Economic growth in Germany, 1500–1850

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Introduction

This study aims to contribute to a growing literature on retrospective national income estimates for periods before the onset of modern national accounting around the middle of the nineteenth century. It does so by producing a GDP estimate based on an assessment of food consumption and the size of employment in the non-agricultural sectors, as has been done for the economies of southern Europe (Federico and Malanima 2004; Malanima 2006; Álvarez-Nogal and Prados de la Escosura 2007). In the German case, such an exercise has the potential to produce new insights in at least two fields of study: First, the size of national income in Germany and its pace of growth during the middle decades of the nineteenth century are still surrounded by great uncertainty given that the available information is highly inconsistent (Fremdling 1988, 1995; Burhop and Wolff 2005). Reaching firmer ground here can improve our knowledge about the timing of Germany's transition to modern economic growth and help us to assess whether this transition occurred as a sudden take-off or rather gradually, as the Crafts-Harley view of the British Industrial Revolution suggests (Crafts 1985; Harley 1999).

Second, a national income estimate for Germany during the pre-industrial period is instructive with respect to patterns of convergence and divergence in early modern Europe. A comparative analysis of real wages during the early modern period suggests a maintenance or slight improvement of material welfare in the north-western part of the continent and a decline in the rest (Allen 2001). However, it may well be that declining real wages were at least partially offset by an increasing work effort (van Zanden 2001; de Vries 2008) and by income from other sources than labour. Looking at welfare from an aggregate perspective, therefore, has the potential to refine our knowledge of development trajectories in different parts of the European continent.

The present paper is part of a continuing research effort to shed more light on aggregate economic development in Germany during the centuries up to the onset of industrialization. Partly it relies on material that has reached working paper status; this holds for prices and wages (Pfister 2010) and information on population (Pfister and Fertig 2010). Partly it also draws on work that hopefully will be completed in the course of the current year. This holds in particular for urban population (Pfister and Scholten 2011) and for the trajectory of labour demand (Pfister et al. 2011). I also expect that first results from a study on grain market integration (Uebele et al. 2011) and on the long-term evolution of the land rent will come forward within the coming months. The results reported here are thus provisional, but it can be expected that they reach a more mature state very soon. Relative to earlier versions, particularly my contribution to the XVth World Economic History Congress in Utrecht 2009, the present paper contains the following major additions: First, it draws on a broader base of price and wage data (Pfister 2010) and slightly revised estimates of population size (Pfister and Fertig 2010) and urban population; second, reference to an estimate of labour demand (Pfister et al. 2011) allows a consistency test of the suggested growth trajectory from 1700; and, lastly, more material is available to support interpretation of the major watersheds of Germany's growth trajectory around 1700 and 1820.

The paper is organized as follows: It starts with a brief outline of the approach followed and then describes the data that have been used for its implementation. Two separate sections present the results and their interpretation, respectively. The conclusion concludes.

The approach

The approach used in this study to estimate GDP for the pre-statistical era is based on a method for the estimation of food consumption as developed by Wrigley (1985) and Allen (1999: 212–214; 2000: 13–4). The rest follows Federico and Malanima (2004: 438–9) and Álvarez-Nogal and Prados de la Escosura (2007: 351): The share of agriculture in national production at the starting point of a modern national account series is used to link food consumption with total output. By assuming a constant ratio between the share of agriculture in total production and the share of agricultural employment in the total labour-force, information on the latter is then used to perform a backward projection of GDP.

Net agricultural output can be represented as follows:

$$Q_{At} = r_t\ c_t\ N_t \tag{1}$$

where Q_{At} is agricultural output, N_t total population, c_t real food consumption per capita and r_t the ratio of food consumption to food production, all in year *t*. r_t is thus an indicator of the balance of external trade in agricultural products.

Wrigley assumed constant per capita food consumption over time; Allen proposed to estimate real per capita food consumption through a demand equation:

$$c_t = a\ P_t^e\ I_t^g\ M_t^b \tag{2}$$

where *a* is a scaling factor, P_t the real price of agricultural goods, I_t the real income per head and M_t the real price of consumer goods apart from food, all at the time point *t*. *e*, *g* and *b* are then the own price, income and cross-price elasticities of food demand. Allen (2000) uses the values of e=-0.6, g=0.5 and b=0.1, whereas Federico and Malanima (2004: 443–4) and Álvarez-Nogal and Prados de la Escosura (2007: 343) prefer the slightly lower values of e=-0.5, g=0.4 and b=0.1. At the same time, the former authors demonstrate that results are not very sensitive to changes in these values. Álvarez-Nogal and Prados de la Escosura produce estimates based both on the Wrigley (constant food consumption per capita) and Allen (explicit food demand estimation) approach. Since there is some evidence that food rations in hospitals reacted to changes in real prices (e. g. for fish, Krug-Richter 1994: 184) I prefer to base my estimates on the consumption estimation approach and to use the constant consumption approach solely for sensitivity tests.

Real food consumption per head c_t and, by implication, agricultural output Q_{At} refer to the total nutritional value of food. This concept includes both subsistence and market production of agricultural goods destined for human consumption. It does not, however, take into account processes of substitution between goods of similar nutritional value but differing cultural utility, such as the substitution of wheat bread by potatoes or meat by alcoholic beverages and grains. Subsequently, estimated real food production is equated with total net agricultural output, which assumes that the share of agricultural production of non-foods for industrial purposes remains constant over time. This may not be true in that the growth of regional proto-industries, particularly of linen production, implied an expansion of the cultivation of industrial crops such as flax. However, even in regions specializing in linen production the share of the arable devoted to flax cultivation rarely exceeded five percent, so that the error introduced by this assumption is small (Achilles 1975: 110–1; Sczesny 2002: 86). The approach followed also considers the use of products from the non-agricultural sectors in agriculture (basically agricultural tools) to be negligible.

Equations (1) and (2) can be used to estimate agricultural output Q_{At} for the time points t_1 … t_i … t_s, t_s being the first year for which national account information is available. Let Q_A/Q be the share of agriculture in national product and L_A/L the share of agricultural employment in the total labour-force. Both are known for the year t_s. In order for Q_{At} to represent agricultural output at constant prices in year t the scaling factor a in equation (2) needs to be defined on the basis of agricultural output in year s:

$$a = Q_{As} / (r_s N_s P_s^e I_s^g M_s^b) \quad (3)$$

On the basis of this output series for the agricultural sector and the share of the agricultural sector in total employment national product can be projected backward under the assumption that the ratio between the shares of agriculture in national product and employment, respectively, remains constant over time. This ratio p can be determined in year s:

$$p = (Q_{As} / Q_s) / (L_{As} / L_s) \quad (4)$$

Multiplying p with the share of agricultural labour in total employment at year t yields an estimate of the share of agriculture in total output. National product in earlier years is then given as:

$$Q_t = Q_{At} / (p\, L_{At} / L_t) \quad (5)$$

Using the constant p to determine the share of agriculture in total production on the basis of the employment structure implies a constant productivity differential between the non-agricultural and agricultural sectors. I shall relax this assumption in a sensitivity test that introduces a rough guestimate concerning the trajectory of p_t over time.

Data

This section describes the sources used for implementing the approach described in the previous section. Each variable is discussed in the order of appearance in equations (1) to (5). Geographical coverage of population and employment structure refers to the territory of 1871 except Alsace-Lorraine. Price and wage information is from ten and sixteen towns, respectively, most of which lie within the present-day boundaries of Germany. Exceptions are Gdansk and Strasbourg; the former is included until the end of the data series in 1812/4, the latter until French occupation in 1681. Backward projection of GDP per capita starts from existing reconstructions of national accounts that begin in 1851 and cover the territory of 1871 with Alsace-Lorraine included. No attempt has been made to adjust the GDP per capita estimate for 1851 to the reduced territory without Alsace-Lorraine; given the uncertainty surrounding the true level of economic activity in the middle of the nineteenth century (see below) such an attempt must be considered futile.

Ratio of food consumption to food production (r). Following Allen (2000: 14) the ratio of food consumption to food production, or the extent of international trade, is set to 1, which is equivalent to saying that were was no cross-border trade in food of any consequence. Only the hinterland of the Baltic exported significant quantities of grain between the late sixteenth and early nineteenth centuries, but the share of exports to production was too low to affect the output growth estimate.[1] Another much smaller export region emerged in

1 Van Tielhof (2002: 337) provides grain export figures the passed the Danish Sound. I assumed that two thirds were coming from German territories, that exports in 1500 were two thirds the level of 1600 and exports in 1850 were identical to the level

Southern Swabia from the later seventeenth century (Göttmann 1991). Only in the course of the American grain invasion from the late 1860s did grain imports assume a significant portion of national consumption (cf. Hoffmann 1965: 540).

Population (N). I use a series compiled from several earlier studies (Pfister and Fertig 2010: 5; cf. Table 1, line 2 below). It must be stressed that the figures for 1650 and 1700 rest on extremely little empirical information and should be considered as highly tentative.

Prices and wages (I, P, M). The estimate of per capita food consumption is based on price and wage information from ten and sixteen towns, respectively, compiled by Pfister (2010). Price index construction largely follows Allen (2001): The silver prices of eleven items covering food, manufactures and energy were aggregated into a basket with fixed quantities representing presumed mean annual consumption by an adult person. Real prices of foods (*P*) and non-foods (*M*) were derived simply by dividing their respective annual cost (prices multiplied with the weights accorded to each item in the consumer basket) in grams of silver by the total cost of the consumer basket. The resulting values for the key years used in the subsequent analysis are reported in Appendix 1.

Following Allen (2000) real income *I* in equation 2 is proxied with the real day wage of unskilled labourers in the building sector.[2] This is problematic in the sense that the labour input in terms of days worked per year may have changed over time and that the income from sources other than labour may have followed a different course than wages (Allen 1999: 214; Álvarez-Nogal and Prados de la Escosura 2007: 345). Hence, sensitivity tests will have to assess the imprecision that follows from proxying real income with wages.

The constant composition of the consumer basket neglects the possibility of changes in consumption patterns, particularly the partial replacement of expensive items by cheaper substitutes. The use of a consumer basket with fixed quantities of individual items, therefore, may overstate the decline of the real wage during the first three centuries of the modern era. Given the absence of reliable budget data before the early decades of the nineteenth century, statements on long-term changes in consumption patters must remain rather speculative, however. Two highly probable dietary changes can nevertheless be considered at least schematically. The first refers to the partial substitution of meat by grains during the sixteenth century, the second to the replacement of grains by potatoes and tropical groceries, notably sugar and its domestic substitutes, from the late eighteenth century. Rough estimates suggest that these processes of substitution may have reduced con-

achieved in the 1790s (van Tielhof 2002: 7, 63). Following Saalfeld (1975: 242) per capita grain consumption in Germany was put at 205 kg in 1800. Assuming a density of 0.75 and a share of vegetable food of 0.75 in total food consumption (cf. Allen 2001: 421) this implies a food consumption of 333 l grain equivalents. Using the baseline index of per capita food consumption given in Table 3 and the population figures in Table 1 total food consumption in grain equivalents was derived for selected years. Implied r then amounts to 1.009 in 1500, 1.022 in 1600, 1.036 in 1650, 1.016 in 1700, 1.010 in 1750, 1.025 in 1800 and 1.015 in 1850. Using these values instead of 1 leaves the growth rates of national product reported in Table 4 unaffected. Average labour productivity in agriculture (Table 3) is estimated to have been higher by a bit more than one percent in 1800 and 1650; the difference is less than 1 percent for the remaining years.

2 Pfister (2010) develops two real wage indices. Since output projections are largely insensitive to the type of index used, only the results obtained with silver wages deflated by the national CPI are presented below.

sumer prices by some 8 per cent between 1500 and 1600, and by another 6 per cent between 1800 and 1850 (Pfister 2010: 7–9). Therefore, sensitivity tests will increase the real wage levels in 1500 and 1850 by 8 and 6 per cent, respectively.

The share of agriculture in the total labour-force (L_A / L). Following earlier studies this share is calculated as

$$L_A / L = 1 - (\text{urban population} + \text{rural non-agricultural population}) / N \quad (6)$$

Lines 1 and 3 of Table 1 provide figures of urban population and the urbanization rate, respectively. They are based on a nearly completed revision and expansion of the dataset originally compiled by Bairoch et al. (1988) covering settlements with 5,000 and more inhabitants. I follow Wrigley (1985) and Allen (2000) in assuming that agricultural activities were marginal side-activities in towns with 5000 and more inhabitants. This is somewhat problematic (cf. Pfister and Scholten 2011 for a discussion) and implies an over-estimation of non-agricultural employment. As we shall see below, however, this is counterbalanced by an underestimation of proto-industrial activities in the countryside.

Table 1: Urban population, urbanization rate and the share of the agricultural population

	1500	1600	1650	1700	1750	1800	1850
1 Urban population, 1000s	803	1147	725	954	1507	2439	4817
2 Population, million	8.7	15.4	9.5	13.4	17.4	21.6	33.8
3 Urbanization rate	0.092	0.075	0.076	0.071	0.087	0.113	0.143
4 Share of rural non-agricultural population	0.150	0.135	0.148	0.171	0.209	0.280	0.384
5 L_A / L	0.772	0.800	0.787	0.770	0.722	0.638	0.556

Sources and definitions: Line 1: total population in settlements with at least 5,000 inhabitants; Pfister and Scholten (2011). Line 2: Pfister and Fertig (2010: 5, column 1); figures up to 1700 were deflated using the approximate share of Alsace-Lorraine in total population of 1815/6 (5.16 per cent; cf. Pfister and Fertig 2010: 6, footnote 1). Line 4: Values in 1500 and 1600 represent arbitrary decisions; see text. Values after 1600 are generated on the basis of Table 2, column 4. Up to 1750 these values were modified to correct for omissions using an exponential adjustment factor; see text. Values for 1650, 1700, 1800 and 1850 were generated from neighbouring values using linear interpolation. Line 5: Share of agricultural employment: 1850 from Hoffmann (1965: 204); other years: sum of lines 2 and 4, line 4 deflated by urbanization rate.

The main source for the assessment of the size of the rural non-agricultural population is Weiss (1993: 104–9) who has analyzed a large body of household listings and church records for Saxony. The first two columns in Table 2 refer to shares of the population with information on occupation in Weiss's database, that is, mostly adult males. "Rural crafts" designate handicraft activities oriented to a local clientele; "outside agriculture" additionally includes the service sector and proto-industry. The third column relates the number of craftsmen to the total rural population.

The ratio of the number of craftsmen to total population is not the information required for the present purpose, but we know it for a number of German regions during the eighteenth century and around 1800 (Schultz 1981: 36–7). We can use this information to calibrate the Saxon series to the national level. Several regions recorded a craftsmen-population ratio that are ca. 0–10 percent inferior to the contemporaneous Saxon values. The thinly populated eastern provinces of Prussia showed much lower values, while the densely populated south-western parts were characterized somewhat higher levels. For Germany as a whole, and apparently not distinguishing between rural and urban regions, Kaufhold (1978: 37–9) places the ratio of master artisans to the total population at 36.4 per thousand around 1800, the corresponding figure for all artisans (which include dependents, many of whom living in the households of masters) at 55.9 per thousand.[3] This compares with 38 for 1780 in the Weiss data. It seems reasonable on this background, therefore, to deflate the series for the craftsmen-population ratio (and hence, the share of craftsmen in the labour-force) in Saxony by 5 percent to estimate the corresponding figure for Germany as a whole.

Table 2: Non-agricultural rural population in Saxony and Germany

	(1) Saxony rural craftsmen, per cent of work-force	(2) Saxony non-agricultural total, per cent of work-force	(3) Saxony rural craftsmen, per 1000 population	(4) Germany, share of rural non-agricultural total in work-force
1565	2	5	5	0.030
1595	4	9	9	0.056
1630	6	12	13	0.079
1660	9	21	23	0.129
1690	10	24	21	0.145
1720	12	29	24	0.175
1750	14	34	28	0.205
1780	19	37	38	0.245
1810	24	44	47	0.300
1840	27	56	48	0.361
1870	33	67	55	0.436

Source for columns 1 to 3: Weiss (1993: 104, 108); explanations for column 4 see text.

In Weiss's data the share of craftsmen in the labour-force (column 1) is five times higher than the craftsmen-population population ratio and this figure rises continuously from 4 in 1565 to 6 in 1870; between 1690 and 1810 the values are very close to the mean. A ratio of 5 is consistent with a low labour-force participation rate of 0.4 and a restriction of crafts to males (cf. also Meier 1986: 39–40). To the extent that rural crafts were predominantly performed by males past their youth and having acceded to the status of household heads this is quite plausible. The rising trend in the ratio of column 1 to column 3 presents a puzzle, however, since it implies a decline of the labour market participation rate. A possible reason may be that the development of export industries in textile and metal processing shifted the economically active population from officially recorded occupations such as farmers and master artisans to under-recorded proto-industrial activities in the framework of a domestic system. Since proto-industrial development will be taken into account separately I prefer to stick with the share of rural crafts in the labour-force as re-

3 Kaufhold's information, however, is largely based on territories with low urbanization rates.

corded in column 1 deflated by 5 percent as a provisional estimate of the share of artisans in the rural labour-force in Germany as a whole.

The development of export-oriented regional proto-industries during the early modern period added a significant segment to the occupational structure of many rural areas (see Kaufhold 1986 for an overview). In Weiss's data for Saxony, the share of non-agricultural activities in the recorded labour-force amounts to 2.2 times the share of rural craftsmen with little temporal fluctuations around this value (column 2 over column 1). This may reflect either the fact that Saxony had an important proto-industrial sector already by the late Middle Ages or the deficiency of the sources used with respect to recording activities performed within a domestic system of production. In fact, the first detailed national statistics on economic activities in 1882, that is, at the time when the factory system had already made significant inroads into industrial production, still show that the share of dependents was higher in industry than in agriculture (59.4 vs. 56.2 per cent; Hohorst et al. 1978: 66). Relying mainly on information on household heads may thus lead to a downward bias with respect to the non-agricultural, essentially proto-industrial population. Many activities in domestic industries, particularly those carried out by children and adolescents, were poorly remunerated, however, which suggests a low contribution to output. This justifies the reliance on the occupation of household heads in the present context. Note also that the downward bias with respect to the assessment of proto-industrial activities in rural areas is probably at least in part offset by the overestimation of non-agricultural employment in towns (see above).

The difference between columns 2 and 1 in Table 2 suggests that about 20 per cent of household heads were active in proto-industry in Saxony in 1750. This comes quite close to a rate of 22 per cent recorded for the worsted manufacture area of the western Black Forest in 1736 (Ogilvie 2003: 18, 31). The difference between the first two columns of Table 2 may thus be held as representative of the trajectory of the labour share of proto-industry in export oriented manufacturing regions. By the early nineteenth century, Germany included several such regions in addition to Saxony and parts of Württemberg, among them Silesia, parts of the Rhineland and Westphalia, the Upper Palatinate and Eastern Swabia (Kaufhold 1986). In c. 1815/6, all these regions made up between a third and forty percent of the German population (Ch. Pfister 1994: 19–23). As a rough guideline, then, the national mean for the non-agricultural population apart from crafts can be assessed at 36 percent of the share recorded for Saxony.

Summing 0.95 times the share of rural crafts and 0.36 times the share of the remaining non-agricultural population in the Weiss series yields an extrapolation of the national share of the rural non-agricultural population (column 4 in Table 2). Combined with the urbanization rate the share of the total non-agricultural population in 1800 amounted to 36.2 per cent. This lies between the shares of the non-agricultural population suggested by Henning (1971: 115; 38 per cent) and Dipper (1991: 98; 37.5 per cent) on the one hand and Kaufhold on the other (1983: 24, 31: 33 per cent). For 1850 this method yields a somewhat higher value than the one given by Hoffmann (1965: 204; 44.4 per cent in 1849/52), namely, 47.2 percent. This may reflect particularly rapid structural change in Saxony, which emerged as an industrial leader during the course of the first half of the nineteenth century. In Prussia, contemporary statistics place the share of the non-agricultural population at 32.0 percent in 1815 and 41.7 in 1849 (Tilly 1978: 441; missing data estimated using exponential interpolation). Since other German states experienced even slower industrial development I prefer to use the Hoffmann figure for 1850.

To develop a plausible figure for the share of the rural non-agricultural population in 1500 is more difficult. Allen (2000: 6–8) and Álvarez-Nogal and Prados de la Escosura (2007: 336) follow Wrigley's (1985: 697, 718) assumption that about 20 percent of the rural labour-force in England and France was employed outside agriculture at this time. This contrasts with a share of 10 percent suggested for fifteenth-century Tuscany by Federico and Malanima (2004: 449). Available evidence also suggests a relatively low share for Germany. Schultz (1981: 36–7) reports ratios of rural craftsmen to population below thirty per thousand for several regions during the late eighteenth century. If multiplied with a household size of about 5, such values are consistent with a share of rural crafts in the labour-force of some 15 percent at best. Weiss's data in Table 2 seem to suggest that non-agricultural activities were virtually non-existent in 1500 (cf. Weiss 1993: 105). This is certainly an exaggeration to the downward side. On the background of what is known on the eighteenth century I consider a share in the 10–15 percent range in 1500 as most likely. Below I shall use a share of 15 percent. Sensitivity tests show that alternative assumptions, particularly placing the share of the rural non-agricultural population at 20 per cent, have little effects on results.

To arrive at a reasonable series for the seventeenth and eighteenth centuries one has to decide on how the share of the non-agricultural rural labour-force evolved during the sixteenth century. Given the strong fall of the real wage (Appendix 1), which suggests a steep decline of the marginal product of labour, and in rough analogy to the reduction of the urbanization rate I opted for a value of -10 per cent. The difference between the resulting ratio (13.5 per cent in the case of the assumption of a value of 15 percent in 1500) and 6.3 per cent, the ratio derived from the Weiss data, is then used to calculate an exponential adjustment factor back from 1780 (assuming that in 1780 there were no omissions). Figures for key years between the time points chosen by Weiss are calculated using linear interpolation. The result is displayed in line 4 of Table 1. Finally, for key years up to 1800 the share of agriculture in the total labour-force (L_A / L) is derived by adding the urbanization rate and the share of the non-agricultural population in the countryside, the latter being deflated by the urbanization rate (line 5 of Table 1).

Year s and parameters a and p. Hoffmann's (1965) reconstruction of national accounts starts in 1851, and the data for the calculation of the parameters needed to calibrate the index of per capita food consumption and the share of agriculture in total employment to an output series (equations 3 and 4) are means over several years beginning in the late 1840s. Q_{As}, required to calculate the food consumption calibrator *a*, was defined by multiplying total output Q_s (see below) with the share of agriculture in output in 1850/54, namely, 0.452. As already mentioned the share of the agricultural labour-force in total employment at the time point where backward projection starts (L_{As}/L_s=0.556) refers to the years 1849/52 (Hoffmann 1965: 33, 35). The resulting value for *p*, the productivity differential between agriculture and the rest of the economy, is 0.813. Alternative values were calculated based on data stretching further into the second half of the nineteenth century. The mean value for the period 1850–1869 (but based on employment shares of agriculture in 1849/58 and 1861/71) is p=0.839, and for the late 1870s I obtain p=0.747. This increase of the labour productivity differential can be expected in the context of the rise of a modern industrial sector. The counterintuitive finding that the productivity gap was higher in the early 1850s than during the 1850s and 1860s as whole may be due to bad harvests in the first period, which depressed labour productivity in agriculture. As long as *p* is set constant the choice of the exact value is irrelevant for growth estimates; however, the different values reported here for the 1850s to 1870s will serve as a background to construct a rough sensitivity test below.

The level of economic activity around 1850 (Q_s). The definition of an explicit value of Q_s for 1850 is important if one wishes to compare the results of this study with the later growth trajectory of Germany or to put them in an international context. Maddison (2006) places German GDP per capita (Q_s/N) in 1851 at 1408 international Geary-Khamis dollars of 1990. Maddison's figure is essentially derived from Hoffmann's (1965) original output series. Burhop and Wolff (2005) propose an improved output series; if this is scaled to the Maddison series in 1913, the resulting value for 1851 is 4.8 per cent higher, which suggests a fairly good consistency between the two series.[4] Burhop and Wolff (2005: 633–5) also demonstrate that even their corrected output, expenditure and income[5] series diverge enormously as one moves back in time from the late 1870s. Whereas the discrepancy between the three series amounts to about 7 per cent in 1880, the expenditure series is 14.4 per cent below the output series in 1851, whereas the income approach based on tax returns yields a value 29.3 per cent in excess of the output estimate (1908$). Burhop and Wolff believe that the income approach based on tax returns represents the series with broadest information base as far as levels are concerned and therefore weigh it heavily in their construction of a compromise estimate. For 1851 its per capita value is equivalent to 1601$, that is, 13.7 per cent above the figure given by Maddison. Fremdling (1988: 340–4, 1995: 79–84), too, has argued that the true level of economic activity in the mid-nineteenth century must have been higher than suggested by Hoffmann's output series.

Two additional reasons suggest that the level of economic activity in 1850 was actually closer to the value indicated by income series based on tax returns than to the one suggested by the output and expenditure approaches. First, an estimate of labour demand for the period 1690–1870 based on real wage and population figures suggests an aggregate growth rate of the German economy during the 1850s and 1860s close to the one indicated by the income series based on tax returns (Pfister et al. 2011). The second argument makes use of the fact that under a Cobb-Douglas or similar production function the labour share in national income is given by the ratio between the marginal and the average products of labour. We can estimate the marginal product of labour in 1851 by deflating the yearly nominal wage income (Gömmel 1979: 27) with the GDP deflator (Hoffmann 1965: 825–827; cf. Burhop and Wolff 2005: 626). In order to compare it with a national income figure,

4 To derive per capita figures, population size given by Hoffmann (1965: 172–4) is used from 1876, whereas data for 1851–1875 are from Kraus (1980: 338). For the earlier period, the two series show only minor deviations (in one year slightly more than 0.5 per cent, much less in most other cases).

5 I use only the revised income series based on tax returns originally compiled by Hoffmann and Müller (1959). The income estimate by Hoffmann (1965) is based on labour and capital incomes and omits income from land. This may explain the extremely low value of this series in 1851 (1120 US$ in per capita terms) and the implausibly high labour share in national income it implies for the years 1851–1860 (0.77; Hoffmann 1965: 507, using the revised IH estimate by Burhop and Wolff 2005 as denominator). Likewise I interpret the gradual disappearance of the gap between this and the other three series until the late 1890s as a reflection of the decline of the share of land in national income as the economy shifted from agriculture to industry.

I assume a labour-force participation ratio of 0.5.[6] Thus defined, the proportion of the marginal to the average product of labour around 1850 amounted to 0.54, 0.64 and 0.69, respectively, for the income (based on tax returns) series, the Burhop-Wolff compromise estimate and the output series. Taking the range of values applied for the English case as a benchmark, only the first figure is plausible.

All this consistently suggests that the income estimate based on tax returns correctly mirrors the true level of economic activity around the middle of the nineteenth century. The mean of the corrected output and income estimates for 1851, 1692 US$ in per capita terms, can serve as a lower bound and will be used in the rest of this study. This value is 5.7 per cent above the compromise estimate of Burhop and Wolff and 20.2 per cent higher than Maddison's figure.

Estimates of output in agriculture and real GDP

Table 3 displays indices of food consumption per capita, total agricultural output and mean labour productivity in agriculture using different assumptions. The baseline version presented in the first panel produces estimates of food consumption per capita that closely mirror the evolution of the real wage (cf. Appendix 1): Food rations may have fallen by about a quarter in the course of the sixteenth century. While recovering during the first part of the seventeenth century, per capita food intake remained about 15 per cent below the level prevailing at the beginning of the modern period until the mid-eighteenth century. Around 1800 this gap rose again to more than a quarter, probably as a consequence of the dislocation brought about by the Revolutionary and Napoleonic Wars (Planert 2007: 125–335). The early nineteenth century not only saw recovery from this negative shock but also further agricultural growth that led to rise of per capita food consumption to 10 per cent below the level recorded at the beginning of the sixteenth century. This development resulted not only from rising real wages but to a minor extent also from a structural energy crisis, which translated itself into a rising real price of non-foods from c. 1700 (cf. Appendix 1) and, through the cross-price elasticity b in equation (3), into a modest substitution of energy by foodstuffs.

Agricultural output per agricultural population as an indicator of average labour productivity in this sector experienced a strong swing downwards and upwards again during the first one-and-a-half centuries of the modern age according to the baseline estimate. This is in line with what one would expect on the background of the strong expansion and subsequent contraction of population in an economy with a largely stagnant technology in agriculture. During the following period up to 1800 mean labour productivity moved within a narrow span of 82 to 92 per cent of the level recorded in 1500. Since population more than doubled during these 150 years (cf. Table 1) the stability of mean output per worker is a considerable achievement, suggesting an outward shift of the production func-

6 Hoffmann (1965: 35) suggests a value of 0.43 for the 1860s and slightly higher values for the 1850s and 1870s. This figure probably underrates activities of family members in domestic industry. By contrast, projections of the dependency ratio by Pfister and Fertig (2010: 37) suggest a share of the age group 15–65 in total population of 0.6. My assumption of a constant participation rate of 0.5 thus constitutes a sort of compromise (cf. also Álvarez-Nogal and Prados de la Escosura (2007: 326–7).

tion, possibly brought about by gradual technical improvements and regional specialization. This result lends support to Kopsidis's (2006) intuition that agrarian progress was well under way well before sweeping agrarian reforms were enacted at the beginning of the nineteenth century. Finally, the first half of the nineteenth century saw an increase of mean labour productivity in agriculture to a level that exceeded the value in 1500 by about one quarter. This is in line with what one would expect on the background of the beginnings of agrarian modernization during this period.

Table 3: Per capita food consumption, agricultural output and labour productivity (indices 1500=1)

	1600	1650	1700	1750	1800	1850
1) Baseline estimate						
Food consumption per capita	0.73	0.84	0.82	0.86	0.71	0.90
Total agricultural output	1.29	0.92	1.26	1.72	1.77	3.49
Agricultural output per agricultural population	0.70	0.83	0.82	0.92	0.86	1.25
2) Shifts in consumption patterns						
Food consumption per capita	0.76	0.87	0.85	0.89	0.74	0.96
Total agricultural output	1.34	0.95	1.30	1.78	1.83	3.72
Agricultural output per agricultural population	0.73	0.86	0.85	0.95	0.89	1.33
3) Shifts in consumption patterns and increase of labour input per capita						
Labour input per capita	1.15	1.15	1.15	1.15	1.44	1.51
Food consumption per capita	0.81	0.94	0.91	0.95	0.89	1.18
Total agricultural output	1.44	1.02	1.40	1.91	2.20	4.58
Agricultural output per agricultural population	0.78	0.92	0.91	1.02	1.07	1.63
4) Constant food consumption per capita						
Total agricultural output	1.77	1.09	1.54	2.00	2.48	3.88
Agricultural output per agricultural population	0.96	0.98	1.00	1.07	1.21	1.39

Sources and notes: Appendix 1 and Table 1, lines 2 and 5. Data on real prices and wages refer to the years 1503/7, 1598/1602, 1648/52, 1698/1702, 1748/52, 1798/1802 and 1843/50.

The second and third panels of Table 3 explore the implications of a cheapening of consumption goods by processes of substitution and of the probable increase of the per capita labour input. Panel 2 rationalizes the fact that the partial substitution of meat by grains during the sixteenth century and the partial substitution of grains by potatoes and sugar during the early nineteenth centuries *ceteris paribus* reduced the price of consumer goods and thus increased food rations in terms of calorie intake.[7] The first line in panel 3 implements what is currently known of the so-called Industrious Revolution into a hypothetical trajectory of the annual labour input per capita. Information pertaining to Germany during the first half of the nineteenth century suggests either a stability of working hours such as in various artisanal trades and industries in Nürnberg or an increase of 10 to 15 percent in the cotton industry (Kirchhain 1973: 86, 88; Gömmel 1978: 190; cf. also Fischer et al. 1982: 140–2). Indirect evidence pertaining to female excess mortality (Klasen 1998)

7 In the present version I have not considered the impact of these dietary changes on the real prices of foods and non-foods (cf. equation 2).

and intra-marital conflict (Sabean 1990: chs. 4–6) points to an increase of labour intensity in agriculture during the decades around 1800. On this basis I assume that annual labour time per head increased 5 percent during the period 1800–1850. For the latter half of the eighteenth century I assume that the labour input grew at a pace comparable to English towns, namely, by about 25 per cent (Voth 2001: 1076). A similar development in Germany is plausible on three grounds: First, low-income contexts are usually characterized by a backward sloping labour supply schedule, and the real wage declined about 30 per cent between 1750 and 1800 (cf. Appendix 1). If we follow Voth (2000: 180) in assuming an elasticity of the labour input on the real wage of about -0.3, labour input must have increased about 10 per cent during the second half of the eighteenth century even with a stable labour supply schedule. Second, the widespread reduction of holidays in Catholic territories during this period led to an increase of the work year of up to about 30 to 50 days (Hersche 2006, vol. 1: 618–28). Third, the increasing availability of differentiated textiles and tropical groceries may have promoted an increase of the labour supply, as argued by the Industrious Revolution hypothesis. As for the sixteenth century I follow de Vries (1993: 110–1; cf. also 2008: 87–92) who reports casual evidence on a reduction of feast days that resulted in the expansion of the working year by about 15 percent between c. 1500 and the early seventeenth century. For the estimates of panel 3 this labour input index is multiplied with the real wage adjusted for changes in consumption patterns.

Relative to the baseline estimate the alternative calculations in panels 2 and 3 suggest more optimistic trajectories of food consumption per capita and average labour productivity in agriculture: The sixteenth-century decline is reduced a bit, and growth in the century 1750–1850 turns out stronger (cf. the figures for total agricultural output in 1850). In contrast to the baseline estimate the intensification of work may have increased output per agricultural population and narrowed down the reduction of food rations during the second half of the eighteenth century. However, given considerable female excess mortality and a decline of physical stature during the early nineteenth century (Ewert 2006) the welfare effect of cheaper calories and more work may have been mixed. Compared to the more conservative baseline the estimate of panel 3 in particular probably represents an overly optimistic scenario.

A good test for the robustness of the baseline estimate is the assumption of a constant food consumption per capita, which abstracts from the consequences of changing real wages and real prices of major categories of goods, and simply rationalizes the implications of the shift of the employment structure for the performance of the agricultural sector given the absence of massive food imports (so-called Wrigley approach, cf. the discussion of equations 1 and 2 above). The results are displayed in panel 4 of Table 3. Given the stability of the employment structure before the early eighteenth century, average output per employed in agriculture remained largely stable over the first two centuries of the observation period. This assumes that the steep decline in the marginal product of labour in the course of the sixteenth century indicated by the fall of the real wage (cf. Appendix 1) was fully compensated by a strong rise of the land rent, which is not very plausible. By contrast, the estimates of panel 4 suggest continuous growth of agricultural labour productivity after 1700. Apart from the slight discrepancy regarding the second half of the eighteenth century this confirms the growth scenario offered by the baseline estimate. The index value of total agricultural output in 1850 is about ten per cent above the one of the baseline scenario and very close to the figure obtained with the approach that makes allowance for changes in consumption patterns. All this suggests that the baseline estimate is fairly robust.

For the purpose of comparison the results of Table 3 with respect to the first of half of the nineteenth century can be summarized as follows: The first three panels suggest a rise of food consumption per capita in the range of 26 to 33 per cent (mean: 29 per cent), of total output in the agricultural sector in the range of 97 to 108 per cent (mean: 103 per cent) and of output per agricultural population in the range of 45 to 53 per cent (mean 49 per cent). If one assumes constant food consumption per capita and relies on the shift of the employment structure alone the implied increases of total agricultural output and of output per employed in agriculture are much lower, namely, 56 and 14 per cent, respectively. This discrepancy is much weaker if one considers the period 1750–1850 rather than the first half of the nineteenth century alone: Total agricultural output grew by 104 per cent according to the baseline estimate and 94 per cent under the assumption of constant food consumption per capita. The evidence for strong growth of output and average labour productivity in agriculture during the first half of the nineteenth century thus strongly depends on the war-related shock that the real wage experienced around 1800 (cf. Pfister 2010: 17). By 1818/22 the real wage had returned to the level of the early 1780s — it stood 24.5 per cent above the level of 1798/1802 and only 5.7 per cent below the value in 1843/50. If one replaces the real wage in 1798/1802 with the value of 1818/22 in the baseline specification, the growth rates of food consumption per capita, total agricultural output and output per agricultural population during the first half of the nineteenth century shrink to 13, 77 and 30 per cent, respectively. Thus a major part of the growth occurring beyond the component implicit in the change of the employment structure occurred in the form of post-war reconstruction until 1820.

This as least in part explains why the estimates of panels 1 to 3 suggest somewhat stronger growth of agricultural output, labour productivity and food consumption than earlier studies during the first half of the nineteenth century. This is particularly true with respect to the evolution of the working-class diet. Meat consumption may have risen by as much as 50 percent between c. 1800 and 1850, and the reduction of bread consumption was fully compensated by an increase of potato consumption (Teuteberg and Wiegelmann 1972: 120; Saalfeld 1975: 242 who in turn relies strongly on Bittermann 1956). If the initial share of meat in the nutritional value of the diet of the urban lower classes is assumed to have amounted to roughly 10 percent, this implies an increase of food consumption per capita by about 5 percent.

Estimates of agricultural output per capita based on contemporary agricultural statistics suggest an increase of 25 percent in Prussia (1816–1849/52) and stability in Bavaria (1800–1850; Böhm 1995: 386. 514).[8] Since Prussia comprised more than half of the Ger-

8 Böhm (1995) gives estimates of grain equivalents. The figure for Prussia is derived from the value of the output of grains, potatoes, peas and beans, beef, pork and milk in prices of 1850 (Finck von Finckenstein 1960: 313–6, 326, 365, 367; Tilly 1978: 433, 441 for milk production in 1816 and 1849, and population; Jacobs and Richter 1935: 53–9 for prices). Tilly (1978: 388–96) develops an estimate of value added in Prussian agriculture implying a much higher growth rate. The main reason is that the estimate for vegetable produce net of inputs into meat production (essentially feed, straw) lies above the one for grain output and, hence, includes some intermediate goods going into meat production (cf. Tables 80, 83 and 431). Since feed and straw output, together with meat production, grew more rapidly than grain and potato production, the resulting overall growth rate is higher than an estimate that consequently excludes intermediate goods.

man population, the national mean certainly lay closer to the first than the second value, which is in turn close to the result of the baseline estimate with respect to food consumption per capita (26 per cent). Helling (1977: 16) places total agricultural output in Germany as a whole in 1846/1850 at roughly double the level of 1800/1810, which is identical with my own estimate. However, Böhm (1995) suggests that Helling's estimate is flawed at least with respect to Bavaria and should be reduced downwards.

As for average labour productivity in agriculture Kaufhold (1983: 22) suggests an increase of 31 percent during the period 1800–1835. In terms of the growth rate p. a., this is identical with the estimates of panels 1 to 3 in Table 3 (0.8 per cent). It may well be, however, that Kaufhold's estimate is too high because he assumes much too slow growth of employment in agriculture (0.3 percent p. a. as against 0.6 percent p. a. 1800–1850 implicit in lines 2 and 5 of Table 1 above). The figures Kaufhold uses are inconsistent with his own assessment of the employment structure and population size (Kaufhold 1983: 20, 22, 24, 33). The estimates for average labour productivity in agriculture of this study can also be compared with the trajectory of labour demand, that is, the level of the marginal product of labour, found by Pfister et al. (2011). They identify labour demand via a structural time series model of the relationship between the real wage and population size. Hence, the labour demand estimate is highly interdependent with the first three panels of Table 3 but largely independent from the specification that assumes constant food consumption per capita. Labour demand, and hence, the level of the marginal product of labour, increased slightly but constantly during the first four decades of the eighteenth century, then declined until the early nineteenth century, and experienced a strong positive shock around 1820 followed by moderate sustained growth until the 1860s. This is consistent with the impression of an onset of agricultural development in the first half of the eighteenth century suggested by all specifications in Table 3 as well as the result that growth accelerated during the first half of the nineteenth century. By contrast, the discrepancy with respect to the second half of the eighteenth century remains.

It can be concluded that there is robust and consistent evidence for an increase of output and labour productivity in agriculture as well as of food consumption per capita during the first half of the eighteenth century and for an acceleration of growth during the first half of the nineteenth century. At the same time, different specifications lead to inconclusive results with respect to the second half of the eighteenth century, and the extent of the acceleration of growth during the first half of the nineteenth century remains difficult to determine. Comparison with other studies using different methodologies suggests that this study overrates growth during this period primarily because it attributes great weight to the low level of the wages of urban construction workers during the war period around 1800. The Revolutionary and Napoleonic Wars were a profound shock to the world economy (O'Rourke 2006), but the agricultural sector may have been less severely affected than urban economies. Reliance on urban wages to assess agricultural output thus probably overstates the economy-wide impact of the war-related shocks.

In the second step of the present analysis, Table 4 combines the output estimates of Table 3 with the trajectory of the employment structure in line 5 of Table 1 into estimates of GDP per capita and its growth rates (cf. equations 3 to 5 above). Given the method to calculate these figures the results turn out largely analogous to those obtained for the agricultural sector alone. Four aspects deserve special mention: First, the discrepancy between the growth estimate based on the assumption of constant food consumption per capita and the other three specifications with respect to the first half of the nineteenth century again disappears in the longer period from 1750 to 1850 (0.31 vs. 0.26 per cent p. a. for the baseline estimate and the constant food consumption p. c. specification, respectively). Second, for periods after 1700 the growth figures of Table 4 remain consistent with the trajectory of labour demand presented by Pfister et al. (2011), except for the second half of the eighteenth century, where the constant food consumption per capita and Industrious Revolution specifications yield more optimistic scenarios than other wage-based assessments. Third, if the real wage in 1798/1802 is replaced by the real wage in 1818/22 the baseline estimate yields a growth rate of GDP per capita of 0.1 per cent in 1750–1800 and 0.5 per cent in 1800–1850. About half of the discrepancy between the constant per capita food consumption specification and the baseline estimate during the first half of the nineteenth century is thus due to recovery from the war-time shock; the rest results from the imputed implications of further real wage growth and rising real energy prices on food consumption and, hence, agricultural output.

Table 4: Estimates of real GDP per capita and its growth rates

GDP per capita (international Geary-Khamis Dollars of 1990)	1500	1600	1650	1700	1750	1800	1850
Baseline estimate	1358	957	1123	1113	1245	1169	1692
same, but variable *p*	1222	861	1011	1002	1245	1315	1692
Allowing for …							
shifts in consumption patterns	1272	929	1091	1081	1209	1135	1692
increase of labour input p. c.	1035	811	952	944	1055	1109	1692
Constant food consumption p. c.	1219	1175	1195	1222	1303	1474	1692

Annual growth rate (per cent)	1500-1600	1600-1650	1650-1700	1700-1750	1750-1800	1800-1850
Baseline estimate	-0.3	0.3	0.0	0.2	-0.1	0.7
same, but variable *p*	-0.3	0.3	0.0	0.4	0.1	0.5
Allowing for …						
shifts in consumption patterns	-0.3	0.3	0.0	0.2	-0.1	0.8
plus increase of labour input p. c.	-0.2	0.3	0.0	0.2	0.1	0.8
Constant food consumption p. c.	0.0	0.0	0.0	0.1	0.2	0.3

Sources: Own calculations using Table 3 and Table 1, lines 2 and 5. For the values of p (equation 4) and GDP per capita in 1850 see text in "Data" section above.

Fourth, Table 4 introduces an additional sensitivity test that allows *p*, the labour productivity differential between agriculture and the rest of the economy (needed to transform information on the share of agriculture in total employment into the share of agriculture in total output), to fluctuate over time. Remember that during the 1850s and 1860s, during the period of early industrialization, p was 0.84, with somewhat lower values prevailing in years of bad harvests. A value below unity is consistent with an expansion of the employment share of the non-agricultural sectors. Conversely, the stability of the employment structure before the eighteenth century (Table 1, line 5) implies that p may have been close to unity during this era. Therefore, in my hypothetical trajectory I set p=1 for all years from 1500 to 1700. The onset of a shift of the employment structure away from agriculture during the first half of the eighteenth century implies the opening of a productivity gap between agriculture and the non-agricultural sectors; correspondingly, I set p at 0.9 in 1750. As already noted, the second half of the eighteenth century is characterized by a discrepancy between a fast growth of the non-agricultural sector and the decline of the real wage, which was only in part due to the war-related shock around 1800. Historical geographers have adduced evidence that this era was plagued with frequent violent precipitation that contributed to land erosion (Bork et al. 1998: 253–71). This suggests a widening of the productivity gap between agriculture and the non-agricultural sectors and, therefore, I set p at 0.8 in 1800. By contrast, part of the first half of the nineteenth century, particularly the 1820s, enjoyed extremely favourable climatic conditions for plant growth (Briffa et al. 1998), so that a reversion of p to a value of 0.9 in 1850 seems plausible. This implies a slightly lower productivity gap between agriculture and the non-agricultural sectors than during the first phase of industrialization that ensued in the following two decades.

Table 4 presents a variant of the baseline specification with variable *p*, where *p* follows the hypothetical trajectory described above. Compared to the baseline estimate with constant *p* the results suggest a more optimistic scenario for the eighteenth and a somewhat more cautious scenario for the first part of the nineteenth century. Given the extremely speculative nature of the proposed trajectory of *p* the main message of this exercise should be that temporal variations of *p*, as long as they occur within plausible limits, do not upturn the result obtained with the assumption of a constant productivity gap between agriculture and the rest of the economy.

Table 5: Alternative estimates of real GDP per capita growth, 1800–1850

Author	period	annual growth rate (per cent)
This study	1800–1850	0.7 (0.3)
Henning (1973: 25)	1800–1850	0.1
Kaufhold (1983: 32)	1800/10–1830/35	0.5
Fremdling (1988: 304–1; 1995: 79–82)	1816–1849	1.8
Maddison (2006)	1820–1850	0.8

Figure for "This study": baseline estimate, in parenthesis specification with the assumption of constant food consumption p. c.

Because of the similitude of the results of Tables 3 and 4 I defer a detailed interpretation into the next section and use the remainder of the present section for a comparison with growth rates of GDP p. c. proposed by earlier research (Table 5). Henning's suggested annual growth rate of output of 0.1 per cent is evidently much lower than all other estimates. Since it is impossible to reproduce the method underlying this figure it is difficult to explain the discrepancy. By contrast, the estimate developed by Kaufhold (1983: 32) for the period 1800/10–1830/35 lies in the middle between the baseline estimate and the constant per capita food consumption specification (0.5 per cent). In fact, while not applying formal calculus he uses an essentially similar methodology as the present baseline estimate, except that his figures of agricultural output are based on contemporary statistics rather than a consumption estimate. Since it was argued above that the consumption approach may overstate output growth in agriculture during the early nineteenth century, Kaufhold's growth figure seems quite plausible and consistent with the present study. An annual growth rate of GDP per capita in the range of 0.5–0.7 per cent in 1800–1850, 0.3–0.5 per cent during the post-reconstruction period from c. 1820, may lie close to the true development of the German economy during the decades immediately preceding the onset of industrialization.

A similar methodology also underlies Fremdling's net output growth estimate for 1816–1849 (Fremdling 1988: 304–1; 1995: 79–82). His figures suggest an extremely high growth rate of 1.8 percent per year, which he himself considers implausible. The reasons for the discrepancy with the present study are, first, that he bases his estimate solely on Prussia, where agriculture grew more rapidly than elsewhere in Germany. Second, the data he uses include an upward bias with respect to the growth of value added in agriculture.[9] Hence, a lower growth rate is much more plausible.

Finally, Maddison (2006), relying on an approach similar to Fremdling (cf. Fremdling 1995: 79), places GDP per capita growth between 1820 and 1850 at 0.8 per cent p. a. At first glance, this seems compatible with the results of the present study. Note, however, that the period of observation starts at a moment when reconstruction after the Revolutionary and Napoleonic Wars was by and large completed and that growth probably amounted to merely 0.3–0.5 per cent p. a. during this period. Hence, Maddison's figures grossly overestimate economic growth not only during the first phase of industrialization but also during the era immediately preceding it. Consequently, Maddison's figure for GDP per capita in 1820, 1077$, is even below my estimates for 1800, when material welfare in Germany stood at a very low level indeed. The same holds for the values given for 1600 (791$) and 1700 (910$). The German case thus corroborates the view that Maddison overrates economic growth during the late pre-industrial period and leaves too little room for income fluctuations during the pre-modern era (Federico 2002).

To conclude, the results of this study are compared with the course of development of the German economy after 1850. The compromise series proposed by Burhop and Wolff (2005) increases by 0.8 per cent p. a. on a per capita basis between 1851 and 1880, and the growth rate rises to 1.7 per cent in 1880–1913. Note, however, that evidence adduced earlier in this study suggests that the true level of economic activity around the middle of the nineteenth century may have been close to the revised Hoffmann-Müller income estimate, and this series displays a growth rate of only 0.4 per cent p. a. on a per capita basis between 1851 and 1880. Even if we disregard the recovery spurt from the war-related shock around 1800, annual growth of GDP per capita accelerated only slowly between the second and the third quarter of the nineteenth century, namely, from 0.3–0.5 per cent to 0.4–0.8 per cent.

Interpretation

The major finding of this study is a gradual transition to sustained growth close to the modern potential rate of growth between c. 1700 and the final decades of the nineteenth century. While there is no evidence for a lasting change of national income levels between c. 1500 and 1700, GDP per capita began to increase at a modest rate of about 0.2 per cent p. a. during the first half of the eighteenth century. Growth paused somewhat during latter part of the eighteenth century, but accelerated to a rate of 0.5–0.7 per cent p. a. in 1800–1850. If we abstract from the shock resulting from the Revolutionary and Napoleonic Wars and subsequent reconstruction, which probably was completed by 1820, GDP per capita growth was slower, perhaps 0.3–0.5 per cent p. a. The early phase of industrialization, which can be dated from the late 1840s to early 1870s, brought only a modest acceleration of economic growth to 0.4–0.8 per cent p. a. The years around 1880 finally saw a transition

9 Cf. footnote 8 above.

to a growth rate of GDP per capita of 1.7 per cent. What follows places the growth experience of each period in a wider context.

GDP per capita fell slightly or remained at best stable between 1500 and 1700. Until the late seventeenth century the employment structure changed little, and a stable negative relationship prevailed between the real wage and population size (Pfister 2010: 21–23; Pfister et al. 2011), suggesting a statistic technology and a steeply falling marginal product of labour. Strong population growth coupled with a strong fall of the real wage suggests weak Malthusian checks. To the extent that falling labour incomes were not compensated by a rise of the land rent per capita welfare declined during the sixteenth century. The huge population loss occurring in the wake of the Thirty Years War conversely led to a vigorous recovery of output in per capita terms. However, growth apparently did not continue into the later seventeenth century since the renewed expansion of population size again exerted a downward pressure on the real wage.

The first half of the eighteenth century, by contrast, saw a modest increase of GDP per capita, despite the continuation of population growth, which suggests the beginning of the transition to sustained growth. Evidence from tree-ring thickness from the northern hemisphere suggests an improvement of conditions for plant growth between the second half of the seventeenth and the early eighteenth centuries (Briffa et al. 1998). Part of the economic growth recorded during this period may thus have resulted purely from climatic change. However, this was a temporary phenomenon that could hardly have caused a transition of the growth regime. At best, a dynamic effect resulted from the reduction of the intensity of price and demographic shocks in that the volatility decline improved the risk-adjusted return on human capital. This increased the incentive to invest into human capital, thus creating a fertile ground for technological progress (Pfister and Fertig 2010: 25, 53–4; cf. A'Hearn et al. 2009: 801 for evidence of increasing numeracy as an indicator of human capital accumulation).

There are two additional explanations of economic growth despite a parallel increase of population size during the first part of the eighteenth century, namely, market integration and the strength of Malthusian checks. The period saw a market shift of employment into the non-agricultural sectors, a decline of inter-urban dispersion of rye prices (Uebele et al. 2011) and an increase of urban hierarchy, which implies growing functional differentiation between towns as well as urban network integration (Pfister and Scholten 2011). This suggests an important impact of the Second Commercial Revolution radiating from the centre of the North Sea basin on the German economy. Its main elements consisted in a spread of the bill of exchange as a means of payment beyond commercial and financial centres and the increasing use of business correspondence, rather than the attendance of periodic fairs, to organize the distribution of manufactures. This was aided by an improvement of postal services, the rise of financial journalism and the proliferation of merchant handbooks that lowered barriers of access to business. All this reduced trade costs particularly with respect to the distribution of manufactures and promoted the development of regional export industries. This in turn provided an incentive for neighbouring agricultural regions to specialize in grain surplus production. Dynamic effects of such a pattern of Smithian growth included learning curves resulting from specialization, which increased the capacity to adapt technological innovations, and incentives to enlarge and improve transport infrastructure that followed from the expansion of inter-regional exchange, which again reduced trade costs.

At least from 1730 Germany was also distinguished by a comparatively strong preventive check (Pfister and Fertig 2010: 44–49). This prevented the renewed emergence of a situation of strong Malthusian imbalance, which had characterized the late sixteenth century, and the erasure of income gains resulting from the expansion of the non-agricultural sectors. At the present stage of knowledge it must remain open whether the relatively prudent system of family formation that seems to have characterized eighteenth-century Germany resulted from increased social control over marriage in the wake of confessionalization (e. g., Robisheaux 1981) or from an increased role of returns on human capital in marriage and fertility decisions, as hypothesized by unified growth theory (Galor and Weil 2000; Galor 2005).

Evidence on economic activity in the course of the second half of the eighteenth century is contradictory: The rise of the urbanization rate and of non-agricultural employment in rural areas suggest a continuation of Smithian growth; the decline of the real wage, which set in well before the negative shock of the Revolutionary and Napoleonic Wars at the close of the century, points to a decline of per capita income. As suggested in the last section, the two findings can be reconciled if one takes into account the evidence of widespread erosion and presumes an increase of the labour input per capita: Erosion lowered the marginal product of labour in agriculture and thus *ceteris paribus* increased the incentive to move into non-agricultural activities. An expansion of the labour input per capita in partial compensation of the fall of the real wage, the drive to reduce holidays in Catholic territories and a genuine Industrious Revolution may have led to a partial substitution of land by labour, mitigated the fall of food rations and the rise of real food prices, and thus rendered possible a further expansion of the non-agricultural sectors. I provisionally conclude that erosion and war shocks (apart from the great wars beginning in the 1790s in particular the Seven Years War 1756–1763) adversely affected economic development during the second half of the eighteenth century but did not stop the process of Smithian growth (including its dynamic effects) that had begun during the previous period.

During the first half of the nineteenth century the rate of GDP per capita growth increased above the level recorded for the first part of the eighteenth century, although it was still modest in comparison to the level reached during the era of high industrialization of the late nineteenth and early twentieth centuries. Part but not all of the difference was due to temporary phenomena: The years up to about 1820 were characterized by reconstruction from the war shock, and during the 1820s agriculture benefitted from extraordinary favourable climatic conditions. It is no wonder, therefore, that the trajectory of labour demand suggests that the German economy experienced a strong positive shock around 1820 (Pfister et al. 2011). Modest growth at a level above the one recorded for the first half of the eighteenth century continued after c. 1820, suggesting that the shock occurring around this time also had a permanent component. This conclusion is corroborated by a strong reduction of the inter-urban dispersion of the rye price and the disappearance of the positive check, which both occurred during the late 1810s (Pfister and Fertig 2010: 44–50; Uebele et al. 2011). Both phenomena refer to an increasing dynamic of market integration as the most likely explanation of the acceleration of economic growth. Possibly the emergence of large territorial states from the Napoleonic era, monetary and tariff reforms as well as the enactment of liberal business law all combined in creating an institutional environment that produced a new downward push on trade costs.

This study has also adduced evidence corroborating the view that economic activity around 1850 was higher than suggested by the (corrected) output series originally compiled by Hoffmann (1965), which implies a downward revision of the growth estimate for the period 1851–1880. Combined with the evidence of moderate growth activity during the first part of the nineteenth century the conclusion emerges that the acceleration of economic growth during the phase of early industrialization (c. late 1840s to early 1870s) was rather gradual. This contradicts the notion of a Rostowian take-off phase into sustained growth during this era (Rostow 1956: 31). Rather, it supports the Crafts-Harley view of the Industrial Revolution originally developed for the British case (Crafts 1985; Harley 1999): During the initial phase of industrialization the new leading sectors had little impact on aggregate output despite rapid growth simply because their size was too small. At the same time, the increase of the supply of manufactures benefitted consumers abroad in the form of declining terms of trade. In addition, the demonstration of a very gradual emergence of sustained growth of per capita GDP from the early eighteenth century lends support to theories that model the transition to the modern growth regime of the industrial era as an endogenous process, either by referring to the dynamic effects of Smithian growth or in the form of unified growth theory.

Conclusion

This study produces evidence for the beginnings of a modest rise of GDP per capita during the first half of the eighteenth century, the transition to slightly more rapid growth during the first half of the nineteenth century and only a gradual acceleration of the rate of GDP per capita growth during the first phase of industrialization occurring between the late 1840s and early 1870s. The results are consistent with a partly independent estimate of the trajectory of labour demand. They confirm the Crafts-Harley view of the Industrial Revolution for the German case and support views that stress the endogenous character of the transition to European industrialization, such as the reference to the dynamic effects of Smithian growth and unified growth theory.

In conclusion, however, the tentative and provisional nature of thus study should be stressed. The indirect approach followed in estimating aggregate output levels is subject to rigid assumptions, and data density is quite low in several respects. While the limitations of the indirect approach will be difficult to overcome in the foreseeable future, the underlying data can be improved, albeit this requires considerable effort. Four directions of research appear particularly promising: First, the assessment of the evolution of the real wage, which is a crucial component of the approach followed by this study, during the first half of the nineteenth century strongly depends on the consumer price index, and information on the trajectory of consumer prices between the early 1800s and the 1860s still remains rather scarce (Pfister 2010: 6–7, 19–21). Enlarging the data base of the CPI during this period has a high potential to improve our knowledge of the evolution of the German economy during the transition to early industrialization. Second, coverage of the employment structure in rural areas, another important variable of the present approach, can be improved by an analysis of seasonal marriage patterns on the basis of parish registers analogous to Kussmaul (1990). Third, this study suggests that changes in the labour input per capita may reconcile some inconsistencies between different specifications, notably with respect to the second half of the eighteenth century. Research into temporal variations of labour time, particularly along the lines of the Industrious Revolution approach, can test this hypothesis. Fourth and finally, an important limitation of the method followed by this study consists in the great weight it attaches to labour income. Research into other sources of income, particularly the land rent, may render it possible to at least tentatively implement an income approach to retrospective national accounting in the future.

Appendix 1: Real price and wage information for key years

(indices, 1503/07 = 1)

	Real price of food	Real price of non-food items	real wage
1598/1602	1.021	0.915	0.557
1648/52	1.045	0.820	0.780
1698/1702	1.061	0.753	0.761
1748/52	1.022	0.912	0.770
1798/1802	1.018	0.925	0.527
1843/1850	0.924	1.304	0.695

Sources and notes: Data described in Pfister (2010). Real wage refers to silver wages deflated by national CPI. Real prices refer to a basket with constant quantities of individual items are based on means for towns with information in respective years, rather than continuous series.

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