest	-0.25	(0.28)	19
2-Upper Bavaria-south/Allgäu	-0.03	(0.89)	28
3-Danube-east	0.12	(0.64)	18
4-Middle Franconia	0.15	(0.48)	25
5-Upper Franconia	-0.11	(0.57)	31
6-Swabia-North/Danube-West	0.45	(0.02)	27
7-Lower Franconia/Palatinate	0.36	(0.01)	47

Source: See table 5.1.

Table 6.3. Seven Weighted-Least-Square-Regressions. Influence of Milk Production on the rejection rate (Birth Years 1831-35) in the Rural Districts of the Major Regions

Regression Nº/ Major region	R^2	Milk coefficient	p-value	Constant	N	Milk production
1-Bavarian forest /Upper Palatinate forest	0.23	-1.5	(.04)	6.4	19	2.1
2-Upper Bavaria-south/Allgäu	0.18	-0.5	(.03)	4.3	28	4.1
3-Danube-east	0.17	-1.0	(.09)	6.6	18	2.7
4-Middle Franconia	0.01	-0.2	(.72)	6.3	25	1.9
5-Upper Franconia	0.16	-2.0	(.03)	9.2	31	1.7
6-Swabia-north/Danube-west	0.18	-0.1	(.03)	7.0	26	2.9
7-Lower Franconia/Palatinate	0.20	-2.3	(.00)	8.7	47	1.8

Note: The six districts that differed from the average by more than five standard deviations have been considered as statistical anomalies. These represented without exception the maxima of the rejection rate in the Major regions, and in four cases came from areas near town, where the Rejection rate was especially high, as has been shown in chapter 6. Due to our lack of information we can only conjecture whether epidemics caused these maxima. I thank Markus Heintel for having discussed with me the adequate treatment of these anomalies. The Weighted-Least-Square-estimates have been used because this method is more robust in dealing with possible heteroscedasticity. Source: see table 5.1.

Table 6.4. Seven Weighted-Least-Square-Regressions. Influence of Population Density (in 1840) on the Rejection rate (Birth Years 1831-35) in the Rural Districts of the Major Regions

Regression Nº. – Major region	R^2	Density coefficient	p-value	Constant	N
1-Bavarian forest/Upper Palatinate forest	0.01	-0.0	(0.62)	3.9	19
2-Upper Bavaria-south /Allgäu	0.07	0.0	(0.18)	1.9	27
3-Danube-east	0.05	-0.1	(0.37)	5.7	18
4-Middle Franconia	0.03	0.0	(0.37)	5.7	25
5-Upper Franconia	0.00	0.0	(0.96)	6.1	31
6-Swabia-north/Danube-west	0.02	0.0	(0.53)	5.2	26
7-Lower Franconia/Palatinate	0.01	-0.0	(0.49)	5.1	47

Note: Density = population density. The sample considered was the same as in table 6.3., and the anomalies have been defined by the criterion used there. Because of the lack of connectivity, there were, indeed, no anomalies which differed from the average by more than five standard deviations. In one court district in Upper Bavaria, there were no figures for the population density. Source: see table 5.1.

Table 6.5. Seven Weighted-Least-Square-Regressions. Influence of Rejection Because of Disease on the Rejection rate (Birth Years 1831-35) in the Rural Districts of the Major Regions

Regression Nº. – Major region	R^2	D/D-ratio coefficient	p-value	Constant	N
1-Bavarian forest /Upper Palatinate forest	0.34	-0.1	(0.01)	6.7	19
2-Upper Bavaria-south/Allgäu	0.09	0.1	(0.12)	1.3	28
3-Danube-east	0.06	-0.1	(0.33)	5.3	18
4-Middle Franconia	0.01	-0.0	(0.57)	6.8	25
5-Upper Franconia	0.27	0.2	(0.00)	0.5	31
6-Swabia-north/Danube-west	0.04	-0.1	(0.33)	6.6	26
7-Lower Franconia/Palatinate	0.07	0.1	(0.07)	2.1	47

Note: see table 6.4. D/D-ratio: rate of those disqualified because of disease. Source: See Table 5.1.

Table 6.6. Seven Weighted-Least-Square-Regressions. Influence of Rye Wages on the Rejection rate in the Rural Districts of the Major Regions (Birth Years 1831-35)

Regression Nº– Major region	R^2	Real wage coefficient	p-value	Constant	N
1-Bavarian forest /Upper Palatinate forest	0.00	0.0	(0.88)	3.2	19
2-Upper Bavaria-south/Allgäu	0.01	0.1	(0.62)	1.7	28
3-Danube-east	0.00	-0.0	(0.94)	3.8	18
4-MiddleFranconia	0.28	-1.4	(0.01)	13.4	25
5-Upper Franconia	0.10	-1.0	(0.08)	11.2	31
6-Swabia -north/Danube-west	0.03	-0.3	(0.35)	7.4	27
7-Lower Franconia/Palatinate	0.05	-0.3	(0.15)	6.5	47

Note: The districts considered as statistical anomalies were the same as in table 6.3. They met the criterion of anomalies either in this table or in table 6.3. Source: See table 5.1.

Table 6.7. Correlation Between Rejection Rate and (1) Wages or (2) per Capita Milk Production in Prussia

	Real wages	Milk production per capita
Rejection rate (1831)	+0.40	-0.79*
13 eastern districts	(0.17)	(0.00)
Rejection rate (1854)	-0.07	-0.68*
13 eastern districts	(0.83)	(0.01)
Rejection rate (1831)	-0.67*	-0.20
12 western districts	(0.02)	(0.53)
Rejection rate (1854)	-0.49*	-0.05
12 western districts	(0.10)	(0.87)

Note: p-values in brackets.
* significant on the 10% level.

Table 6.8. Determinants of Heights of Female Convicts from Wasserburg Prison, Birth Groups 1819-49 and 1850-89

	Regression 1: born between 1819-49		Regression 2: born between 1850-89	
	coefficient	p-value	coefficient	p-value
Constant	154.8	0.00	155.4	0.00
Birth region				
Upper Bavaria-south	2.4	0.00	2.1	0.03
Bavarian forest	2.8	0.00	2.4	0.01
Danube-east	1.6	0.04	0.6	0.48
Danube-west	0.8	0.28	1.0	0.20
Middle Franconia	2.1	0.21	1.3	0.41
Upper Franconia-west	1.8	0.57	2.1	0.30
Upper Franconia-east	-3.1	0.16	0.1	0.98
Swabia-south	3.4	0.00	0.7	0.50
Lower Franconia	3.4	0.08	-1.1	0.48
Age				
20	-2.7	0.19	-1.5	0.05
21	-0.1	0.93	-0.9	0.24
22	0.5	0.48	0.1	0.94
23	0.4	0.59	-0.5	0.47
Birth decade				
1830s	-0.8	0.08	-	-
1840s	-0.4	0.37	-	-
1860s	-	-	1.8	0.00
1870/80s	-	-	1.3	0.00
Town/rural areas				
Munich	-0.4	0.66	-2.2	0.02
Other towns	0.0	0.95	0.8	0.30
Social determinants				
Middle/upper classes	1.2	0.03	-0.2	0.78
Illegitimate	-1.1	0.00	-0.5	0.25
R^2	0.05		0.04	
N	1523		980	

Constant refers to a lower class woman aged 23-49. who was legitimately born in the northern parts of the Upper Palatinate in the 1820s (1) or in the 1850 (2).
Source: see Table 5.5.

Table 7.1. Heights and Variation in Heights in Bavaria

Birth Cohort	Height	Standard Deviation	Variation Co-efficient (CV)	Non-Agricultural (in %)
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. town	173.4	6.4	3.71	
1937. rural area	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. Non-agricultural: Share of non-agricultural population (according to recruiting records).

Sources: *Staatsarchiv München*, RA 27231-28366; *Staatsarchiv Amberg*, BA Hemau 761-786, LG Hemau 1207-1226; *Staatsarchiv Nürnberg*, BA Nürnberg; *Bayerisches Kriegsarchiv*, Abt. Musterung/Ergänzung, Bd. 92-94; *Staatsarchiv Speyer*, G 7 Militaria; for 1937: R. Harbeck (1959), pp. 321-323; data for1955/1965: friendly communication from the Institut für Wehrmedizinalstatistik und Berichtswesen,

Table 7.2. Height Intervals in Town and in Rural Areas (Four Districts, Birth Cohorts of the 1830s)

	Between 155.6 und 175.1 cm (share in %)		< 155.6 cm (share in %)		> 175.1 cm (share in %)	
	Rural	Urban	Rural	Urban	Rural	Urban
District						
Upper Franconia	87.6	84.5	5.0	6.0	7.4	9.5
Middle Franconia	88.8	86.3	5.5	8.2	5.7	5.5
Swabia	85.7	84.4	4.4	6.0	9.9	9.6
Lower Bavaria	87.7	83.6	3.3	3.3	9.0	13.1

Source: Bavaria, Bd. I-IV (1860ff.). "height intervals" refers to the share of conscripts (in %) whose respective heights range in the same, well-defined area.

Table 7.3. Six Weighted-Least-Square-Regressions of Variation Coefficient (CV) and Between-Group-Difference (BGD). 1815-39 Sample.

Dependent variable:	CV	CV	CV	CV	BGD	BGD
Sample:	Urban/rural	Rural	Urban/rural	Rural	Urban/rural	rural
Non-agricultural	0.82	1.33	0.82	1.26	2.96	4.27
population*100 (in %)	(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. R^2	0.22	0.18	0.24	0.21	0.18	0.14
F	20.22	15.44	12.15	9.60	8.49	6.47
N	71	66	71	66	71	66

Notes and abbreviations: Estimates based on Weighted-Least-Square-Regression method. Constants refer to variation coefficient or BGD in a hypothetical district, where the independent variables would be zero. The cases are weighted by sample size.

Rural: Urban areas excluded; BGD: between-group difference in cm between a) lower class and b) upper/middle class occupation of

CV: Variation coefficient. Time is 1 for 1815-19, 5 for 1835-39. Source: See table 7.1.

Table 7.4. Regional Differences in the 1815-39 Sample

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

Abbreviations:
BGD: see Table 7.3;

Non-agricultural: Share of the non-agricultural population
* early industrial. Source: see table 7.1.

Table 7.5: Winners and losers: their height and share in population

	Height 1815-19	% of sample	Height 1835-39	% of 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 4.1.

Table 8.1. Heights around 1860 and 1960 (birth year)

Country	Heights around 1860	Heights around 1960
Spain	161.9	175.6
Russia	162.9	176.8
Belgium	165.9	175.3
France	166.2	175.0
Germany	166.6	178.4
Hungary	164.0	175.3
Netherlands	166.7	180.9
Denmark	167.4	179.0
Ireland	167.9	175.5
Norway	169.1	180.0
USA	170.6	176.8

Source: J. Baten / J. Komlos (1998); Ph.B. Eveleth/J.M. Tanner (1990).

Table 8.2. Regressions of Heights, GDP, and GDP Growth

	Dependent variable: GDP growth	Dependent variable: GDP in 1913	Dependent variable: Height around 1900
Explanatory variables:			
Height around 1860	0.11	128.84	0.96
	(0.00)	(0.00)	(0.00)
Literacy	-0.45		
	(0.26)		
GDP in 1870		1.44	0.01
		(0.00)	(0.62)
Constant	-16.43	-20740.29	7.34
	(0.01)	(0.00)	(0.84)
Adj.- R-quare	0.53	0.89	0.63
N	15	18	15

Source: see table 8.1 and figure 8.2. P-values in parentheses.

Table A.1. Basket of Goods, Nuremberg Lower Class Households (in %)

Expenses (in %)	1810	1849
1. Food (including luxury)		
Bread	31.1	26.7
Meat	9.6	9.6
Beer	11.0	10.5
Milk	9.0	8.2
Flour/semolina/rice	1.5	1.5
Fat/lard	1.0	1.5
Potatoes	5.8	5.1
Eggs	0.5	0.7
Butter	0.5	0.6
Total	70.0	65.0
2. Rent	8.6	8.7
3. Clothing	8.0	8.0
4. Heating	5.8	5.7
5. Light	1.9	1.9
6. Household equipmentt	2.0	2.0

Source: R. Gömmel (1978), S. 211.

Table A.2. Wheat Prices in Florin/Bushel (about 1810)

	Means	N	Rounded means
Bavarian forest	8.45	3	8.50
Western lower Franconia/middle Franconia/eastern Danube area	8.94	20	9.00
Middle Danube area/eastern middle Franconia	9.86	23	10.00
Country area outside Munich. northern part	10.48	25	10.50
Upper Franconia/country area outside Munich. southern part	12.00	4	12.00
Swiss border	12.33	3	12.50

Source: Montgelas-Statistik: Bayerische Staatsbibliothek cgm 6854, Getreidehandel.

Table B.1. Regression of Heights, Method: RMSLE (earlier Sample, Recruiting 1760-87).

	Old Bavaria		Upper Palatinate		Palatinate	
	Parameter	p-value	Parameter	p-value	Parameter	p-value
Constant	168.6	0.00	169.9	0.00	170.8	0.00
"Leibsoldat"	4.8	0.00	3.9	0.00	3.5	0.00
"Grenadier"	8.0	0.00	6.7	0.00	5.7	0.00
Officer	2.5	0.00	3.9	0.00	4.4	0.00
NCO	1.5	0.00	2.4	0.00	1.5	0.00
Birth year:						
1725-29	-3.5	0.00	-4.3	0.00	-4.6	0.00
1730-34	-2.1	0.00	-3.4	0.00	-4.6	0.00
1735-39	-1.3	0.00	-3.4	0.00	-3.9	0.00
1740-44	-1.3	0.00	-1.8	0.00	-2.7	0.00
1745-49	-0.7	0.00	-0.7	0.01	-1.1	0.00
1755-59	-1.0	0.00	-0.3	0.27	-1.0	0.00
1760-64	-1.9	0.00	-1.4	0.00	-1.1	0.00
1765-69	-2.7	0.00	-1.7	0.00	-1.4	0.00
Age						
16	-3.1	0.04	-7.1	0.00	-8.9	0.00
17	-1.7	0.04	-5.2	0.00	-7.4	0.00
18	-1.3	0.01	-3.2	0.00	-4.6	0.00
19	-0.5	0.14	-1.2	0.00	-2.6	0.00
20	-0.6	0.03	-1.1	0.00	-1.9	0.00
21	-0.1	0.56	-0.4	0.01	-1.0	0.00
22	-0.3	0.32	-0.7	0.00	-1.1	0.00
Number of cases N	5586		5882		4838	

Source: see Table 4.2

Table B.2. Regression of Heights Using RMSLE, Elite Soldiers Excluded (Earlier Sample, Recruited 1760-87)

	Bavaria		Palatinate	
	parameter	p-valuet	parameter	p-value
Constant	165.2	0.00	170.3	0.00
Officer	7.8	0.00	6.4	0.00
NCO	6.2	0.00	3.4	0.00
Birth year				
1725-29	-5.0	0.00	-5.7	0.00
1730-34	-4.0	0.00	-3.9	0.00
1735-39	-1.7	0.01	-3.7	0.00
1740-44	-2.6	0.00	-2.4	0.00
1745-49	-0.3	0.61	-1.6	0.00
1755-59	-0.4	0.41	-0.8	0.03
1760-64	-1.4	0.00	-0.5	0.17
1765-69	-3.2	0.00	-0.9	0.06
Age				
16	-2.8	0.28	-9.2	0.00
17	-3.1	0.00	-7.7	0.00
18	-2.0	0.03	-4.9	0.00
19	0.3	0.63	-2.7	0.00
20	-0.8	0.02	-2.0	0.00
21	0.1	0.68	-1.4	0.00
22	-1.1	0.11	-1.2	0.00

Source: See Table 4.2.

Table B.3. *Regression of Heights, Using RSMLE, All Army Categories, Old Bavaria (Later Sample, Recruiting 1805-11)*

	parameter	p-value
Constant	165.9	0.00
"Leibsoldat"	4.3	0.00
"Grenadier"	6.7	0.00
Officer	3.4	0.00
NCO	3.4	0.00
Birth year		
1770-74	-1.1	0.01
1775-79	-0.3	0.29
1785-89	0.8	0.01
1790-95	1.0	0.01
Age		
16	-3.9	0.01
17	-2.3	0.00
18	-1.4	0.00
19	-1.5	0.00
20	-0.7	0.05
21	-0.1	0.86
22	-0.1	0.86
N	4596	

Source: see Table 4.2.

Table B.4. *Comparison of Occupational Structure: the Total Population and the Male Prison Sample*

	Prison Sample		Population (census of 1882)	
Professional groups	numbers	%	numbers	%
Primary sector				
Peasants	87	4.7	583821	35.9
(Day) laborers	762	40.8	238344	14.7
Other	28	1.5	14343	0.9
Secondary sector				
Metal-processing	80	4.3	50291	3.1
Textile	60	3.2	41478	2.6
Woodworking	83	4.4	58238	3.6
Food (including luxury)	180	9.6	78861	4.9
Clothing (including cleaning)	198	10.6	86714	5.3
Construction	169	9.1	99633	6.1
Other	108	5.8	117901	7.3
Tertiary sector and mixed groups				
Trade	32	1.7	59837	3.7
Inns/hotels	16	0.9	19617	1.2
Other	32	1.7	41072	2.5
Domestic servants	4	0.2	7267	0.4
Civil servants/liberal professions	23	1.2	107654	6.6
Without profession	5	0.3	19620	1.2

Sources: see table 5.1; Baten/Murray 2000.

Table B.5. Comparison of Occupational Structure: the Total Population and the Female Prison Sample

	Prison Sample		Population (census of 1882)	
Professional groups	Numbers	%	Numbers	%
Primary sector				
Peasants	170	4.6	664995	42.3
(Day) laborer	1395	44.1	274978	17.5
Other	24	0.8	9438	0.6
Secondary sector				
Metal-processing	33	1.0	28735	1.8
Textile	17	0.5	44487	2.8
Woodworking	79	2.5	33687	2.1
Food (including luxury)	56	1.8	40880	2.6
Clothing/Cleaning	436	13.8	99657	6.3
Construction	121	3.8	57834	3.7
Other	193	6.1	71253	4.5
Tertiary sector and mixed groups				
Trade	116	3.7	69363	4.4
Inns/Hotels	153	4.8	35644	2.3
Other	83	2.6	34528	2.2
Domestic servants	199	6.3	19794	1.3
Civil servants/liberal professions	49	1.6	58837	3.7
Without profession	41	1.3	29500	1.9

Sources: Sources: see table 5.1; Baten/Murray 2000.