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The Population History of Germany: Research Strategy and Preliminary Results

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Ulrich PFISTER* and Georg FERTIG+

Abstract

The paper presents the project of an aggregative reconstruction of the population of Germany from the sixteenth century to 1840, when official statistics began to provide complete coverage of all German states. The creation of estimates of population size and of annual series of the crude birth, marriage and death rates rests on three types of sources: First, pairs of partial censuses of hearths, taxpayers, communicants, etc. for the same regional aggregate at two different points in time are used to derive annual growth rates of population. This information is used to derive approximate estimates of total population size in ten-year intervals. Second, to develop aggregate series of vital events the project aims to analyse approximately 450 to 600 parish registers. Third, the project makes use of proto-statistical material on population size and the number of vital events that states began to collect selectively from c. 1740. On the basis of material from Gehrmann (2000), from published studies on c. 140 parishes and from selected other sources we construct a preliminary dataset for the period 1730–1840. Our cumulative rates of natural increase are broadly consistent with independent estimates of population growth. We use these series for two explorative analyses: First, on the basis of inverse projection we generate tentative estimates of the gross reproduction rate, of life expectancy and the dependency ratio. The results suggest an increase of the life expectancy and of the dependency ratio, the latter being the result of persistent population growth. Second, by adding a real wage series we study Malthusian adaptation with two methods, namely, VAR and time varying cumulated lag regression. The results consistently suggest the presence of both the preventive and the positive check during the eighteenth century. Whereas the preventive check persisted into the nineteenth century, mortality became exogenous in the early nineteenth century. Particularly the 1810s turn out as a period of major change in at least three dimensions: real wages increased, life expectancies rose, and the positive check disappeared. Thus, Germany became a non-Malthusian economy well before the advent of industrialisation. Additional information suggests that market integration was a driving force behind this process.

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1. Introduction

This paper describes a project that aims at an aggregative reconstruction of the population of Germany during the last three centuries of the pre-statistical era. To assess its feasibility, a substantial amount of preliminary research has been carried out. We describe the ways used to identify sources and to create basic time series, carry out consistency tests for the data currently available and undertake a tentative analysis for the period 1730–1850.

In a nutshell, the structure of the project is as follows: First, we intend to create series of absolute numbers of births, marriages and deaths. These series will be based on two types of sources. One is the proto-statistical information collected by state officials from the 1730s; the other one is a sample of 450–600 parish registers, which reach back into the seventeenth and as much as possible into the sixteenth, centuries. We use Weighted Least-Squares regression with fixed effects to create a national series out of this information and scale it to the respective national figures in 1818. Second, we collect information on partial censuses (lists of communicants, tax payers, hearths, burghers, etc.) from the late fifteenth to the early eighteenth century. The ratio between these partial aggregates and total population is usually unknown, due to variations in household size, age structure and other variables. Hence, we only retain pairs of the same type of lists for two time points and work with the growth rate during the intervening period. These growth rates are aggregated to decade-wise national growth rates until 1740, when the first estimate of total population size becomes available. We also intend to improve existing estimates of population size from 1740 to 1800 by the use of additional proto-statistical census material. Together, we expect that steps (1) and (2) will render it possible to create mutually consistent series of population size and crude birth, marriage and death rates at least from the late sixteenth century. Third, these series, together with information on mortality from existing parish studies, will be fed into a generalised inverse projection of life expectancy (e_o) and the gross reproduction rate (GRR). Gross rates of vital events will also be used to study processes of Malthusian adaptation.

At the current state of research we have collected numbers of births, marriages and deaths from approximately 140 parish studies, which are mostly published. We have also put together a small body of information on pre-statistical partial censuses up to the early eighteenth century. For both vital events and population size, we have located proto-statistical information starting in the 1730s. At the maximum (i.e., during the 1780s) these data cover about 60 per cent (population) and 30 per cent (vital events) of the estimated national totals. From c. 1818, the overwhelming majority of German states reported vital events in their official statistics, and from 1840 coverage is complete. On the basis of this preliminary dataset, we construct national series of raw numbers of vital events for the period 1730–1840. The data density of this preliminary reconstruction is probably equal if not superior to the reconstructions undertaken for other European countries. In addition, we show that our national series of births and deaths are broadly consistent with independent estimates of population size. In our view, this warrants exploratory analyses of our dataset. The results, while still preliminary, shed new light on German demographic and economic history during the century preceding industrialisation.

Our research plan refers to national aggregates in the first place. Defining a useful geographical frame of reference for a long period of fundamental political upheavals is far from trivial, however. A relevant part of the present study is therefore devoted to the conversion of official statistics and earlier estimates of total population size to a homogeneous and meaningful territory. In addition, given the strong economic fragmentation of Germany before the age of railway construction, it is highly desirable to conduct parallel analyses on the disaggregate levels of individual states or regions. We hope that as data density increases in the course of the project, disaggregate analyses will become possible for at least some states, such as Saxony, Wurttemberg and possibly a few others.

The paper is organised as follows: Section 2 develops the motivation of the project; Sections 3 and 4 present new material with respect to population size and gross rates of vital events, respectively, and test their consistency. In Sections 5, 6 and 7, we carry out tentative analyses of this material for the period 1730–1850. Section 5 uses inverse projection to produce estimates of e_0 and GRR; Section 6 implements two methods to study Malthusian adaptation, namely, VAR and time varying cumulated lag regression. The conclusion in Section 7 summarises the results and presents avenues of future research.

2. Motivation

To some extent, our project presents a catch-up of German historiography on the paradigmatic *Population History of England* (Wrigley and Schofield 1981). Beyond this, however, there are at least three recent developments in economic history that motivate an aggregative population reconstruction for Germany during the last three centuries of the pre-statistical age.

First, in the wake of new growth theory in economics, a strand of the literature on long-term growth has emerged that models both technological progress and the demographic transition of the eighteenth and nineteenth centuries as endogenous processes (Kremer 1993; Galor and Weil 2000; Lucas 2002; Galor 2005). Galor and Weil (2000) and Galor (2005) in particular base their analysis on the following three statements: (1) population size is positively related with technological progress, since a larger population increases the potential for innovation and since bigger markets create incentives for their implementation in production. (2) The majority of innovations are skill-intensive, implying that an acceleration of technological progress increases the return on human capital. (3) Depending on the relative returns to labour and human capital, parents prefer either quantity or quality in their children and orient their fertility behaviour accordingly. These three premises suggest the following stylised account of the trajectory that the European economies underwent between the seventeenth and the nineteenth centuries: Initial population growth resulting from a Malthusian disequilibrium led to moderate technological progress. As a response to the increase the rate of return to human capital that followed from technological progress, parents moved out of quantity and into quality with respect to their children, implying a check on fertility or even a decline of the birth rate. The increase of the stock of human capital contributed to an acceleration of technological progress, which in the long run eliminated the vulnerability with respect to climatic shocks. In sum, a Malthusian disequilibrium leading to strong population growth may trigger an initial wave of technological progress, which then sets in motion a virtuous cycle of declining fertility, increasing technological progress and accelerating growth of output per capita.

While many stylised facts can be invoked in support of such a model, a rigorous empirical test is still in its early stage. A major offshoot of this strand of the new growth theory so far has been the stimulation of new empirical research into the population dynamics of the late pre-industrial and early industrial era. This includes econometric implementations of a Malthusian system (Lee and Anderson 2002; Crafts and Mills 2009) as well as partial analyses of the relationship between population size and the real wage (Chiarini 2010) and of Malthusian adaptation to fluctuations of the real wage. The growth model outlined above implies that in an initial phase the preventive check increases in strength, whereas the positive check becomes weaker as soon as sustained income growth sets in. Earlier studies of this issue have used distributed lag regression methods, using grain prices as a proxy for income and sometimes including climatic fluctuations as exogenous variables (see notably Lee 1981, Weir 1984, Galloway 1988). More recent studies use real wage data and specify Malthusian adaptation in the framework of VAR analysis, treating all variables as endogenous. Eckstein et al. (1985), who refer to Sweden between 1750 and 1850, constitute the first research of this new type. Because of its historical depth, the material from the *Population History of England* still constitutes the most important object of a comprehensive study of long-run changes in Malthusian adaptation. At present, however, the available results are inconclusive. Nicolini (2007) finds an early disappearance of the positive check and the emergence of a negative reaction of fertility on a positive real wage shock from the eighteenth century (cf. also Crafts and Mills 2009). In contrast, Rathke and Sarferaz (2010), employing a time-varying VAR specification, suggest a weakening of the preventive and an aggravation of the positive check in the course of the eighteenth century. While mutually contradictive, both studies are difficult to reconcile both with earlier research by Galloway and Weir and the literature in growth economics invoked above. Studies on other European countries reaching back before the middle of the eighteenth century still remain rare (for Italy, see Galloway 1994b; Fernihough 2010). A clarification of the methodology used to assess Malthusian adaptation and a multiplication of long series of vital events for other European countries is required to advance research in the field.

Second, an aggregative population reconstruction holds the potential to enrich our picture of the long-run growth trajectories of different parts of Europe during the early modern period. Existing research on real wage divergence within Europe stresses the contrast between a dynamic north-west and a stagnant rest of the continent. Major forces that are highlighted in producing this divergence include regional proximity to Atlantic trade networks and institutional constraints on rulers that contributed to the security of property rights (Allen 2001, 2003; Acemoglu et al. 2005; Chor 2006). A study of economic development in early modern Germany can both enlarge and refine this perspective. It appears that this country embarked on a path of slow but sustained growth of per capita output from the early eighteenth century (U. Pfister 2009), thus holding an intermediate position between the stagnant south of Europe and the dynamic core in the North Sea region. Interestingly, this structural break followed a change in Malthusian feedback. The sixteenth century was characterised by a strong negative relationship between population size and the real wage, with an increase of the population by one per cent reducing the real wage by about 0.8 per cent. At the same time, population size grew by possibly more than 70 per cent from 1500 to 1600 (Table 1 below) and the real wage fell by about 45 per cent, suggesting weak Malthusian adaptation. By contrast, the link between population and the real wage weakened considerably after the Thirty Years' War (1618–1648; U. Pfister 2010). In part, this may have been due to a continuous increase of labour productivity, possibly as a consequence of market integration and regional specialisation. In addition, the strengthening of Malthusian adaptation, particularly of the preventive check, may have contributed to this change in the demographic system. An aggregative reconstruction of the German population extending back into the late sixteenth century allows for testing this conjecture. It thereby contributes to a comparative analysis of economic development prior to the industrial revolution.

The third motivation relates to the evolution of the material standard of living during early industrialisation and the era immediately preceding it. In Germany the real wage experienced a significant shift upward between the late eighteenth century and the early 1820s; during the following decades the level attained during the early 1820s remained an upper limit. It was reached again several times, but was overcome only in the 1880s (U. Pfister 2010). By contrast, regional investigations into the physical height of males suggest a continuation of the downward trend of the late eighteenth century far into the nineteenth century (Ewert 2006; cf. also Komlos 1998). An aggregate population reconstruction will show if the rise and later stability of the real wage was counteracted by an increase of the dependency ratio, and to what extent a higher wage level simply compensated for the loss of the physical quality of life, evidenced by rising mortality, in early industrialisation towns. Hopefully, the new data generated by our project will render it possible to implement broad concepts of the material standard of living, such as the Human Development Index, and put the results in a comparative perspective (for Great Britain, see Crafts 1997; Voth 2004).

3. Population size

3.1 Geographical coverage and existing information on population size

Table 1 summarizes the received knowledge with respect to the evolution of population size during the pre-statistical era. Most studies refer to Germany within the boundaries of the *Kaiserreich* founded in 1871; some of them exclude Alsace-Lorraine (Column 1). This concept of geographical coverage is useful if one intends to extend series established by the statistical offices during the late nineteenth-century *Kaiserreich* back into the late pre-unification period. For the study of a longer period that extends back into the early modern era, it is useful to choose another geographical frame of reference, however, and to include only those territories that were part of both the Holy Roman Empire (*Reich*) and the second *Kaiserreich*. Relative to the *Deutscher Bund*, the inter-state organisation founded in 1815 as a successor to the early modern *Reich*, dissolved in 1803, this covers all member territories except for the Habsburg lands (Austria, Bohemia and Moravia, present-day Slovenia) and the territories that were part of the Low Countries (Limburg and the Grand Duchy of Luxembourg). Relative to the *Kaiserreich,* this area excludes the Prussian provinces of Posen, Eastern and Western Prussia, the Duchy of Schleswig (the northern half of the Province of Schleswig-Holstein), and Alsace-Lorraine. None of these territories belonged to the early modern *Reich*. In comparison to the Old *Reich,* our research excludes the Habsburg lands (which in those days also comprised the southern Netherlands), except for the *Vorderen Lande* (today the extreme southwest of Germany), which are included. For the early modern period, we consider this geographical frame of reference both historically more meaningful and more amenable to historical-demographic research than the territory of the *Kaiserreich* of 1871. For what follows, it is useful to know that Schleswig and the three other

Kaiserreich provinces we exclude from the analysis cover a surface of 10,689 square km. This is 19.1 per cent of the surface of the *Kaiserreich*, Alsace-Lorraine excluded (526,336 square km). Hence, our geographical frame of reference, referred to as Germany in the rest of this study, includes 424,884 square km (Statistik des deutschen Reichs 1874). In Column (2) of Table 1, we adjust the figures presented by earlier studies to the population within the boundaries of what we call Germany.

Table 1: Population size of Germany, 1500–1840

	(1) Total population *Kaiserreich*, after 1740 excl. Alsace-Lorraine	(2) Total population Germany	(3) Total population, revised
1500	9.2	7.2	
1510		7.7	
1520	10.5	8.3	
1530	11.3	8.9	
1540	12.1	9.5	
1550	12.9	10.1	
1560	13.7	10.8	
1570	14.4	11.4	
1580	15.1	11.9	
1590	15.7	12.4	
1600	16.2	12.8	
1618	17.2	13.5	
1650	10.0	7.9	
1700	14.1	11.1/11.7	
	excl. Alsace-Lorr.		
1740	16.3	14.3	14.6
1750	17.4	15.2	15.6
1755	18.0	15.8	16.1
1765	18.0	15.8	16.0
1770	18.6	16.3	16.6
1780	19.5	17.1	17.4
1790	20.5	18.0	18.4
1800	21.6	19.0	19.4
1805	22.5	19.7	20.2
1815	24.3	21.1	
1840	31.3	27.4	

Sources for Column (1): 1500–1700: Ch. Pfister (1994: 10, 74–76, 1996: 38–43), 1500–1618 re-estimated using Koerner (1959: 328) and calculating growth rates using an exponential function; 1740–1840: Gehrmann (2000: 97). For Columns (2) and (3), see text.

The estimates in Column (1) for 1520–1600 rely on partial censuses of aggregates such as hearths, taxpayers, burghers, etc. A rough estimate of population density in 1600, which arrived at 30 inhabitants per square km, was used to calibrate this information to a national level (Ch. Pfister 1994: 75–6). Population size in other years back to 1520 was then calculated using annual growth rates derived from partial censuses established at different points in time for the same territory and whose information had been standardised by decade. The estimates for 1500 and 1618 are extrapolations on the basis of the observed growth rates in 1520–1530 and 1590–1600, respectively. For Column (1) of Table 1, we have recalculated the figures given by Ch. Pfister using Koerner's extended dataset (Koerner 1959: 328) and applying an exponential (rather than linear) function to calculate annual growth rates. To adjust these estimates to our geographical definition of Germany, one simply needs to transform them by the ratio of the surface of this territory to the surface of the *Kaiserreich*, namely, 0.7870 (Column 2). We add an extrapolation for 1510, which is derived from the growth rate in 1520–1530, analogous to the one for 1500.

The figures Ch. Pfister gives for 1650 and 1700 are conjectures, the first being based on an exhaustive review of partial censuses by Franz (1979). Since Franz assesses population losses caused by the Thirty Years' War (1618–1648) relative to population size in the immediate pre-war period, the estimate for the territory of what we define as Germany can be derived by deflating the number suggested by Ch. Pfister by the surface ratio (0.7870). To the extent that the estimate for 1700 is informed by an assessment of the pace of post-war recuperation, the procedure used for earlier years can be applied to this figure as well. An alternative method is to deflate Ch. Pfister's figure by the share of the population of the areas of the later *Kaiserreich* that we do not include in our definition of Germany. The censuses of the early nineteenth century suggest a ratio of 0.1674.[1] The first figure given for 1700 in Column (2) of Table 1 is based on the surface ratio, the second figure on the population ratio of the early nineteenth-century. Given the comparatively low population density in the north-eastern provinces of Prussia and in Schleswig, the second figure is about five per cent higher than the first.

From 1740 the baseline series in Column (1) relies on Gehrmann's (2000) analysis of proto-statistical material for northern Germany. Gehrmann inflates his estimates for the population of northern Germany to the national level on the basis of its share in the population of the *Kaiserreich*, excluding Alsace-Lorraine in 1840. Taking our population estimates for the reduced territory of Germany in 1815 and 1840 as a reference (below, Table 2), we find that the proportion of the northern German population in the national population was 0.2582 in 1815 and 0.2598 in 1840, respectively. We use the mean (0.2590) to calibrate Gehrmann's estimates for northern Germany to the total population within our revised geographical borders from 1740 to 1805.

Improving the reliability and density of information on population size constitutes a major object of our study. We start with an analysis of the census material and demographic statistics of the period 1815–1840 (Section 3.2), continue with a brief digression on the proto-statistical era (Section 3.3) and conclude with the development of a method to

1 Gehrmann (2000: 97, Footnote 283) places the share of Alsace-Lorraine in 1815 at 5.16 per cent. In the censuses of 1825–1837, the share of the eastern provinces of Prussia and Schleswig in the total population of the later *Kaiserreich* without Alsace-Lorraine was 12.18 per cent (definition of total population as in Appendix 1; cf. Section 3.2 below). If total population is increased by Alsace-Lorraine (that is, by 5.16 per cent) the share declines to 11.58 per cent. In 1815/16, the share of the eastern provinces and Schleswig in total population was a mere 11.07 per cent, which at least in part reflects particularly severe under-registration in the north-eastern Provinces of Prussia; if the correction suggested by Ipsen (1972: 180) is applied, the proportion in 1815/16 rises to 11.62 per cent.

use partial censuses of the early modern era to estimate population growth by decade for the period before 1740 (Section 3.4).

3.2 State censuses, 1815–1840

From 1841, figures on population size and vital events were recorded regularly by state bodies. They are generally considered to be reliable. The compilation by Kraus (1980) can be used to create aggregate series on the national level. Future research will add precision to these figures by considering the additions and corrections suggested by Gehrmann (2010). The only minor challenge is how to isolate Holstein in the information for the later province of Schleswig-Holstein.[2]

From 1815/16—that is, after the end of the Revolutionary and Napoleonic Wars—almost all German states conducted population censuses at intervals of three years (1819, 1822, 1825, 1828, 1831, 1834, 1837 and 1840). Many early censuses were of poor quality, however. There exist substantial discrepancies between (strong) apparent population growth from one census year to the next and the natural increase (difference between the numbers of births and deaths) recorded in the meantime, creating spurious immigration (Gehrmann 2000: 83–5). From 1834, the establishment of the *Zollverein*, which distributed customs revenue according to population size among member states, created a strong incentive at a thorough and exhaustive execution of censuses, so that the phenomenon of spurious immigration had disappeared by 1840.

Table 2 produces estimates of population size in years before 1840 on the basis of aggregate correction factors derived from the work of Ipsen (1972) and Gehrmann (2000; cf. also Marschalck 1974). Two correction factors can be calculated, one for 1815/16 and one for 1825 (Column 3). According to Ipsen (173, 180; cf. Gehrmann 2000: 97) in 1815/16[3] the uncorrected censuses recorded a population of 23.66 million in the borders of the *Kaiserreich* excluding Alsace-Lorraine. If corrected for under-registration in Prussia alone, the figure increases to 24.30 million. This implies a correction factor of 0.0270. Applying it to adjusting population size within the reduced territory referred to by the present study allows for some under-registration in states other than Prussia as well. The correction factor for 1825 makes use of the fact that the share of northern Germany in total population seems to have remained largely constant over time. In the appendix to his study, Gehrmann (2000) provides figures that correct errors in official censuses at five-year intervals, and 1825 is also a year in which most states carried out a census. The share of northern Germany in total population (*Kaiserreich* without Alsace-Lorraine) in 1840 and corrected population size for that region in 1825[4] can then be used to estimate population size in

2 Up to 1840, figures for Holstein are provided by Gehrmann (2000: 380–91). For the present analysis, the share of births and deaths in Holstein for the respective figures in the total province are used to interpolate the number of vital events during the post-1840 period. The share of Holstein in the population of the province in 1840 is used to generate a series of population size on the basis of figures for the whole province during the subsequent years.

3 Many censuses dated in 1816 were carried out at the beginning of the year, so that they largely reflect the state of population at the end of 1815.

4 For this exercise, the population of Northern Germany was calculated on the basis of the material given in the Appendix of Gehrmann (2000). Since some minor territories

1825. This figure is 2.28 per cent above the figure one receives for the territory of the later *Kaiserreich* on the basis of Kraus (1980).[5]

Table 2: National population, 1815–1840 (in million)

(1) Year	(2) Official count adjusted for territories with lacking census	(3) correction factor	(4) revised estimate	(5) extrapolated on the basis of natural increase	(6) implied correction factor
1815/16	20.59	0.0270	21.15		
1822	22.39			22.97	0.0258
1825	23.35	0.0228	23.88		
1828	24.10			24.63	0.0220
1830				25.05	
1831	24.84			25.23	0.0155
1834	25.56			25.81	0.0096
1835				26.09	
1837	26.40			26.55	0.0058
1840	27.37				

For sources and methods used to derive Column (2), see Appendix 1.

Column (4) of Table 2 applies these two correction factors to the counts derived from official censuses given in Column (2). Note that these figures are already adjusted for omissions that result from the fact that censuses lack in some small territories for earlier years (see Appendix 1 for details). Bringing together these revised counts with information on natural increase based on the series of births and deaths developed below in Section 4.2 leads to a quite consistent result: The difference between natural increase in 1816–1825 and estimated population growth in 1815/16–1825 is only -0.2 per cent of population in 1815/16; the respective discrepancy for the period 1825–1840 amounts to -0.3 per cent.

The good consistency between natural increase and estimated population growth in 1815/16–1825 and 1825–1840 warrants the extrapolation of population size for other years during this period on the basis of the births and deaths series (Column 5).[6] Relative to the effective counts in census years, this extrapolated series suggests a continuous decline of the implied factor to correct for under-registration over the 1820s and 1830s (Column 6).

Still, the negative sign of the discrepancy between natural increase and estimated population growth in 1815/16–1825 and 1825–1840 suggests the existence of some unac-

do not seem to be covered by this compilation, the sum even for 1840 is smaller than indicated on p. 97 of Gehrmann's study.

5 On the basis of Kraus (1980) and adjusting for population in small territories with no censuses in earlier years (cf. Appendix 1), population in the borders of the later *Kaiserreich* excluding Alsace-Lorraine was 23.14 million in 1815/16 and 26.61 million in 1825. The first figure is a 0.4 million below uncorrected population size quoted by earlier research (cf. Gehrmann 2000: 97), which draws on work by Prussian statisticians conducted in the late 1870s. We have not been able so far to clear up this discrepancy.

6 The small discrepancy between natural increase and population growth is taken into account by way of exponential adjustment. The year 1819 is omitted because the number of states that did not conduct a census in that year is quite large and because underregistration in the existing census is reputed substantial.

counted under-registration, particularly on the background that there is some consensus that net cross-border migration was directed outward rather than inward during this period (Oltmer 2010: 9). This impression is corroborated by an exercise which, rather than relying on aggregate correction factors, makes use of the actual correction of under-registration on the level of individual provinces proposed by Ipsen (1972: 180; Westphalia in 1816 from Gehrmann 2000: 85). The resulting estimates of population size are 21.13 million for 1815/16 and 23.63 million for 1825. The latter figure is 1 per cent lower than the estimate given in Table 2, and its combination with the information on natural increase would increase spurious immigration accordingly. This implies that if correction for under-registration is limited to Prussia, population growth is almost certainly overestimated. An important challenge for future historical-demographic research into this period therefore consists in producing bottom-up assessments of under-registration in early nineteenth-century censuses for other German states.

3.3 The proto-statistical era

From about 1740, official authorities of Protestant states in particular began to collect information on vital events and population size. Before the early nineteenth century, however, this material lacked a conceptual framework, and its quality is often deficient (Ch. Pfister 1994: 6–7; Gehrmann 2000: 37–83).

An exhaustive analysis of proto-statistical sources in northern Germany in its present-day borders has been carried out by Gehrmann (2000). It can in principle be complemented by the three additional Prussian provinces considered by the present research, namely, Pomerania (bei der Wieden 1999), Silesia, and the possessions on the lower Rhine (cf. Behre 1905: App. 4 and 5), as well as the Electorate of Saxony (which was considerably larger than the nineteenth-century Kingdom of Saxony). In addition, we have collected archival material on population size for several territories of south-western Germany.[7] This can be complemented with the information that, in Bavaria, the population shrank at an annual rate of -0.30 per cent between 1771 and 1794.[8] Taken together, we are able to extend Gehrmann's database by a considerable margin: Whereas the area studied by him comprises about a quarter of the German population in 1815, the additional information allows us to cover probably more than half of the national population during the 1770s and 1780s.

Table 3 presents annual growth rates of population size for periods similar to those in Table 1 for various territories, and confronts them with the growth rates reported by Gehrmann for northern Germany. All this information can be fed into a revision of Gehrmann's national estimate by weighting all territories (including Bavaria between c. 1770 and 1790) according to their share in national population in 1815/16.[9] The combina-

7 The figures still need adjustment for minor border changes. For Wurttemberg, annual series of population size will be extended until 1804. For the united Margravate of Baden, point estimates will probably be possible for 1789 and 1800.

8 Lee (1977: 12), with the figure in 1771 reduced by 106898 to take account of the loss of the Innviertel in the wake of the Peace of Teschen (1779; Denzel 1998: 110–1).

9 The southern German states, except the Palatinate, experienced a strong expansion during the Napoleonic period so that weighting by population in 1815/16 is a rather rough procedure. Since the data on Bavaria in the late eighteenth century refer only to the old territory, this state was attributed a weight of only 1.5 million. Electoral Saxony

tion of all territories yields annual growth rates which are very close to those reported by Gehrmann with two exceptions: For 1765–1770, we calculate a slightly higher value (0.78 per cent); most territories apparently recovered more rapidly from the shocks related to the Seven Years' War than northern Germany. By contrast, due to the stagnation experienced by Saxony, our revised growth rate for 1805–1815 is considerably lower than that given by Gehrmann (0.48 per cent). Given the extreme shocks that hit the German population during this period (see Section 4.3 below), the reduced rate is more consistent with the course of vital rates than the original estimate. If we use our series of growth rates to project population backwards from 1815, we come out with a figure for 1750 that is about 2 per cent above the one proposed by Gehrmann (Table 1, Column 3; the value for 1740 is generated simply by adjusting the value in column 2 by the ratio between the revised and the original estimate in 1750).

Table 3: Annual rates of population growth in south-western Germany, Pomerania, and the Electorate of Saxony, 1750–1815 (per cent)

(1)		(2)		(3)		(4)		(5)		(6)
Baden-Baden		Palatinate		Wurttemberg		Pomerania		El. of Saxony		Gehr-
period	r	period	r	period	r	period	r	period	r	mann
								1750–55	0.48	0.65
				1757–65	0.10	1753–67	-0.17	1755–65	-0.32	0.00
				1765–70	0.98			1765–70	0.93	0.68
		1772–80	1.33	1770–80	0.93	1767–80	1.37	1770–80	0.23	0.46
1780–9	0.83	1780–90	0.98	1780–90	0.85	1780–90	0.74	1780–90	0.68	0.55
				1790–00	0.67	1790–00	0.70	1790–00	0.44	0.50
						1800–05	0.92	1800–05	0.76	0.80
								1805–15	-0.08	0.70

Sources: Baden-Baden: GLA Karlsruhe 74/9062 (microfilm copies 559–61), 74/9069 (microfilm copies 124–9); Palatinate: GLA 77/6148 (microfilm copies 52–4), 77/6150 (microfilm copies 139–46), cf. Traiteur (1789) for partly lost originals; Wurttemberg: HStASt A 8 154–156 (1790), 185–188 (1800), 218 (1757–1780); Pomerania: Bei der Wieden (1999: 97–101); Electorate of Saxony: Schirmer (1996: 57–8); Northern Germany (Column 6): Gehrmann (2000: 97).

So far this exercise suggests that Gehrmann's series is quite robust, and it substantiates the claim that national population can be extrapolated on the basis of information for northern Germany with considerable precision at least back into the mid-eighteenth century. Future research will attempt to collect further material from outside the area studied by Gehrmann in order to broaden the database and further scale down the weight of northern Germany in the estimate of national population. Note, however, that there is a strong bias towards Protestant regions in the data. Given that state-building was notoriously weak in ecclesiastical territories, it appears highly improbable that it will be possible to substantially reduce this confessional bias in future research.

is weighted according to population size before the huge losses of territory experienced as a result of the Congress of Vienna (2.034 million).

3.4 Using partial censuses to assess population size in the pre-statistical era

During the pre-statistical era, which in Germany dates until the early eighteenth century, demographic information was collected by various authorities—state, ecclesiastical, communal—at irregular intervals. Data collection was typically connected with concrete needs for information. Accordingly, these censuses mostly referred to specific aggregates, such as households, taxpayers, communicants, etc.; they did not comprise the population as a whole (Rödel in Andermann and Ehmer 1990; Ch. Pfister 1994: 3–7). Our methodology in analysing this heterogeneous body of material will largely follow the tracks of Koerner (1958, 1959) and Ch. Pfister (1994, 1996).

As mentioned earlier, Ch. Pfister, who relies on data compiled by Koerner, estimates population size in 1600 by first aggregating a great number of household counts and relating the result to the size of the area covered, which produces a measure of house density per square kilometre. This figure is then multiplied by six to produce a rough estimate of population density which then can be multiplied with the size of the national territory to produce an estimate of total population.

The estimate for 1600 has been used by Ch. Pfister as an anchor to extrapolate population size in other years on the basis of growth rates. These in turn are derived from pairs of partial censuses established for the same administrative unit in two different points in time. On the basis of the mean annual growth rate between the two points in time, it is possible to extrapolate the number of units counted (hearths, communicants, etc.) at the beginning and the end of each decade. These can then be aggregated across all areas with appropriate information to yield an aggregate annual growth rate by decade. With this method, Ch. Pfister produces estimates of population size backwards from 1600 until 1520.

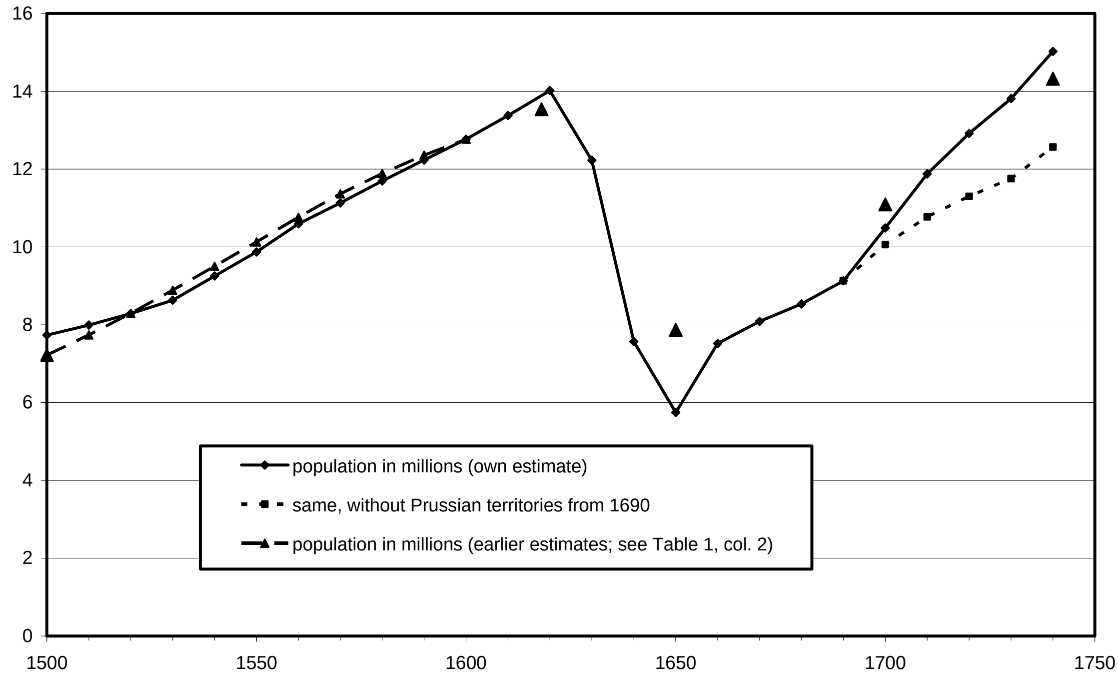
Particularly if the aggregation is done directly on the basis of growth rates, the method has the advantage that it does not need to rely on so-called reduction factors; that is, on information about the ratio between the counted units and total population size, such as mean household size, the age and sex structure (in the case of lists of communicants and burghers), etc. (cf. Mols 1954–56: II, 110–164). Of course this presupposes that the reduction factor stays constant between two censuses, but this assumption is in any case less problematic than choosing an arbitrary value. A clear limitation of the method stems from the fact that it follows the actual movement of population size only in a smoothed way since the extrapolation of population change over a time span of usually more than one decade misses short-term variations of the growth rate. The relevance of this caveat increases with the average time interval between two censuses across all data pairs. It will therefore be important to identify preferably pairs of censuses with short intervals in between. We also intend to compare our estimates with estimates of natural increase derived from parish registers (see the following chapter) in order to better capture the short-term fluctuations of population size.

In what follows, we present an exploratory analysis on the basis of 64 census pairs (see Appendix 2 for the documentation). It relies only to a small extent on Koerner, particularly his original research, which has a regional focus on Thuringia. We have been unable to reproduce most data pairs on the basis of his publications, but his hand-written material is deposited at the State archive of Thuringia in Weimar; we expect to draw on it in future expansion of our dataset. In addition, we use other and partly more recent regional studies, particularly from Hesse-Kassel, Bamberg, Bavaria during the post-Thirty Years' War period, Wurttemberg, the bishopric of Speyer at the beginning of the sixteenth century and

Oldenburg. Also included is information on Prussian territories from the old study by Behre (1905) that may not be reliable in every respect. Finally, we had the opportunity to draw on unpublished counts of communicants collected by Christian Schlöder in the archives of two archbishoprics of western Germany.

In the further course of our research we intend, first, to perform an exhaustive research for data pairs in existing research in regional history. This includes in particular a reanalysis of the material assembled by Franz (1979) for the era of the Thirty Years' War and the use of studies describing relevant sources (i.e., Andermann and Ehmer 1990). Publications of lists of burgers, that exist for Wurttemberg in particular (von Hippel 1978: 417 and passim, 2009a, 2009b), will also provide valuable information. Second, we shall collect information on counts of communicants from visitation records in Catholic bishoprics and Lutheran Wurttemberg and possibly Saxony. This body of material will in particular improve coverage of the west and the south-east (Würzburg, Bavaria, maybe eastern Swabia). Possibly, a third focus will lie on the broadening of information from partial state censuses in the centre and north-east (Thuringia, Brandenburg and Mecklenburg).

Figure 1: Tentative re-estimates of total population size, 1500–1740



Sources: See Appendix 2.

Figure 1 reports the results of an analysis of the data we have collected so far, using Ch. Pfister's estimate for 1600 (adjusted to our reduced territory) as an anchor. Estimates of population size by decade are extrapolated forward and backward from this year on the basis of growth rates by decade. To aggregate the annual growth rates of individual data pairs into national growth rates by decade, data pairs should be weighted. In the present exercise, arbitrary weights have been attributed according to whether an administrative unit was small, medium or large in size. In future versions of this analysis, we shall relate the administrative units for which we have information to units existing around 1815/16 and define weights according to population size in that year (cf. Ch. Pfister 1994: 19–23). Given the strong regional differences with respect to the evolution of population as they have become apparent in the context of the discussion of Table 3 above, much depends on correctly weighting individual data points, and not too much importance should be attributed to the preliminary results in Figure 1.

It is nevertheless encouraging to see that the new estimates are broadly consistent with earlier research. The series starting with the assumption of a population density of 30 inhabitants per square km in 1600 produces an extrapolation for 1740 that is about 12 per cent below Gehrmann's estimate for that year if Behre's material for Prussian lands is excluded and about five per cent higher if Behre's information is included. We expect that this discrepancy narrows as the dataset grows and the Prussian data are checked with respect to their reliability. The discrepancy between Ch. Pfister's figures and the new estimates is particularly large for 1650, which underscores the necessity of a reappraisal of the population losses incurred in the wake of the Thirty Years' War. The inclusion of information on the bishopric of Speyer for the early sixteenth century produces a figure about 10 per cent above the one implied by Ch. Pfister's series (who simply extends the growth rate recorded for 1520–30 back to 1500). This illustrates the need to search for early information starting in the late fifteenth century to correctly represent the pattern of the secular population increase during the sixteenth century.

Another direction of future research is given by the claim that population density in 1600 was about 30 inhabitants per square km, which needs substantiation or revision. Of course, our series of growth rates based on partial censuses could be calibrated to Gehrmann's estimate of population size in 1740, but this would deprive us of a cross-check of the latter figure. As a spin-off of the compilation of information from partial censuses, we therefore intend to collect information on the ratio between the number of partial aggregates (households, citizens, communicants, etc.) and total population wherever this information is available. Hopefully, this will enable us to confirm or improve the estimate for 1600 and to produce a well-founded estimate of population size for a few other time points.

4. Series of birth and death rates, 1730–1840

A major goal of our research consists in constructing national series of numbers of births, marriages and deaths back into the second half of the sixteenth century. In this section, we describe the sources that can be used to this end and develop a methodology to create aggregate series of vital events on the basis of a heterogeneous body of information, most of which inevitably suffer from occasional gaps. We also implement this research strategy with a preliminary dataset which provides a fairly broad coverage from the middle of the eighteenth century onwards, while its density rapidly peters out as one moves back into earlier time periods.

We start with a description of the available sources and of the method to aggregate them into time series of vital events (Section 4.1). We then create a handful of aggregate series for particular regions, source types and time periods and combine them into national series of crude birth and death rates (Section 4.2). Since the consistency of these series with independent estimates of population size is quite satisfactory from 1730 onwards, we feel that a substantive interpretation of their properties and of their evolution over time is warranted (Section 4.3).

4.1 Sources and methods

From the late 1810s, the overwhelming majority of German states systematically collected information of vital events from pastors and assembled it into aggregate figures. National series can be created on the basis of the publication of this material by Kraus (1980). With minor extrapolations and interpolations, roughly two thirds of all deaths and four-fifth of all births can be covered from 1818; coverage rises to about 93 per cent for both series from 1827, and after 1840 coverage is complete. To create contiguous series from 1818 to 1850, the three series in 1818–1826/9, 1827–1840/3 and 1841–1850 were spliced by using the means in 1827–1829 and 1841–1843 to derive splicing factors (see Appendix 1). We expect to increase coverage of the early part of this period in future versions of these series by drawing on the sources described by Gehrmann (2009, 2010).

As mentioned in Section 3, German states began to collect information on vital events in their territories from about 1740. Gehrmann (2000) provides an exhaustive compilation of the material that exists for northern Germany, which can be complemented by series of vital events in Pomerania (bei der Wieden 1999) and for a short time period in Electoral Saxony (1743–1777; Schirmer 1996). We expect that the series for Electoral Saxony, which comprised roughly ten per cent of the German population, can be extended to later years (cf. Gehrmann 2010). Outside Prussia, Saxony and some minor territories studied by Gehrmann (2000), series of vital events collected by eighteenth century state authorities seem to be rare. At present, we are only aware of two short series in the Palatinate (1772–1786, 1789 and 1790) and Wurttemberg (1785–1804).[10] As in the case of early estimates of population size, there is a strong confessional bias that probably cannot be corrected by future archival research. Nevertheless, the existing series constitute an impressive body of data, which at present covers about 30 per cent of vital events on the national level around 1790. Up to now, its analysis has been handicapped by the short duration of many series, by gaps and by changes in geographical coverage. The application of pooled regression, explained later in this section, will render it possible to use it for the construction of aggregate series of vital events.

A drawback of the proto-statistical data is its confessional bias. Therefore, an important part of the information on vital events before the late 1810s has to come from parish registers, and coverage of the long period up to the 1730s must rely exclusively on this type of source. In the full version of our investigation we plan to analyse approximately 450 to 600 parishes, which is slightly more than the number of parishes studied by Wrigley and Schofield (1981). In comparison to England, Germany is certainly larger and more varied with respect to patterns of social organisation and market areas, but for simple statistical reasons the additional information gained beyond a several hundreds of parishes will certainly approach nil. However, we design a sample that is slightly larger than that used by Wrigley and Schofield because most of the sources that are easy to come by (and which we intend to make use of) show a strong regional bias and are also more abundant from the

10 Cf. Schaab (1967). Schaab does not mention the extension of statistical reporting to vital events in Wurttemberg. However, births and deaths are recorded in the territory-wide *Seelentabellen* from 1785 (HStASt A 8 139–141).

middle decades of the eighteenth century than for earlier periods of time. In addition, the marked reduction of the volatility of life events over time, described in some detail below, implies that, for a given margin of error, sample size must be larger for earlier than later periods.

More specifically, we expect to gather annual (and partly monthly) numbers of baptisms, marriages and burials from the following six types of sources:

(1) *Existing collections of data series*. From an earlier project, we have retained a series of numbers of vital events on 35 parishes in Westphalia from 1750 (cf. Fertig 1999). There is also a dataset compiled by Reinhard Spree on the basis of published local studies covering different parts of Germany west of the Elbe. It contains information for 25 parishes, mostly going back to 1740. By consulting the original studies, it is possible to extend more than half of these series back into earlier periods of time. Exhausting compilations of vital events exist for two Westphalian regions, namely for Tecklenburg from 1750 (Küpker 2008; 18 parishes) and Recklinghausen (Krüger 1977; 27 parishes, three of which with data extending back into the seventeenth century). The strong concentration of data in Westphalia, at least for the period from 1750, requires its treatment as an own geographical unit in order not to bias the sample.

(2) *Series from published local studies*. We are currently building a bibliography of local studies in which we check for numbers of vital events. Such studies fall into two categories, namely, academic research by historical demographers, and *Ortsfamilienbücher*. In the latter type of works (also known as *Ortssippenbücher*), genealogists have compiled information on all local families. In effect, this amounts to family reconstitutions. We have so far identified series from academic studies for about 46 parishes. About 50 references have not been checked yet, and we hope to still find a few more studies containing numbers of vital events. As to the *Ortsfamilienbücher* (often discussed in the historical-demographic literature, e.g., Knodel 1975; Knodel and Shorter 1976; Gehrmann and Roycroft 1990: 59–62), they typically leave out information about events that the authors could not connect to other events. Thus, their main content does not constitute a useful source for the present investigation. Also, stillbirths and infants deceased a few days after birth may not be reported, and defective registration must be checked ex post. However, some *Ortsfamilienbücher*, notably for parishes located in Wurttemberg, provide annual numbers of vital events. We have so far gathered serial information for 41 parishes from *Ortsfamilienbücher*.

We hope that types (1) and (2) will eventually yield a series of vital events for approximately 200–250 parishes.

(3) *Published parish registers*. To facilitate person-related research, local historians have published entire parish registers (Henning and Wegeleben 1991). We are currently inspecting publications of this type and believe that eventually they can cover about 30 parishes.

(4) *Parish registers in machine-readable form*. Instead of publishing the full text of parish registers, genealogists have also converted them into databases (*Verkartungen*) that are meant to serve as a base of family reconstitutions. This type of source can be accessed through networks of genealogists and contacts with individual researchers. The idea is to convert genealogical databases into series of numbers of life events, with the additional benefit that monthly series or series organised by gender can easily be created on the basis of these datasets. However, the same caveats apply as in the case of other genealogical work discussed under type (2) above. A preliminary survey suggests that approximately 25–50 parishes can be covered by sources of type (4).

(5) *Aggregated series deposited in archives*. For Gotha we have found a compilation of the annual number of life events for at least about 50 parishes of this small territory drawn up by the state authorities in the 1860s.[11] Of course, this material will have to be cross-checked with the original parish registers. We hope that at least 25 series going back to the early seventeenth century can be retained. Similar compilations may exist in other archives, but at the present moment it is impossible to speculate about their number and quality.

(6) *Unpublished parish registers*. We expect that source types (1) to (5) will yield series of life events with satisfactory quality for 250 to 350 parishes. Since there are few series that span more than one and a half centuries and many are shorter than a century, it is necessary to consider at least about 250 additional parishes whose records have to be analysed directly on the basis of archival material. Types (1) to (5) will probably be biased against the early period until the middle of the seventeen century, as well as against the south-east (Bavaria), the lower Rhineland, the centre (inland Lower Saxony, Saxony-Anhalt, Thuringia) and the east in general (see map 1 in Appendix 3). The choice of parish registers analysed on the basis of manuscript sources will be made so as to possibly reduce these biases.

Before being aggregated to national series of births, marriages and deaths, all this material will be subjected to a number of procedures, most of which are inspired by Wrigley and Schofield (1981):

(a) *Quality control*. Depending on the type of source, quality control can take place at an early time point in its use or at the moment when the series of the numbers of vital events exist already. When series are taken over from existing studies (type 2), we must rely on statements of the authors about the quality of the sources used. With respect to parish registers analysed directly on the basis of the manuscript records, the methods developed by Wrigley and Schofield (1981: ch. 1) to detect and correct under-registration will be adapted. In existing series, a strong discrepancy between the number of births and deaths occurring over several years are interpreted as an indicator of massive under-registration of burials.

(b) *Stillbirths and infants dying before baptism*. We intend to implement the concept of life-birth, which was not generally applied during the pre-statistical period. Lutherans and Reformed baptised later than Catholics, so that many infants dying shortly after birth may be omitted from baptismal records in Protestant regions. We shall draw on the discussion of these issues by existing local studies to devise appropriate methods of correction (see also Kraus 1980: 3–4 and Gehrmann 2000: 378).

(c) *Checks for representativeness and re-balancing*. As is clear from what has been said so far, data availability is a major selection criterion of parishes. This raises the issue of potential biases that need correction in the course of aggregating series from individual parishes to national figures. Wrigley and Schofield (1981: ch. 2 and pp. 77–83) correct for parish size. We should be able to consider this variable as well and to test whether parishes of different size experienced unequal growth rates. Given the low rate of urbanisation in Germany before 1850 as well as its slow change (cf. Bairoch et al. 1988: 259), we do not expect this to constitute a major challenge. Still, the methodology developed below will render it easy to flexibly adjust for biases with respect to size. By contrast, it may well be that that our material will not be representative with respect to patterns of landownership, land use, family organisation, etc. Information on many of these variables becomes available if at all only in the course of the nineteenth century (cf. Huppertz 1939; Szołtysek et al. 2010). In the end,

[11] Staatsarchiv Gotha, Herzogliches Statistisches Bureau zu Gotha, Sect. II, Loc. XVI, No. 1–2.

the most feasible test for representativeness may be the one for regional representativeness, the population distribution in 1815/16 serving as a benchmark. Regional biases could then be balanced by appropriate weighting.

The aggregation of hundreds of series from parish registers faces the challenge of gaps in individual series and of the variability of the time points when series start and end. Retaining only those parishes in the analysis that display long and contiguous series does not only lead to a huge loss of data but also introduces a kind of survivorship bias in the sense that parishes suffering extreme shocks will be under-represented—with serious consequences for the precision of observed levels of mortality during crisis years. Splicing series of shorter duration at regular intervals of, for example, a quarter century also does not provide a satisfactory solution because data that do not fit into this scheme are lost. This happens more frequently the farther one moves back in time, and even the series produced by state officials during the proto-statistical period are almost impossible to join by way of splicing. A further drawback of this method follows from the fact that the ratios used for splicing are possibly influenced by idiosyncratic fluctuations of one of the two series during the year or a short time span whose values are used to join the two series.

As a solution to this challenge, we propose the aggregation of the series from individual parishes into larger groups by way of pooled regression with fixed effects for localities and years using Weighted Least-Squares (WLS) as an estimation method. In concrete terms, we shall implement the following specification:

$$\ln(V_{ij}) = c + \sum_{i=1}^{k-1} \alpha_i L_i + \sum_{j=1}^{l-1} \beta_j T_j + \varepsilon_{ij} \tag{1}$$

with V being the number of vital events (births, deaths) in locality i and year j, L an array of dummy variables for all localities excluding the last one and T an array of dummy variables for all years covered by the dataset, except the last. A logarithmic specification is preferred in order to adequately capture variation among low values—otherwise, the estimate would be largely dominated by extreme values, particularly in the case of deaths. Using an estimate of equation (1), a time series can be calculated as the exponential of the sum of the constant c and the individual elements of the parameter vector β. Note that this series has no meaningful dimension; it is simply calibrated to the level of locality k (the last one for which no fixed effect dummy is introduced). It therefore must be scaled to a meaningful regional or national aggregate.

Estimating equation (1) with the standard method Ordinary Least-Squares (OLS) would be tantamount with the assumption that vital events would move in parallel in all localities irrespective of size. This is because the regression parameters for locality fixed effects L (which must be included to control for the entry and exit of a particular locality from the sample) capture the mean level of the number of vital events in each locality. In order to arrive at a correct series of the aggregate number of vital events, it is necessary therefore to reintroduce size into the estimation procedure. We choose to proceed by WLS and use the mean number of the total of births and deaths in 1788–1792 in a particular locality for weighting all observations of that locality in the data.[12] This means that quite a few parishes for which information is available only for the nineteenth century must be

12 It is basically this feature, apart from the inclusion of information on population size, that distinguishes our approach from the one pursued by Galloway (1994b: 228–34) in his reconstruction of the population of Northern Italy.

excluded from this analysis; since the focus is on the period before the onset of official statistics in 1818, this loss is irrelevant. By contrast, two parishes whose registers end earlier were allocated the weight of the mean numbers of births and deaths in the five last years for which information was available.

For the purpose of comparison, the series described in the following section were also constructed in a variant where shorter series covering sub-periods with homogenous geographical coverage were joined by way of splicing wherever possible. In most cases and years, the variants produced by pooled regression estimated with WLS and the spliced series move together quite closely (see in particular Figures 2 and 3 below). Differences are probably in large part due to the fact that the versions based on pooled WLS regression use all available data, whereas splicing excludes data that do not cover an entire sub-period. We can conclude that pooled WLS regression constitutes a valid method to create aggregate series of life events from a great number of parish registers.

4.2 Creating aggregate series of vital events

The object of this section is to establish preliminary national series of the Crude Birth Rate (CBR) and Crude Death Rate (CDR), extending backward in time as far as possible. Marriages are not considered at this moment because their coverage is very unequal in the sources that we have been using so far. We proceed in three steps: First, we create four regional series of the numbers of births and deaths for the period 1818–1850, which are only used by way of comparison with the national series derived from official statistics. Second, we construct a bundle of regional series extending backwards from 1825 to some point in time between the middle of the eighteenth century and 1640. Finally, we aggregate these series and the information from official statistics into national CBR and CDR series and discuss their consistency.

As mentioned earlier, the information from parish records that can be retrieved from existing data collections and publications has a strong regional bias. One way to explore the consequences of this and of limited data density is to compare the parish material with the series created on the basis of official statistics for the time period 1818–1850 (see beginning of Section 4.1 above and Appendix 1). For this purpose, all parishes with continuous data for the period 1818–1850 were simply aggregated into four series: *Westphalia* (63 parishes), *North other* (17 parishes; all concentrated in the north-west, mostly near the coast of the North Sea), *South* (30 parishes mostly from Wurttemberg, with a few from Hesse and Rhineland-Palatinate and one from eastern Swabia in Bavaria) and, as a subset of the latter, *Wurttemberg* (23 parishes). The first three series were calibrated to the national average in 1841–1843 and two versions of a national series were created. Version 1 weights *North other* with 0.17, *Westphalia* with 0.33, and *South* with 0.5. Because *North other* refers to a relatively small region with distinct demographic characteristics—slow growth and a high variation of mortality—Version 2 considers only *Westphalia* and *South* with equal weights. In addition, the series from parishes in Westphalia and Wurttemberg were both calibrated to their regional aggregate, the Province of Westphalia and the Kingdom of Wurttemberg, respectively, in 1841–1843. The entire dataset refers only to localities with a population of less than approximately 5,000. Table 4 shows the result of the comparison of these series derived from parish registers with official statistics.[13]

Table 4: Comparison of the series of the number of births and deaths derived from parish registers with official statistics, 1818–1850 (per cent)

	(1) Share in total 1841–1843	(2) difference 1818	(3) difference 1818–20	(4) difference 1848–50	(5) mean diff. 1818–50	(6) standard dev. of difference
a. Births						
National series 1	0.58	3.1	0.9	-5.0	0.2	3.3
National series 2	0.48	0.1	-1.8	-4.8	-0.9	3.2
Westphalia	7.6	-2.1	-0.5	0.7	0.1	1.5
Wurttemberg	1.3	13.8	3.6	-4.7	1.2	5.0
b. Deaths						
National series 1	0.54	2.4	10.4	-3.5	8.6	8.7
National series 2	0.46	1.0	5.4	-6.2	3.0	8.2
Westphalia	7.5	-0.5	-0.6	-1.0	0.4	5.3
Wurttemberg	1.2	7.3	6.4	1.0	6.5	14.4

Note: For the composition of the national series, see text. All series are calibrated to the mean number of births or deaths respectively, according to official statistics in 1841–1843. The reference for the national series is the national total, for Westphalia the total for the Province of Westphalia and for Wurttemberg the total for the Kingdom of Wurttemberg.
Sources: Official statistics: see Appendix 1; parish registers: see Appendix 3.

Let us start with Westphalia. Data density is highest in this region, namely, about 7.5 per cent of all births and deaths in the province as a whole. The series created from parish registers fits the official statistics quite well; in 1818—that is, almost a quarter century distant from the years that are used to calibrate the series—the difference is -2.1 per cent in the case of births and -0.5 per cent in the case of deaths. For other years, the differences are in a similar range. The long-term movement of vital events in the whole province can thus be adequately traced by the records of the 63 parishes that are currently in our dataset. The standard deviation of the yearly discrepancy between the two series is above 1 one per cent and amounts to 5.3 per cent in the case of deaths. Apparently not all short-term movements are represented accurately by the parish series. This is related in part to the fact that short term movements are slightly more pronounced in the parish series than in the official statistics; the coefficient of variation (the standard deviation relative to the mean)

13 The Westphalia series does not include the eighteen parishes of Tecklenburg studied by Küpker (2008). Inclusion of this small region increases the size of the dataset by about a third, but renders it much less consistent with the figures for the whole province than the dataset without Tecklenburg. This seems to be due mainly to Tecklenburg's slow population growth associated with marked de-industrialisation, a rather a-typical experience during the first half of the nineteenth century. The experience with this dataset suggests that data should be scattered geographically and that the inclusion of entire regions may bias the results. The same conclusion follows from the comparison of variants 1 and 2 of the national series in Table 4 (see text below).

for deaths amounts to 13.6 per cent in the former and 9.6 per cent in the latter series. Thus, considerable data density is needed to even out idiosyncratic short-term movements of vital events in individual parishes.

This conclusion is corroborated by the series for Wurttemberg, which is based on a sample that barely exceeds 1 per cent of the total number of vital events in the whole kingdom. Both series lie considerably above the values of the official statistics at the beginning of the period (3.6 per cent in 1818–1820 in the case of births and 6.4 per cent in the case of deaths). This does not necessarily imply a misrepresentation of the long-term trend, since in 1815–1817, for which comparison with official statistics is also possible, differences are small and negative (-0.0 per cent in the case of births and -1.9 per cent in the case of deaths). The major problem thus seems to lie in the capture of short-term fluctuations given idiosyncratic movements of small populations. In fact, the high standard deviation of the difference between the number of deaths in the parish series and the official statistics (14.4 per cent) is largely due to a single event, namely the mortality crisis of 1837, which corresponds with a nation-wide cholera epidemic that was particularly severe in some large parishes included in our sample. In Nagold, for instance, a small *Amtsstadt* which makes up about 15 per cent of all deaths in the parish series in 1841–1843, the number of deaths rose fivefold in 1837.

While we apparently need at least a 5 to 10 per cent sample to adequately render short-term variations of vital events on the regional level, this does not need to be true for the national level. The second variant of the aggregate series, which only uses parishes in the South and in Westphalia and constitutes a sample of less than a half per cent of the national number of vital events, tallies astonishingly well with the official statistics in 1818 with a difference of 0.1 per cent in the case of births and 1.0 per cent for the number of deaths. Other discrepancies are larger, but only the value for deaths in 1848–1850 deviates more than 5 per cent from official statistics. Note also that the second variant, which excludes the thin North rest series, tends to show a somewhat better fit with the national statistics than the first variant, although it rests on a smaller amount of data. The standard deviation of the yearly differences is also much closer to Westphalia than to Wurttemberg. All this suggests that as soon as the number of parishes in our sample moves considerably beyond 100 and as the strong regional bias is reduced, the series aggregated from parish registers can adequately capture national movements in vital events.

In a second step we produce a handful of series of numbers of births and deaths extending from the first quarter of the nineteenth century backwards, at least until the mid-eighteenth century. They are all calibrated to the national figures in 1818 so that the resulting aggregate series can be joined with the official statistics. Since samples do not stay constant over long periods of time and have more gaps the farther one moves back in time, it is impossible to simply add up the figures for one year. Therefore, pooled WLS regression will be applied following equation (1) above, with the mean number of births and deaths in 1788–1792 serving as weights for all observations of each locality. For the sake of comparison, some series are also constructed by splicing the data for shorter time periods with homogeneous coverage. Specifically, we establish the following series:

Towns (1735–1825). These births and deaths series are based on 13 communities making up for 1.86 per cent of the estimated number of vital events on the national level in

1788–1792.[14] Towns are identified as localities showing regularly more than 100 births or deaths annually. This threshold implies a population size of about 5000, which is the criterion used by Bairoch et al. (1988) to define towns. Applying this criterion to our research will facilitate the appropriate weighting of the *Towns* series according to aggregate characteristics. The series are dominated by Berlin and Hamburg, which alone make up 1.26 per cent of the national number of vital events around 1790. This, the large size of this sample compared to the samples relating to rural parishes and the specific movement of vital events in towns (see below) underscores the need to treat towns, and possibly towns below the level of metropolises, as independent units of analysis.

Westphalia (1750/53–1850). These births and deaths series are based on 55 parishes making up for 0.33 per cent of the estimated national number of vital events in 1788–1892. The series estimated with pooled WLS regression begin in 1750, those produced by splicing shorter bits of data in 1753.

North other (1700/20–1850). The basis is constituted by 23 parishes with 0.12 per cent of the national number of vital events in 1788–1792. Most communities are located close to the North Sea coast in the extreme north-west of the country. This regional concentration is slightly mitigated by the inclusion of two parishes in the lower Rhineland and one that today forms part of the metropolitan area of Berlin. The series created with pooled regression start in 1720, while those based on splicing shorter series extend back to 1700, albeit on a very thin database of only eight parishes.

North combined (1690–1760). The series are calibrated to the mean of the *North other* and *Westphalia* series in 1750/51. Coverage grows from 16 parishes in 1690 to 29 in 1740.

South (1640/75–1850). These births and deaths series are from 51 parishes situated mostly in Wurttemberg, Rhineland-Palatinate and northern Hesse; only three are from Bavaria and one from Baden. The share in the estimated total number of vital events in 1788–1792 is 0.19 per cent. Comparison with the sample characteristics of the *Westphalia* series suggest that parishes were on average much smaller in the south-west than in the north-west. The challenge posed by heterogeneous data referring to small populations is thus greater in the former than the latter region, and relatively more parishes need to be studied in the south-west to even out the idiosyncrasies of local population movements. The spliced series extend back to 1675, whereas the series created by pooled WLS regression start in 1640. From twelve parishes in 1640 and 16 in 1650, coverage rises to 34 parishes in 1700.

Territories (1735–1825). These series are based on the proto-statistical information collected by state officials. The bulk of the data relates to northern Germany (Gehrmann 2000: Appendix); additions are the series for Pomerania, Electorate of Saxony (1743–1773) and the Rhenish Palatinate (1772–1790). In 1788–1792, this sample covers approximately a third of the estimated national total of life events.[15]

14 The national series is the one developed in the last part of this section below. To describe the share of each sample in the national aggregate, we simply compare the number of births and deaths combined in 1788–1792, the years used for weighting individual observations.

15 Sources: Pomerania: bei der Wieden (1999: 97–101); Electorate of Saxony: Schirmer (1996: 57–8); Rhenish Palatinate: GLA 77/6148 (microfilm copies 28–30, 52–4), 77/6150 (microfilm copies 139–46) 77/6151 (microfilm copies 154–6, 160–1), 77/9729 (microfilm copy 552); in addition see Traiteur (1789) for partly lost originals. In any case, the years 1787 and 1788 are missing for the Palatinate. Weights were es-

To describe their characteristics, all of these series were decomposed into trends and cycles using the standard Hodrick-Prescott filter with $\lambda=100$ on the natural log of all values. Figures 2 and 3 show the trends for the births and deaths series respectively. The dimension is largely meaningless, as all series were calibrated to the national number of births and deaths in 1818, taken in natural logs for this analysis. Five observations can be made on these graphs. First, and in a methodological perspective, it turns out that smoothed series created with pooled WLS regression and spliced series are largely identical. This corroborates the claim that pooled WLS regression is an adequate method to establish series of vital events on the basis of parish records. Since it allows for capturing all availably data—which is not the case with splicing—it should be preferred over splicing (possibly combined with interpolating missing data). The difference in level visible in two out of three deaths series is related to the fact that the plunge in mortality levels in 1818 (following the crisis of 1817) is assessed differently by the two methods. Probably this is due to the fact that the spliced series include parishes for which information becomes available only after 1788–1792.

Second, births and deaths rise faster in towns than elsewhere. This is consistent with the result that the urbanisation rate of Germany rose by a more than a quarter during the second half of the eighteenth century.[16] Third, the number of births rises faster in the *Territories* than in the series based on parish records. A version that excludes Pomerania, the Rhenish Palatinate, and Westphalia displays a much weaker trend, however. This suggests that it may be advisable to work with different compositions of this series in the further analysis. Fourth, the comparison of the series based on parish records support the widely shared impression that population growth was stronger in the south-west than elsewhere, whereas the north-western coastlands stagnated at least from the early eighteenth century. Westphalia probably conformed to this pattern until the 1770s, when it embarked on more rapid growth.

Finally, it appears that some of the births series were characterised by long swings of two to three decades. These are particularly pronounced in the series of the north, with peaks in 1705, 1736, 1770, 1801 and 1822, troughs occurring in 1719, 1753, 1785 and 1810. Until the beginning of the nineteenth century, cycle-length roughly corresponds to the marriage age; that is, the duration of one generation. It could be that these cycles constitute an echo of the series of mortality crises of the late seventeenth century that culminated in the early 1690s (see the graph of the deaths in the south).

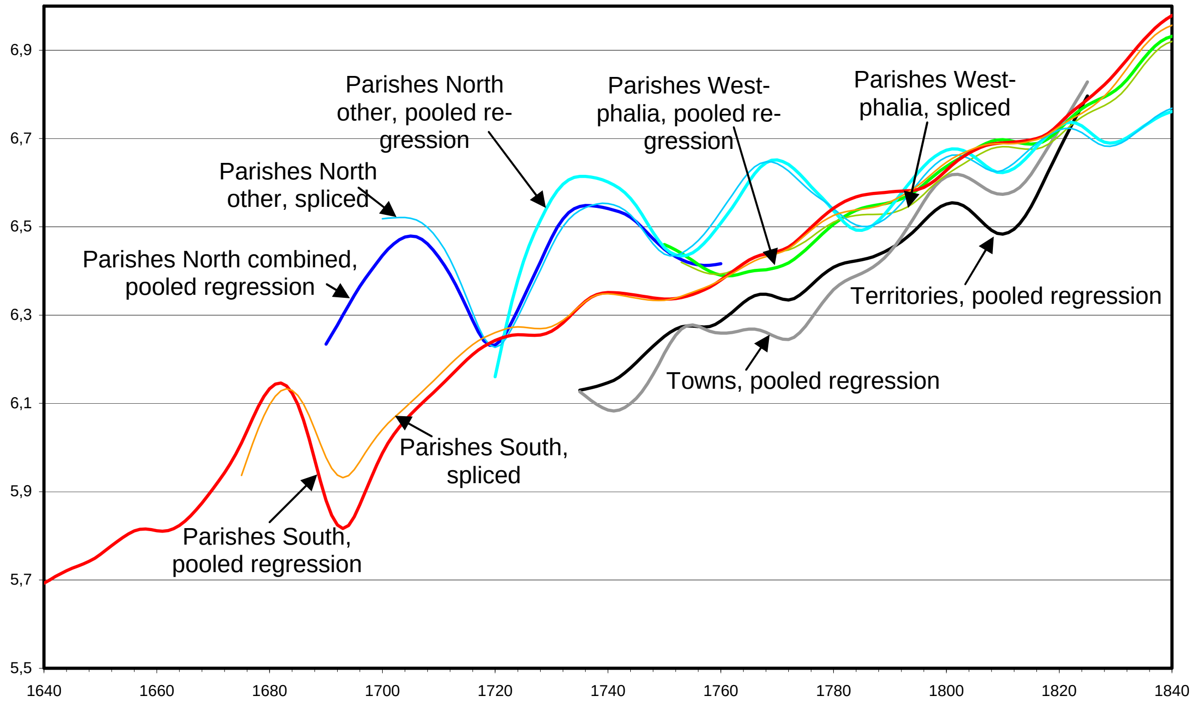
In contrast to the smoothed series, the cycle (or de-trended) values produced by the filter have an intuitive meaning: Because we filter the natural logs of the original series, cycle values approximate deviation from trend in per cent. For instance, Table 5.a shows that from 1700–1724 to 1725–1749 the standard deviation of the de-trended annual number of births in southern parishes declined from about 6.1 to about 3.8 per cent. While detrended values have an intuitive meaning, their erratic movement renders them much less amenable to visual inspection than smoothed data. We therefore provide two kinds of tabulated information: Table 5 shows the standard deviations of the de-trended values for different time periods and thus renders it possible to see whether the volatility of the num-

tablished on the basis of the years 1789 and 1790 in the case of the Palatinate and on the basis of isolated figures for 1786 and 1789 in the case of Electorate of Saxony.

16 This follows from ongoing work by U. Pfister on a revision of the dataset of Bairoch et al. (1988).

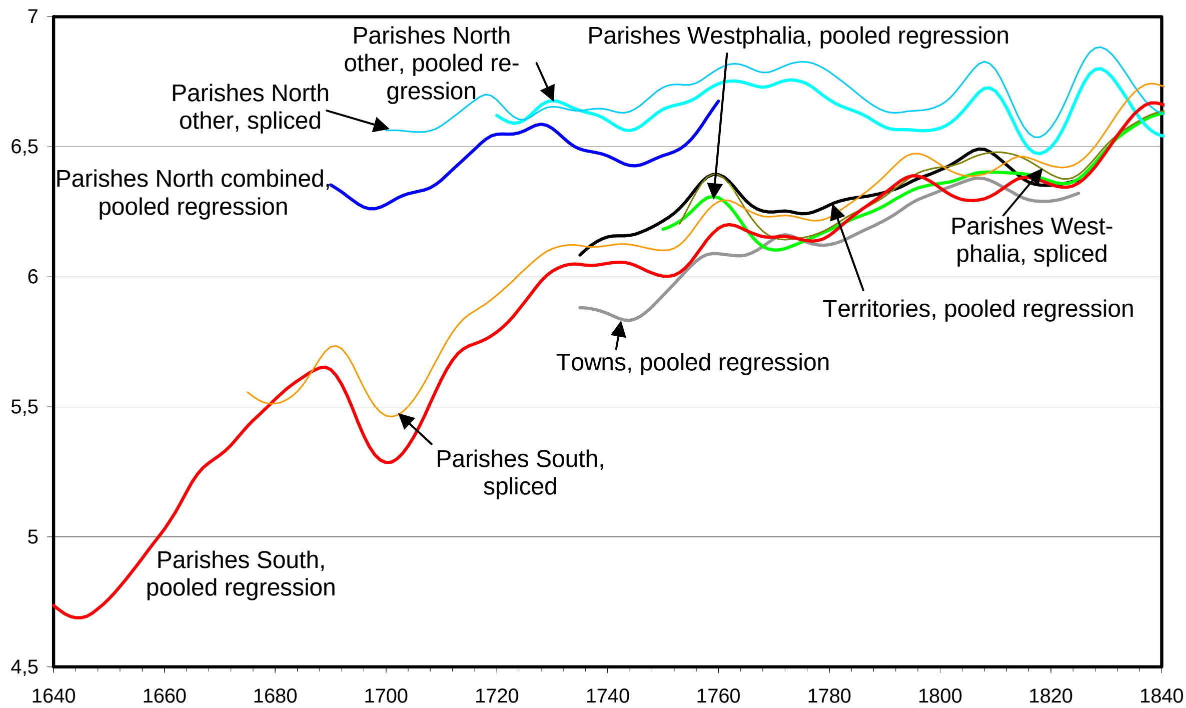
ber of life events has changed over time. Table 6 provides Pearson correlation coefficient between series constructed in different ways and between series from different regions.

Figure 2: Trends of births series, 1640–1825



Sources: Own calculation.

Figure 3: Trends of deaths series, 1640–1825



Sources: Own calculation.

An initial observation regarding this material is again of a purely methodological nature: The upper panel of Table 6 shows that series obtained through splicing several short series with homogeneous geographical coverage and series constructed with pooled WLS regression display the same short-term movements; all correlation coefficients are about 0.9. The discrepancies that exist may well be related to the fact that the series based on pooled WLS regression rest on slightly more data than the spliced series. This finding further corroborates the validity of pooled WLS regression to derive aggregate series of births and deaths. The final column of Table 6.a displays the correlation between *Territories* series relying on all information currently available and series based on a reduced dataset that excludes Pomerania, the Electorate of Saxony, the Rhenish Palatinate and Westphalia. The fact that the correlation between these two versions of *Territories* series is a bit lower than in the other comparisons of Table 6.a (around r=0.8) suggests that the addition of regions outside northern Germany adds information on short-term variations of vital events and that the latter were far from unified across the country. Closer inspection shows that the differences between the two series are mainly due to the strong volatility vital events experienced in Saxony during and after the Seven Years' War.

A second tendency apparent in Table 5 is a certain reduction of the volatility of vital events over time, a fact well-known from local studies (Imhof 1984). This is particularly the case for the southern series, which are the longest in our data: Between the last quarter of the seventeenth and second quarter of the eighteenth century, the standard deviation of the de-trended births series diminishes by 73 per cent, for deaths the reduction is 40 per cent. After this period there occurred no further reduction; rather, the shocks connected with the Napoleonic Wars and the harvest failure of 1817 led to a temporal increase of the volatility of the number of vital events. A weaker and later reduction of volatility occurred in Westphalia (particularly if considered together with the *North combined* series) and in the towns. In the *Territories* series, there is at best a weak reduction of the volatility of the number of deaths, but official statistics for the country as a whole display a much diminished level of volatility of both births and deaths by the second quarter of the nineteenth century (last entry in brackets under the *Territories* heading). It is noteworthy that the de-trended rye price in up to 23 towns also shows a marked reduction in volatility over the century between the end of the Thirty Years' War and the middle of the eighteenth century (last column of Table 5.a). This either reflects an improvement of climatic conditions, which reduced the frequency and severity of harvest failures (Ch. Pfister 1984: I, 129–31), or growing market integration. Particularly the decline of the volatility of the annual number of births may be linked to this phenomenon, since births react through different channels on material deprivation: delayed marriage, reduced levels of sexual intercourse either because of heightened mobility or because of depressed libido, and amenorrhea caused by malnutrition. High levels of deaths, in contrast, could also be caused by epidemic disease. The stronger reduction in the volatility of births compared to deaths may therefore have been the result of a reduction in the severity of subsistence crises around the turn of the eighteenth century, while outbreaks of epidemic diseases apart from bubonic plague persisted into the first half of the nineteenth century.

Table 5: The declining volatility of vital events (standard deviation of de-trended series)

	(1) South	(2) North combined	(3) Westphalia	(4) North other	(5) Towns	(6) Territories	(7) rye price
a. Births							
1650–1674	0.066						0.288
1675–1699	0.137						0.249
1700–1724	0.060	0.137					0.163
1725–1749	0.038	0.073					0.118
1750–1774	0.040		0.070	0.069	0.090	0.096	0.186
1775–1799	0.042		0.037	0.086	0.062	0.037	0.117
1800–1824	0.068		0.050	0.068	0.057	0.056	0.238
1825–1849	0.041		0.052	0.080		(0.033)	0.242
b. Deaths							
1650–1674	0.164						
1675–1699	0.207						
1700–1724	0.139	0.154					
1725–1749	0.122	0.161					
1750–1774	0.116		0.137	0.146	0.146	0.185	
1775–1799	0.114		0.099	0.139	0.081	0.086	
1800–1824	0.139		0.107	0.185	0.093	0.115	
1825–1849	0.113		0.082	0.150		(0.037)	

Note: Series were de-trended using a Hodrick-Prescott filter with λ=100 on the natural log of the original values. This implies that the de-trended values can be interpreted approximately as per cent deviation from trend. Figures in brackets under the heading *Territories* relate to national figures based official statistics.
Sources: Parishes as in Appendix 3; territories and four towns from Gehrmann (2000: Appendix) and the sources indicated in Footnote 15yy. Rye price refers to a series created using pooled regression on the basis of data for 23 towns (on-going work by one of the authors).

Table 6: Correlation of de-trended vital event series (bivariate Pearson correlation coefficients)

a. Correlation of different versions of the same series

	South pooled regr./spliced 1675–1818	Westphalia pooled regr./spliced 1753–1818	North other pooled regr./spliced 1720–1818	Territories all/reduced 1735–1818
Births	0.90	0.87	0.92	0.79
Deaths	0.94	0.92	0.89	0.85

b. Correlation between regional series over time

	1700–24	1725–49	1750–74	1775–99	1800–24
Births					
South-North combined	0.06	0.02			
South-Westphalia			0.54	0.05	0.33
South-North other			0.21	-0.23	0.09
Towns-Territories			0.88	0.68	0.72
South-Territories			0.67	0.31	-0.12
Westphalia-Territories			0.54	0.62	0.05
Deaths					
South-North combined	0.10	0.02			
South-Westphalia			0.62	-0.04	0.44
South-North other			0.44	0.17	-0.10
Towns-Territories			0.72	0.40	0.70
South-Territories			0.75	0.13	0.23
Westphalia-Territories			0.49	0.42	0.33

Sources: See Table 5.

An important word of caution must be made, however. There is a tendency for series based on large samples to display a lower volatility than series derived from small samples: see notably *North other* with Westphalia or with the national series from official statistics in the second quarter of the nineteenth century. Also recall the earlier finding that series based on small samples reflect idiosyncrasies of small populations to a larger extent than big samples. Thus, as data density diminishes as we move back in time, the more variable the annual number of vital events will become. The fact that, as a consequence of population growth, most parishes had smaller populations in the seventeenth than in the nineteenth century and therefore were characterised by stronger fluctuations of life events works in the same direction. This has an important implication for the research strategy underlying this research: If the comparison between parish registers and official statistics for the first part of the nineteenth century conveys the impression that the analysis of 200–300 parishes might suffice to adequately capture the mid- and short-term movement of vital events on the national level, the smaller size of parishes and the greater volatility of demographic events in the seventeenth and early eighteenth century calls for a considerably larger sample if we want to make sure that the observed volatility decline is not in part or wholly spurious and that our sample of parishes adequately captures nation-wide demographic conditions. Since the calculation of standard errors is based on standard deviations (and other expressions derived from a similar concept) sample size should at least be adapted to the higher volatility of deaths during earlier periods. The volatility of the number of deaths in southern parishes was more than 80 per cent higher during the late seventeenth century than during the second quarter of the nineteenth century. In England, the volatility of the death rate during the first part of the seventeenth century exceeded the one prevailing two centuries later at least by a factor of three (Rathke and Sarferaz 2009: 12; in the *Population history of England*, too, however, sample size increases over time; cf. Wrigley and Schofield 1981: 56–62). Given that parish size was smaller in early periods than towards the end of the observation period we should allow for a sample that has rather more than double the size considered sufficient for the first half of the nineteenth century. We therefore plan to collect data for about 450 to 600 parishes.

Finally, the lower panel of Table 6 presents information on correlations between different series. At least from the middle of the eighteenth century there is no evidence of increased co-movement—there was no move towards an integration of short-term movements on the regional level into a national pattern. Correlation among different regional series was stronger in the third quarter of the eighteenth and the first quarter of the nineteenth century than during the period in between, suggesting that the periods were hit by nation-wide political and climatic shocks, whereas shocks in between were of a more regional nature. From a methodological perspective, it is of interest to note the tendency of series based on large samples to display stronger mutual correlation than series based on small samples: confer the absence of correlation between *South* and *North combined* before the middle of the eighteenth century with the strong relationships of *Territories* with the series for Westphalia and the towns, respectively. This is in line with what has been said before about the effects of sample size on volatility. In addition, the strong correlation between towns and territories may reflect a better integration of towns relative to the countryside into wider markets for products and labour, but also into networks of mobility that promoted the spread of epidemic disease. Despite its appreciable size, the series for the rural parishes in the south does not correlate particularly well to the series for the territories, particularly after the shocks related to the Seven Years' War (1756–1763) and the great subsistence crisis of the early 1770s. Given that information on territories comes almost exclusively from the north, the low inter-correlation between the two series may reflect strong regional differences with respect to the short-term movement of vital events.

The third and final step in the construction of national series of the crude birth and death rates consists in combining the series we have created so far and in relating them to population size. We construct national numbers of births and deaths between 1690 and 1850 as a combination of the regional series developed so far as follows:

1690–1734	0.5 · South + 0.5 · North combined
1735–1749	0.3 · Territories + 0.1 · Towns + 0.3 · South + 0.3 · North combined
1750–1817	0.4 · Territories + 0.1 · Towns + 0.3 · South + 0.1 · Westphalia + 0.1 · North other
1818–1850	1.0 · Official statistics (Appendix 1)

Since all regional series established for periods before 1818 are calibrated to the national number of births and deaths respectively, in 1818 the procedure followed actually implies that the synthetic series for the earlier period is spliced with the information from official statistics using the values in 1818. This is justified on the grounds that the regional and the national series fit well in that year anyway (Table 4 above). The series *Westphalia* and *North other*, which are both based on parish registers, are included, despite the fact that the *Territories* series already covers these regions as well. Given that the latter contains many gaps and omissions, the series based on parish registers adds significant information. For the period 1735–1749, the weight of the *Territories* series has been diminished in the favour of the *North combined* series because information for territories is less abundant during this period than later. Note also that the database is very small for the period up to 1734. By contrast, thanks to information available for entire territories from 1735 onwards, we cover about a third of the estimated national number of vital events around 1790, so that the data density for that period is considerably higher than in reconstitution studies for other countries.

These national series of births and deaths have been converted into crude birth and death rates (CBR, CDR) by using the revised estimates of population size in column (3) of Table 1 and column (4) of Table 2. For the period before 1740, the growth rate by decade implicit in Figure 1 (version excluding Prussia) has been used to produce rough estimates of population size in 1690, 1700, 1710, 1720 and 1730 backward from 1740. Annual population size was interpolated by calculating the cumulative natural increase since the last previous population estimate plus an exponential adjustment for the discrepancy between natural increase and recorded population growth during the time span between the previous and the following population estimate. The result is displayed in Figure 4 below.

Table 7: Discrepancy between natural increase and population size, 1690–1850 (per cent)

	(1) (natural increase – population growth) / initial population	(2) natural increase / population growth
1690–1700	-2.9	-28.4
1700–1710	5.3	74.7
1710–1720	-3.3	-67.5
1720–1730	-4.3	-106.8
1730–1740	-1.8	-26.1
1740–1750	-2.9	-44.2
1750–1755	-0.2	-7.5
1755–1765	-0.3	61.0
1765–1770	0.0	1.0
1770–1780	-0.6	-13.0
1780–1790	-0.7	-12.8
1790–1800	-0.5	-10.1
1800–1805	0.3	7.2
1805–1815/16	-1.3	-25.4
1815/16–1825	-0.2	-3.7
1825–1840	-0.3	-2.2

A measure of consistency of the CBR, CDR and population size series can be derived by comparing the natural increase calculated from the numbers of births and deaths with the growth of population size between two years. Column (1) in Table 7 relates the discrepancy between the cumulative natural increase and population growth between two years to initial population; Column (2) simply relates cumulative natural increase to estimated population growth. The size and the sign of the discrepancy measures can indicate different types of inconsistencies: If we assume zero net migration, there should be no discrepancy between natural growth and population size. If deaths are under-registered or the mean level of estimated population size is too low, the discrepancy will be positive. By contrast, if initial population size is too low (because of initial under-registration and an improvement of census quality over time, for instance) the discrepancy will turn out negative. If net migration is directed outward, as was the case in Germany during the period of observation, the discrepancy should be positive because natural increase exceeds population growth.

Cross-border emigration during in the eighteenth century has been estimated at about 740,000 to Eastern Europe, 60,000 to the Netherlands and 130,000 to America; that is, about five per cent of total population (Fertig 2000: 81; van Lottum 2007: 200). By contrast, eighteenth century immigration is hardly discussed in the literature. The few identifiable migration streams (such as Swiss migration to south-west Germany and Brandenburg, and the Lutheran minority that was expelled from Salzburg in 1732) mostly petered out after 1740. It may be possible to sum up the few dozens of thousands Huguenots, Salzburgers, Bohemians and other religious groups who immigrated in a publicly visible way because they had a clear group identity. Counting becomes more difficult with the Swiss who trickled into south-west Germany between the Thirty Years' War and the mid-eighteenth century. Generally, the level of spatial mobility was lower than in the nineteenth century, but many people were mobile over short distances and did not emphasize national identity at all. The net balance of such small movements to and from Germany's high wage or low wage neighbours is simply unknown. Taken together, we guess that migration may have led to an excess of natural increase over population growth in the order of magnitude of 0.5 per cent per decade on average, and we have the impression that most immigration was before 1740 and thus before the period we currently are able to analyse.

Column (1) in Table 7 shows that the discrepancy between natural increase and population growth was always less than 1 per cent in absolute terms between 1750 and 1805. The total adds up to 1.5 per cent; on the background of what we have just said about migration we would rather like to see a figure in the order of magnitude of 2–3 per cent. There may thus be a slight tendency towards an under-estimation of population growth, although our births and deaths series are on the whole consistent with the modified Gehrmann estimates of population size. This impression is corroborated by the small negative discrepancies recorded for the early nineteenth century (see the discussion of Table 2 above) as well as the still moderate but also negative discrepancies in the 1730s and 1740s. Finally, there is the negative discrepancy in 1805–1815/16; the dislocations brought about by the Napoleonic Wars and the concomitant border changes had the effect that demographic data are beset by many gaps and that series for earlier periods are difficult to join with those for the period after the conclusion of the Peace of Vienna (1815). Clearing up the discrepancies existing in the data for 1805–1815/16 constitutes an important element in future work to improve these series.

Taken together, the discrepancies between natural increase and population growth relative to initial population add up to -3.2 per cent during the 110 years between 1730–1840. On the basis of what we know about migration, we would prefer to see a positive discrepancy in the order of magnitude of five per cent. This implies the possibility that population around 1740 may have been up to ten per cent higher than the estimates given in Table 1. As a consequence, the high fertility and mortality levels that Figure 4 shows for the 1730s would be reduced from 43 to 39 per thousand of the birth rate and from 37 to 34 per thousand for the CDR. Accordingly, there would be absolutely no time trend for the birth rate, and the decline of the death rate would occur more slowly. This conjecture is highly speculative, however. An increase by ten per cent would put population size in 1740 at the upper boundary of what seems plausible from Figure 1. One should also take note that so far we have not dealt with the issue of stillbirths yet, which may entail minor revisions both of the birth and death rates. It may well be that the majority of our sources before 1815 over-registered deaths, since stillbirths were not baptised but buried, and registered accordingly (Gehrmann 2000: 280). Assuming that stillbirths made up about 4 per cent of all births (Kraus 1980: 330) this would entail an upward revision of natural increase by about 1.5 per thousand per year or 1.5 per cent per decade. In that case, the discrepancies recorded in Table 7 would be quite compatible with the suggested rates of net migration, at least for the period 1750–1805.

Three further observations are to be made about our CBR and CDR series. First, an alternative run was made that excluded Pomerania, the Rhenish Palatinate, and Westphalia from the important *Territories* series; at the same time, unrevised population figures were used (Column 2 of Table 2). Between 1750 and 1805, the absolute magnitude of the discrepancies between natural increase and population growth were slightly larger in this variant, however, without showing a clear pattern. By contrast, the discrepancy recorded for the 1740s was smaller (-0.6 per cent). Our preferred series is dominated by Pomerania during this decade. For the rest, the exercise attests to the stability of our findings.

Second, discrepancies become persistently large as one moves back in time beyond 1730. We believe that these estimates should not be used in the further analysis; this is why they have been charted in broken lines in Figure 4. This breakdown of our research design may be closely related to the fact that the important *Territories* series, which cover a significant share of national population, break away in 1735, which demonstrates the need for a massive input of additional data as a precondition for a thorough analysis of earlier periods.

Third, while the consistency between natural increase calculated from the numbers of births and deaths and estimates of population growth is quite satisfactory in absolute terms, the fit is less impressive if we wish to interpret natural increase as a rough indicator of population growth. Column (2) of Table 7 shows that even during the period when we consider data quality and quantity acceptable (1730–1805), natural growth and population growth deviate by a percentage in the double-digit range. This shows that it would be highly problematic to rely on natural increase and rough estimates of cross-border migration to estimate population size in the past and stresses the need to collect at least indirect information on population size, as outlined in Section 3.4 above.

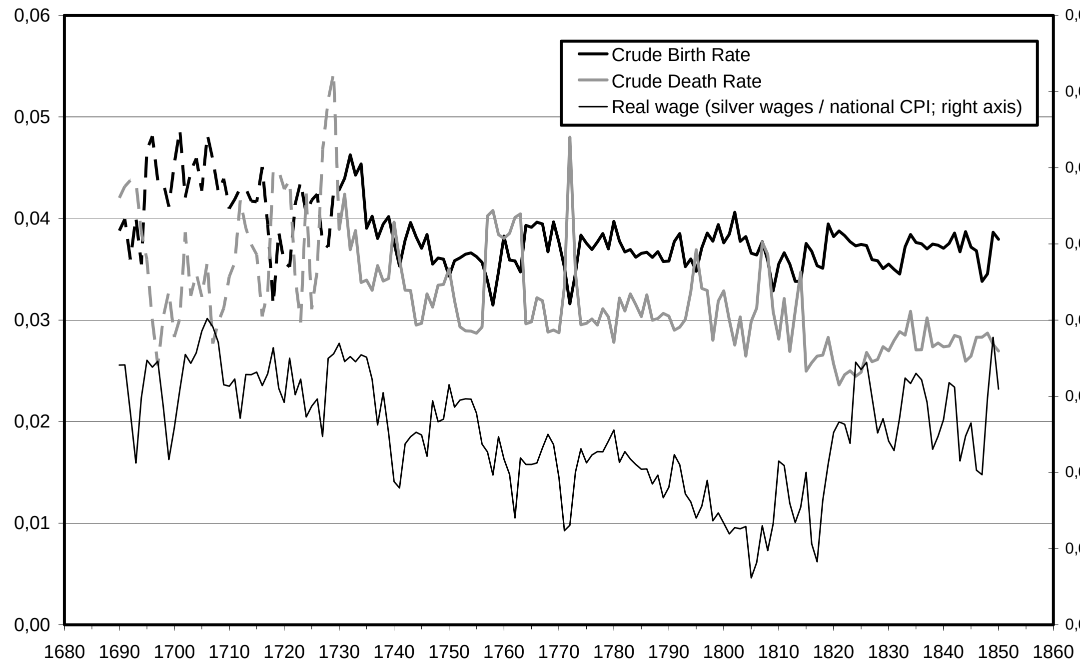
4.3 The evolution of the crude birth and death rates, 1730–1850

Given that our series for the annual numbers of births and deaths and for population size are broadly consistent at least back to about 1730, we believe they warrant at least an exploratory analysis that can allow preliminary statements regarding the salient features of German population history during the century before the onset of industrialisation. Before we carry out such an analysis in the two chapters that follow, it may seem useful to provide a short description of the evolution of the crude birth (CBR) and death rate (CDR) during that period (Figure 4; Table 8).

First, we can chart the early and hesitant stage of a secular decline in mortality, whose beginnings can tentatively be located in the 1740s. From then on, there were periods of several years with a regular surplus of births over deaths and the CDR oscillating at some point above 30 per thousand. These periods were still interrupted by crises that drove the CDR close to or even above 40 per thousand. Whereas the birth rate remained largely constant during the whole period 1740–1840, the death rate fell below 30 per thousand during a longer period from the early 1820s, which were marked by an exceptionally favourable real wage. Whereas material conditions deteriorated again from the 1830s to the 1850s, the death rate jumped above 30 per thousand only during crisis years, at least on the national level.

Second, it appears that the volatility of vital events declined over time. This follows from Table 8, which presents the standard deviation of the de-trended values of the CBR and CDR in different time periods. As the de-trended values were calculated on the basis of the natural logs of the original values, they can approximately be interpreted as per cent deviation from trend. An important caveat about the results of Table 8 relates to the fact that data density increases over time and that volatility is negatively correlated with sample size (see Section 4.2, notably the discussion of Table 5). Part of the decline in the volatility of vital rates may thus be spurious. Given the different evolution of the volatilities of the birth and the death rates, however, we believe that the data in Table 8 reflect a real change in volatility.

Figure 4: Crude birth rate, crude death rate and real wage, 1690/1730–1850



Sources: Crude birth and death rates: see text; real wage: data described in Pfister (2010). The dimension of the real wage (right axis) is the fraction of a consumer basket consumed annually by an adult town dweller that can be purchased with the summer day wage of an unskilled building labourer.

In concrete terms, the volatility of the birth rate declined by about 30 per cent between the period of the 1750s and 1760s and the period of the 1770s and 1780s, and remained on the same level for the rest of the observation period. The volatility decline of mortality is less clear-cut. Nevertheless, the maximum value occurs early in the series, namely in 1750–1769, and the second peak during the Revolutionary and Napoleonic Wars is considerably lower (1790–1809). But the value prevailing 1730–1749 is only undercut in 1830–1850. A separate analysis based on the absolute number of births and deaths in parishes located in southern Germany suggests that a substantial part of the volatility decline occurred in fact already between the late seventeenth century and the second quarter of the eighteenth century (Table 5 above; see also the strong oscillations of the broken graphs in the left part of Figure 4). This occurred parallel to a decline in the volatility of the rye price, which indicates an improvement in the security of food provision. There are several possible explanations for this finding: First, it appears that climatic conditions improved during early eighteenth century (Ch. Pfister 1984: I, 129–31), which may have reduced the frequency and severity of harvest failures. Second, growing market integration may have mitigated regional food shortages; in fact, on-going research suggests that price dispersion between rye markets declined notably between the mid-seventeenth and the second quarter of the eighteenth century. Third, maybe partly as a result of changing climate and/or growing market integration, sustained growth of labour productivity set in during the first part of the eighteenth century (Pfister 2009: 13). The apparently substantial decline of the volatility of vital rates between the late seventeenth century and the 1730s/1740s was an important precondition for the onset of a secular mortality decline.

Table 8: The declining volatility of vital rates (standard deviation of de-trended values)

	1730–49	1750–69	1770–89	1790–1809	1810–29	1830–50
Crude birth rate	0.046	0.049	0.034	0.038	0.034	0.036
Crude death rate	0.069	0.110	0.079	0.090	0.071	0.039
Rye price	0.126	0.147	0.161	0.149	0.275	0.240
Real wage	0.069	0.0.68	0.069	0.070	0.119	0.093

Sources: Crude birth and death rates: this study; real wage (silver wages deflated by national CPI): Data described by Pfister (2010); rye price: on-going research (see note to Table 5).
Note: De-trended values were calculated using a Hodrick-Prescott filter with λ=100 on the natural log of original values.

The further decline in the volatility of vital rates after the last peak in the 1750s/1760s, albeit at a much reduced pace, contrasts with the increase in the volatility of the real wage between the eighteenth and the first part of the nineteenth century. The decoupling of population dynamics from economic shocks, which we shall explore in greater detail in Chapter 6 below, may have been related to two phenomena: First, many German states maintained grain stocks and pursued an active policy of food provision to the poor during periods of shortages, which may have mitigated the demographic consequences of harvest failures (Löwe 1986; Schmidt 1991). Second, the development of proto-industry, trade, and seasonal and life cycle-specific migration provided large segments of the poorer population with a non-agricultural income. While harvest failures greatly reduced the exchange entitlements of agricultural workers through the collapse of the demand for labour, the availability of alternative sources of income stabilised exchange entitlements and thus reduced the demographic effects of output variations in agriculture. The finding that real wages of rural workers in Prussia were more variable during the first half of the nineteenth century than those of urban building labourers offers at least indirect support to this hypothesis (Pfister 2010: 20).

Despite the reduction in the volatility of vital rates, demographic crises persisted well into the nineteenth century. With their short description we conclude this section. A convenient way to identify subsistence crises is to look for combinations of a positive trend deviation of the mortality rate and a negative trend deviation of the birth rate and the real wage. The analysis of the absolute numbers of births and deaths in parishes of southern and north-western Germany as well as Figure 4 suggest that Germany suffered largely the same crises as Northern France between the late seventeenth and early eighteenth century (cf. Dupâquier 1989: 191–2): The catastrophe in 1689–1694 was followed by new crises in 1710/12 and 1718/21. Additional strong divergences between births and deaths show up mainly in our data of the extreme north-west, although the crisis in 1727 comes out strongly in the real wage series. The later course of the eighteenth century saw subsistence crises in 1740, coupled with the beginning of the war of Austrian Succession (1740–1748), 1758 and 1762/3 (Seven Years' War), as well as in 1772 and 1795. The little-known crisis in 1813/4 shows up in almost all of our series. The global harvest failures in 1816/7 following the outbreak of the Tambora volcano in Indonesia, which manifest themselves in a serious plunge of the real wage, led to a low birth rate in 1817/18, whereas mortality peaked only in 1819.[17] While the death rate in Figure 4 shows only small blips thereafter, the analysis of de-trended series still shows substantial short-term divergences of mortality and fertility during the well-known crises of 1829/32 and 1846/48. Minor subsistence crises occurred in 1837 and 1843.

Insufficient food supply resulting from harvest failures was not the only reason for excess mortality, however. Epidemic disease constituted another important factor, but its impact is difficult to trace on the national level. Excess mortality related to causes other than subsistence crises seems to have occurred particularly during war periods (Seven Years' War, 1756–1763; Napoleonic Wars, 1803–1815). Although wars were related to depressed real wage conditions, mortality peaks during times of war do not seem to have been related to subsistence crises. Low levels of welfare may have increased the vulnerability with respect to diseases and—to a lesser extent than during the Thirty Years' War—war-related mobility and unhealthy sanitary conditions during sieges may have facilitated the outbreak and spread of epidemics. Together with research in the development of the agrarian sector and of markets of agricultural goods, an in-depth analysis of epidemic diseases will contribute to a better understanding of the downward trend of mortality apparent from Figure 4.

5. The trajectory of e_o and GRR, 1730–1840

Given the availability of preliminary national series for births, deaths, and population numbers, we shall now present trajectories of standard demographic measures for fertility and mortality, life expectancy at birth (e_o) and the gross reproduction rate (GRR), for the period 1740 to 1840. This serves a double purpose. First, standardising the crude demographic rates in this way makes our results more relevant in terms of our theoretical framework.

17 The suspicion that the absence of excess mortality in 1817/18 is related to a strong change in the database in these two years is only partly confirmed by an inspection of the official statistics of those states that recorded vital events from 1815: In Wurttemberg, mortality peaked in 1817, but in Mecklenburg-Schwerin, Hanover and Holstein, mortality rose gradually until 1819/20. In the parish series for Westphalia, there were weak mortality peaks in 1816 and 1819. For Prussia, see also Bass (1991: 45–6).

Life expectancy and GRR account for the age distributions of the investigated populations. They correct for spurious cohort effects such as a rise in fertility when large cohorts reach their twenties, or a rise in mortality when there are many new-born children. Moreover, they are systematically connected to other theoretically relevant measures such as the size of the working age population, infant mortality (q_o), and the intrinsic population growth rate. Hence, existing research prefers e_o, GRR and connected measures over crude rates, and these measures allow us to place Germany into a comparative international framework.[18] Second, estimating e_o and GRR allows us to experiment with the consequences varying assumptions about population sizes and vital rates would have for the interpretation of the demographic system.

The method we use is a classical one: inverse projection (IP) developed by Ron Lee (1974) in the 1970s and implemented in the software *Populate* by Bob McCaa in the 1990s. In the meantime, a technically superior approach has been developed by Oeppen (1993), namely, Generalised Inverse Projection (GIP). GIP incorporates IP as well as back projection techniques such as those used by Wrigley/Schofield (1981) and criticised by Lee (1985). The strength of GIP is that it enables us to use any available piece of information in a very flexible way, tempting researchers, however, to infer more from their data than they reasonably should. The theoretical rigour of IP as well as the easy data handling in *Populate* makes IP a good starting point. The basic idea of IP is a mathematical one, the weak ergodicity theorem (Wachter 1986), which states that population pyramids tend to forget their shape with the passage of time. Thus, in order to reconstruct the population pyramid of any given year, we need the vital events of the last decennia, not an initial (or final) age distribution ('vital rates, not initial states'). Formally, any population pyramid is defined by four elements: (1) the next earlier or later population pyramid; (2) births and deaths between the two pyramids; (3) the age distribution of deaths (life table); and (4) migration and its age structure. For life tables (3) and migration (4), good guesses are possible (including use of the four families of Princeton life tables). Since populations have a weak memory, adjacent population pyramids (1) also do not matter in the long run. Vital rates (2) remain.

Inverse Projection runs forward from the earliest year, not backwards from the earliest modern census (as was the approach used by Wrigley and Schofield). Choices to be made in inverse projection include the initial and later values of population size, mean age at childbearing, life table region, life expectancy, population age structure and annual growth rate. *Populate* estimates these variables for the subsequent years (or rather quinquennia) using the crude vital rates. Estimates typically stabilise after 50 years. We shall first develop our estimate, based on the national series constructed above. Second, we shall compare it to estimates based on the same series of vital events, but different assumptions about age structures and migration (or total population). We shall show that neither the choice of life tables or initial age structures, nor precision in excluding stillbirths from the series is very relevant, but that the use of external evidence on total population size beyond the aggregation of vital events is crucial for the stability of GRR and e_0 estimates. Third, we shall compare our preliminary results for Germany with what is known for England, France, Italy and Sweden. In addition to GRR and e_0 estimates, we shall discuss projections of the age structure and the implied dependency ratio.

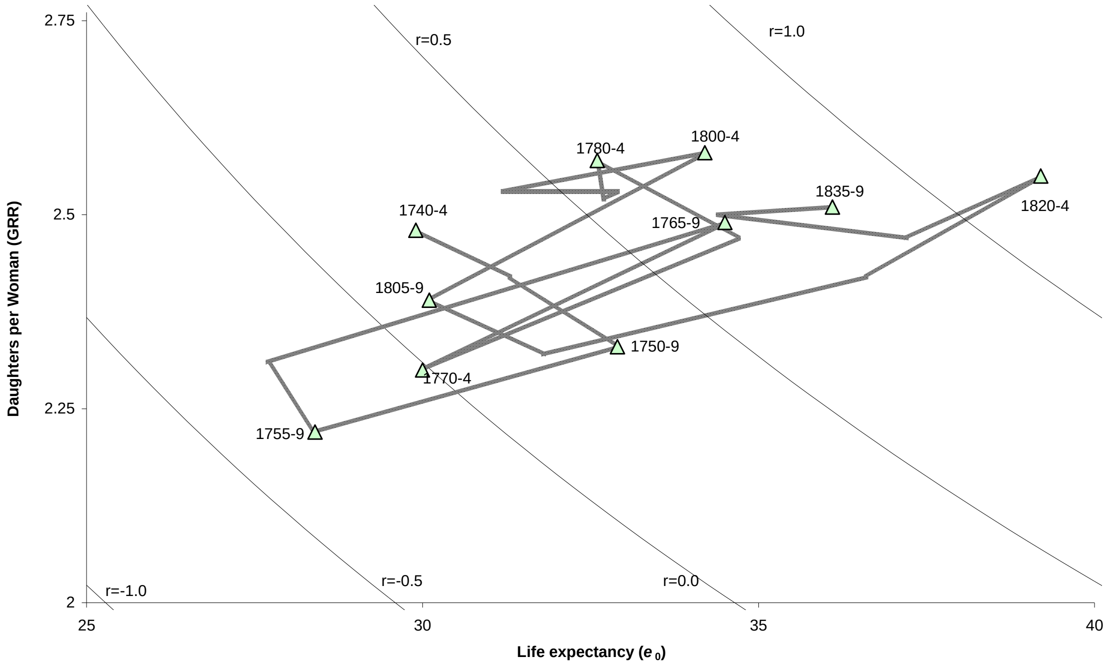
18 As Sardon (1996) has shown, GRR is also algebraically connected with the widely available Princeton index of fertility, If: GRR=If · 12.44.

In constructing an acceptable combination of vital rates, population counts, and age distribution assumptions, we shall start with a data combination that uses all information we currently have collected for the period 1740 to 1840, corrected for stillbirths. We jettonise the data before that date because the density of sources on which they are based is low; experimenting with the parts of the national series before 1740 has yielded rather high life expectancies around 32 years which are quite probably brought about by an under-registration of deaths. The available data on births and deaths for 1840 to 1850, while from official territorial statistics, do not add up properly with the official data on total population, and yield too high migration rates. In comparing different estimates, we reduce the use of information subsequently in order to test which kind of information is crucial and which is not. Our data series 'basis' combines the following information: population estimates and quinquennial sums of births and deaths starting in 1740, as presented above, with a correction for stillbirths. For this purpose, we have subtracted 4 % from the series of deaths for the period until 1780, since during this period stillbirths were typically recorded among the burials but not among the baptisms, at least in Protestant regions (see section 4.2 above). The mean age of childbearing is set at a 31 years. The standard values are 27, 29, 31, and 33; we opt for a relatively high age since the age at first marriage was relatively high in Germany during the eighteenth and early nineteenth centuries (mean values between 25.5 and 27 years; Ehmer 1991: 292). For the starting year, we use population age distributions and mortality schedules from standard life tables, not from empirical data, since the latter are not available, and also since we believe that nationwide age pyramids are more uniform and far smoother than local age pyramids.[19] The age pyramid of type 'west' with which we start has a life expectancy of 31, since in stable populations, e0 is the inverse of the CDR, which our empirical estimate puts at 32 per thousand for 1740-4. The initial intrinsic growth rate is positive, 5 per thousand, based on our estimate of the empirical growth rate for the same quinquennium. These assumptions determine the starting point of the GRR and e_0 estimates. The results of the entire exercise should not be seen as presenting a reliable projection; one should check the out-coming population age distribution (for the final year) against an empirical, census based age schedule. This we currently do not have for Germany in 1830.[20]

[19] As a contrast, compare Lee's experiments with Wrigley's local data on Colyton (Lee 1974: 499).

[20] The earliest full population pyramid we have is for Westphalia in 1864. In a later version of this paper, we intend to use inverse projection for the period 1750 to 1864 for Westphalia, and test it accordingly.

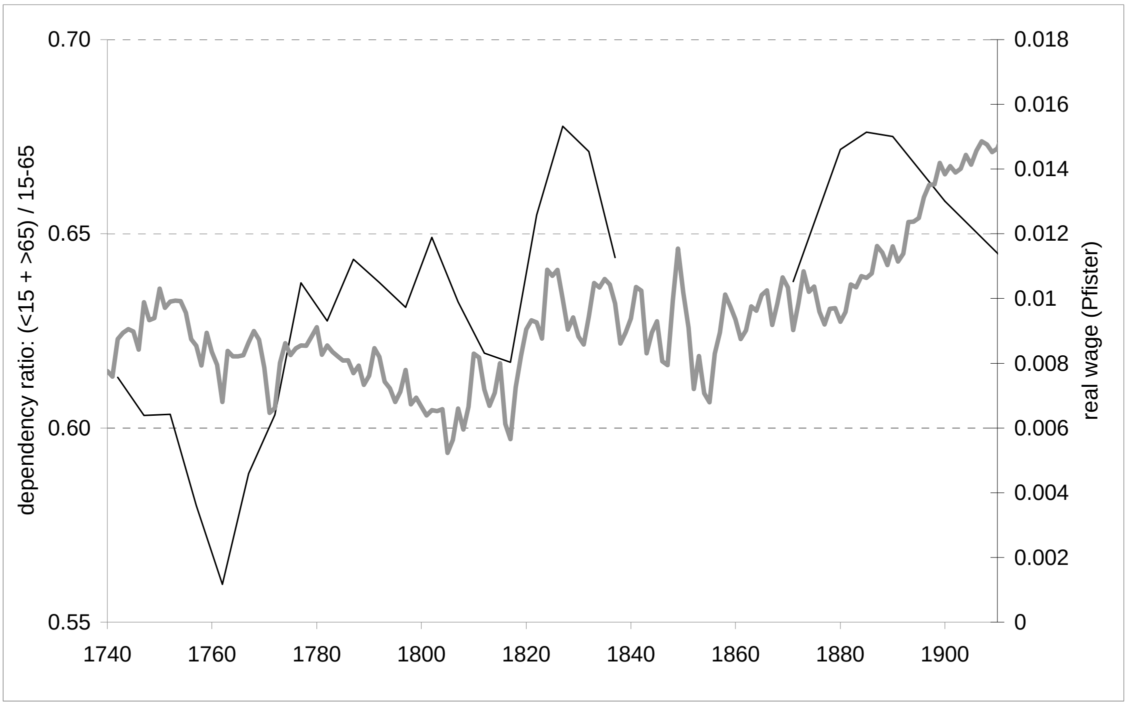
Figure 5: Estimates of e_0 and GRR, 1740–1839 (Model 1: 'basis')



Sources: Own calculation.

Figure 5 shows our current estimate ('Model 1: basis'), which is based on the set of assumptions discussed above. We have labelled only the most important data points in order to keep the graph transparent. The thin concave lines connect points where different combinations of fertility and mortality yield identical intrinsic growth rates. Our estimate runs from a GRR of about 2.5 daughters and an e_0 of under 30 years to a GRR level of (again) about 2.5 and an e_0 of 36 years. Overall, there is more movement from left to right (a decline in mortality) than from the downside up (slight increases in fertility). The marked variations in e_0 in the eighteenth century suggest that mortality crises were heavy. We can clearly see the Seven Years' War (the 1756–1763, with mortality crises in the late 1750s and early 1760s, see Figure 4) and the subsistence crisis of 1771. As such crises also affected fertility, declines in fertility were mostly associated with parallel rises in mortality, and vice versa. This explains the slight inclination to the lower left of the path in Figure 5. In the early nineteenth century, the most conspicuous development is the strong increase in life expectancy between 1805 and the early 1820s. This fits with the doubling of real wages in the same period, corresponding with the good terms of trade proto-industrial producers enjoyed in the Napoleonic period, as well as with the good agricultural harvests in the 1820s. Later, the incomes of the lower classes declined in the pre-revolutionary period up to 1848. This period of 'pauperism' is visible in the renewed fall of the life expectancy during the 1830s.

Figure 6: The dependency ratio and the real wage



Sources: dependency ratio: own calculation; real wages as described in Pfister (2010); Gömmel (1979).

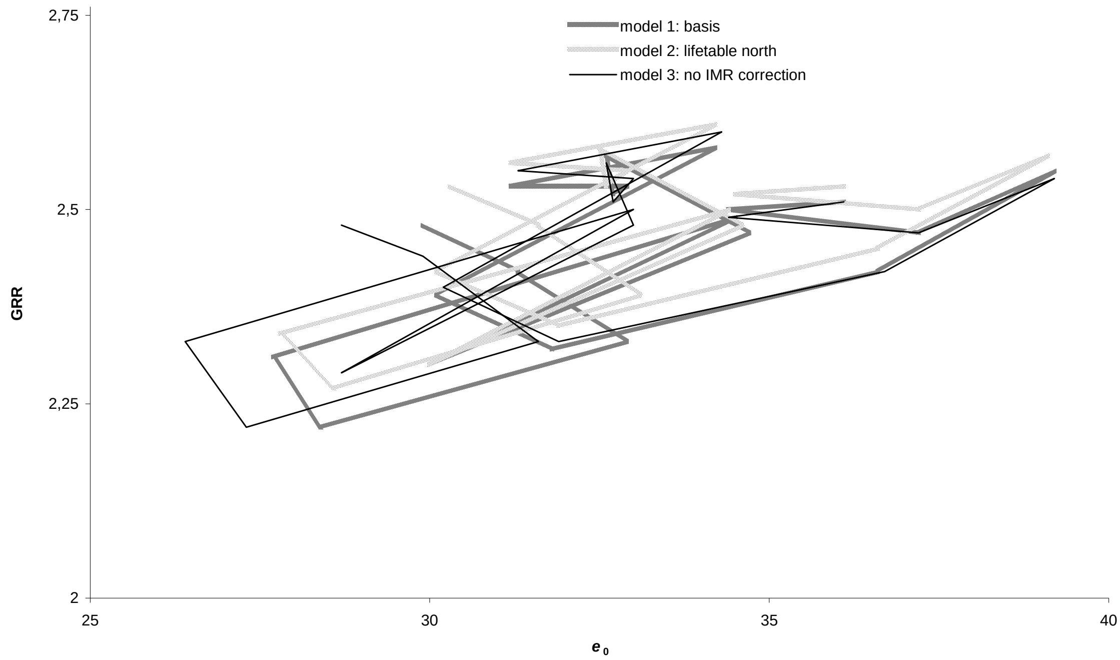
Figure 6 displays the evolution of two variables important from the viewpoint of households, namely, the dependency ratio and the real wage. The dependency ratio is the ratio of non-working age to working age persons (with cut-offs at age 15 and 65), as implied by our inverse projection. Also depicted are dependency ratios for 1870 to 1910 based on official *Reich* data. We see clearly a rise in the dependency ratio between c. 1760 and 1830. This was primarily a consequence of the growing number of children relative to adults, which in turn resulted from the acceleration of population growth following the onset of the mortality decline around the middle of the eighteenth century (see Table 1, Figur 4). The real wage did not move in the same direction as the dependency ratio. From a householder's perspective, in the late eighteenth century more mouths had to be fed from a declining income. Thus, household incomes per capita probably declined more rapidly than the real wage among the labouring classes during this period.

After a short respite, the dependency ratio experienced another rise by about ten per cent between the late 1810s and the mid-1820s, precisely during a period when the real wages rose very rapidly. This reduced the impact of the spectacular rise of the real wage increase on the material standard of living considerably, at least in as much as per capita income on the household level is considered (cf. Horrell and Humphries 1992). The strong increase of the dependency ratio can partly reconcile the divergent movements of the real wage and the biological standard of living, as measured by the physical stature of males during this period (Ewert 2006; cf. also Komlos 1998).

In the remainder of this chapter, we construct alternative series of e_0 and GRR in order to test the sensitivity of the baseline projection displayed in Figure 5 to variations with respect to the underlying life table and total population size estimates, as well as to assumptions about the migration rate and the registration of still-births. In doing this, it would make little sense to let the initial e_0 and growth rates vary, since they are basically fixed by the empirical data we feed into the projection. Any experimental values for the starting quinquennium (1740-4) would be immediately corrected by the empirical values for the next one (1745-9). Rather, Figure 7 contrasts the baseline model (Model 1) with a west life table model (Model 2) as well as a model that does not correct for stillbirths (Model 3). Looking at different classes of life tables makes sense because the age distribution of the total population and the shape of the mortality schedule are unknown. Age schedules are used on the basis of the corresponding Princeton life tables. At the same level of e_0, a north life table has a lower infant mortality than a west life table, but a much higher mortality in the age groups between 1 and 15. Concerning Model 3, we simply disregard the correction of the death rate for the registration of still-births during the period up to 1780 applied in the baseline specification of Model 1 and use the uncorrected series developed in Section 4.2. As Figure 7 shows, the consequences of variations of assumptions about both the underlying life table and the mis-registration of stillbirths are quite limited.

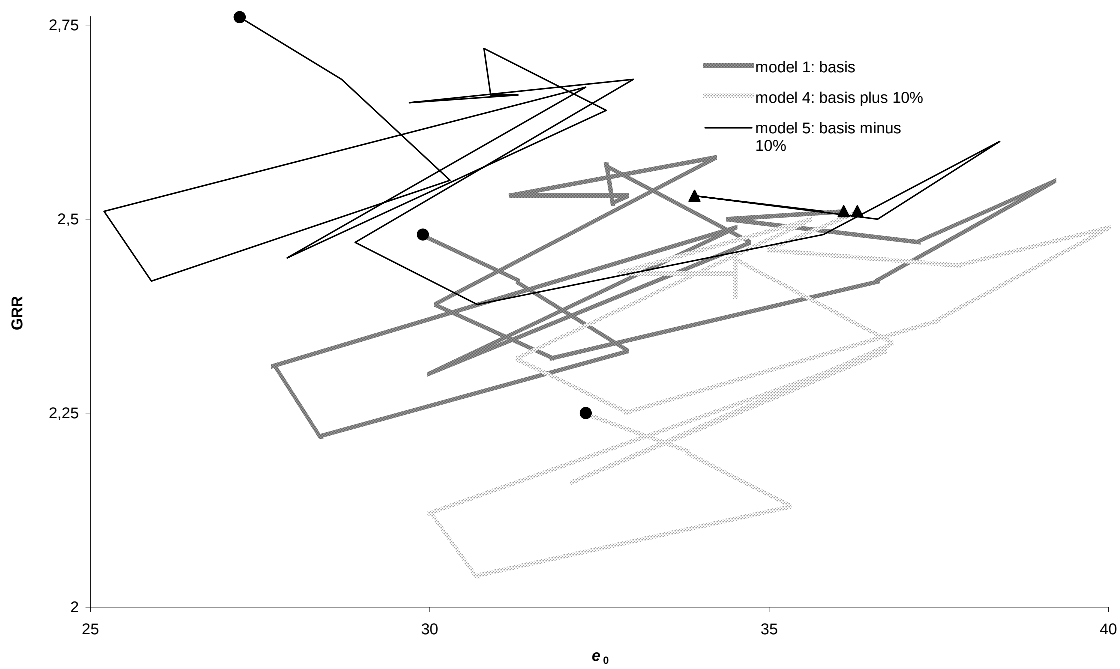
Another issue, addressed in Figure 8, relates to the sensitivity of our projections with respect to biases in our estimates of population size and, implicitly, net migration. The total population estimates are based not on the vital events themselves (as in the case of the *Population history of England*), but on independent sources. But if these are inaccurate (e.g., if we underestimate the initial population and consequently believe that less people emigrated on balance than actually did), then we may be misled to see parallel changes in fertility and mortality (in the given example: a seeming demographic transition based on the statistical artefact of too low an initial population). In order to test the sensitivity of our results with respect to the size of initial population and population growth, we augmented the population for 1740 by 10 per cent in Model 4 and reduced it by 10 per cent in Model 5. In both models, the difference with respect to our baseline specification is reduced proportionally until in 1840 it is zero. Figure 8 contrasts the baseline model with Models 4 and 5. We have marked the starting point of each series with a dot, and their end points with triangles. While the overall shape of the paths is similar, we see that assumptions about the total population, or, implicitly, net migration, are of considerable importance both for its level and direction. This corroborates the need to base estimates of population size (and implicitly, migration) on external sources rather than vital events.

Figure 7: Alternative estimates of e_0 and GRR, 1740–1839: Varying assumptions concerning life tables and stillbirths



Sources: Own calculation.

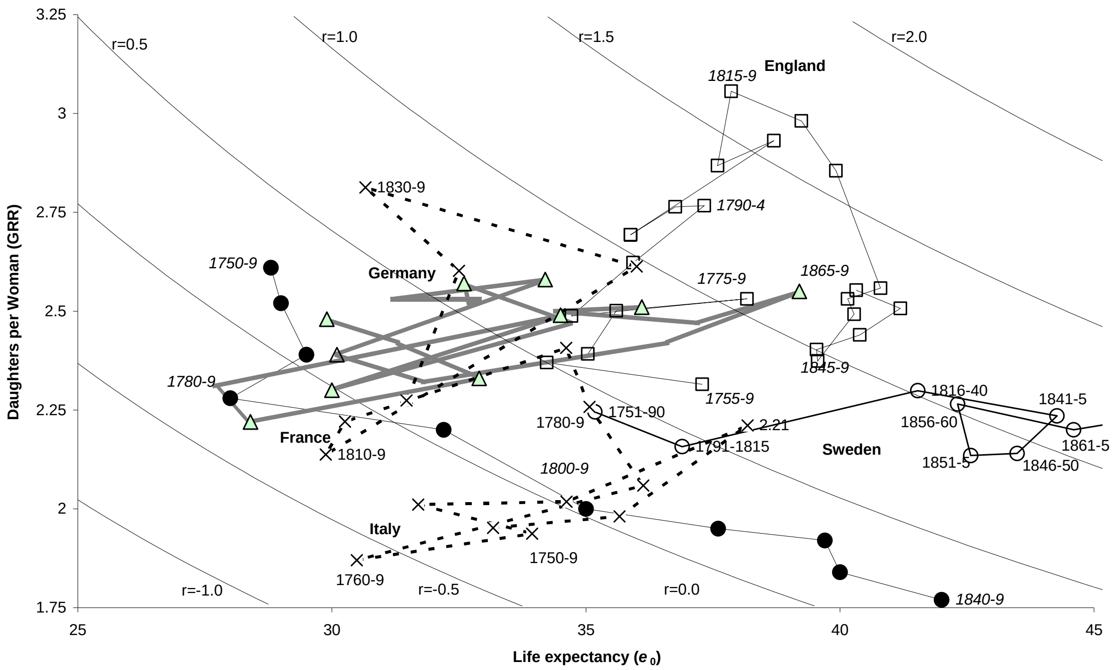
Figure 8: Alternative estimates of e_0 and GRR, 1740–1839: Varying assumptions concerning initial population and migration



Sources: Own calculation.

In a European context (Figures 9 and 10), we can compare our projection with earlier work on England, France, Sweden and, partly, Italy. The Swedish data, which were the first to be available in the international discussion on long term demographic change, suggest that the late nineteenth century fall in fertility was preceded by and thus reacted to a previous fall in mortality. This fits originally widely accepted explanations of the demographic transition, which suggested that fertility behaviour was determined by tradition rather than economic fluctuations and changed only in a delayed fashion when life expectancies rose due to modernisation. The English pattern is paradox in terms of this older transition theory. It showed that fertility could vary strongly in pre-transitional populations (later, the Italian data by Galloway 1994b represented in Figure 9 and 10 have shown the same), and also that it rose strongly during the early Industrial Revolution. Whatever the exact mechanisms, the English case is discontinuous. It may suggest that a relatively sudden change in the economy, such as a rise of per capita income resulting from technological progress, pushed fertility upwards while life expectancy had already risen above the French levels. The French case in contrast suggests a more continuous explanation, such as the mutual reinforcement of fertility and mortality declines, or the continuous accumulation of human capital.

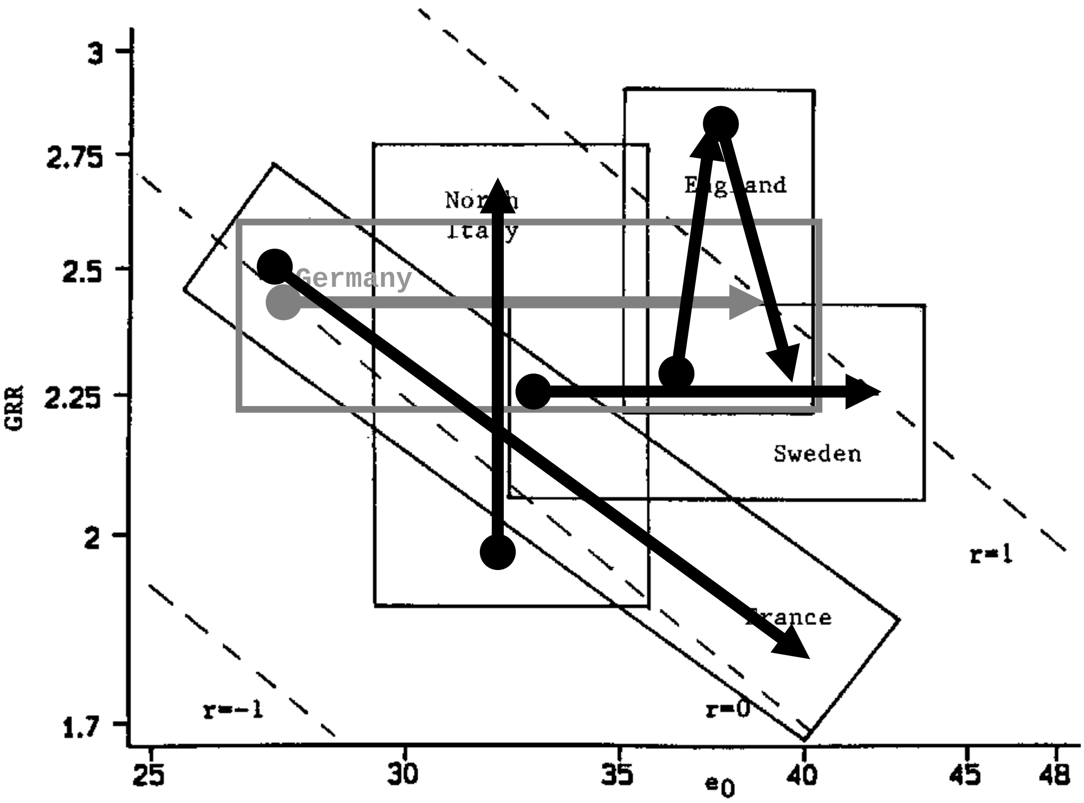
Figure 9: Estimates of e_0 and GRR in England, France, Germany, Italy and Sweden



Sources: For Sweden see Statistiska centralbyrån (1999); for England and France, see Wrigley and Schofield (1981: 246); for Italy, see Galloway (1994b), for Germany, see text.

The German pattern looks vaguely similar to that which has been long well-known for Sweden, albeit on a lower level of life expectancy. Variations of mortality are stronger in the German path than in all others. This may partially be due to the quinquennial data aggregation, in contrast to longer periods in the French and Swedish, but not the English data. To some degree, the heavier fluctuations in Germany may have a factual basis that this country— as opposed to England, France or Sweden—frequently was a theatre of war in the eighteenth century and that market integration was probably weak by comparison. Fertility seems to have fluctuated with mortality not in the sense that it ensured homeostasis when mortality was strong, but rather as a joint reaction to the same crises. However, the German fertility fluctuations were less decisive in pushing the GRR/e_0 track into zones of faster population growth than the long decrease of mortality that began after the Seven Years' War, paused during the Napoleonic era and temporarily ended c. 1830. As the schematic in Figure 10 shows, this shift brought Germany from a zone that it had shared with *Ancien Régime* France into a zone that was not far from England during the Industrial Revolution, albeit below the high fertility values typical for the English experience. The demographic path of Germany—if our estimates catch it correctly—seems thus to tell us a story of economic development from a low starting point.

Figure 10: Simplified representations of demographic terrains covered by Germany, North Italy, England, France and Sweden, mid-18th to mid-19th centuries.



Sources: Based on Fig. 7.14 in Wrigley and Schofield (1981: 247), Fig. 14 in Galloway (1994b: 253), and our own results. Germany is represented in grey.

6. Shifting patterns of Malthusian adaptation, 1730–1850

A Malthusian system can be described with four relationships (formal expositions include Lee 1978: 156–64; Møller and Sharp 2008: 2–5; for graphical representations, cf. Weir 1984: 28–30; Clark 2007: 20–9): First, the real wage has a negative impact on the death rate; this is the so-called positive check. Second, a positive relationship between the real wage and the birth rate constitutes the so-called preventive check. Taken together, the relationships between mortality and fertility on the one hand and the real wage on the other constitute processes of demographic adaptation to fluctuations in material welfare. Third, there is a negative relationship between population size and the real wage. This mechanism can be termed Malthusian feedback because, fourth, in a closed economy changes in population size are defined by the difference between the birth and the death rate. Through relationships three and four, demographic adaptation to real wage fluctuations feeds back into the real wage. Together, the four relationships define a homeostatic system; they accommodate for real wage shocks and exogenous mortality shocks so that vital rates and the real wage revert to their equilibrium value.

Ideally, the equilibrium levels of the real wage and of population size depend on the parameters of the relationships that define Malthusian adaptation. If the reaction of the birth rate to fluctuations in the real wage is weak, mortality must bear the brunt of adaptation. Such a situation, characterised by a weak preventive and a strong positive check, can be termed a high-pressure system. One would expect that it accompanies a low equilibrium level of the real wage, since this produces the high vulnerability of mortality with respect to short-term fluctuations of material welfare. In contrast, a strong preventive check can be capable of maintaining the real wage on a level that is conducive to a low vulnerability of mortality with respect to economic shocks; a high elasticity of the birth rate on the real wage and a low one of mortality (i.e., a strong preventive and a weak positive check) can be labelled a low-pressure system. In other words, there is a trade-off between the positive and the preventive check.

Negative Malthusian feedback of population size on the real wage exists whenever the aggregate production function is characterised by a falling marginal product of labour. Still, its gross impact can be mitigated by an outward movement of the production function as a consequence of technological progress or a continuous increase of the efficiency of factor allocation due to growing international specialisation (so-called Smithian growth). In its strict sense, therefore, a Malthusian system presupposes a static aggregate production function. A Malthusian system is absent when mortality and fertility are exogenous (i.e., do not depend on the real wage) and (gross) negative feedback is lacking.

An analysis of German demographic history in the perspective of a Malthusian system holds the potential to subject to close scrutiny our earlier description of the changing nature of mortality crises and of the evolution of fertility and mortality patterns. In the present study, we do not undertake an econometric analysis of Malthusian feedback (cf. Lee and Anderson 2002; Crafts and Mills 2009; Chiarini 2010), particularly since data quality and density for population is very limited for the pre-1740 era. Nevertheless, graphical inspection aided with some simple regressions suggests the existence of three distinct phases with respect to the relationship between the real wage and population size during the three-and-a-half centuries preceding industrialisation (Pfister 2010: 21–27). During the sixteenth century, and possibly during the first part of the seventeenth century, there was a strong negative relationship between the real wage and population size; a one per cent increase of population translated into a reduction of the real wage of not much less. The enormous fluctuation of the two variables—an increase of population by about 70 per cent (Table 1 above) and a concomitant reduction of the real wage by about 45 per cent—imply that Malthusian adaptation was rather weak. A second phase set in some time during the second half of the seventeenth century and was characterised by a still negative but rather weak response of the real wage to population growth. Finally, negative feedback was broken up by about 1820, and a sustained rise of the real wage set in during the late 1850s.

Earlier research on short-term adaptation of the birth and death rates to income fluctuations relative to pre-industrial Germany includes Galloway's (1988: 291–7, 1994a) studies on the relationships between numbers of births and deaths with grain prices and climate in Prussia from 1756 and the study of Guinnane and Ogilvie (2008) on two communities in Wurttemberg from 1651 using a similar design. Fertig's (1999) work on the determinants of the number of marriages in Westphalia from 1750 may also be counted among this literature. Galloway and Guinnane and Ogilvie all find a preventive and a positive check. According to Galloway, both relationships were of similar magnitude in Prussia and were in the middle range compared with other countries. In the communities studied by Guinnane and Ogilvie, the preventive check seems to have been stronger than elsewhere and the positive check faded away in the early nineteenth century. However, many results of this study fail to attain statistical significance. In contrast to these two studies, Fertig (1999: 256) finds a positive relationship between rye prices and the number of marriages during the second half of the eighteenth and a negative one during the first part of the nineteenth century. His explanation of this finding is that the rural population of Westphalia turned from surplus producers into buyers of grain over time. The finding underscores the need to employ real wage data (income data might even be better) to adequately study Malthusian adaptation. All these studies used distributed lag regression, a method we shall come back to below.

Table 9: Unit root and stationarity tests of vital rates and the real wage

	Augmented DF	Phillips-Perron	KPSS
a. 1730–1789			
Crude birth rate	-3.15*	-2.84^{+}	0.409*
Crude birth rate, de-trended	-5.47**	-5.26**	0.065
Crude death rate	-5.75**	-5.75**	0.350^{+}
Crude death rate, de-trended	-6.00**	-5.94**	0.042
Real wage	-2.53	-2.36	0.702*
Real wage, de-trended	-4.92**	-4.42**	0.068
b. 1790–1850			
Crude birth rate	-4.69**	-4.73**	0.059
Crude birth rate, de-trended	-6.42**	-6.27**	0.039
Crude death rate	-3.89**	-3.78**	0.542*
Crude death rate, de-trended	-6.70**	-7.08**	0.053
Real wage	-1.38	-1.96	0.786**
Real wage, de-trended	-6.50**	-4.90**	0.031

Notes: De-trended values were calculated using a Hodrick-Prescott filter with λ=100 on the natural log of original values. Options used in the unit root tests (all include an intercept in the test equation estimate): Augmented Dickey-Fuller test (null hypothesis: series has a unit root): Lag length selection with Schwarz information criterion, maximum lags=10; Phillips-Perron test (null hypothesis: series has a unit root) and Kwiatkowski-Phillips-Schmidt-Shin test (null hypothesis: series is stationary): spectral estimation with Bartlett kernel using Newey-West bandwidth. Levels of statistical significance: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$.

In what follows, we draw on our series of birth and death rates and on the real wage series from Pfister (2010) to implement two methods to identify patterns of short-term Malthusian adaptation, namely time-varying distributed lag regression and Vector Autoregression. The application of these methods requires that the underlying time series are stationary; that is, the effect of a shock disappears after some time. Therefore, Table 9 reports the results of standard tests of whether a series is stationary (Kwiatkowski-Phillips-Schmidt-Shin test) or whether it has a unit root; that is, it follows a non-stationary process (Augmented Dickey-Fuller and Phillips-Perron tests). The tests are carried out separately for the two periods in which we divided the data. For the Crude birth and death rates, all but one of the eight unit root tests reject the null hypothesis at the 1 per cent level and thus suggest that these series are stationary. This is not surprising since the weak ergodicity theorem indeed suggests that populations tend to forget past shocks. However, the KPSS test, which is a direct test of stationarity, rejects the null hypothesis at the 5 per cent level in two out of four cases. In addition, the real wage clearly follows a non-stationary process in both periods. On this background it was decided to perform the subsequent analysis with natural log values de-trended using a Hodrick-Prescott filter with $\lambda=100$. As Table 9 shows all de-trended series are unambiguously stationary.

We start our analysis by first implementing a Vector Autoregression analysis (VAR) for two time periods, namely, 1730–1789 and 1790–1850. The delimitation of the two time periods was chosen arbitrarily in order to balance sample size. The design follows the earlier studies by Eckstein et al (1985) and Nicolini (2007; cf. also Crafts and Mills 2009; Fernihough 2010).

The implementation of a VAR presupposes an ordering of the series that also reflects assumptions about temporal or causal priority. We follow standard practice of the recent literature (apart from Eckstein et al. 1985 and Nicolini 2007 see also Rathke and Sarferaz 2009: 9; Fernihough 2010: 8) by ordering the crude birth rate first, the death rate second and the real wage last:

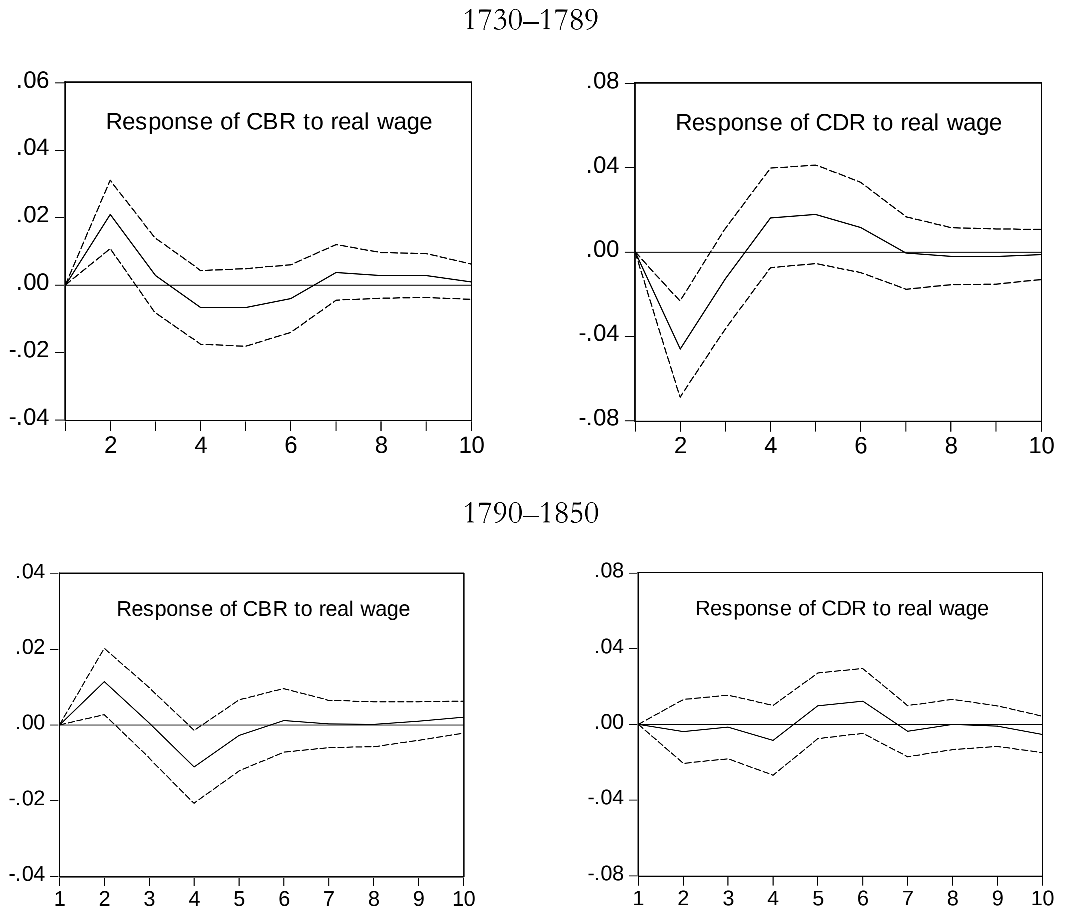
$$y_t = [CBR_t, CDR_t, w_t] \tag{2}$$

The rationale behind this ordering is that, particularly in periods of crisis, mortality is affected immediately by changes in the real wage, whereas the time lag between the decision to have a child and conception is on average several months, pregnancy adding another nine months.

We performed several tests for optimal lag length. The majority of tests suggested an optimal lag number of 1 in the first period, and 2 in the second. However, the sequential modified LR test statistic for the first period suggested an optimal lag length of 4; we therefore show the results based on a lag length of 4.

Our discussion of the results is essentially based on the impulse response diagrams displayed in Figure 11. These show the reaction of the first variable on a shock with the size of one standard deviation of the other variable over a lag of ten years. It turns out that the pattern of Malthusian adaptation differed strongly between the two periods considered. During the first period up to 1790, the birth rate reacted positively on a real wage shock, whereas the response of the death rate was negative. As our series consist of log deviations from trend, a rough estimate of the elasticity of the vital rates on the real wage can be made by dividing the response in year 2 (the only one that is statistically significant; actually this conforms to a lag of one year) by the standard deviation of the real wage. The result is $e_{b,w} = 0.30$ for the birth rate and $e_{d,w} = -0.67$ for the death rate. These values may be compared with Weir's (1984) study of the demographic effects of grain price variations on vital rates in France and England as well as with Fernihough (2010) who applies a similar design as ours on Italian data. Our elasticity of the death rate on the real wage is on the same level with the positive check in France during the late seventeenth and early eighteenth century, and considerably above the value recorded for England and Italy. It should be noted that our results are sensitive to the inclusion or exclusion of the Electorate of Saxony, which experienced strong fluctuations of vital rates between the 1750s and early 1770s; without this large territory, the elasticity of the death rate on the real wage would amount to -0.42, which approximates the value found for France around the turn of the nineteenth century. The elasticity of the birth rate on the real wage is rather higher than the values reported by Weir and Fernihough (-0.2 and less).[21] Our results are also broadly consistent with the findings on two Wurttemberg parishes for the eighteenth century (Guinnane and Ogilvie 2008). Tentatively we may conclude that, in Germany, the positive check dominated the preventive check during the eighteenth century, but the latter was strong by comparison (cf. also Nicolini 2007: 112–3).

Figure 11: Impulse responses of vital rates and the real wage (Response to Cholesky One S.D. Innovations ± 2 S.E.; de-trended time series)



The findings for the period 1790–1850 present an entirely different picture. The positive check disappears (with $e_{d,w}$ = -0.04), whereas the preventive check remains, but its strength is weaker than during the first period; the elasticity of the birth rate on the real

21 Perhaps the elasticities we find are higher than those reported by Weir simply because we use the real wage rather than a grain price a as an indicator of real income.

wage in year 2 diminishes to 0.12.[22] With the turn of the nineteenth century, population dynamics lost the homeostatic closure that characterised the Malthusian age. Mortality in particular was now largely exogenous, and only the preventive check retained some of its earlier strength. This result is in line with the disappearance of Malthusian feedback (i.e., a negative relation between the real wage and population size), the weakening of mortality crises from the early nineteenth century and the strong increase of life expectancy, which all occurred in a short time period during the early nineteenth century.

Whereas these findings are in many ways indicative and shed new light on the Germany economy and society during the century preceding industrialisation, we conclude this chapter by stressing their tentative and provisional character. As our research unfolds, we hope to add in particular the following extensions: First, we expect to be able to improve data density for the period 1730–1818 and to extend the time series forward and backward in time. In particular, it would be interesting to know to what extent the serious mortality shocks during the last quarter of the seventeenth and the beginning of eighteenth century were caused by exogenous shocks or by Malthusian pressure. Likewise, we hope to be able to check whether indeed, as suggested above, demographic adaptation to real wage fluctuations was weak during the later sixteenth century and whether the assertion of the European marriage pattern strengthened the preventive check. Introduction of the marriage rate into the analysis will render it possible to refine the observation of the preventive check. Since the birth rate was affected by bad nutrition and the social dislocation connected with subsistence crises, its fluctuation partly reflects the operation of the positive check, and it can only partly capture the preventive check.

Second, the causal ordering we chose following Nicolini (2007) supposes 'that real wages do not affect CDR within the same year' (Nicolini 2007: 107). This is a rather implausible assumption given the short term (monthly) nature of many subsistence crises and, specifically, the epidemics linked to economic unrest. Ordering births first is also implausible. Through intrauterine mortality, same-year effects of real wage fluctuations on the birth rate should be expected and are well-documented in the English case by Lee (1981: 371). Similar problems arise when we consider why the deaths of pregnant women are not allowed to influence births within the causal ordering proposed by Nicolini (2007). Better VAR models could possibly be constructed using monthly or weekly data for both the real wages (particularly the grain prices that form an important part thereof) and the demographic series.

Third, as our series can be extended to a longer time period, it will be highly advisable to implement a time-varying VAR approach as proposed by Rathke and Sarferaz (2010). Using the English material analysed by Nicolini (2007) and Crafts and Mills (2009) these authors show that the results obtained with a standard VAR, as replicated here, is highly sensitive to changes in the volatility of the underlying series and to the delimitation of subperiods. The application of a time-varying VAR can control these problems and permits a direct observation of the changes in Malthusian adaptation over time.

On this background, the second part of the present chapter implements a time varying distributed lag regression analysis of Malthusian checks. While less general than the VAR approach, this method allows more explicit modelling of Malthusian adaptation. At the

22 The result depends in part on the exact delimitation of the second period. If the whole war period and the crisis of 1817/19 is left aside and the analysis is confined to the years 1820–1850 and only two lags, the response of the birth rate to the real wage is stronger and the volatility of the real wage is weaker, so that the elasticity rises to 0.18.

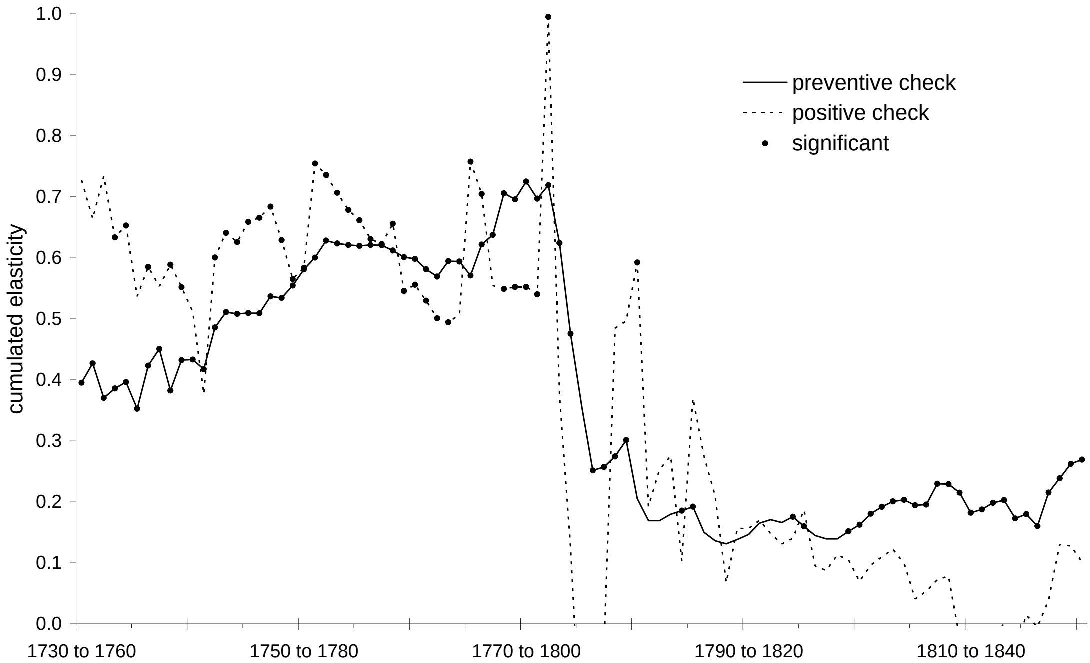
same time, it is more parsimonious with respect to the number of degrees of freedom it consumes. It therefore provides a test of the robustness of the results obtained with VAR and presents a means to identify the time point when the transition between the two regimes identified with the VAR analysis occurred.

Regression analysis of short term fluctuations in vital events has been introduced to modern social and economic history by Franklin Mendels (1981). Moreover, a central chapter in Wrigley and Schofield's (1981) *Population History of England* exploits the Cambridge Group's English data with the help of a refined version of Mendels's technique: the calculation of cumulative elasticities from distributed lag regressions (Lee 1981). Since then, distributed lag short term analysis has been used in a large number of studies in historical demography (for an overview, see Galloway 1988, for more recent applications see Fertig 1999 and Guinnane and Ogilvie 2008). The basic concept of the method is to estimate the strength of birth rate or death rate reactions to income fluctuations. Not only contemporaneous influences are observed, but also reactions that take a few years' time. A regression is estimated that includes lagged values of income fluctuations as independent variables; in some versions of the method, it also includes past values of the dependent variable, or first and second order autoregressive effects. The overall strength (cumulated elasticity) of these influences of the income fluctuations on fertility or mortality is calculated by summing up the regression coefficients.

In order to test the robustness of our general findings, we first translated the VAR design presented above into a distributed lag regression specification that includes lags 0 to 3 of the real wage (with a few modifications as discussed below), using the de-trended series as described at the beginning of this chapter. Our VAR analysis had yielded the following elasticities in year 2 (in regression terms, at lag 1): $e_{b,w} = 0.30$ for the birth rate and $e_{d,w} = -0.67$ for the death rate in the period 1730-89; $e_{b,w} = 0.12$ and $e_{d,w} = -0.04$ in 1790-1850. The corresponding elasticities estimated using distributed lag regression at lag 1 are: $e_{b,w} = 0.32$ for the birth rate and $e_{d,w} = -0.70$ for the death rate in the period 1730-89; $e_{b,w} = 0.08$ and $e_{d,w} = 0.02$ in 1790-1850. In other words, the two methods yield very similar results. We therefore feel justified to make comparisons between results of studies based on both methods, and to use both approaches.

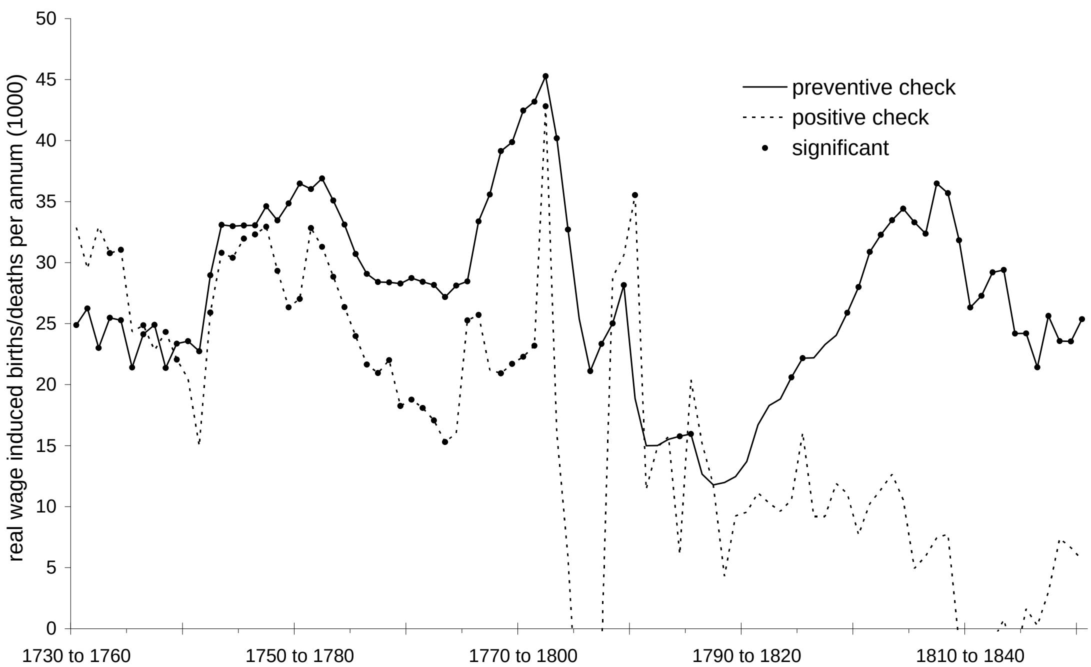
Figures 12 and 13 display estimates of Malthusian checks using moving time windows of distributed lag regression analysis for the birth rate (preventive check) and the non-infant death rate (positive check). We introduced several modifications to the specification used by earlier studies. While previous studies tested the individual regression coefficients only, we test the cumulated elasticities directly, using a joint F Test with the null hypothesis that the sum of the regression coefficients equals zero. We do not include lag 4, usually insignificant, in order to economise on degrees of freedom. Moreover, we use moving time windows of 30 years for the individual regressions in order to get an impression when structural breaks in the relation between real wages and vital rates occur. Cumulated elasticities are calculated and tested for the lag when they are at their maximum. Since we use de-trended natural logs of all series, regression coefficients can be directly interpreted as elasticities.

Figure 12: Cumulated elasticities for the preventive and positive checks, 1730 to 1850



Sources: Own calculation.

Figure 13: Absolute numbers of real wage induced births and non-infant deaths, 1730 to 1850



Sources: Own calculation.

Otherwise, the design follows the standard procedures developed by Lee, Galloway and Weir. Non-infant deaths have been estimated following a method designed by David Weir (1984, p. 37):

$$nid_t = d_t - (imr \cdot (s \cdot b_t + (1 - s) \cdot b_{t-1})) \qquad (3)$$

where nid_t = non-infant deaths in year t, d_t = all deaths in year t, *imr* = infant mortality rate, *s* = separation factor; i.e. the proportion of infant deaths occurring within the calendar year of birth, and b_t = births in year t. This method has been preferred over the one used by Lee (1981, 357-358) because it minimises the consequences of missing values in the birth series. The separation factor has been assumed to be 0.74, again following a suggestion by Weir. The infant mortality rate has been assumed to be 0.170.[23]

Following Weir (1984), we include two lags of the dependent variable as regressors. The full regression model has the form:

$$n_t^* = \sum_{k=0}^{3} \beta_k w_{t-k}^* + \gamma_1 n_{t-1}^* + \gamma_2 n_{t-2}^* + \varepsilon_t \tag{4}$$

for t = year, from the starting year of a time period to its end year 30 years later; k = lag 0 to lag 3; where n_t = birth rate or non-infant mortality rate at time t; w_t = real wage at time t; β_k = regression coefficients for the real wage and its lags; γ_1 and γ_2 = regression coefficients for lags 1 and 2 of the dependent variable; and ε_t = error term.

Figure 12 depicts the intensification and reduction of the positive and the preventive checks over time; Figure 13 translates these figures into absolute numbers of persons (in thousands per annum in Germany) whose death occured earlier (positive check) or whose birth was procrastinated due to real wage fluctuations. Occasional and insignificant negative impacts are not included in the graphs. Dots mark regressions that yield significant lag sums (in other words, the sum of the coefficients is jointly significant for the lag where it reaches its maximum). In reading the graph, one should bear in mind that the depicted elasticities refer to time periods of 30 years, not time points.

A first conclusion that emerges from Figures 12 and 13 relates to the strong fluctuation of the estimates across adjacent observation periods. This should be read as a warning against making arbitrary decisions about the cutting points between early and later time periods. Including a few data points (such as the Seven Years' War or the crisis of the early 1770s) can change the results massively. Second, when moving time windows are used, the distributed lag analysis does not corroborate the impression suggested by the VAR analysis that in the earlier period, the positive check was stronger than the preventive check. Third, it seems that in the eighteenth century, the preventive and the positive check moved in a parallel fashion. At first sight, this questions the Malthusian intuition that there was a trade-off between positive and preventive checks—that populations had to suffer from stronger positive checks when the preventive check was weak. A possible interpretation for this joint movement of the two checks may be that there were times (of war and climatic shocks in particular), when national real wages and local income fluctuations were closely correlated, and other times when they were more at variance. Fourth, it is remarkable that both births and deaths reacted strongly, and on equal levels, to income fluctuations, particularly during the crises in the second half of the eighteenth century. Last, when we move on to the nineteenth century, we see the positive checks (or the impact of hunger crises) disappear, while the preventive check stays in force on a somewhat reduced level. This cor-

23 This is a rather arbitrary assumption taken over from Fertig (1999); cf. Gehrmann and Roycroft (1990: 83). We shall use time varying and/or regional estimates based on Inverse Projection in later versions of this investigation. Our current estimates of IMR from Inverse Projection do not fit well with what is known on IMR from family reconstitution studies. Empirical data could also be generated from family reconstitution studies to calculate time varying or regional separation factors.

roborates our earlier impression that the early nineteenth century saw a profound change in the demographic regime, particularly with respect to mortality.

7. Conclusion

In this study we develop a research strategy for aggregative population reconstruction for pre-industrial Germany and construct a preliminary dataset both to demonstrate the feasibility of our approach and to produce tentative but nevertheless new and, as we find, interesting insights into German population history during the century preceding the onset of industrialisation.

An aggregative population reconstruction for Germany faces two challenges: While probably small, cross-border migration is virtually impossible to assess with an acceptable degree of precision before the middle decades of the nineteenth century, so that it is fairly risky to extrapolate past population size on the basis of the numbers of births and deaths alone. Second, the country was repeatedly affected by serious shocks resulting from food crises, epidemic disease and political upheavals that led to frequent disruptions of the church administration, which was of crucial importance for the registration of vital events. For this reason, uninterrupted series of parish registers are rare, and studying only parishes with complete records back into the early seventeenth and late sixteenth century would introduce a kind of survivorship bias.

On this background we develop a research strategy that rests essentially on two pillars: First, we intend to use comprehensive censuses and partial censuses of hearths, taxpayers, communicants, etc. to construct estimates of population size at intervals of ten years. From c. 1740—that is, for the proto-statistical era—it is possible to draw on census material produced by state authorities. A certain focus lies on the northern German territories studied by Gehrmann (2000), but additional sources exist for other regions. Some of this information is used in this study to revise Gehrmann's estimate of national population size in 1755–1800, which rests on an extrapolation of growth rates recorded for northern Germany. Our revisions are so far minor and suggest that Gehrmann's estimate is fairly robust.

For the period before 1740 we intend to rely on partial censuses established by lay and church authorities for specific fiscal, military, religious and other purposes. They all relate only to a segment of the population. To infer total population size from them would require knowledge of the ratio between the partial aggregates counted and total population size, such as household size or age structure. As this information is impossible to come by with any acceptable degree of precision, we analyse only pairs of partial censuses established at two points in time and referring to the same territory as well as the same kind of aggregate. We then use the growth rate between the two to interpolate population growth by decade. By weighting individual growth rates according to the weight of the respective localities or regions in national population at the beginning of the nineteenth century, we calculate aggregate growth rates by decades which can then be used to project population size backward from 1740. Koerner's (1959: 328) estimate of a population density of 30 inhabitants per square km in 1600 (or an improved version of this estimate) can serve as a benchmark to assess the consistency of these estimates. While this approach has its weaknesses, we believe that it at least renders it possible to trace the smoothed mid-term evolution of population size. Our experimentation with a small dataset of 60-odd data pairs suggests that Ch. Pfister's (1994) estimates of population size for the period c. 1500–1650 and Gehrmann's estimate for 1740 are mutually compatible, but the margin of error still remains large.

The second pillar of our research strategy relates to the way we construct long series of annual numbers of births, deaths and marriages.We complement the now familiar use of parish registers with material compiled by state officials from the 1730s. Once again, the bulk of this material comes from northern Germany (Gehrmann 2000), but similar information is available for a few other territories, some of which have been used in the present study. Even this preliminary database (which also includes c. 140 parishes) covers about a third of the estimated national number of vital events around 1790. This implies a data density that considerably exceeds the one of aggregative reconstruction studies carried out for other European countries.

Meanwhile, we also apply pooled Weighted Least-Squares (WLS) regression with fixed effects for localities and years to create aggregate time series of vital events from a great number series at the parish level that differ in time length and exhibit occasional gaps. The alternative would consist in splicing shorter series with stable geographical coverage and in interpolating missing values. The former leads to data loss, and the arbitrary choice of splicing ratios may distort the resulting aggregate series; the latter entails the risk of an underestimation of crisis mortality. We therefore believe that pooled WLS regression is superior to splicing, particularly as one moves back in time periods before the second quarter of the eighteenth century, when disruptions were much more serious than later. Pooled WLS regression is also the only means to analyse the material collected by state officials during the proto-statistical era, since these series are mostly short, of unequal duration and beset with many gaps. We used easily available annual series of births and deaths from approximately 140 localities to experiment with different methods and to compare the results with the official statistics that become available from 1815/8. Wherever it was possible to construct series, both by splicing shorter series and with pooled WLS regression, they were very close to each other and we believe that differences result mainly from the fact that pooled WLS regression uses data that is lost in splicing. Comparisons with official series from 1815/8 suggest that on the regional level vital events can be acceptably reproduced with samples from approximately 60 parishes upwards. Aggregate series based on weighted regional series fitted official statistics on the national level quite well, despite the strong regional bias of our material. We believe that during the first part of the nineteenth century it would be possible to represent the development of vital events on the national level satisfactorily with only 200 to 300 parishes.

Two minor elements complement our research strategy. They refer to the definition of the geographical boundaries of Germany and the handling of official statistics up to 1840. In contrast to earlier work, which takes the *Kaiserreich* of 1871 as reference point in order to join series covering the pre-unification period with the official statistics of the later nineteenth century, we propose to study Germany in the borders of the *Deutscher Bund* of 1815 with the exclusion of the Habsburg lands, Limburg and Luxemburg. This definition, which excludes the north-eastern provinces of Prussia, the Duchy of Schleswig and Alsace-Lorraine, is historically meaningful since it essentially conforms to the boundaries of the old *Reich* during the eighteenth century, exclusive the bulk of the Habsburg lands. We believe that this territory is also more amenable to historical-demographic research on the pre-modern period than the later *Kaiserreich*. As a preliminary exercise we have converted and homogenised existing estimates of population size from 1500 to 1840 to this geographical frame of reference (Table 1).

Our study is apparently the first to make full use of Krause's (1980) compilation of official statistics for the pre-1841 period (from 1841 official statistics cover all states). Between 1815/8, the majority but not all German states reported vital events annually and carried out censuses at regular time intervals. In the present study we inflate this information to national series of life events and propose an aggregate correction for underregistration in early censuses. In future research we expect to refine our estimate of underregistration and deal more explicitly with the isolation of still-births and infant mortality.

To assess the feasibility of our research strategy, we created time series of the crude birth and death rates (CBR, CDR) from 1850 backward to 1730. For this purpose, we combined official statistics from 1815/8, proto-statistical information on population size and vital events collected by state officials and series obtained from approximately 140 parish registers into a single dataset. With the exception of the first to decades and the period 1805–1815, cumulative natural increase and population growth between adjacent years for which there is an estimate of population size are by and large identical. The estimates of population size (derived largely from Gehrmann 2000) and the series of annual numbers of births and deaths are thus mutually consistent. Together with the close fit between aggregate series derived from parish registers by way of splicing and with pooled WLS regression, as well as the broadly consistent picture resulting from our experimentation with a small dataset of partial censuses, this amounts to a demonstration of the feasibility of our proposed research strategy.

On the background of our experience with this preliminary study, future research into an aggregative population history of German will require work on the following agenda:

First, a massive input of data from parish registers and partial censuses is required for the pre-1730 period. For time periods before 1730, our information on vital events and population size is grossly inconsistent. Since we relate this to the fact that proto-statistical information becomes available only from c. 1735, this demonstrates the need for additional data. Because the volatility of the death rate declined over time by possibly more than 50 per cent, and because parish size was smaller during the early part of the observation period, we plan to collect information on more than double the number of parishes judged as sufficient for reconstructing aggregate trends in first half of the nineteenth century, namely 450–600 parishes. As we continue to collect material on parish registers from published sources, we intend to rely to a great extent on own work on archival sources. This is because the readily available material is heavily biased towards a few regions in the south-west and the north-west of the country, as well as towards the time period from the second quarter of the eighteenth century. It should also be noted that marriages often lack in the data that are currently available to us, so that its collection ex post requires additional archival research.

Second, archival research of minor extent is required to fully mobilise information on population size and vital events collected by state officials during the proto-statistical era from about 1740. Particular attention will be paid to the fact that proto-statistical sources are heavily biased against Catholic regions. The analysis of a sufficiently large number of parish registers from Catholic regions and of lists of communicants established by church authorities will at least in part offset this bias.

Third, detailed work is necessary to homogenise all series with respect to stillbirths.

Fourth, the low level of consistency between our vital events and population series in 1805–1815 and the evidence of under-registration in the censuses of the early nineteenth century require a detailed study of the production of statistical material under the conditions of rapid changes of boundaries and state organisation at the beginning of the nineteenth century. This work can draw on detailed information about census organisation and vital events registration in individual states provided by Gehrmann (2009, 2010).

Fifth, we require information that orients the weighting both of regional series obtained from parish registers and growth rates derived from pairs of partial censuses. This is because we shall never be able to compose a random sample; data availability will always remain a prime selection criterion, and so regional and size biases will persist. These biases will have to be corrected by the weighting of individual observations or regional series, as we have done so on the basis of provisional criteria in the present study. Research into the aggregate characteristics of the German population will be oriented primarily towards a comprehensive description of the population distribution according to regional administrative units, community size and religion at the beginning of the nineteenth century. We shall also try to project information on the patterns of land use and sectorial structure, which becomes available only from the third quarter of the nineteenth century, back to population structure at the beginning of the century.

Sixth, we intend to complement the aggregate analysis by a systematic collection of disaggregate information on a wide array of demographic variables from published family reconstitution studies and work on household patterns. As explained in greater detail in Section 5, the accurateness of inverse projection strongly depends on the amount of information on variables such as age structure, age-specific mortality, age-specific fertility, etc. that is fed into the analysis. The many local studies carried out over the past 40 years contain such information and can be used to improve the quality of our aggregate projections of life expectancy and the gross reproduction rate.

Finally, disaggregated time series on a monthly or weekly level, or by sex, can be used to get a much sharper picture of the fundamental mechanics of Malthusian adaptation.

Given the acceptable consistency of our data back to 1730, we consider it warranted to carry out exploratory analyses of our vital rate and population size series. We therefore conducted an inverse projection to study the trajectory of life expectation and the gross reproduction rate, and we performed both VAR and distributed lag regression analyses of Malthusian adaptation. We also looked at summary indicators of the absolute number of births and deaths in 47 to 67 parishes located predominantly in the south-west and the north-west for which we have data extending from the second half of the seventeenth century to the 1720s to produce statements about the general demographic conditions around 1700. Taken together, this research leads to the following preliminary statements about the population history of Germany during the century and a half preceding industrialisation:

First, there was a marked reduction of the volatility of vital events between the fourth quarter of the seventeenth and the second quarter of the eighteenth century. At a much slower pace, this tendency continued into the nineteenth century. This result is subject to caveats on methodological grounds, since volatility is negatively correlated with data density, and the size of our dataset increases over the observation period. Nevertheless, at least part of the volatility decline is probably real, particularly in the case of mortality. The strong reduction of the volatility of life events between the late seventeenth century and the second quarter of the eighteenth century went together with a decline of the volatility of the rye price and it was also the period in which a sustained rise of per capital GDP and of labour productivity in the agricultural sector set in, albeit at a very slow pace. It may well be then that the decline in the volatility of vital events that occurred in the early 1700s was a defining moment in German economic and social history: It reduced the risk of decisions with respect to the life cycle of individuals and thus increased the risk-adjusted return on human capital. This may have encouraged individuals to invest in the accumulation of skills and knowledge, which in turn promoted technological progress and economic growth.

At the present stage of research, there is no final explanation for the volatility decline at the beginning of the eighteenth century. Nevertheless, two candidates stand out: On the one hand, there is evidence that the fourth quarter of the seventeenth century marked the culmination of the so-called Little Ice Age, and climatic conditions improved during the early eighteenth century. This may have reduced both the frequency and the severity of harvest failures. Conversely, growing market integration may have improved the security of food provision and promoted regional specialisation, which increased agricultural productivity and raised income. A process of market integration during the period in question is manifested by the reduction of the inter-market variability of rye prices and an increase of urban hierarchy during the first half of the eighteenth century.

Second, the early onset of a secular mortality decline, as suggested by the theory of demographic transition and similar to the path followed by Sweden, can be identified in the second half of the eighteenth century. The great volatility decline of the early eighteenth century was an important precondition for this process, since until the 1720s population growth in the mid-term was the result of rapid alternations of serious mortality crises and phases of recuperation. By contrast, in the seven decades from about 1745, the death rate oscillated between 0.03 and 0.035 most of time, interrupted only by a handful of serious mortality crises, two of them occurring during the Seven Years' War (1756–1763: 1757/8, 1762/3), two other during the Napoleonic Wars (1807, 1814) and two falling in between (1771/3, 1795). After the end of the Napoleonic Wars, the death rate plunged below 0.03, which corresponds well with the favourable real wage conditions prevailing during the 1820s. It reverted to a somewhat higher level during the more difficult 1830s and 1840s, but only during two years was there a blip across the 0.03 level (1834 and 1837). The birth rate, by contrast, showed no clear long-term trend and fluctuated within a narrow band between 0.035 and 0.04 during most years. At present, the arguments developed to account for the volatility decline after the fourth quarter of the seventeenth century constitute also the most plausible explanations of the onset of the decline in mortality or possibly the demographic transition itself.

Third, in the mid-term perspective, we have used Inverse Projection to trace the movement of life expectancies and gross reproduction rates, thus accounting for changes in the age distribution of the population. While these methods are quite sensitive with regard to possible errors in existing estimates of population size and the assessment of migration, our preliminary results seem to show that Germany experienced a strong rise of the life expectancy between the end of the Seven Years' War (1756–1763) and c. 1830. At the same time, a modest increase of the Gross Reproduction Rate may have occurred. In comparison, Germany moved in the same direction as Sweden in the e_0, GRR space, but from an initially lower level of life expectancy. The strong increase of life expectancy coupled with the stability or a moderate rise of fertility implied the move from a pattern characteristic of *Ancien Régime* France to a demographic terrain similar to England's before, and after, the early phase of the Industrial Revolution (the latter itself being associated with a fertility boom).

Inverse projection also suggests that the population growth following the onset of a secular mortality decline led to a strong increase of the dependency ratio between c. 1760 and 1830. We believe that this had a negative impact on per capita income on the household level. In particular, the adverse evolution of the earner-consumer balance must have dampened the effect of the strong rise of the real wage during the late 1810s and early 1820s on material welfare by about 10 per cent. The increase of the dependency ratio can partly reconcile the opposing movements of the real wage and the biological standard of living during this period.

Fourth, our VAR and distributed lag analyses of Malthusian adaptation suggest the disappearance of the positive check, that is, a negative short-term response of the crude death rate on the fluctuation of the real wage, sometime around the Napoleonic Wars. That mortality became exogenous to short-term economic fluctuations fits well with the parallel disappearance of severe mortality crises and a massive rise of the life expectancy. It is also compatible with the finding that Malthusian feedback in the form of a negative relationship between population and the real wage disappeared around the same time. The economic forces shaping this important structural break, which occurred well before the onset of industrialisation during the 1840s, remain obscure at the present stage of research. Our results should also be qualified with respect to the fact that they relate to the national level only. The favourable development on a national level does not rule out the possibility of severe mortality crises and of a persistence of the positive check in disadvantaged regions. The north-eastern provinces of Prussia are a case in point (Bass 1991: 45–6).

Fifth, German population dynamics were decidedly Malthusian in the eighteenth century, despite the reduction in the severity of mortality crises. There was a negative feedback in that the real wage fell along with the increase of the population as a result of the persistent gap between the birth rate and the death rate; this negative feedback was, however, weaker in the eighteenth than in the sixteenth century. There was both a substantial positive and preventive check. The strength of both checks seems to have approached the upper margin of the range of values observed for European countries during the eighteenth century. A strong positive check is consistent with a low life expectancy, particularly if compared with other European countries. The presence of the preventive check, which persisted at a lower level into the first half of the nineteenth century, may explain why Malthusian feedback was weaker in the eighteenth than in the sixteenth century and why modest advances in income per capita could be realised.

The early nineteenth century, particularly the period between 1810 and 1830, thus stands out as a period when the German economy and population made a big leap forward in three interconnected dimensions: real wages and life expectancies rose, and hunger disappeared. It is the same period when state borders were reorganised, the Old Empire was dissolved, and territorial states put much effort in developing their economies. Positive and negative policy integration (Kopsidis 1998), road construction (Borchard 1968: 260–278) and tariff reduction might have been instrumental in bringing about a positive shock. In addition, the late eighteenth and early nineteenth centuries were the heyday of proto-industrial growth in the countryside. To be sure, our results are based on preliminary data and should be elaborated further in particular by more disaggregate research. But they seem important as they run counter to the standard account of German economic development. The usual story has the take-off dated after 1850, when the age of railway construction, a rapid growth of heavy industry and the transition to the factory system in the textile sector set in. It may well be that the focus of German economic history on post-1850 growth has been contingent upon the lack of earlier data, and that what happened in the 1810s was as important as the structural and institutional changes around mid-century.

How do our findings, whose preliminary character needs to be stressed, tally with recent theorising about the onset of the transition between the Malthusian and post-Malthusian stages of economic development? There are no signs that the onset of sustained growth in the first half of the eighteenth century and of the mortality decline since the 1740s were caused by population-related technological progress, as suggested by Galor and Weil (2000) and Galor (2005). By contrast, we attach great importance to the impressive decline in volatility both of vital events and grain prices that occurred between the fourth quarter of the seventeenth and the second quarter of the eighteenth century. It reduced the risk of decisions with respect to the life cycle of individuals and thus increased the risk-adjusted return on human capital. This may have encouraged individuals to invest in the accumulation of skills and knowledge, which in turn promoted technological change and economic growth. Its causes were probably exogenous, market integration and the improvement of climatic conditions being the most proximate candidates. During the remainder of the eighteenth century, however, economic growth still remained weak and did not suffice to prevent a decline of the real wage, while dependency rates rose to levels they would maintain over the nineteenth century. The operation of the preventive check, which was strong by international comparison, may well have been crucial in preventing renewed decline of material welfare.

Another salient result, the disappearance of the positive check on the national level (albeit possibly not in all regions) in the 1810s, was probably also caused by exogenous processes: Market integration created sources of income outside agriculture for the labouring poor through the development of proto-industries and supra-regional labour markets. As a consequence, exchange entitlements suffered less in harvest failures than in situations in which agricultural labour was the sole source of income for the lower classes. Hence, the demographic vulnerability with respect to fluctuations of agricultural output decreased over time, despite the renewed increase of grain price and real wage volatility during the first half of the nineteenth century as compared to the second half of the eighteenth century.

Our preliminary results thus suggest that market integration was a more important force behind the onset of the demographic transition and the disappearance of the positive check than endogenous forces in the system linking economic and demographic variables. Further research will show whether this finding is robust. Most importantly, however, our evidence points to a departure of the German economy from a strictly Malthusian pattern well before the onset of industrialisation. Exploring the origins of this process requires a massive input of new data covering periods much earlier than those we have analysed in this paper.

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Appendix 1: Population size and vital events, 1815–1850

Source: Kraus (1980); Gehrmann (2000: 380–387) for Holstein. Geographical coverage is the *Kaiserreich* of 1871 without Alsace-Lorraine, Ost- and West Prussia, Posen and Schleswig.

Population size

Amt Bergedorf (dominion of Hamburg and Lübeck): Population in 1822 is assumed at 10,100 (the figure for 1824 is 10,113).
Holstein includes Fehmarn and Lauenburg. Population in 1816, 1819, 1822, 1828, 1831, 1834 and 1837 is interpolated on the basis of natural increase between 1815, 1820, 1825, 1830, 1835 and 1840; the small discrepancies between natural increase and population growth are taken into account by way of exponential adjustment. Population from 1841 is derived from the population of Schleswig-Holstein by using the share of Holstein in the later province in 1840 (60.38 per cent).
Oldenburg: Population size of the Grand Duchy in 1821–1835 is extrapolated on the basis of the mean ratio of the population the Grand Duchy with the population of the Duchy alone in 1836–1840.
Lacking information for some small territories is taken into account by inflating the national figure according to their shares in total population in later years:

- Anhalt: Population in 1822, 1828 and 1831 is assumed to be equivalent to the mean share in national population in 1834 and 1837 (0.56 per cent)
- Hohenzollern: Population from 1815/16 to 1831 is assumed to be equivalent to the mean share in national population in 1834 and 1837 (0.23 per cent)
- Schaumburg-Lippe: Population from 1815/16 to 1834 is assumed to be equivalent to the share in national population in 1837 (0.11 per cent)
- Thuringian states (Thüringische Staaten): Population from 1815/16 to 1837 is assumed to be equivalent to the mean share in 1841–1843 (3.26 per cent). Population in 1840 is extrapolated on the basis of population and natural increase in 1841.

Population in 1815/16 is aggregated using the figures for 1816 (cf. Gehrmann 2000: 97, Footnote 283) except Frankfurt, Hamburg and Nassau (1817) and Amt Bergedorf (1815).

Numbers of births and deaths

Births in Bavaria (total) 1822 are interpolated with the mean of Bavaria (without the Rhenish Palatinate) in 1821 and 1823 plus the Rhenish Palatinate 1822.
Bremen: Values for the extended territory before 1823 are extrapolated using the figures given by Gehrmann (2000: 392–3) for the city alone and inflating them by the mean ratio between the series for the two aggregates in 1823–1825.
Hamburg: Values for the extended territory before 1821 are extrapolated using the figures given by Gehrmann (2000: 392–3) for the city alone and inflating them by the mean ratio between the series for the two aggregates in 1821–1823.
Holstein: The values in 1841–1850 are extrapolated on the basis of the ratio with Schleswig-Holstein in 1836–1840.
Nassau: Values in 1843–1844 and 1846–1850 are interpolated with the means of the neighbouring years.
Oldenburg: Values before 1836 are extrapolated on the basis of the mean ratio between the Grand Duchy of Oldenburg and the Duchy alone in 1836–1840.
In 1841–1843, the difference between the aggregate figures given by Kraus (1980: 330–1) and those calculated bottom-up differ by 0.07–0.15 per cent (births) and 0.17–0.05 per cent (deaths). A difference of 0.15–0.20 is close to the share of number of births and deaths in Frankfurt and Amt Bergedorf (c. 1800, in scattered years between the 1820s and 1850s), which lack in the calculation made bottom-up. The series given by Kraus from 1841 can therefore be considered valid.

Aggregate series:
Series 1 consists of the values given by Kraus (1980: 330–1) for 1841–1850.
Series 2 is the aggregate calculated on the basis of individual states in 1827–1843, excluding Anhalt, Amt Bergedorf, Frankfurt, Hesse, Hohenzollern, Schaumburg-Lippe, the Thuringian states, and Waldeck-Pyrmont.
Series 3 (1818–1829): As Series 2, but without Hesse, Saxony, Oldenburg and Bavaria (deaths only; the births series includes Bavaria).
The three series are spliced using the mean ratios in 1827–1829 and 1841–1843.

Appendix 2: Partial censuses

Table 10: Partial censuses

Administrative unit	Region	Year 1	n 1	Year 2	n 2	Type	r p. a.	Source
Grafschaft Erbach	south	1501	368	1551	417	hearths	0.25	Koerner (1958: 191)
Amt Leonberg	Wurttemberg	1525	928	1598	1604	hearths	0.75	Koerner (1958: 192)
Kreis Biedenkopf	Hesse	1502	280	1577	499	hearths	0.77	Koerner (1958: 192)
Kreis Marburg	Hesse	1502	584	1577	1320	hearths	1.09	Koerner (1958: 192)
S-Hanover		1539	3038	1603	4308	hearths	0.55	Koerner (1958: 192)
Erzbistum Magdeburg		1563	7642	1600	7864	hearths	0,08%	Koerner (1958: 192)
Amt Grimma	Electorate of Saxony	1532	741	1585	853	hearths	0.27	Koerner (1958: 192)
Amt Liebenwerda	Electorate of Saxony	1550	310	1570	322	hearths	0.19	Koerner (1958: 192)
Amt Weimar	Thuringia	1541	702	1588	1023	hearths	0.80	Koerner (1958: 192)
Amt Weißensee	Thuringia	1525	506	1588	854	hearths	0.83	Koerner (1958: 193)
Amt Gotha	Thuringia	1557	832	1588	1108	hearths	0.93	Koerner (1958: 193)
Amt Schmalkalden	Thuringia	1543	1243	1585	1867	hearths	0.97	Koerner (1958: 193)
Amt Themar	Thuringia	1573	205	1603	198	hearths	-0.12	Koerner (1958: 193)
Ernestinisches Gebiet		1555	9216	1588	10406	burghers	0.37	Koerner (1958: 309)
Wurttemberg		1598	54771	1634	66800	burghers	0.55	von Hippel (1978: 417, 421)
Wurttemberg		1634	66800	1645	20040	burghers	-10.37	von Hippel (1978: 421, 437)
Wurttemberg		1645	20040	1655	28724	burghers	3.67	von Hippel (1978: 437; Boelcke 1987: 95)
Wurttemberg		1655	28724	1700	64000	burghers	1.80	von Hippel (1978: 437; Boelcke 1987: 95)
Wurttemberg		1700	320000	1707	342800	pop.	0.99	Boelcke (1987: 95)
Wurttemberg		1707	342800	1757	453651	pop.	0.56	1707: Boelcke (1987: 95); 1757: GStASt A 8
Umgebung Kassel	Hesse	1575	1845	1624	1989	burghers	0.15	Lasch (1969: 62)
Umgebung Kassel	Hesse	1624	1989	1639	1240	burghers	-3.10	Lasch (1969: 62)
Umgebung Kassel	Hesse	1639	1240	1681	1760	burghers	0.84	Lasch (1969: 62)
Hochstift Speyer		1500	13135	1530	11646	adults	-0.40	Andermann / Ehmer (1990: 93)
Bavaria		1666	519000	1694	551000	rural pop.	0.21	Schlögl (1988: 80)
Oldenburg		1662	62000	1702	65680	pop.	0,14	Hinrichs / Reinders (1987: 664)
Oldenburg		1702	65680	1769	79071	pop.	0,28	Hinrichs / Reinders (1987: 664)
Schleusingen	Prussia	1631	4035	1649	1460	households	-5.49	Behre (1905: 69)

Schleusingen	Prussia	1649	1460	1659	2444	households	5.29	Behre (1905: 69)
Magdeburg	Prussia	1688	75132	1713	140886	pop.	2.55	Behre (1905: 198)
Magdeburg	Prussia	1713	140886	1740	186226	pop.	1.04	Behre (1905: 198)
Halberstadt-Hohnstein	Prussia	1688	38472	1713	64859	pop.	2.11	Behre (1905: 198)
Halberstadt-Hohnstein	Prussia	1713	64859	1740	83663	pop.	0.95	Behre (1905: 198)
Neumark	Prussia	1688	68973	1713	114639	pop.	2.05	Behre (1905: 198)
Neumark	Prussia	1713	114639	1740	160473	pop.	1.25	Behre (1905: 198)
Bamberg villages		1558	347	1623	521	taxpayers	0.63	Morlinghaus (1940: 75)
Bamberg villages		1623	1746	1653	850	taxpayers	-2.37	Morlinghaus (1940: 75)
Bamberg villages		1653	850	1672	1172	taxpayers	1.71	Morlinghaus (1940: 75)
Bamberg villages		1672	1172	1731	2066	taxpayers	0.97	Morlinghaus (1940: 75)
Bamberg villages		1731	2066	1750	2360	taxpayers	0.70	Morlinghaus (1940: 75)
Ahrgau	Bm. Köln	1665	3100	1684	2650	comm.	-0.82	own research (Schlöder)
Ahrgau	Bm. Köln	1684	2110	1715	2312	comm.	0.30	own research (Schlöder)
Ahrgau	Bm. Köln	1715	4961	1732	4410	comm.	-0.69	own research (Schlöder)
Ahrgau	Bm. Köln	1732	18041	1743	20694	comm.	1.26	own research (Schlöder)
Dekanat Piesport	Bm. Trier	1606	7527	1669	7304	comm.	-0.05	own research (Schlöder)
Dekanat Piesport	Bm. Trier	1669	10183	1684	10541	comm.	0.23	own research (Schlöder)
Dekanat Piesport	Bm. Trier	1684	9645	1715	12219	comm.	0.77	own research (Schlöder)
Dekanat Piesport	Bm. Trier	1715	10202	1773	16430	comm.	0.82	own research (Schlöder)

Appendix 3: Parishes

The following table and map list the parishes for which we have so far obtained series of births and deaths. No details on gaps are given. The table is sorted according to Bundesland.

Abbreviations of Bundesland and region: Bavaria-S: historical region of eastern Swabia; BW: Baden-Wurttemberg; Wurtt: historical Wurttemberg; NRW-R: North Rhine-Westphalia, lower Rhine; NRW-W: North Rhine-Westphalia, Westphalia; L'Saxony, Lower Saxony; Rhinel-Palatinate: Rhineland-Palatinate; Sch-Holstein: Schleswig-Holstein.

Abbreviations of sources: OFB: Ortsfamilienbuch or Ortssippenbuch with summary statistics of life events (main author: Burkhart Oertel); Spree: data collection kindly made available by Reinhard Spree to Georg Fertig in the late 1980s.

Table 11: Parish Series of Births and Deaths

Locality	Bundesland, region	used … From	to	Source
Lenggries	Bavaria	1740	1805	Spree
Löpsingen	Bavaria-S	1588	1705	OFB
Memmingen	Bavaria-S	1740	1805	Spree
Möttingen	Bavaria-S	1592	1850	OFB
Rudow	Berlin	1740	1805	Spree
Radolfzell am Bodensee	BW-Baden	1623	1799	Kessler (1992)
Broggingen	BW-Baden	1653	1850	Spree; OFB
Altensteig	BW-Wurtt	1701	1850	Spree
Altensteigdorf	BW-Wurtt	1632	1850	Spree; OFB
Assamstadt	BW-Wurtt	1670	1850	Spree; OFB
Beihingen	BW-Wurtt	1808	1880	OFB
Berneck	BW-Wurtt	1687	1850	Spree; OFB
Bondorf	BW-Wurtt	1624	1850	Spree; OFB
Bösingen	BW-Wurtt	1808	1880	OFB
Ebhausen	BW-Wurtt	1612	1850	OFB
Egenhausen	BW-Wurtt	1611	1850	OFB
Emmingen	BW-Wurtt	1636	1880	OFB
Gaildorf	BW-Wurtt	1613	1850	Spree; OFB
Hochdorf	BW-Wurtt	1644	1880	OFB
Iselshausen	BW-Wurtt	1631	1850	OFB
Mötzingen	BW-Wurtt	1618	1850	Spree; OFB
Münster/Unterrot	BW-Wurtt	1694	1850	Spree; OFB
Nagold	BW-Wurtt	1630	1850	OFB
Nebringen	BW-Wurtt	1651	1850	OFB
Oberschwandorf	BW-Wurtt	1654	1850	OFB
Ölbronn	BW-Wurtt	1695	1850	OFB
Pforzheim	BW-Wurtt	1750	1805	Spree
Schietingen	BW-Wurtt	1739	1850	OFB
Tailfingen	BW-Wurtt	1588	1850	Spree; OFB
Unterjettingen	BW-Wurtt	1653	1850	Spree; OFB
Walddorf	BW-Wurtt	1654	1850	OFB
Altona	Hamburg	1720	1850	Gehrmann (1994), accessed through GESIS

Albach	Hesse	1652	1800	Imhof (1975)
Allendorf	Hesse	1691	1825	Imhof (1975)
Gießen	Hesse	1701	1800	Imhof (1975)
Großen Linden	Hesse	1701	1800	Imhof (1975)
Hanau	Hesse	1701	1766	Spree
Heuchelheim	Hesse	1658	1800	Imhof (1975)
Klein-Linden	Hesse	1701	1800	Imhof (1975)
Lang-Göns	Hesse	1684	1800	Imhof (1975)
Leihgestern	Hesse	1639	1800	Imhof (1975)
Wieseck	Hesse	1718	1800	Imhof (1975)
Duisburg	NRW-R	1713	1814	Jägers (2001) accessed through GESIS
Langenfeld-Richrath	NRW-R	1739	1809	OFB
Lülsdorf	NRW-R	1729	1809	OFB
Mondorf	NRW-R	1664	1809	OFB
Ahsen	NRW-W	1750	1850	Krüger (1977)
Alme	NRW-W	1766	1850	own study
Altschermbeck	NRW-W	1815	1850	Krüger (1977)
Beelen	NRW-W	1750	1850	own study
Borken	NRW-W	1750	1850	own study
Bottrop	NRW-W	1779	1850	Krüger (1977)
Brackel	NRW-W	1750	1850	own study
Buer	NRW-W	1780	1850	Krüger (1977)
Büren	NRW-W	1750	1850	own study
Calle	NRW-W	1750	1850	own study
Datteln	NRW-W	1681	1850	Krüger (1977)
Diestedde	NRW-W	1750	1850	own study
Dorsten mit Umland	NRW-W	1753	1850	Krüger (1977)
Ende	NRW-W	1750	1850	own study
Ergste	NRW-W	1750	1850	own study
Erle	NRW-W	1815	1850	Krüger (1977)
Feudingen	NRW-W	1750	1850	own study
Flaesheim	NRW-W	1784	1850	Krüger (1977)
Gladbeck	NRW-W	1793	1850	Krüger (1977)
Hagen	NRW-W	1817	1840	Hohorst (1977), accessed through gesis
Hamm-Bossendorf	NRW-W	1653	1850	Krüger (1977)
Henrichenburg	NRW-W	1730	1850	Krüger (1977)
Herbede	NRW-W	1750	1850	own study
Herdecke	NRW-W	1818	1840	Hohorst (1977), accessed through gesis
Herringen	NRW-W	1750	1850	own study
Herscheid	NRW-W	1750	1850	own study
Herstelle	NRW-W	1750	1850	own study
Herten	NRW-W	1709	1850	Krüger (1977)
Hervest	NRW-W	1815	1850	Krüger (1977)
Hirschberg	NRW-W	1750	1850	own study
Hohenwepel	NRW-W	1788	1850	own study
Holsterhausen	NRW-W	1815	1850	Krüger (1977)
Holtwick	NRW-W	1750	1850	own study
Horneburg	NRW-W	1650	1850	Krüger (1977)
Horst	NRW-W	1666	1850	Krüger (1977)

Isselhorst	NRW-W	1750	1850	own study
Kirchhellen	NRW-W	1779	1850	Krüger (1977)
Langenberg	NRW-W	1750	1850	own study
Lembeck	NRW-W	1815	1850	Krüger (1977)
Löhne	NRW-W	1750	1850	own study
Lotte	NRW-W	1750	1850	own study
Marl	NRW-W	1673	1850	Krüger (1977)
Mellrich	NRW-W	1750	1850	own study
Nordwalde	NRW-W	1750	1850	own study
Oberfischbach	NRW-W	1750	1850	own study
Oberhudem	NRW-W	1750	1850	own study
Oberkirchen	NRW-W	1750	1850	own study
Oer	NRW-W	1689	1850	Krüger (1977)
Osterfeld	NRW-W	1712	1850	Krüger (1977)
Ostinghausen	NRW-W	1750	1850	own study
Ottenstein	NRW-W	1750	1850	own study
Polsum	NRW-W	1721	1850	Krüger (1977)
Pr. Oldendorf	NRW-W	1750	1850	own study
Recklinghausen mit Umland	NRW-W	1747	1850	Krüger (1977)
Rhade	NRW-W	1815	1850	Krüger (1977)
Roxel	NRW-W	1750	1850	own study
Schlüsselburg	NRW-W	1750	1850	own study
Schwelm	NRW-W	1817	1840	Hohorst (1977), accessed through gesis
Selm	NRW-W	1750	1850	own study
Spenge	NRW-W	1768	1850	Spree
Suderwich	NRW-W	1692	1850	Krüger (1977)
Velen	NRW-W	1750	1850	own study
Waltrop	NRW-W	1735	1850	Krüger (1977)
Werther (Stadt)	NRW-W	1750	1850	own study
Westerholt	NRW-W	1775	1850	Krüger (1977)
Wulfen	NRW-W	1815	1850	Krüger (1977)
Abbehausen	L'Saxony	1672	1850	Norden (1984)
Atens	L'Saxony	1656	1850	Norden (1984)
Blexen	L'Saxony	1608	1850	Norden (1984)
Bockhorn	L'Saxony	1700	1850	Spree (Lorenzen-Schmidt 1987)
Burhave	L'Saxony	1661	1850	Norden (1984)
Dedesdorf	L'Saxony	1700	1850	Spree (Lorenzen-Schmidt 1987)
Eckwarden	L'Saxony	1582	1850	Norden (1984)
Großenmeer	L'Saxony	1669	1850	Spree (Lorenzen-Schmidt 1987)
Krautsand	L'Saxony	1715	1850	OFB
Langwarden	L'Saxony	1696	1850	Norden (1984)
Misselwarden	L'Saxony	1704	1850	OFB
Neuenwalde	L'Saxony	1681	1850	OFB
Stollhamm	L'Saxony	1610	1850	Norden (1984)
Tossens	L'Saxony	1683	1850	Norden (1984)
Waddens	L'Saxony	1724	1850	Norden (1984)
Wichmannsburg	L'Saxony	1669	1850	Behnke and Porth (2009)
Bretzenheim	Rhinel-Palatinate	1681	1792	Rettinger (2002)
Budenheim	Rhinel-	1679	1850	Rettinger (2002)

	Palatinate			
Diefenbach	Rhinel-Palatinate	1650	1850	OFB
Essensheim	Rhinel-Palatinate	1624	1799	Rettinger (2002)
Finthen	Rhinel-Palatinate	1746	1799	Rettinger (2002)
Fischbach-Weierbach	Rhinel-Palatinate	1757	1798	OFB
Gonsenheim	Rhinel-Palatinate	1686	1797	Rettinger (2002)
Kastel	Rhinel-Palatinate	1765	1818	OFB
Kirchenbollenbach	Rhinel-Palatinate	1756	1791	OFB
Kirn	Rhinel-Palatinate	1759	1850	OFB
Koblenz	Rhinel-Palatinate	1720	1797	François (1982)
Marienborn	Rhinel-Palatinate	1698	1799	Rettinger (2002)
Mombach	Rhinel-Palatinate	1651	1797	Rettinger (2002)
Nieder-Olm	Rhinel-Palatinate	1664	1850	Rettinger (2002)
Ober-Olm	Rhinel-Palatinate	1655	1850	Rettinger (2002)
Offenbach (Glan)	Rhinel-Palatinate	1748	1798	OFB
Oppenheim	Rhinel-Palatinate	1581	1798	Zschunke (1984)
Sien	Rhinel-Palatinate	1757	1798	OFB
Worms	Rhinel-Palatinate	1750	1797	Rommel (1996)
Zornheim	Rhinel-Palatinate	1705	1797	Rettinger (2002)
Zwickau	Saxony	1740	1837	Spree
Hohenfelde	Sch-Holstein	1647	1850	Spree (Lorenzen-Schmidt 1987)
Leezen	Sch-Holstein	1740	1850	Spree (Gehrmann 1984)
Marne	Sch-Holstein	1667	1850	Spree (Lorenzen-Schmidt 1987)
Neuenbrook	Sch-Holstein	1692	1850	Spree (Lorenzen-Schmidt 1987)

Map 1: Location of Parishes with Series of Births and Deaths

Source: Table 11; Kartography: Johannes Bracht.