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Agricultural development during early industrialization in a low-wage economy: Saxony, c. 1790-1830

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Abstract

The characteristics of regional paths of industrialization had a deep impact on agricultural development during early industrialization in Germany. From 1840 rising incomes in the course of a "high wage-low energy cost" industrialization based on coal and steel and a rapid urbanization triggered a demand driven agricultural revolution in Northwest Germany. In contrast, Saxony's early industrialization c. 1800-1860 followed a "low wage-high energy cost" trajectory based on textile production and slow urbanization. The low level and slow growth of income meant that up to 1830 the adaptation of agricultural innovations neither followed demand impulses transmitted through markets, nor did they facilitate inter-regional specialization according to comparative advantage. Rather, regional agriculture ac-commodated to population growth by expanding the cultivation of subsistence crops, mainly potatoes, probably at the detriment of animal husbandry. Whereas the increase of sown area indicates an intensification of land use yield ratios remained at best stable between the early 1790s and the late 1820s. Hence, local supply could barely cope with population growth, and since grain market integration did not evolve over time imports did not com-pensate for the shortcomings of domestic production. Our evidence of a deteriorating food standard goes a long way toward explaining the decline of the biological standard of living during Saxony's early industrialization.

JEL Codes: N93, O13, Q11.

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1. Introduction

Recent research shows that food demand of high-income urban centres and industrial districts constituted a major force behind agricultural growth in early modern and nineteenth-century Europe (Allen 2000; Campbell 2010; De Vries 1974; Grantham 1989, 1999; Hoffmann 1996; Kussmaul 1990; Wrigley 1987, 1988; van Zanden 1999; for Germany see Kopsidis 2006c, pp. 277-374; Kopsidis, Hockmann 2010; Kopsidis, Wolf 2012). The present study explores the argument that food demand patterns affected both, the magnitude of aggregate agricultural growth and the structure of farm output, with the type of early industrial development as the main variable driving food demand.

Many early industrial districts in north-western Europe were characterized by a combination of high wages and cheap energy (Allen 2009). Cheap energy allowed exploiting agglomeration effects through a spatial concentration of industrial locations, which promoted agricultural specialization and a rise of market-oriented production. High wages created an incentive to expand output livestock products with a high value added whose demand was characterized by a high income-elasticity. In agriculture the rising demand for superior foodstuffs promoted a shift towards intensive and highly productive systems of mixed farming and animal husbandry.

By contrast, in most parts of the European mainland there predominated a pattern of early industrial development that combined the scarcity of energy with an abundance of well-trained labour (Cameron 1985). Many regions of this type specialized on light industries, mainly textiles, the larger ones developing an engineering sector. High energy costs implied that modern machinery was difficult to operate profitably; accordingly, capital intensity and wages were low. At the same time, the use of water power and forests as energetic resources implied a spatial dispersion of industrial location. This variant of regional industrial development had three major implications for agricultural growth:

First, only little room existed for pushing up aggregate growth rates beyond the increase of population as long as wages remained depressed.

Second, low incomes and the spatial dispersion of industry constrained the deepening of regional labour division and the development of efficient food markets. In particular, low incomes implied that food consumers were unable to bear price markups related to distance costs. Hence, “Thünen and Smithian economics” could not operate as the driving forces of agricultural development. Agricultural growth remained slow. The “Thünen and Smithian growth” mechanism implied that productivity gains in agriculture accrued from the exploitation of regional comparative advantage within an expanding integrated market area (Wrigley 1987, 1988; Grantham 1989, 1999; Kopsidis, Wolf 2012). Rather, we should expect a Boserupian scenario in which labour-biased agrarian innovations served to expand local production of subsistence crops to accommodate for population growth (Boserup 1965). Apart from the introduction of the potato the introduction of forage crops such as clover and turnips could have al-

lowed deflecting feed grains such as oats and barley to human consumption. Due to the fact that most of the new crops and patterns of crop rotation were land-saving and labour consuming the room for part-time farming on small plots by a spatially dispersed industrial workforce increased.

Third, Engel's law implied that pressure on wages resulting both from population growth and the competitive edge of British industries over continental manufacturing regions caused a shift in food consumption and farm output. Highly income elastic livestock products rich in proteins, such as meat and dairy products were replaced by staple foods like grain and potatoes to reduce the cost per calorie.[1] Hence, agricultural growth in a context of an industrialization path characterized by cheap labour and energy scarcity could go together with an unaltered high if not rising weight of crop output in total farm production and constant low if not deteriorating nutritional standards. Consumers in such a low-wage economy just could not afford to buy the protein rich superior product mix supplied by an agricultural sector based on the most advanced contemporary systems of convertible husbandry and mixed farming.

Our study confronts this stylized description of an early industrial region characterized by a factor mix of abundant labour and scarce energy with information on the evolution of the agrarian economy in Saxony during the late eighteenth and early nineteenth century. Saxony constitutes Germany's most important early industrial region with a large textile sector and it shows clearly the characteristics of the low wage-high energy cost variant of the first phase of industrial development. Its experience can be contrasted with the Ruhr area, where the opening-up of rich coal deposits from the 1840s onwards fostered a development pattern according to the high wage-cheap energy type. In Northwest Germany expanding and integrating agrarian markets triggered a demand driven dynamic agricultural growth in an expanding geographical area. Extraordinary productivity gains accrued out of an increasing regional specialization according to comparative advantage. Literally insatiable demand of urban-industrial consumers for livestock products featured prominently in this context due to non-neutral technical change that favoured the expansion of livestock farming (see especially Kopsidis 1996, 2002; Kopsidis, Hockmann 2010).

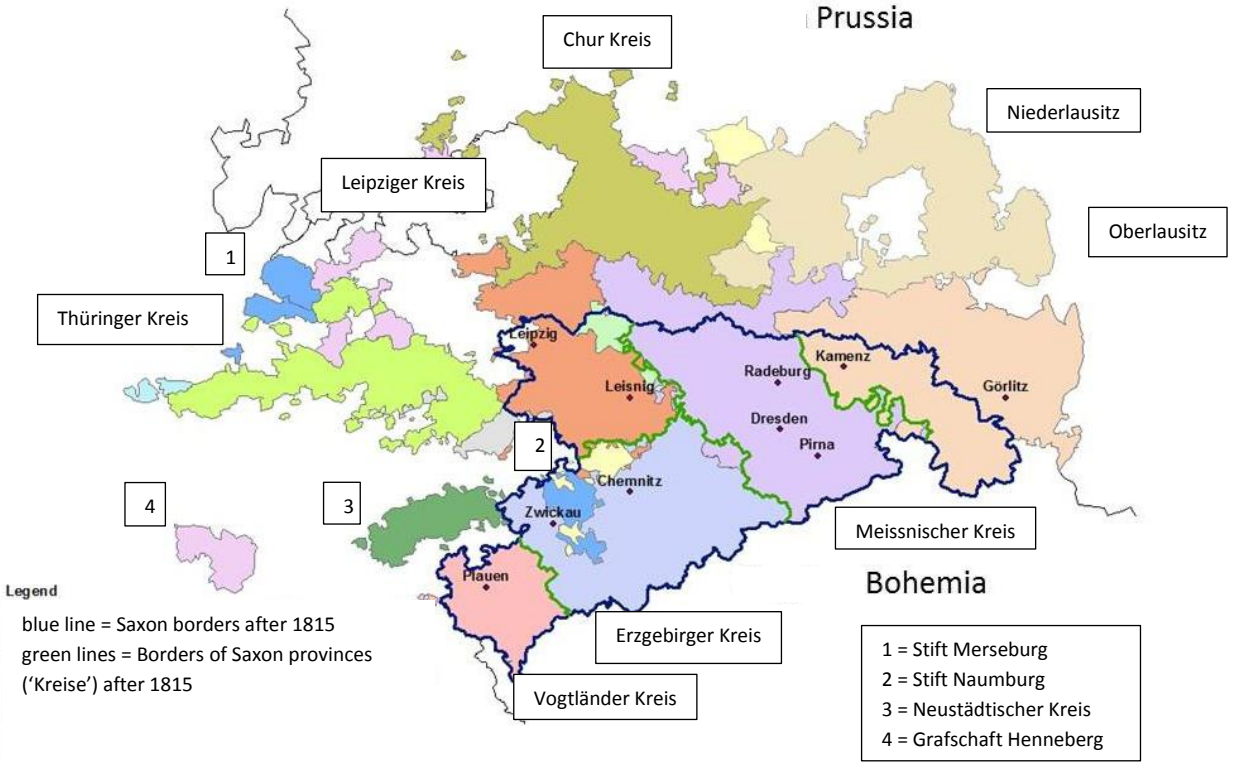
Our analysis of Saxony's agrarian economy develops a new dataset based on annual records of seeding quantities and crop output on a regionally highly disaggregated level for the period 1790-1830. This source is unique in that it constitutes the earliest comprehensive body of information on agrarian production for a German region known to date, and the present research is the first to make full use of it.

The text is organized as follows: We begin with an overview that identifies major forces shaping supply and demand in Saxony's agricultural sector (section 2) and discuss our major data source (section 3). The analysis proper begins with an investigation of aggregate farm output growth and structural change (section 4). In a second step,

[1] Research undertaken around 1960 in developing countries suggests an income elasticity of demand for calorie-rich staple foods in the order of magnitude of 0.4–0.6 and values of 1.2–1.5 for animal foodstuffs (Mellor 1970, pp. 57-80).

information on seed quantities is employed to identify sources of growth (section 5). Section 6 examines regionally disaggregated data, primarily with the objective to see whether structural change in farming was linked to regional specialization and growing market orientation of agriculture. Finally, section 7 explores the implications of our findings for nutritional standards and the relative weights of agricultural subsistence and market production in total food supply. Section 8 concludes by a summary of results.

Figure 1: Saxony in 1792 and after 1815



Sources: Blaschke, Jäschke (2009); Grünebaum (2012)

2. Background: Demand and supply forces in agricultural development

The geographical location of Saxony is not trivial to describe since territorial boundaries underwent massive change during the period under observation (see map 1). The territory of the present-day Free state of Saxony is largely identical with the Kingdom of Saxony created in 1815 (solid blue line in map 1). During the early modern period the Electorate of Saxony had covered a much larger territory. Due to the fact that Saxony ended the war period beginning in 1792 as an ally of Napoleon, it lost in 1815 about 60 per cent of its territory comprising around 40 per cent of total population. The losses consisted mainly of thinly populated lowland regions; by contrast, the area close to the south-eastern border constituted a densely populated upland zone with a heavy concentration of (proto)-industries.

Major variables driving food demand include population size, structural change, income and relative prices. Within the borders of the reduced Kingdom of Saxony population nearly doubled between 1750 and 1850 (Table 1). This territory constituted the most densely populated part of Germany and showed extraordinarily high rates of demographic growth: the exponential trend increased 0.5 per cent p. a. during the three decades following the Seven Years' War (1756-1763) and 1.1 per cent during the two-and-half decades after 1815. In Germany as a whole, population grew at an annual rate of 0.4 per cent 1750-1800 and 0.7 per cent 1815-1840 (Pfister 1994, pp. 16-23; Pfister, Fertig 2010, p. 5).[2] Furthermore, despite the river Elbe Saxony was more or less a land locked country. Hence, simply maintaining food standards in an environment characterized by limited foreign trade with agricultural commodities and restricted land resources constituted a formidable challenge.

Table 1: Population size, 1750-1870

	Kingdom of Saxony (from 1815; 14,999.2 km^2)			Electorate of Saxony (until 1814; 37,415 km^2)	
Year	Population	Annual growth (%)	Population density (km^2)	Population	Population density (km^2)
1750	1,046,627	--	70	1,806,846	48
1763	1,012,579	-0.25	68	1,748,067	47
1790	1,192,060	0.61	79	2,057,915	55
1810	1,273,663	0.33	85	2,198,789	59
1814	1,226,583	-0.94	82	2,117,512	57
1830	1,527,152	1.38	102		
1850	1,912,600	1.13	128		
1870	2,509,300	1.37	167		

Note: The original population figures 1750-1830 out of the archival sources represented an underestimation and were multiplied by the factor 1.088 (see also Stams 2007).
Sources: Own calculation of corrected population numbers. The original figures are from Schirmer (1996, p. 57f.) and Kiesewetter (2007, p. 174).

Population growth was concentrated in the upland districts in the south-eastern part of Saxony that were poorly suited for farming but experienced an early development of export-oriented textile manufacture. Thus, between 1772 and 1830 the *Erzgebirgischer Kreis* and *Vogtländischer Kreis* experienced annual population growth rates that were two to three times higher than in the administrative districts covering the fertile northern, north-western and central plains, even if Leipzig and Dresden, the two largest cities by far, were both located in the plains. The fact that population density in the two south-eastern districts was above the average of the whole territory

[2] Related to the territory of the later Kingdom of Saxony population increased only at a rate of 0.4 per cent p. a. during the second half of the eighteenth century. However, two big exogenous shocks, first, the Seven Year War and, second, the famine of 1771/72 which mainly hit the proto-industrial upland areas (Keller 2002, pp. 186-7), caused extraordinary high population losses that depressed average long-run population growth. Indeed, after 1772 annual rates of population growth jumped up to 0.8 percent for the next two decades. Population losses of the famine were fully replaced already in 1779.

already by 1755 suggests that these regional differences in population growth had earlier roots (Table A.1).

Patterns of population growth were thus closely linked with structural change but not with urbanization. Structural change was relevant in view of agricultural demand because the expansion of non-agricultural sectors held the potential for the development of agricultural product markets as well as for regional specialization. However, to what extent this potential could be exploited under the conditions of a rurally based industrialization deeply rooting in preceding processes of proto-industrialization is still an open question.

On the background of early and rapid industrialization the share of non-agricultural rural population in total population more than doubled from 20.5 per cent to 43.3 per cent during the period 1750-1870 (Table 2). Vigorous growth of the non-agricultural population in the countryside contrasted with the constant size of the full time farmers' population, which numbered about 250,000 both in 1750 and 1843. The expansion of the non-agricultural sectors thus reflects the multiplication of rural households possessing little or no land. In fact, so-called *Gärtner* and *Häusler* as well as *Inwohner* accounted for 38.5 per cent around 1750 and 52.2 per cent of all households in 1843, and the expansion of this segment of the population contributed 69 per cent of total population growth 1750-1843. *Gärtner* and *Häusler* owned some land between a garden and a few hectares whereas *Inwohner* had to rent all their plots (Blaschke 1967, pp. 190-191, Gross 1968, p. 30).

Table 2: Non-agricultural population (Kingdom of Saxony, excluding *Oberlausitz*)

Year	Total population	Share of non-agricultural rural population	Share of urban population
1660	455,882	12.9	
1720	670,492	17.5	--
1750	796,610	20.5	36.0
1780	873,333	24.5	--
1810	1,040,625	30.0	32.3
1840	1,407,937	36.1	33.8
1870		43.6	39.7

Sources: Own calculation based on estimates by Weiss (1993, pp. 104, 110 and 120). Additional sources for urban population are Wächter (1901, p. 195), and Blaschke (1967, p. 163).

By contrast, urban population grew slower than total population until about 1830, implying that as late as 1840 the urbanization rate was actually lower than in 1750 (Table 2).[3] Only after 1830 did urban population growth begin to outstrip rural population growth (Wächter 1901, p. 195; Blaschke 1984; Herzog 2000; Keller 2001, pp. 440-441, 2002, p. 314). Moreover, while communities with less than 2,000 inhabitants comprised 29 per cent of total urban population in 1750 they contributed almost 40

[3] Urban population comprises all inhabitants of communities possessing the juridical status of towns.

per cent to the rise of urban population in 1750-1834 (Table 3). These small towns differed little from the so called large 'industrial villages' (*Industriedörfer)* that developed dispersed all over the more industrial parts of Saxony during early industrialization (Keller 2002, p. 314).[4] Of all forms of settlements 'industrial villages' and small towns experienced the strongest demographic expansion until around 1830/40. A clearly recognizable relationship between industrialization and urbanization emerged only after this period.

Table 3: Urban growth according to community size, Kingdom of Saxony 1750-1834

Size classes of towns (population)	Urban population in 1750	Annual growth (per cent) 1750-1834	Absolute increase 1750-1834
<2,000	112,314	0.50	58,093
2,000 - 5,000	119,872	0.41	49,486
5,000 - 10, 000	42,707	0.13	4,831
>10,000	108,464	0.33	34,332
Total urban population	383,357	0.39	146,742

Source: Own calculation based on Blaschke (1967, p. 138-141).

The sectoral and spatial distribution of Saxony's population reflects the specific development pattern of its industrial sector. Already by the middle of the eighteenth century the country possessed an important proto-industrial sector. Mainly because of the rapid expansion of cotton processing and calico printing growth of textile manufacture accelerated during the second half of the eighteenth century. During the first decades of the nineteenth century this sector, together with related branches such as tool making, engineering and dying, transformed into a major early industrial district. Already by 1849 the share of farm labour in all labour had fallen to 37.4 per cent, compared to 56 per cent for Germany as a whole, and industry had evolved into the largest sector (Forberger 1958, 1982; Tipton 1976, pp. 14-38, 185; Keller 2002, pp. 178-214, 297-315; Karlsch, Schäfer 2006, pp. 14-70; Kiesewetter 2007).

Two major factors slowed down the concentration of industrial activities in urban agglomerations and contributed to the persistence of dispersed manufacture that included high shares of domestic outworkers. First, waterpower from the many streams in the uplands constituted the main source of energy in manufacturing until the 1850s. Until this point in time coal was too expensive in the industrial areas. This meant that spatial concentrations of large factories using steam power and exploiting Marshallian agglomeration effects could not develop. Rather, manufacturing facilities needed to spread out along the streams.

Second, Saxony's industrialization depended on a combination of comparatively low wages, a skilled labour force, highly innovative craftsmen, and experienced merchants organizing the entire supply chain and permanently looking for new international markets. After the appearance of machine-spun cotton yarn on international

[4] Industrial villages are settlements with a significant industrial sector that did not possess the juridical status of a town.

markets in the 1790s Saxony's export-oriented textile sector managed to withstand tough British competition, which fully exploited the economies of scale of steam powered factory production, by permanently reorganizing the entire chain of production on all its stages. Until the 1850s organizational change taking place mainly within traditional (proto)-industries seemed to be more important for the survival of Saxon textile production than factory-based technological change (Karlsch, Schäfer 2006, p. 32). Productivity-enhancing technical elements of British industry, such as mechanical spinning and power looms, were adopted only to the extent to which they fitted into relative factor scarcities and prices prevailing in Saxony. However, this implied as one core element of Saxony's successful early industrialization the ability to draw on a labour force willing to work at low wages.

Information on wage income is consistent with this stylized picture of Saxony's early industrialization. In a German comparison rural and urban wages in Saxony seemed to have moved at the lower bound during the time under consideration. Moreover, the available evidence suggests that incomes of the population at large fell during the Revolutionary and Napoleonic Wars (1792-1815) and that the post-war recovery of real wages was possibly not sufficient to raise per capita household income above the pre-war level. Hence, even after 1815/17 food demand rose at best parallel to population growth (Pfister, Kopsidis 2013).

Effects of the supposed trajectory of food demand can be traced indirectly through the evolution of the biological standard of living, meat consumption and relative prices. Physical stature of army recruits fell almost continuously after the second half of the 1770s, reached a nadir during the second half of the 1830s and stabilized on a slightly higher level during the 1840s (Ewert 2006, pp. 62-63). Physical stature is strongly influenced by the amount of protein-rich food received during early childhood; it is useful, therefore, to relate it to meat consumption per capita. Table 4 charts this information from 1835 onwards, which at the same time constitutes the earliest bit of evidence we have on output of animal farming in Saxony. In 1835/40 meat consumption per capita took a low value of 15 to 16 kg and rose to 18-19 kg in 1845/50, which tallies well with the evolution of physical stature during these years. However, only after plunging to slightly below 15 kg in 1855, the last major food crisis in German history, did a sustained rise of meat consumption per head set in. In a structural perspective, the consumption level of 15-19 kg of meat per person prevailing in the 1830s and 1840s reflects a very low nutritional standard; drawing on a wide literature on pre-industrial living standards in Europe Allen (2009, pp. 35-36) considers 26 kg as representative of what he designates as a 'respectable lifestyle' basket.

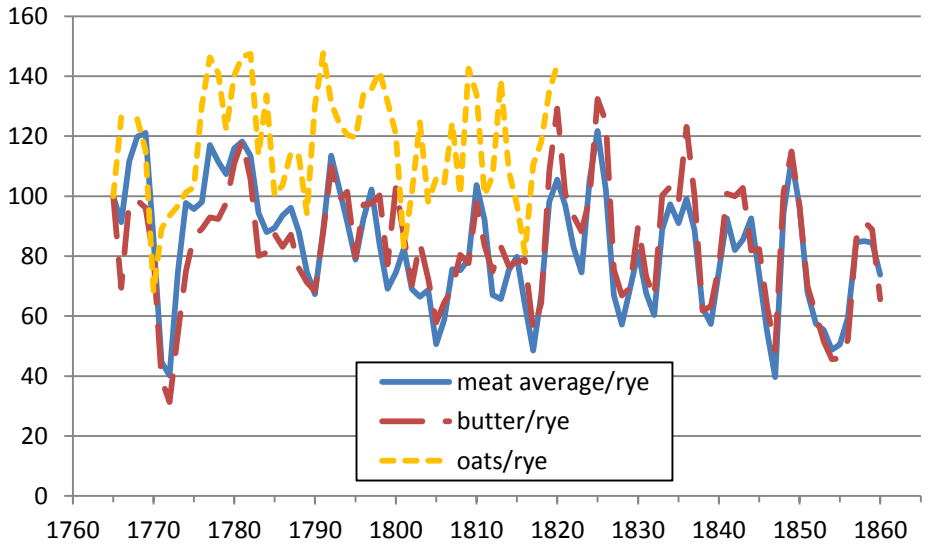
Table 4: Meat consumption per head in Saxony, 1835-1890 (sum of pork and beef in kg)

1835	1840	1845	1850	1855	1860	1865	1870	1880	1890
16.1	15.1	18.2	18.9	14.9	22.2	25.6	22.6	29.2	34.4

Source: Martin (1895, p. 150).

Constraints on the supply side or on the demand side (as well as a combination of both) could explain the unsatisfactory development of food standards during Saxony's early industrialization. Reflections about supply side-constraints should start from the fact that animal production was more land-intensive than staple crop production. To the extent that land-saving innovations such as the cultivation of forage crops and the conversion of pasture to grassland could not compensate for the pressure resulting from population growth to extend arable farming fodder became scarce. Hence, the price of protein-rich animal foods rose relative to grain, and consumption shifted from animal to vegetable food. Alternatively, according to Engel's law the decline of per capita incomes suggested above implied that in the face of dropping purchasing power households had to concentrate expenditures on those foods with the highest calorie content per money unit and had to reduce the consumption of protein-rich livestock products. Additionally, having in mind that during the nineteenth century bread grain was the classic Giffen-good grain consumption per capita could even have increased under the conditions of changing relative prices to the disadvantage of grain.

Figure 2: Prices of meat, butter and oats relative to rye in Leipzig, 1765-1860 (indices, 1765=100)



Note: The meat price relates to the average of the prices for beef, veal, pork and mutton.

Source: Own calculation; data definitions as in Pfister (2013).

The relative prices charted in Figure 1 and analysed in Table 5 support the demand-related argument rather than the one referring to supply constraints. The regression results demonstrate that the relative price for both goods – meat to rye and butter to rye – fell by about -0.5 per cent per year between 1765 and 1860.[5] By con-

[5] This downward trend was only interrupted by a sudden upward shift of about 20 per cent around 1820. However, for the price relative of butter and rye this upward shift is statistically significant only at the 10 per cent level.

trast, the relative price between oats, potentially an important forage crop, and rye stayed flat between the mid-1770s and 1820.

Table 5: Trend estimates of price of meat and butter relative to grain in Leipzig (OLS estimates, t values in parentheses)

Dependent variable	Constant	Year	Period dummy	R^2adj	F	p
ln (meat / rye)	13.3	-0.006	0.223	0.125	8.01	<.001
	(4.21)	(-3.61)	(2.22)			
ln (butter / rye)	11.3	-0.005	0.199	0.065	4.38	0.015
	(3.31)	(-2.78)	(1.86)			

Source: Own calculation; data definitions as in Pfister (2013).
Notes: Tests on structural breaks using Chow-tests and Recursive Estimates-tests suggest a weak, statistically non-significant structural break in 1818 for both, the price of meat and butter relative to grain. Hence, a dummy variable has been introduced that takes the value of one in and after 1818 and of zero before 1818. The meat price relates to the average of the prices for beef, veal, pork and mutton.

To conclude, supply constraints could not have mattered for the low level of meat consumption since in this case the price relative between meat and grain should have risen over time. Rather, the trajectories of the relative prices of meat and butter compared to rye correspond well to the supposed evolution of household income per capita: In view of faltering purchasing power households could afford less meat and butter. That the relative price between oats and rye did not follow the decline observed for the relative prices of meat and butter suggests that a growing proportion of oats production was released to human consumption, primarily in the form of mush.

A similar tendency is apparent for beer as well. During the period 1795-1830 its real price (but not the price relative to rye) also fell at an annual rate of -0.5 per cent. In case of need, beer could be substituted for water, which suggests income elastic demand. Faltering household income may thus have reduced beer consumption over the period under study. The resulting decline of the real price of beer set an incentive to reduce commercial production of barley.

However, the results of the analysis of relative prices do not imply that supply was totally irrelevant for the development of agriculture in Saxony during the late eighteenth and early nineteenth centuries. In the remainder of this section we address the main supply forces acting on agriculture, namely, technological change, agrarian institutions, trade and war.

According to contemporary experts and subsequent historiography Saxony developed the most intensive farming systems among all German states between c. 1750 and 1870 despite only medium-quality soils on average (Kiesewetter 1980, 1981; Dipper 1989, pp. 67-68; Stams 1998; Hunger et al. 2000; Schirmer 2000). This was basically the result of an early adoption of land-saving technological innovations. Due to the fact that contemporary agricultural censuses focused on staple crops the diffusion of innovations in farming is impossible to track in quantitative terms, but the chronology of

major developments emerges from qualitative contemporary accounts. Particularly following the famine of 1771/72 intensification of agriculture accelerated significantly (Leonhardi 1802, p. 57). In parallel to the boom in potato cultivation occurring during the final quarter of the eighteenth century clover, pulses and turnips gradually became an integral part of crop rotation systems practiced in Saxony. Likewise, permanent stable feeding of cattle was established as common practice by c. 1800.

Table 6: Farm structure in 1853

Farm size in Saxon Acres (Sächsische Äcker)	Farm size in hectares	Farm land in hectares	Share in total farm land (per cent)
0-3	0 - 1.7 ha	28,645	2.5
3-10	1.7 - 5.5 ha	81,852	7.1
10-30	5.5 - 16.6 ha	238,789	20.6
30-75	16.6 ha - 41.5 ha	473,440	40.9
75-200	41.5 ha - 110.7 ha	126,248	10.9
>200	> 110.7 ha	209,378	18.1
Total		1,158,353	100

Source: Langsdorff (1889, p. 48).

The adoption of these innovations took place under the pre-reform traditional agrarian institutional regime that distributed property rights between landlords and peasants and among community members (Schirmer 2000, p. 138; Keller 2002, p. 188; Karlsch, Schäfer 2006, p. 68). Agrarian reforms that paved the way for full individualization of property rights by creating mechanisms for public enclosures of commons and for the redemption of feudal duties and corvée were enacted only in 1832 following the revolutionary events of 1830/31 (Gross 1968). Apparently, in Saxony the traditional regime of distributed property rights and commons did not present serious obstacles to agricultural innovation and growth. At least partly this is explained by the fact that the so-called *mitteldeutsche Grundherrschaft* (Central German seigneurial system) prevailing in Saxony — except in the Marggravate *Oberlausitz* — counted among the most liberal agrarian regimes in eighteenth century Germany (Haun 1892; Kötzschke 1953, pp. 89-185; Lütge 1957). Existing tenure systems secured strong peasant property rights, peasants were personally free, and all feudal duties and corvée were only charged to land (*Reallasten*). Duties and corvée were comparatively low as a result of the policy of the central government to protect independent peasant farms against encroachments of nobles (*landesherrlicher Bauernschutz*) as a way to secure its fiscal revenues (Keller 2002, pp. 185-188). As a result, by the end of the eighteenth century nearly independent family farms that were free from any landlord intervention in their farm management cultivated about four fifth of the arable (Gross 1968, pp. 38-79; Schirmer 2000, pp. 166-168). Pre-reform peasants in Saxony approached the ideal of owner occupiers and resembled much the English yeoman with one important difference: they had much better property rights in their farms. The first true agricultural census carried out in 1853 still mirrors the paramount importance of small to medium-

sized family farms: Nearly 62% of all farmland was held by units owning between 5.5 and 41.5 hectares (Table 6; see also Gross 1968, p. 23).

Moreover, it is important to note that the land poor classes, which constituted the majority of the rural population, were only weakly integrated into the seigniorial system. Thus, a more or less free labour market existed in Saxony long before the agrarian reforms (Tipton 1976, pp. 32-33).

Table 7: The evolution of sheep stocks, 1779-1873

Administrative district (Kreis)	*1779*	*1834*	*1873*
Erzgebirgischer and *Vogtländischer Kreis* (uplands)	31,771	81,491	33,103
Meißnischer Kreis (plains)	91,662	174,028	54,074
Kingdom of Saxony		604,950	206,833
Growth (per cent)	*1779-1834*	*1834-1873*	
Erzgebirgischer and *Vogtländischer Kreis (uplands)*	+156.5%	-59.4%	
Meißnischer Kreis (plains)	+89.9%	-68.9%	
Kingdom of Saxony		-65.8%	

Source: Own calculation; for data sources see Appendix and Heyne (1890, p. 53).

Taken together, the existing agrarian institutions of the *Ancien régime* presented no obstacles to changes in farming practices so that both land use and labour allocation could respond flexibly to population growth and early industrial development. Nevertheless, grazing rights constitute an important exception from this general conclusion. Successful inbreeding of Spanish merino sheep into local stock in 1765 led to a boom in sheep husbandry. Whereas Saxony specialized in linen and cotton processing and had no important woollen industry of her own it quickly emerged as a major provider of high-quality raw wool to other industrial districts on the European mainland (Heyne 1890; Chorley, 1990; Schirmer 2000, p. 166; Sammler 2004). Consequently, and despite agrarian intensification, the number of sheep more than doubled in 1779-1834. Moreover, the densest populated industrial areas that were scarce of fertile land – Erzgebirge and Vogtland – experienced particularly high growth rates of sheep stocks (Table 7).

Sheep husbandry was the domain of the landlords and constituted one of their most profitable activities. At the same time, sheep husbandry depended on temporary grazing rights on peasant land (*Servituten*), namely, commons and fields left fallow. After 1770 landlords increasingly became capitalistic entrepreneurs and re-activated old grazing rights, whose exercise had fallen into desuetude long time ago. Since pasture on fallow and common land hindered the introduction of the innovations mentioned earlier, particularly the cultivation of potatoes, clover and forage crops, and the expansion of grassland, peasants struggled against the re-activation of grazing rights by going to court en masse (Blaschke 1974, p. 72). Moreover, because of harsh land use conflicts no German territory saw bigger peasant riots than Saxony, with the most violent one occurring in 1790 (Stulz, Opitz 1956, pp. 11-123). The central government suc-

ceeded in pacifying the situation by a peasant friendly jurisdiction that promoted voluntary enclosures that included the redemption of grazing rights. Indeed, voluntary partial 'enclosures by will', which very probably had already become frequent during the second half of the eighteenth century, experienced a boom between 1790 and 1830 (Gross 1968, p. 17; Czok, Gross 1989, p. 294; Gross 1989, p. 310). A very large part if not the majority of seigniorial grazing rights thus seemed to have been redeemed by 1830.

This suggests the availability of solutions for land conflicts in pre-reform Saxony according to the Coase-theorem. Coase developed his theorem by analysing land use conflicts between cattle-raisers and farmers (Coase 1960). The pure Coase-theorem states that as far as trade in externalities is possible and certain conditions are met (no transaction costs, clearly defined property rights, no obstacles to bargaining) bargaining will lead to an efficient allocation of resources independent of the distribution of property rights. Coase demonstrates that independent of the arrangement of property or land use rights between cattle-raisers and farmers the chosen solution to internalize negative external effects of grazing cattle on arable land has no effect on (agricultural) growth. In other words, regardless of whether farmers pay the cattle-raisers for not damaging the crops or the latter pay the first for grazing on the arable land agricultural growth will be the same. Indeed, it appears that in late eighteenth and early nineteenth centuries Saxony intense bargaining between peasants and their landlords enabled the early adaptation of agricultural innovations conducive to growth without introducing full private property rights in land through radical agrarian reforms. The sole precondition was a more or less clear definition of the divided property rights between peasants and their landlords within the existing seigniorial system and institutions capable of solving land use conflicts. In fact, Saxony was one of the best administered states of Germany.

The example of Saxony demonstrates that a Coase-solution of land-use conflicts needed a capable state apparatus to provide the institutional framework for voluntary agreements and to control the conflict. However, it should be mentioned here that after the enactment of agrarian reforms farmers were keen to get rid of the remaining grazing rights in the first place, rather than to redeem feudal duties as such (Keller 2002, p. 299). This suggests a limited efficiency of the pre-reform bargaining framework at least in some parts of Saxony. In section 6 a regional comparison will be carried out to see to what extent grazing rights presented an obstacle to agricultural development in different parts of Saxony and why conflicts on the internalization of external effects of sheep grazing between the two land possessing classes — peasants and landlords — strongly affected the food standards of land poor rural classes.

Trade in agricultural products held the potential to accommodate food supply to population growth and to promote agricultural development by creating room for regional specialization according to comparative advantage, i. e., Smithian growth. Unfortunately, however, statistics on grain trade started only during the 1830s and remained fragmentary for quite a long time (Kiesewetter 2007, pp. 258-263). An excep-

tion is the foreign trade statistics for the normal harvest year 1792. The data reveal that the excess of exports over imports of bread grain (rye and wheat) accounted for only 0.9 per cent of total net crop production of bread grains (Schröter 1912, p. 10, own calculation; Schirmer 1996, pp. 40-51).[6] This is consistent with our finding in section 7 that at the beginning of the 1790s the Electorate of Saxony must have been by and large self-sufficient with respect to (staple) food.

For the remainder of the period under study we have to rely on indirect evidence. An important variable affecting trading costs is the supply of transport infrastructure. First efforts to extend the network of paved roads started at the end of the eighteenth century but accelerated significantly only after 1815. In 1827 the Kingdom of Saxony possessed 1,255 km of paved roads. Road length more than doubled until 1845 (2,527 km) and amounted to 2,925 km in 1850 (Pätzold 1916; Speck 1953, p. 161). Thus, a modern system of overland transport began to emerge only towards the end of our observation period.

Trading costs were also affected by tariffs and non-tariff barriers to trade. Saxony possessed many internal tariffs and liberalized its domestic trade regime relatively late, namely, after the constitutional revolution of 1831. Saxony's partition in 1815 created a new border between grain surplus and deficit regions. However, whereas tense relations with Prussia, which gained the former Saxon territories, impeded Saxony's industrial exports, the traditional domestic North-South-grain trade was little affected as grain exports from former Saxon territories to the Kingdom of Saxony were exempted from Prussian export duties (Kiesewetter 2007, p. 223). Partial relief for Saxon industrial exports to pay for food imports brought the liberalization of navigation on the River Elbe in 1821, which enabled custom-free transit trade through Prussia in direction of the North Sea. Whereas Saxony strictly adhered to its traditional free trade policy many trade partners pursued a protectionist trade policy during the 1820s. Only the foundation of the German Customs Union (*Deutscher Zollverein*) in 1834 opened a large market for Saxon industrial exports to Central Europe. To sum up, it appears that the permanently instable international situation and the many wars during the French period as well as the situation after 1815 did not create an environment favourable to improve the conditions for long distance trade with bulky goods like grain.

Ongoing work by our research group produces econometric evidence that Saxon grain markets were well integrated into the German market already during the quarter-century following the Seven Years' War. However, given a largely stable institutional framework and the hesitant development of physical transport infrastructure the degree of food market integration changed little between 1790 and 1830. After some war-related disintegration of markets during the period 1790-1815 the degree of market integration only returned to the level observed before 1790. Based on this evidence we conclude that Saxony's agriculture was exposed very early to market forces promoting regional specialization. However, before the coming of the railway the first

[6] The crop harvest of 1792 (8.22 million GE) approximates closely the average harvest 1791-1812 (8.27 million GE; own calculation, for original data sources, see appendix).

stage of developing a modern transport infrastructure after 1815 only offset the negative impact that increased trade resulting from population growth exerted on marginal costs in the transport sector. Hence, in our analysis we assume that within the post-1815 territorial boundaries of the Kingdom of Saxony on average the ratio of traded grain to domestic output remained by and large stable between the 1790s and the 1820s (see also below, section 7).

Finally it has to be mentioned that the supply of important inputs like labour and livestock was negatively affected by war after 1805. Saxony repeatedly became a theatre of war from 1806 onwards. Moreover, as an ally of Napoleon it had to contribute troops, draught animals and provisions, particularly meat, to the French war effort on repeated occasions. Saxony was forced by Napoleon to modernize its army thoroughly and to introduce the French system of universal conscription. Finally, in 1812 two thirds of Saxony's army of c. 32,000 invaded Russia as part of the *Grande armée*; these forces were to a large part annihilated (Gülich 2006, pp. 28-34). On this background we presume that labour and draught animals were diverted from agriculture on a large scale. Provision of meat must have decimated cattle stocks, which in turn reduced manure input. After 1805 land productivity must have been negatively affected by a reduction of man-land and capital-land ratios. Conversely, there existed a considerable growth potential stemming from post-war reconstruction in the years after 1815.

3. Sources and data preparation

This study builds a new dataset from a unique source on seeding amounts, harvested quantities and stocks of most crops cultivated on arable land recorded annually at a highly disaggregate level in 1755, 1772, 1789-1812 and 1815-1830 (for archival sources see Appendix). In addition, these lists give the number of consumers according to sex and age class (below 15, 15-60 and above 60). Indeed, from the late eighteenth century to 1830 Saxony had probably the best records of crop output in agriculture among all European states.

Whereas the first lists were drawn up at irregular intervals from 1755 onwards serious efforts to improve their accuracy only took place after 1790 (Schirmer 1996, p. 88). A decree of the Elector from 19th August 1791 regulated in detail the procedures of data collection. It mentioned as the main purpose of these comprehensive statistical reports the government's desire to obtain precise knowledge of grain supply and demand in order to be able to act early enough to prevent sharp increases in grain prices in case of a harvest failure.[7] Thus, in the wake of the big peasant uprising of 1790 fear of food riots by the rural lower classes may have motivated state authorities to strictly monitor food supply.

All local authorities, including the bailiffs of manors became involved into the process of gathering information that had to be put into standardized forms until end of

[7] HStAD 10026, Geheimes Kabinett, Loc. 653/1, fol. 68ss.

October. The superior administrative level controlled the results for consistency. Concealing grain stocks or reporting harvested quantities too late was subject to heavy fines. Since local authorities apparently did not include small property holders into their assessment of output and stocks even after 1791/92 (Grünebaum 2012, p. 16) recorded harvest quantities were probably somewhat below the actual level. Given the small share of farm units with less than five hectares in total farm land — about ten per cent in the middle of the nineteenth century (Table 6 above) — underestimation must have remained slight, however. Also note that before 1832 the recorded number of consumers underestimated actual population size by about nine percent (cf. note to Table 1). This speaks into the direction that the two measurement errors more or less cancelled each other out and that observed quantities of per capita output follow actual output quite well, at least from 1791/92 onwards. This assumption is validated by our later demonstration that during the early 1790s, when the Electorate of Saxony was by and large self-sufficient relative to grain, aggregate output per head was comparable to the level of per capita consumption of staple crops that conventional wisdom assumes to have prevailed in Germany around 1800 (section 7 below).

All field crops that could be used for human consumption in the broadest sense were covered by the harvest statistics. Apart from standard bread grains, namely, rye and wheat, these included types of grain that were at least partly used as animal feed. Specifically, the lists cover rye, wheat, barley, oats, peas, lentils, millet, buckwheat, vetches, maslin, and potatoes. For each crop the following information was collected: (1) the quantity of seeds sown at the beginning of the crop year ('*Betrag der beschehenen Aussaat'*); (2) the number of harvested sheaves ('*Anzahl sämtlicher zugewachsenen Schocken'*); (3) the amount obtained from threshing ('*Ertrag des Ausdrusches von den eingebrachten Schocken*'); and (4) the volume of existing stocks carried over from the previous year ('*Betrag der vorhandenen Vorräte*'). Except from variable (2) all information was given in *Dresdner Scheffel* (Dresden or Saxon bushel), which contains 103.821 metric litres. The crops covered by these output statistics presumably made up for more than 85% if not 90% of total crop production and possibly between two thirds and three quarters of entire farm output. Clover and turnips were the only important crops that were left out because they were exclusively used for feeding animals. They were certainly cultivated on less than 15% of the arable land. Industrial plants like flax and hemp did grow on roughly 2% at most of the crop area.[8] The first Saxon livestock census was carried out in 1834. Thus, for our period of observation no data on livestock exist.

Until 1812 output and population data was collected on the level of 14 larger administrative units and more than 130 smaller ones. The most important districts were the so-called seven *Kreise*. Together with the two margraviates *Ober*- and *Unterlausitz*

[8] According to the first continuous series on land use 13.8 per cent of Saxony's arable was cultivated with clover and turnips on average 1886–1895 (Kalender und Statistisches Jahrbuch 1888ff). Ernst Engel assumed for Saxony more or less the same use of the crop area like in Belgium. This would mean a share of industrial plants (flax, hamp etc.) in all arable land around 2.5% during the 1840s (Engel 1853, 277-283).

they comprised 96 per cent of Saxony's territory (Map 1, Table A1).[9] In 1792 the second administrative level consisted of more than 130 *Ämter* and five small principalities (Stams 2007, p. 23; Blaschke, Jäschke 2009). Crop data for 105 *Ämter* is available for the years 1792-1811, however with gaps. From 1815 onwards the drastically reduced territory of the Kingdom of Saxony included only four *Kreise* (*Vogtländischer Kreis*, *Erzgebirgischer Kreis*, *Leipziger Kreis*, *Meissner Kreis*) and the Margraviate *Oberlausitz* as the largest administrative units. The secondary administrative level consisted of eleven *Amtshauptmannschaften*, two *Ämter*, one unit which contained all *Bergämter* (local mining authorities), and two counties of the *Marggravate Oberlausitz* (map 1, Oettel 2006, p. 70). To the extent that we carry out a regionally disaggregated analysis we concentrate on the larger administrative districts, that is, the *Kreise*. Additionally, tables in the Appendix include information on administrative units not subdivided according the *Kreise-Ämter* principle during the era of the Electorate; for the post-1815 period Appendix tables include information on all administrative units of the secondary level.

To calculate total crop output and growth Saxon bushels were transformed into grain equivalents (GE; refer to Appendix for details). GE reflect the caloric value of all plants in relation to feed barley and thus provides a method to express physical output of different crops in a uniform scale. In the present context the use of this unit of measurement serves two purposes: First, the measurement of output in GE renders it possible to assess the capability of a given agricultural sector to ensure a certain caloric standard of the population. One unit GE, which corresponds to 100 kg of barley, is equivalent to 326,000 kcal.[10] Second, application of a unit of measurement other than weight or bushels is crucial to put potato output, which grew ever more massive in terms of physical weight as the nineteenth century progressed, in proper relationship with grain output: The caloric content of potatoes equals only 22 per cent of barley, or a fifth of rye.[11] This is very similar to the relative price of potatoes to rye (data as in Figure 1); however, we do not possess prices for potatoes before 1800. Therefore, we cannot give output at current prices, and grain equivalents constitute the only way to render output of different types of vegetable foodstuffs comparable.

[9] Stams presents all larger administrative units and their share in Saxony's territorry in 1792: *Thüringischer Kreis* (9.1%), *Kurkreis* (13.8%), *Leipziger Kreis* (9.2%), *Meißnischer Kreis* (17.8%), *Neustädter Kreis* (2.1%), *Vogtländischer Kreis* (3.7%), *Erzgebirgischer Kreis* (12.4%), *Niederlausitz* (12.6%), *Oberlausitz* (15.2%). The remaining territorries (the two cathedral chapters Merseburg and Naumburg, the shire Henneberg, the Ganerbschaft Treffurt including the bailiwick Dorla and the areas under direct jurisdiction of the local mining authorities) accounted for the remaining 4.1% (Stams 2007, p. 25).

[10] During the Second World War the unit grain equivalent was developed by the German agricultural economist Emil Woermann to measure simultaneously physical production of agriculture and food supply of the population (Finckenstein 1960, pp. 5-9, Schulze Mönking, Klapp 2010, pp. 7-9). Grain equivalents are used until today to calculate the level of an economy's self-sufficiency in food.

[11] Using grain equivalents instead of bushels significantly reduces the share of potatoes in Saxon crop production from a third to only a tenth around 1810 and from nearly a half to a fifth around 1830 (table 9, figure 4). Until now all the literature has referred to bushels to analyze the role of potatoes for Saxony's agriculture and food supply (Schirmer 1996, p. 51, Karlsch, Schäfer 2006, p. 24, Keller 2002 p. 187).

4. Growth and structural change of output

Table 8 presents levels and growth rates of major crops' output as well as of the aggregate crop production between key years. In addition, Table 9 gives the shares of major crops in total crop output. Figures 2, 3 and 4, respectively, show the trajectories of the output of major crops as well as of the aggregate crop production. The evolution of output structure over the period of observation is presented as well.

The results of a companion paper to this study that estimates total crop output with a consumption function suggests that output data before 1791/92 are either unreliable or not representative (Kopsidis, Pfister 2013). In 1755, 1772 and 1789/90 recorded output attains only 61, 87 and 93 per cent, respectively, of projected output; agricultural censuses obviously failed to keep track of actual production prior to 1791. Under-registration appears particularly severe in 1755, and we shall not use this census in our later analysis.[12] The census of 1772 fell in the concluding phase of the crisis period of 1770-1772, arguably the most serious subsistence crisis that hit Germany during the eighteenth century (Post 1990). As late as 1773 Saxony's population fell slightly, and the average crop year price of rye in Leipzig was 94 per cent higher in 1772 than on average during 1750/59 and 1773-1775. Thus, even if under-reporting was less severe in 1772 than in other years before 1791 output levels in that year are certainly not representative of long-term developments in agricultural output. On this background we do not interpret changes in aggregate levels before 1791. Nevertheless, since there is no reason to suspect that under-reporting was grossly selective we interpret differences in growth rates between individual crops and regions 1772-1791/93 as evidence of structural change.

The following three findings concerning aggregate growth of crop output and its structural change over time emerge from Tables 8 and 9 and Figures 2 to 4:

First, the war period that lasted from 1792 to 1815 was characterized by stagnation and eventual decline of aggregate crop output. From 1791 to 1805 aggregate crop output expanded at a slow rate of 0.4 per cent p. a., which was much less than the rate of increase of population (0.6 per cent p. a.). In the seven years after 1803/05, when Saxony became involved into the Napoleonic Wars by being forced to support Napoleon's war effort with troops and provisions and by becoming itself a theatre of war, net crop production contracted at an annual rate of -2.2 per cent, and population growth virtually came to a standstill. To the extent that the disruption of trade during the war period prevented the compensation of domestic shortfalls by imports the nutritional standard of the population at large must have deteriorated considerably during the quarter of century starting in 1790.

[12] That the collected data severely underestimated real harvests was already noted by the contemporary state bureaucracy (HStA Dresden, 10026 Geheimes Kabinett, Ernte- und Konsumentenverzeichnisse Loc. 561/1, pp. 27-29).

Table 8: Output quantities (in million grain equivalents) and growth of total gross crop production, 1772-1812 and 1815-1830

	1772	1791/93	1803/05	1810/12	1815/17	1818/20	1828/30
Rye	2.65	3.84	3.37	3.07	1.01	1.34	1.36
Wheat	0.50	0.67	0.59	0.54	0.16	0.21	0.26
Barley	1.17	1.45	1.55	1.25	0.50	0.55	0.54
Oats	1.16	1.46	1.72	1.46	0.68	0.73	0.88
Potatoes	0.25	0.47	0.75	0.82	0.40	0.58	0.79
Other	0.35	0.45	0.57	0.47	0.17	0.19	0.23
Total[#]	6.07	8.34	8.54	7.62	2.91	3.60	4.07

Exponential trend growth rates for selected periods

	1772-1791/93*	1791-1805	1805-1812	1818-1830	1815/17 - 1818/20*
Rye	1.9%	-0.9%	-2.2%	-0.1%	9.9%
Wheat	1.5%	-0.7%	-4.5%	2.4%	10.6%
Barley	1.1%	0.5%	-3.4%	0.3%	3.0%
Oats	1.2%	1.4%	-1.7%	2.2%	2.6%
Potatoes	3.3%	4.1%	0.6%	2.5%	13.7%
Other	1.3%	2.0%	-2.1%	2.2%	3.3%
- pulses[+]	*1.0%*	*3.6%*	*-3.6%*	*3.1%*	*1.4%*
Total[#]	1.6%	0.4%	-2.2%	1.2%	7.3%
Pop.**	0.7%	0.6%	0.4%	1.2%	1.1%

Source: Own calculation; for data sources see Appendix.

Note: The category "Other" refers to peas, lentils, millet, buckwheat, vetches, and maslin; += pulses refer only to peas, lentils, and vetches; * exponential growth rate between key years; # = aggregate crop output; ** = population.

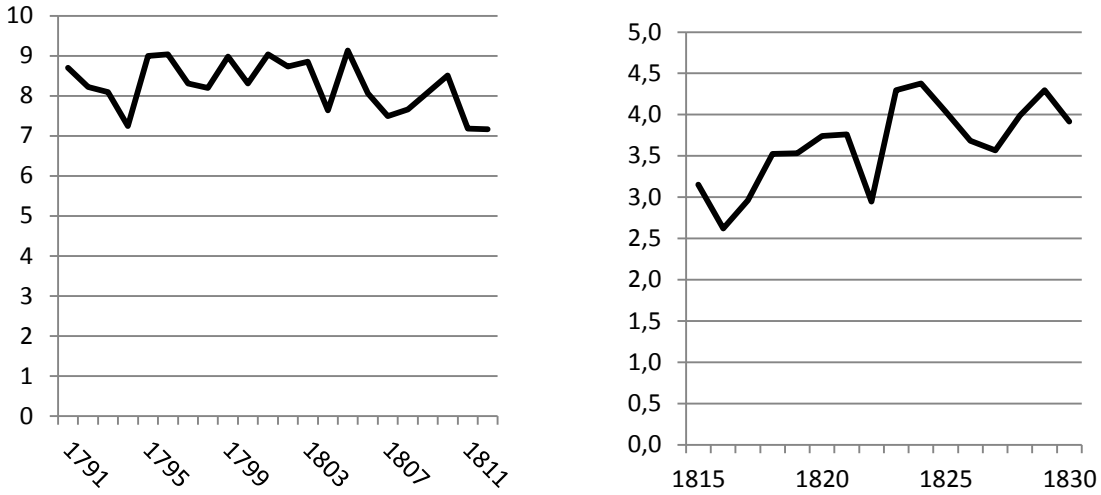
Table 9: Shares of major crops in total gross crop output in per cent, 1791-1812 and 1815-1830

	1772	1791/93	1803/05	1810/12	1815/17	1818/20	1828/30
Rye	44	46	39	40	35	37	34
Wheat	8	8	7	7	5	6	6
Barley	19	17	18	16	17	15	13
Oats	19	18	20	19	23	20	22
Potatoes	4	6	9	11	14	16	19
Other	6	5	7	6	6	5	6

Source: Own calculation; for data sources see Appendix.

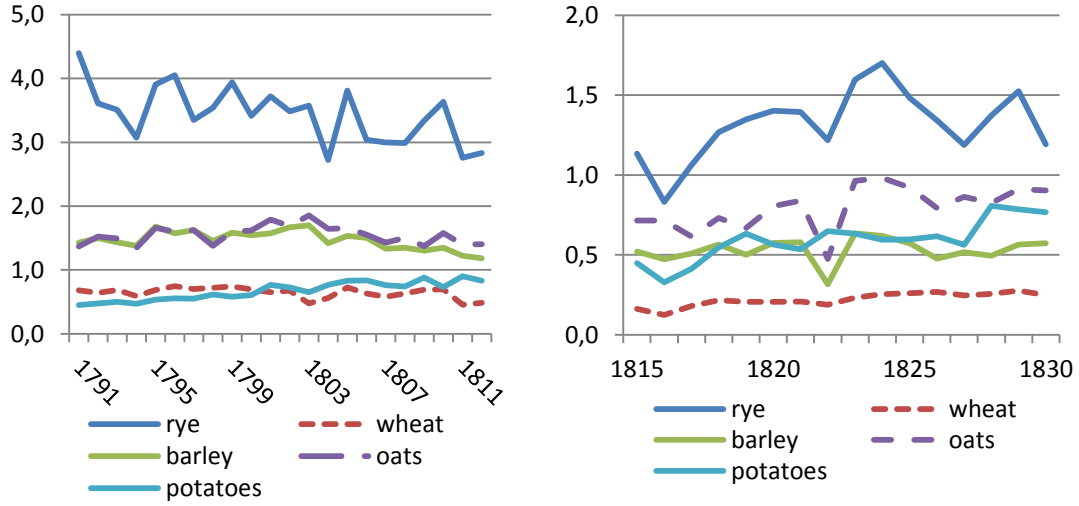
Note: 'Other' refers to peas, lentils, millet, buckwheat, vetches, and maslin.

Figure 3: Total gross crop production in Saxony, 1791-1812 and 1815-1830 (million grain equivalents)



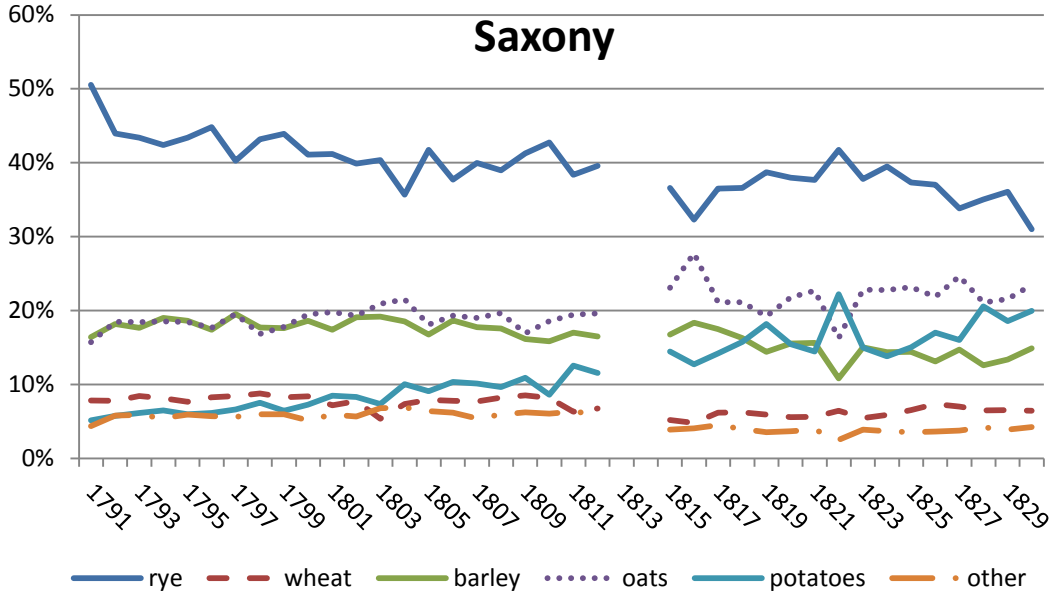
Source: Own calculation; for data sources see Appendix.

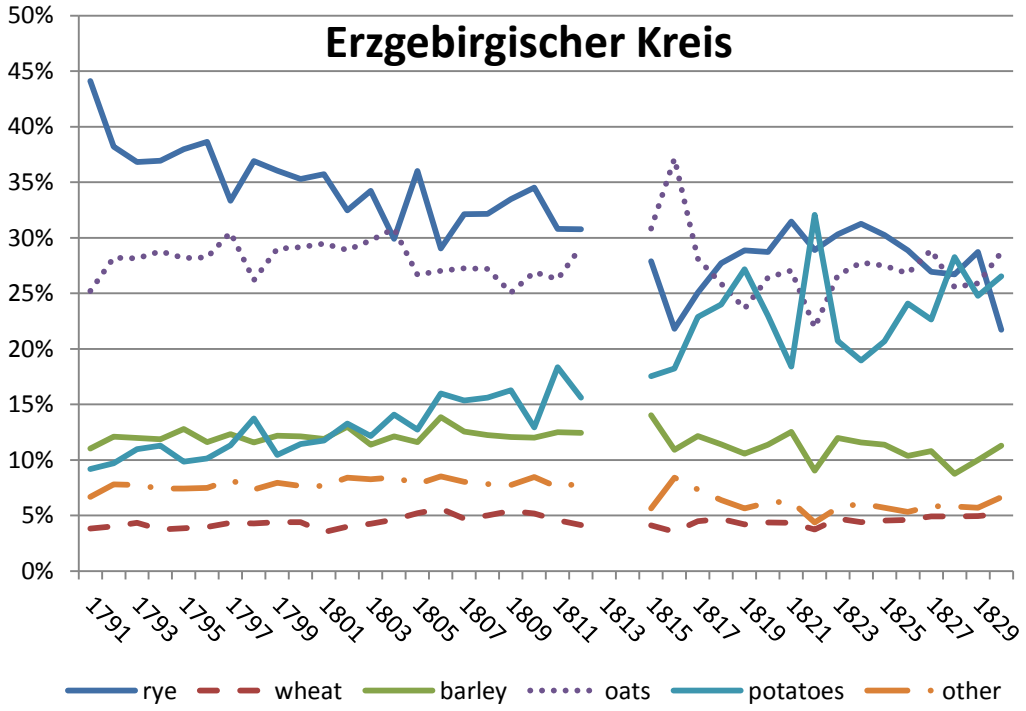
Figure 4: Output of major crops, 1791-1830 (in million grain equivalents)

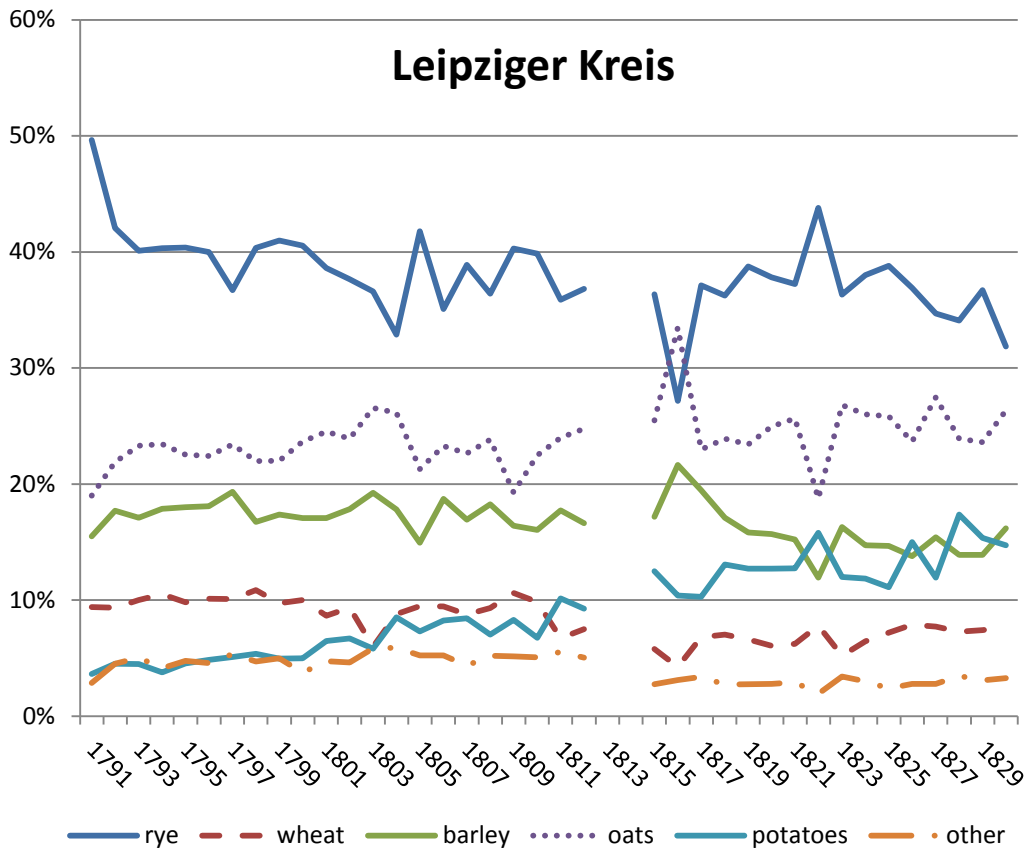


Source: Own calculation; for data sources see Appendix.

Figure 5: Structure of total gross crop production for Saxony, the *Erzgebirger Kreis,* and the *Leipziger Kreis*, 1791-1830 (shares in per cent)







Source: Own calculation; for data sources see Appendix.
Note: 'Other' refers to peas, lentils, millet, buckwheat, vetches, and maslin.

There exist several potential explanations for the wartime stagnation and decline of crop output. On the one hand, the decline of exports resulting from the disruption of international trade reduced domestic income and, hence, food demand. On the other hand, the contribution of men and provisions (particularly to the extent that these included meat) to Napoleon's war efforts may have reduced inputs of labour, manure and draught animals. In later sections we shall attempt to sort out evidence confirming or invalidating these explanations.

Second, the period after 1815 was characterized by strong output fluctuations during the initial years followed by a more steady development later on. During the period 1818-1830 the exponential trend growth rate of total crop output was 1.15 per cent p. a., which fell slightly short of population growth (1.22 per cent p. a.). This is a first major result of the present investigation: Even during the absence of major shocks crop output in Saxony barely kept up with population growth. Yet, substantial growth did occur. That it took place with largely given land resources and on the background of a declining share of agriculture in the total labour force (Table 2 above) implies technological progress and an intensification of arable farming.

Aggregate output grew at an annual rate of 7.3 per cent on average between 1815/17 and 1818/20; at the same time 1816 marked the low point of the post-war period. Three shocks acted on the agricultural sector in the years 1815-1818, namely,

adverse climate following the outbreak of the Tambora volcano, post-war reconstruction and a strong rise of wage incomes. In 1816 temperatures were abnormally low in the winter months but not much below the average long-term level during spring and summer (data from Luterbacher et al. 2004; see Post 1977 for an analysis of the 1816/17 crisis). Thus winter crops — rye and wheat — were more severely affected by adverse climate than summer crops, namely, barley and oats. This explains the opposed direction of the short-term fluctuations of bread and feed grains in 1816 (Figure 4) as well as a part of the particularly strong recovery of rye and wheat output compared to barley and oats between 1815/17 and 1818/20 (Table 8).

Recovery of output in 1818/20 was also aided by post-war reconstruction. To the extent that the war had diverted labour and animals from agriculture, peace enabled the recovery of man-land and capital-land ratios, which in turn benefitted output levels. The positive income shock occurring at the end of the 1810s may also have played a part in output growth between 1815/17 and 1818/20 as it improved household's purchasing power. Modest output growth relative to population growth after 1818 suggests, however, that this positive income shock did not extend beyond the late 1810s.

Third, there occurred significant changes in the structure of crop output over time.[13] Major structural changes were the above average growth and increasing weight in total crop production of wheat, potatoes and oats. Conversely, output of rye and barley grew slower than average, and their weight in total output decreased over time. This trend was blurred by war effects and other shocks until the end of the 1810s but particularly marked in the subsequent years 1818-1830. Only potatoes and oats showed output growth above average in all three sub-periods 1791-1805, 1805-1812 and 1818-1830 (Table 8).

Barley constituted a tradable good like wheat and rye and entered human consumption primarily in the form of beer. The decline of its weight in total crop output is consistent with the fall of the real price of beer since this reduced the incentive to cultivate barley.

Wheat output behaved slightly better than rye during the war period and grew almost as fast as potato production after 1815.[14] Nevertheless, absolute output levels of wheat remained low in comparison with the other crops even as late as 1828/30 (Figure 3). In 1790-1830 wheat was on average 30 to 40 per cent more expensive than rye, depending on the source for prices (for sources see Figure 1). Thus, wheat must have been consumed primarily by the prosperous segments of society. Its low share in total crop output in 1828/30 of 6% thus points to the absence of mass demand for

[13] Only the share of crops subsumed under the heading "Other", which comprises peas, lentils, millet, buckwheat, vetches, and maslin, did hardly change. This category contributed a largely stable share of about six per cent to total crop output over the whole period of observation. However, because of the small magnitude of this share and because of the heterogeneity of the category we shall not consider it in the subsequent analysis.

[14] Exponential growth rates over the entire war period 1791-1812 were -1.2% for rye and -1.0% for wheat (own calculation, for data sources see Appendix).

traded grain. At the same time, the vigorous growth of wheat output is consistent with the notion of increasing income inequality during early industrialization.

Potato output increased faster than the production of any other crop for all sub-periods considered. Accordingly, the share of potatoes in total crop output grew from 4 per cent in 1772 to 11 per cent in 1810/12 and from 14 per cent in 1815/17 to 19 per cent in 1828/30 (Table 9 and Figure 4). The growing weight of potato production in total output confirms conventional wisdom that considers this crop as the single most important land saving agricultural innovation of the eighteenth and early nineteenth centuries. Comparing the provinces *Erzgebirgischer Kreis* in the uplands and *Leipziger Kreis* in the Central German lowlands, whose borders remained more or less stable over the entire observation period, reveals that the share of potatoes in total crop production was significantly higher in densely populated industrial districts in the less fertile uplands (Figure 4).

Throughout the time of unrest 1791-1812 oats production was less affected by war, and in 1818-1830 its production grew faster than output of rye and barley. Like barley, oats was primarily used as a feed grain, but was consumed as well especially by the poor rural classes as gruel (Kopsidis 2013). According to calculations of the famous mathematician Gauss the average annual oats consumption of Prussia's rural population in 1831-1853 was ten times higher than of the urban ones (0.3 bushels compared to 0.03 bushels or 8.4 kg versus 0.8 kg; Bittermann 1956, p. 76, Meitzen 1871, p. 388). According to Gauss's figures about 8 per cent of Prussia's oats net production served human consumption (own calculation, figures from Meitzen 1871, p. 386). However, considering the lower real incomes before 1830 the share of oats used for human consumption very likely was higher in Saxony. In contrast to the other three major grains oats was tradable only to a limited extent at best. During the period 1790-1820 its price was half of the price of rye (data as in Figure 1), but transport costs per ton-kilometre were the same. The few data on trade flows available, like for instance the foreign grain trade statistics for 1792, demonstrate accordingly that oats was the least traded grain (Schröter 1912, p. 10; Schirmer 2000, pp. 135-136). In addition, due to its low nutrition requirements oats was a robust grain growing well on less fertile soils in the uplands.

Taken together, the growing importance of potatoes and oats in total crop output implies that a substantial part of agricultural growth during the period of observation occurred in the form of increased production of subsistence rather than market crops. We interpret this as a demand effect, specifically, as the reflection of a fall in household incomes per capita, particularly in the case of oats: Faltering per capita incomes forced households to reduce consumption of high value added foodstuffs like meat and dairy products as well as beer. In contrast, consumption of staple foods that were cheaper than bread, namely, potatoes and, possibly, mush from oats, expanded.

A final aspect of structural change relates to differences between Saxony in the borders before and after 1815 with respect to output structure. In comparison with the former territory the much smaller one created in 1815 showed higher output

shares of potatoes and oats and lower shares of rye and wheat (Table 9, Figure 4). Since the distribution of soil qualities varied little between the two different territories of Saxony, differences in natural resource endowment cannot account for the change in output structure.[15] Below we shall demonstrate that the expansion of subsistence crop cultivation — that is, of potatoes and oats — took place primarily in industrial areas characterized by high population densities. Hence, differences in output structure between 'greater' and 'smaller' Saxony primarily reflect the fact that all densely populated industrial regions laid in the smaller post-1815 Saxon territory.

5. Sources of output growth: Seed quantities and yield ratios

In this section we explore sources of output growth by analysing information on seed quantities and output for the main sorts of grain, namely, rye, wheat, barley and oats. Under the condition of stable seed densities the total amount of seed gives a rough indication of the area sown and its change over time. However, according to information relating to four model estates belonging to the crown (*Kammergüter*) seeding densities started to decrease significantly after 1800 to reach low modern levels already by the middle of the nineteenth century (Herz 1964, pp. 75-76). However, certainly in the uplands (Herz 1964, p. 79) and very likely on most of the peasant farms if not on the majority of large estates seeding densities remained unchanged on high levels during the entire period under consideration. Otherwise it could not be explained that on average Saxon yield ratios stayed at best constant c. 1790-1830 whereas they immediately jumped up on the four model estates after seeding densities were reduced. In fact, the agricultural geographer Herz assumes for nineteenth century Saxony that in a first phase yield ratios only increased due to falling seeding densities.

In addition, output to seed ratios, or yield ratios in short, provide a measure of soil productivity that is widely employed to assess the level and change of productivity in pre-modern agriculture. We begin by presenting findings on yield ratios and continue with a discussion of changes in seed quantities. Finally, the combination of the two variables allows identifying sources of output growth. To prepare the subsequent analysis of regional differences in agricultural development we also present the data in regionally disaggregated form comparing the highly fertile *Leipziger Kreis* in the plains and the industrial and densely populated less fertile upland area *Erzgebirger Kreis*. Table 10 shows yield ratios for the main grains in selected years. Note that yields in 1772 and 1815/17 were affected by major subsistence crises whereas the values in 1828/30 are influenced by the harvest failure in 1830/31.

[15] Saxony lost 60% of its territory in 1815. However, Saxony not only lost large fertile areas at the border to Thuringia and in the North but as well the most part of the sizeable territories Oberlausitz and Unterlausitz with mainly poor soils (map 1). Even after 1815 the Saxon rump state contained large areas of very fertile land around Leipzig and Dresden. Thus, average soil quality does not seem to have differed significantly between the respective territories of Saxony before and after 1815.

Growth of yield ratios between 1772 and 1791/93 will not be considered due to the fact that the extremely low level of 1772 would lead to an overestimation of growth. According to the literature the three years-average 1791/93 represents normal harvest years at the end of an agricultural boom period. 1803/05 stands for the last peace years. Conditions for farming had started to deteriorate during the 1790s but the situation significantly aggravated after 1805. The years of 1810/12 constitute the end of the difficult "French period". Saxony's agriculture reached its secular nadir in 1816 due to a catastrophic crop failure which was an exogenous shock resulting out of a natural disaster – a volcano eruption in Indonesia. In order not to overestimate the long-term dynamics of post-war agricultural growth the analysis focuses on the period 1818/20-1828/1830.

Table 10: Yield ratios in Saxony, 1791-1830

	1772	1791/93	1803/05	1810/12	1815/17	1818/20	1828/30
rye	3.43	4.42	3.87	3.73	2.95	3.75	3.70
wheat	4.93	5.86	4.86	4.65	4.03	5.00	5.35
barley	4.11	4.94	5.30	4.75	3.96	4.32	4.56
oats	3.28	4.49	4.97	4.40	3.59	3.82	4.21
Indices (1791/93 = 100)							
rye	78	100	88	84	67	85	84
wheat	84	100	83	79	69	85	91
barley	83	100	107	96	80	87	92
oats	73	100	111	98	80	85	94

Exponential trend growth rates for selected periods (Saxony)

	1791-1805	1805-1812	1791-1812	1815/17-1818/20*	1815-1830	1818-1830
rye	-0.9%	-1.9%	-0.9%	8.3%	1.2%	-0.4%
wheat	-1.1%	-3.8%	-1.1%	7.4%	2.0%	0.9%
barley	0.6%	-1.6%	-0.4%	2.9%	1.0%	0.9%
oats	0.9%	-0.9%	-0.2%	2.1%	1.3%	1.4%

Exponential trend growth rates for selected periods (*Leipziger Kreis* and *Erzgebirger Kreis*)

	1791-1812 ERZ	1791-1812 LEI	1818-1830 ERZ	1818-1830 LEI
rye	-1.2%	-1.0%	-1.0%	-0.3%
wheat	-0.6%	-1.2%	0.5%	0.9%
barley	-0.3%	0.1%	1.0%	0.9%
oats	-0.3%	-0.2%	1.4%	0.8%

Source: Own calculation; for data sources see Appendix.
Notes: *exponential growth rate between key years. ERZ = Erzgebirger Kreis, LEI = Leipziger Kreis.

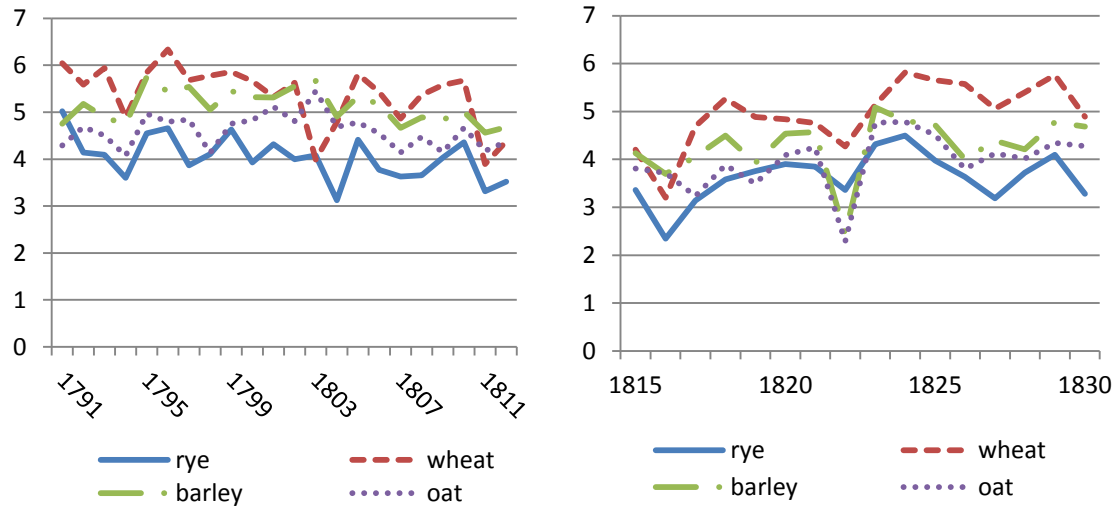
In 1791/93 aggregate yield ratios in Saxony ranged between 4.5 and 6 (Table 10, Figure 5). This corresponded to levels found elsewhere in Central Europe (Kopsidis 2006a, 2006b; van Zanden 1999, p. 361). Over the following two decades output to seed ratios for rye and wheat decreased with an exponential trend growth rate of about -1 per cent p. a., whereas those of barley and oats only fell marginally. Indeed, until 1803/05 yield ratios of these two grains actually increased, namely, by 7 per cent

in the case of barley and 11 per cent in the case of oats. Only as Saxony became a theatre of war after 1805 yields of barley and oats joined the downward movement of rye and wheat.

The general fall of yield ratios 1803/05-1810/12 implies that at least a part of the output decline during these years can be interpreted as the result of an involuntary reduction of critical inputs other than land, such as labour, manure and drought animals. Men, food (particular meat) and horses drained out of agriculture to provide Napoleon's war machine.

Divergence of yield ratios between bread grain on the one hand and barley as well as oats on the other hand, at least until 1803/05, may be tentatively related to falling industrial wages in Saxony's rurally based large export-oriented textile industries given the war-related disruption of world trade. Indeed, barley and oats were used for both, fodder and human consumption. Especially oatmeal gruel was used by poor rural classes as a cheap substitute for more expensive bread grain, which needed expensive energy to be baked. Thus, it appears that due to faltering demand farmers shifted inputs from cash crops to subsistence crops. This seemed to be all the more true as the rising (rural) population had to be fed solely out of domestic resources until 1815.

Figure 6: Yield ratios in Saxony, 1791-1830



Source: Own calculation; for data sources see Appendix.

In the one-and-a-half decade after 1815 yield ratios grew vigorously at annual rates between one and two per cent (Table 10, Figure 5). Aggregate increase was greater for bread grain (25 per cent in the case of rye and 32 per cent for wheat) than for barley and oats (15 and 18 per cent, respectively), which suggests a reversion of the input shift towards inferior grains as prevailed during the first part of the war period 1791/93-1803/05. However, the post-war improvement of bread grains' yield ratios started from a level even below the depressed standard prevailing in 1772. In part this can be attributed to the fact that winter grain was affected more severely by short-term adverse climatic conditions in 1816 than spring grain (see above). Moreover, in the case of rye all of the post-war yield recovery was actually completed in 1818; in

1818-1830 the yield ratio moved by and large flat (exponential trend of -0.4 per cent p. a.). Post-war reconstruction and the outward shift of demand resulting from the positive income shock of the second half of the 1810s noted in section 2 contributed to a quick recovery of rye yields. Afterwards, no sustained productivity growth can be observed for the most important bread grain rye. By contrast, the yield ratio of wheat continued to grow 1818-1830 at a rate of 0.9 per cent p. a., which corresponds to the growth rate of barley. Oats even achieved 1.4 per cent p.a. Notably, the most expensive and the cheapest grain – wheat and oats – experienced the strongest yield increases after 1815 (Table 5). Later in this section we will develop an explanation of the contrasting behaviour of different grains.

Table 10 and Figure 5 suggest that despite vigorous productivity growth after 1815 yield ratios had not returned to their pre-war levels of 1791/93 even by the late 1820. The picture may be blurred by the massive changes of territorial boundaries occurring in 1815. For this reason Figure 6 compares two large administrative districts whose boundaries remained by and large stable over time and which were characterized by contrasting natural and economic settings, namely, the *Leipziger Kreis* and the *Erzgebirge*.

Regional disaggregation confirms the impression of a rather sluggish trajectory of rye yields (Table 11, Figure 6): By the end of the 1820s yield ratios of rye had only reached the level prevailing around 1800 in both regions, and even for the bumper harvests of 1824/25 yields failed to surpass those recorded in favourable years during the 1790s. Yield ratios for wheat, barley and oats performed better. By the late 1820s they had reached the level prevailing during the early 1790s. Again, we defer the explanation of the behaviour of rye to a later part of this section.

Together with information for 1772 and for other administrative units (Table 11, Appendix Tables A.13-16, Figures 1a-b) Figure 6 also suggests that yield differentials between macro-regions, namely the two regions (1) 'less fertile industrial uplands' and (2) 'fertile plains' (see food note 20), remained stable over the late eighteenth and early nineteenth centuries even if growth rates of yield ratios varied considerably between individual administrative districts within this two macro-regions. In 1791/93-1810/12 the leading agrarian regions, namely, *Thüringer Kreis*, *Leipziger Kreis*, *Stift Merseburg* and *Stift Naumburg*, ('fertile plains') showed yield ratios that were up to two thirds higher than the Saxon average. By contrast, grain yields in less fertile regions such as the *Vogtländischer Kreis* ('uplands') but the *Niederlausitz* as well ranged between one quarter and one third below average. Within the reduced Kingdom of Saxony regional yields still ranged between 60 and 140 per cent of the aggregate average in 1815/17 and 1828/30.

Table 11: Exponential trend growth rates of yield ratios for selected regions, 1791-1830 (in per cent)

	Rye	wheat	barley	oats
1791-1812				
Chur Kreis	-1.4	-1.5	-0.8	-0.6
Thüringischer Kreis	-0.7	-1.2	-0.7	0.0
Meißnischer Kreis	-0.8	-0.7	-0.1	0.1
Leipziger Kreis	-1.0	-1.2	0.1	-0.2
Erzgebirgischer Kreis	-1.2	-0.6	-0.3	-0.3
Oberlausitz	-0.7	-0.4	0.6	0.4
Saxony	*-0.9*	*-1.1*	*-0.4*	*-0.2*
1818-1830				
Meissner Kreis	-0.2	1.3	1.5	2.2
Erzgebirger Kreis	-0.3	0.9	0.9	0.8
Leipziger Kreis	-1.0	0.6	1.0	1.4
Vogtländer Kreis	-0.6	0.0	-0.9	-0.7
Oberlausitz	-0.4	0.7	0.9	1.6
Saxony	*-0.4*	*0.9*	*0.9*	*1.4*

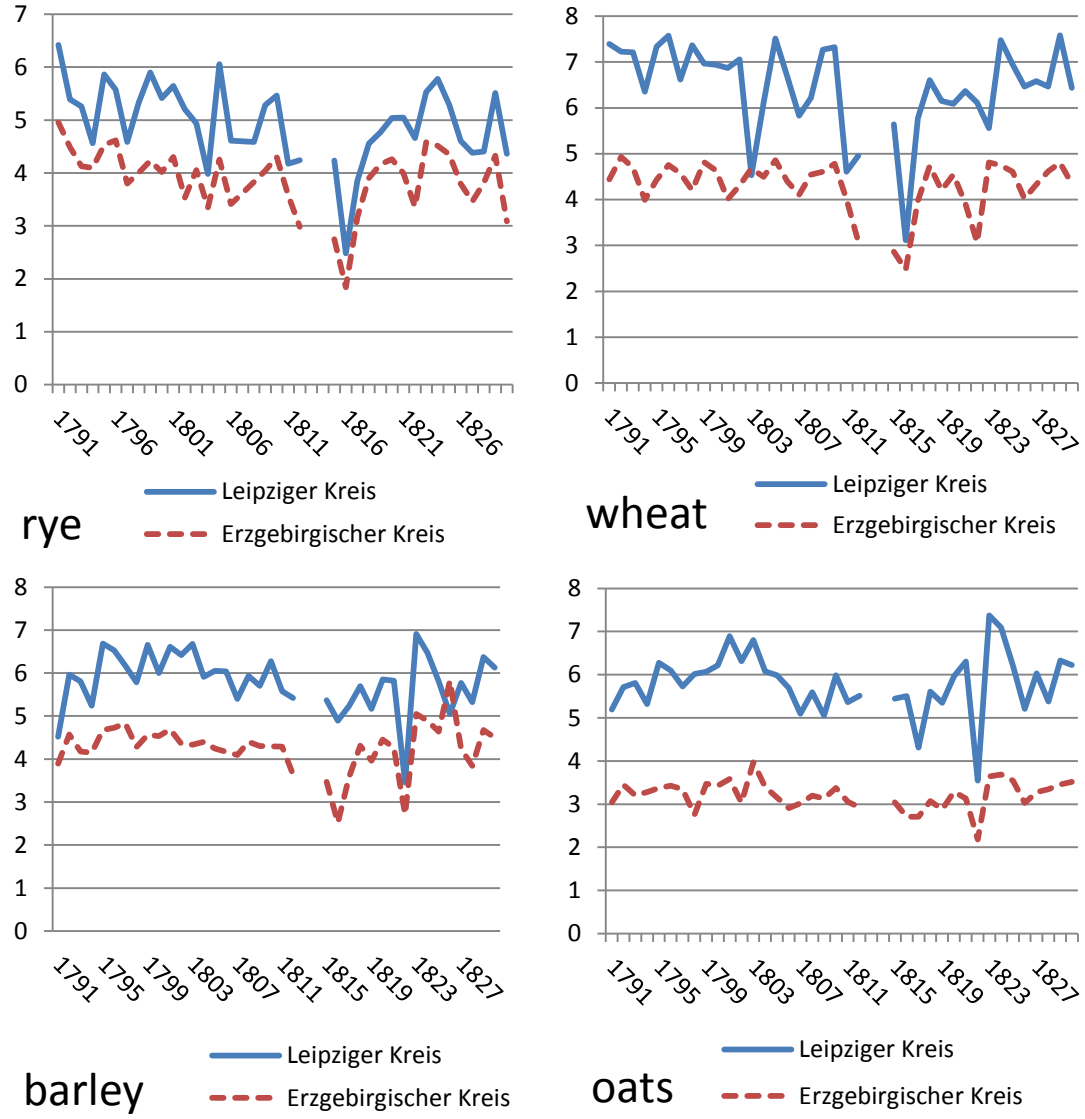
Source: Own calculation; for data sources see Appendix.

The stability of regional differences of yield ratios indicates the absence of ongoing processes of market-related spatial specialization during the period of observation. If it were otherwise we would find evidence of efforts to increase yields in naturally advantaged regions, which had the highest potential to increase output by introducing new farming techniques.

The rather unspectacular behaviour of yield ratios in Saxony has to be weighed up against evidence concerning the area sown; if the latter expanded even the maintenance of stable yield ratios implies an outward shift of the production function as a consequence of technological change.[16] To shed light on this issue Tables 12 and 13 present information on the rate of change of seed quantities between key years. Seed quantities serve as a rough indicator of the area sown. Since expansion of the arable area through land reclamation and drainage played only a minor role during the period under consideration (Herz 1964, pp. 23, 34), the expansion of seed quantities indicates primarily the extent to which the share of fallow land in the total arable land was reduced as a consequence of the introduction of new agricultural techniques and farming systems.

[16] A Ricardian extensive margin – defined as augmentation of the cultivated area without technical change – implies necessarily decreasing yields per unit land. An extension of the arable land without falling yields means that technical change at least is able to compensate for the yield-depressing effects of diminishing marginal returns inevitably connected with the extensive (and intensive) margin.

Figure 7: Yield ratios in two contrasting regions: *Leipziger Kreis* and *Erzgebirge*



Source: Own calculation; for data sources see Appendix.

In general, the intensification of arable farming by reducing fallow land rested on improved manuring rendered possible by stable feeding and the cultivation of nitrogen-fixing crops, most notably clover. However, the only fallow-reducing innovation our data reflects is the diffusion of pulses, namely, peas, vetches and lentils, which are nitrogen-fixing crops. Indeed, of all crops pulses showed the by far most dynamic growth 1791-1805 (except potatoes) and 1818-1830 (Table 8). By contrast, during periods of agricultural crisis 1805-1812 and 1815-1817 their production developed below average. Interestingly, during the early period 1772-1792 pulses showed the slowest growth of all crops. All in all this speaks into the direction that the diffusion of fallow-reducing farming systems accelerated at the end of the eighteenth century until Saxony entered the war in 1806. Afterwards the drain of resources out of agriculture to feed Napoleon's war machine seemed to have blocked any further agricultural intensification. After 1817/1818 fallow-reduction continued at high speed.

During the years 1791-1805 the total of all seed quantities expanded at 0.5 per cent p. a., suggesting a slight increase of the area sown (Figure 7, Table 12a-b). However, individual grains show variable growth patterns. Seed quantities of rye and barley remained stable whereas those of wheat and oats — the distinct 'upper class' and the 'lower class' staple grains — increased annually by 0.4 and 0.5 per cent, respectively. With the exception of some minor administrative units this conclusion also holds in a regionally disaggregated perspective. After 1805 seed quantities of all grains slumped down immediately. The decline continued at a slower pace 1806-1811 to aggravate significantly in 1812 (Table 12a-b, Figure 7). Indeed, on February 15 in 1812 Saxony's army was fully mobilized to participate in Napoleon's campaign against Russia, which implied a massive withdrawal of labour and other resources from agriculture. All these facts strongly speak in favour that war- and armament-related productivity declines in farming resulting from involuntary reductions in inputs other than land, namely, labour, manure and draught animals, constituted the most proximate explanation of aggregate output decline, at least after 1805.

By contrast, even after the completion of post-war reconstruction seed quantities expanded during the period 1818/20 - 1828/30 with annual rates between 0.3 per cent (rye) and 1.5 per cent (wheat). Only the quantity of barley seed shrank by -0.6 per cent p. a. (Table 13a-b, Figure 7). Again seed quantities of wheat and oats showed the most dynamic growth. Overall, this finding points to a reduction of the area left fallow in the total arable land and, hence, to an intensification of farming. Seen in this perspective, the unspectacular development of the yield ratios noted above appears in a somewhat different light: that regional yield ratios of wheat, oats and barley ranged on the same level in the second half of the 1820s as during the early 1790s (Table A.13, Figure 6 above) means that Saxon peasants succeeded in expanding the sown area without suffering a decline in land productivity. This implies the introduction of productivity enhancing new farming techniques. However, in contrast to Westphalia after 1840 agricultural technical change in pre-1830 Saxony was at best only able to compensate for diminishing marginal returns of intensified land use.

The detailed analysis of the development of soil fertility in Central Saxony during the eighteenth and nineteenth centuries by Herz (1964) contributes to explain the sluggish pace of productivity growth. According to Herz until c. 1830 only single elements of new farming systems were introduced into traditional farming systems. Yields only started to increase continuously after the mid-nineteenth century as a long trial and error process ended and comprehensive new farming systems fully adjusted to Saxon conditions were implemented. Only the complete implementation of new farming systems allowed reducing fallow and raising yields simultaneously. On the background of the Prussian experience after 1840 (Kopsidis, Hockmann 2010, Kopsidis, Wolf 2012) we add the point that only the rise of real wages after 1855 and the demand for meat and dairy products that followed made the introduction of productivity-enhancing mixed farming the first time profitable in Saxony.

Table 12a: Rate of change of seed quantities for selected regions, 1791/93-1810/12 (per cent, annual growth rate)

	1791/93-1803/05	1803/05-1810/12	1791/93-1803/05	1803/05-1810/12
	Rye		wheat	
Chur Kreis	0.4	-1.6	1.1	-2.4
Thüringischer Kreis	0.1	-1.5	0.4	-1.4
Meißnischer Kreis	0.0	-0.3	0.8	0.0
Leipziger Kreis	0.1	-0.2	0.4	-0.4
Erzgebirgischer Kreis	0.1	-0.5	1.5	1.4
Vogtländischer Kreis	-0.2	-0.1	-1.2	2.2
Mg. Oberlausitz	-0.2	-1.1	-0.5	2.2
Mg. Niederlausitz	0.1	-2.8	-0.7	-2.9
Saxony	*0.0*	*-1.0*	*0.4*	*-0.5*
	Barley		Oats	
Chur Kreis	-0.1	-3.8	1.5	-1.3
Thüringischer Kreis	0.6	-3.3	-0.1	-1.3
Meißnischer Kreis	0.0	-0.5	1.3	-0.1
Leipziger Kreis	-0.7	-0.7	0.5	-0.3
Erzgebirgischer Kreis	0.1	0.7	0.2	-0.2
Vogtländischer Kreis	0.1	-0.7	0.1	0.1
Mg. Oberlausitz	-0.4	-0.9	0.9	-1.1
Mg. Niederlausitz	-0.6	-4.0	1.0	-2.9
Saxony	*-0.1*	*-1.5*	*0.5*	*-0.6*

Source: Own calculation; for data sources see Appendix.

Table 12b: Rate of change of seed quantities of all four main grains in total, 1791-1812 (annual exponential trend rates)

	1791-1805	1805-1812
Chur Kreis	+0.6	-1.3
Thüringischer Kreis	+0.2	-2.2
Meißnischer Kreis	+0.4	-0.3
Leipziger Kreis	+0.1	-0.4
Erzgebirgischer Kreis	+0.3	-0.1
Vogtländischer Kreis	+0.0	+0.0
Mg. Oberlausitz	+0.0	-0.7
Mg. Niederlausitz	+0.1	-3.5
Saxony	*+0.2*	*-0.9*

Source: Own calculation; for data sources see Appendix.

Table 12c: Rate of change of seed quantities for selected regions, 1815/17-1828/30 (per cent, exponential growth rates between key years, per cent)

	rye		wheat		barley		Oats	
	1815/17-1818/20	1818/20-1828/30	1815/17-1818/20	1818/20-1828/30	1815/17-1818/20	1818/20-1828/30	1815/17-1818/20	1818/20-1828/30
Meissner Kreis	3.2	-0.1	5.3	0.5	2.9	-0.9	3.1	0.5
Erzgebirger Kr.	-3.4	2.2	-2.0	3.3	-5.0	0.9	-1.8	1.6
Leipziger Kreis	0.1	0.2	2.9	1.5	-1.5	-0.6	-0.4	0.7
Vogtländer Kr.	0.5	0.2	5.0	1.5	0.1	-0.3	1.1	0.3
Oberlausitz	2.4	0.0	1.9	1.7	-0.4	-1.1	-0.9	0.9
Saxony	1.4	0.3	2.9	1.5	0.1	-0.6	0.1	0.9

Source: Own calculation; for data sources see Appendix.

Table 13: Rate of change of seed quantities for all four main grains in total, 1818-1830 (annual exponential trend rates, per cent)

	1818-1830
Meissner Kreis	+0.0
Erzgebirger Kreis	+1.6
Leipziger Kreis	+0.3
Vogtländer Kreis	+0.2
Oberlausitz	+0.2
Saxony	*+0.4*

Source: Own calculation; for data sources see Appendix.

Figure 8: Seed quantities of all grains for Saxony, 1791-1830 (million Saxon bushels)

Source: Own calculation; for data sources see Appendix.

Different growth rates of both output and seed quantities among the four grains and potatoes indicate processes of substitution. This is especially true for the first period 1791-1812 without any noteworthy net foreign trade in food. Until 1805 the tremendous losses of rye output (-455,942 grain equivalents) were only replaced halfway through potatoes (+229,976 GE). The combined losses of wheat and rye (-539,956 GE) could only be absorbed by the combined increase of barley (+97,909 GE), potatoes,

and above all oats (+240,032 GE). That the still meagre food ratios around 1790 did not fell stronger until 1805 was nearly exclusively prevented by the combined expansion of the two cheapest staple crops, potatoes and oats, that were both essentially non-tradables (see section 7). Whereas total production of all four main grains and potatoes increased by minor 27,962 GE to 6.26 mio GE in 1803/05 it slumped to 5.70 million GE until 1809/1811 (-561,983 GE) indicating an extremely critical food situation for 1805-1812. Interestingly, only the output of the most expensive staple grain, namely, wheat increased during the crisis period after 1805 (+28,680 GE, own calculation, for data sources see appendix).

Concurrently to output, a divergent development of the cultivated area of rye on the one hand and oats on the other hand, which actually is visible from the end of the eighteenth century onwards, is consistent with our general thesis that faltering household incomes not only led to expansion of potato cultivation but also to the redirection of growing quantities of feed grain — namely oats — to human consumption, at least until c. 1805 (Table 12). Additionally, over the entire period 1790-1830 the much stronger growth of wheat seed quantities relative to barley and rye suggests that a switch occurred on good soils from barley and rye to wheat cultivation. Indeed, mainly barley and wheat competed for scarce soils of superior quality.[17] Due to the fact that barley could not switch to less fertile soils as wheat expanded the area sown with barley dwindled. In contrast, rye could change over to less fertile soils. This might account for the relative poor performance of the yield ratio of rye noted earlier.

On the regional level the *Erzgebirge* shows particularly high growth rates of seed quantities after 1815, although differentials between different grains roughly follow the same pattern as in Saxony as a whole (Table 13a-b). Recall that as a result of proto-industrial development population density was higher in upland than in lowland regions (section 2). This provided the large labour force required for the implementation of contemporary land saving and labour intensive agricultural innovations to intensify grain cultivation. However, the low incomes of the upland's rural-industrial population seem to have precluded the implementation of the most productive and soil-conserving methods of mixed farming. Whereas in all other Saxon regions seed quantities of rye did not change they boosted up by 2.2 per cent p. a. in the *Erzgebirge* 1818-1830. Indeed, during the first two thirds of the nineteenth century rye 'conquered' the *Erzgebirge*. However, this occurred within the existing pattern of extensive ley farming,

[17] Contemporary German experts charged with assessing land taxes roughly differentiated between four qualities of land: as first class the so called wheat land, as second class the so called barley land, and the bulk of land in the third and fourth class: oats and rye land, respectively. The term wheat land does not mean that only wheat was cultivated on this soil but that wheat played an important role in crop rotations on this kind of land. Looking at average crop rotation systems noticed for sub-categories of the four soil qualities reveals that wheat and barley cultivation often took place on nearly all superior soil qualities whereas rye and oats was excluded from the very good land. However on good but not on premium land wheat, barley, rye and oats could be cultivated. On lesser soil qualities only rye and oats competed for the land (Engel 1867, pp. 116-135, for the Prussian province Saxony see especially p. 134). Only during the second half of the nineteenth century did the development of new seeds render it possible to expand the cultivation of demanding grains to less fertile soils.

the so called *Lehdesystem*, with four years of cropping and six to twelve years of arable pasture (*Ackerweide*). Intensification simply occurred through repeated cultivation of rye, so far restricted to the first year of the cycle, at the expense of the fallow period. Contemporary observers deplored overexploitation of the soil and believed that yields fell (Herz 1964, pp. 41-42, 65, 75, 79). Our data fully supports this view. In the *Erzgebirger Kreis* rye yields declined during the two periods 1791-1812 and 1818-1830. Simultaneously seed quantities expanded first moderately (1791/93-1803/05) and later on exceptionally in a Saxon comparison (1818/20-1828/30), (Table 11, 12a, 14b). In addition it appears that after 1815 the by far largest extension of cultivated area on marginal land off all regions without changing the cropping systems resulted in strongly increasing grain yield fluctuations in the *Erzgebirge*: Only after 1815 Erzgebirge's yield fluctuation started to clearly outstrip Saxon averages (Table 15, Table 13a-b).

In sum, it appears that before the coming of the railway interregional trade could not meet the rising bread grain demand of Erzgebirge's industrial population and that rye cultivation was profitable for local producers even if they were confronted with high cultivation costs and growing yield risks. At the same time, the local population's effective demand for superior food was too low to enable the switch to soil conserving farming systems involving mixed farming. Thus, the regional pattern of change in sown area suggests that agricultural development in Saxony was shaped less by a response to growing demand transmitted by a well-integrated domestic food market to all Saxon farmers than by adjustment of farming to regional population growth.

Information on seed quantities also allows for some kind of simple growth accounting by disaggregating output growth into the fractions attributable to the expansion of area sown and increases of yield ratios, respectively. However, cross effects prevent that the calculated percentages of both — changes in yields and in the sown area — add up precisely to the output growth rate. Despite that flaw, comparing the growth rates of yields and sown area in relation to output growth rates roughly reflects the relative weight of both changes.

Table 14a shows that output decline during the period 1791-1812 was mainly due to falling yields. This was especially true for the two bread grains rye and wheat. Concerning oats the extension of the sown area neutralized the negative effect of yield losses. Only barley was affected mainly by reductions of sown area. Yield declines and related output losses of the two bread grains rye and wheat were concentrated in the first period 1791-1805 whereas output of barley and especially of oats rose mainly due to increasing yields. After 1805 yields of all grains slumped, and these losses were not compensated anymore by gains in sown area. Abstracting from the crisis years 1815-1817 output growth after the Napoleonic Wars (1818-1830) was characterized by a positive yield growth except for rye. Extension of sown area strongly supported yield increases in the cases of wheat and oats, whereas area sown and yield ratios of rye and barley moved in opposite directions, which slowed down output expansion of these two grains. Looking at the total of all grains the contributions of the expansion of

sown area and of increases in yield ratios to output growth were roughly of similar magnitude during the post-war period 1818-1830.

Table 14a: Sources of grain output growth in Saxony, 1791/93-1828/30 (per cent)*

	output growth	seed growth	yield growth	output growth	seed growth	yield growth
	1791-1805	**1791-1805**	**1791-1805**	**1815-1817**	**1815-1817**	**1815-1817**
Rye	-12.3	0.2	-12.5	32.8	4.1	27.5
Wheat	-12.2	5.4	-16.7	35.1	9.0	24.0
Barley	6.7	-0.7	7.5	9.4	0.3	9.0
Oats	17.7	6.4	10.6	7.9	0.3	7.6
all grains	0.7	2.3	-1.6	17.7	2.1	15.3
	1805-1812	**1805-1812**	**1805-1812**	**1818-1830**	**1818-1830**	**1818-1830**
Rye	-9.7	-6.5	-3.4	1.8	3.0	-1.2
Wheat	-7.8	-3.5	-4.5	23.9	15.8	7.0
Barley	-19.2	-9.8	-10.4	-0.5	-5.7	5.6
Oats	-15.2	-4.4	-11.3	19.8	9.8	9.1
all grains	-13.5	-6.2	-7.8	9.6	4.8	4.6
	1791-1812	**1791-1812**	**1791-1812**	**1815-1830**	**1815-1830**	**1815-1830**
Rye	-20.8	-6.3	-15.4	35.1	7.2	26.0
Wheat	-19.1	1.7	-20.4	67.4	26.2	32.6
Barley	-13.8	-10.5	-3.7	8.8	-5.4	15.1
Oats	-0.2	1.8	-2.0	29.2	10.1	17.4
all grains	-12.9	-4.0	-9.3	29.1	7.0	20.6

Table 14b: Sources of grain output growth in the Erzgebirger Kreis, 1791/93-1828/30 (per cent)*

	output growth	seed growth	yield growth	output growth	seed growth	yield growth
	1791-1805	**1791-1805**	**1791-1805**	**1815-1817**	**1815-1817**	**1815-1817**
Rye	-12.9	1.6	-14.3	41.9	-10.0	57.7
Wheat	19.6	19.8	-0.2	37.0	-5.8	45.4
Barley	3.5	0.7	2.7	11.6	-14.2	30.2
Oats	10.8	2.6	8.0	2.1	-5.2	7.7
all grains	1.5	2.5	-1.0	14.4	-7.6	23.9
	1805-1812	**1805-1812**	**1805-1812**	**1818-1830**	**1818-1830**	**1818-1830**
Rye	-9.5	-3.1	-6.6	13.6	23.8	-8.3
Wheat	-6.5	10.1	-15.1	42.4	38.5	2.8
Barley	-1.1	4.8	-5.6	12.8	9.6	2.9
Oats	-11.7	-1.2	-10.6	32.2	17.4	12.6
all grains	-9.4	-0.8	-8.7	24.3	18.9	4.5
	1791-1812	**1791-1812**	**1791-1812**	**1815-1830**	**1815-1830**	**1815-1830**
Rye	-21.2	-1.6	-19.9	61.2	11.5	44.7
Wheat	11.8	31.9	-15.2	95.0	30.4	49.5
Barley	2.4	5.6	-3.1	25.9	-6.0	34.0
Oats	-2.1	1.4	-3.4	34.9	11.3	21.2
all grains	-8.1	1.7	-9.7	42.2	9.8	29.5

Table 14c: Sources of grain output growth in the Leipziger Kreis, 1791/93-1828/30 (per cent)*

	output growth	seed growth	yield growth	output growth	seed growth	yield growth
	1791-1805	**1791-1805**	**1791-1805**	**1815-1817**	**1815-1817**	**1815-1817**
Rye	-11.7	0.7	-12.3	36.5	0.2	36.2
Wheat	-12.1	5.4	-16.6	42.2	8.8	30.6
Barley	7.1	-7.6	15.9	3.2	-4.4	8.0
Oats	19.2	5.7	12.8	9.5	-1.2	10.9
all grains	0.7	2.3	-1.6	17.8	-0.8	18.8
	1805-1812	**1805-1812**	**1805-1812**	**1818-1830**	**1818-1830**	**1818-1830**
Rye	-8.5	-1.4	-7.3	1.4	1.8	-0.4
Wheat	-8.8	-2.6	-6.3	26.1	16.1	8.6
Barley	-11.9	-4.7	-7.5	0.4	-6.0	6.8
Oats	-12.5	-2.1	-10.6	13.3	7.0	5.9
all grains	-13.5	-6.2	-7.8	7.6	3.2	4.2
	1791-1812	**1791-1812**	**1791-1812**	**1815-1830**	**1815-1830**	**1815-1830**
Rye	-19.2	-0.7	-18.6	38.4	2.0	35.6
Wheat	-19.8	2.6	-21.8	79.3	26.4	41.9
Barley	-5.6	-11.9	7.2	3.6	-10.2	15.3
Oats	4.3	3.5	0.9	24.0	5.7	17.4
all grains	-12.9	-4.0	-9.3	26.8	2.4	23.8

Source: Own calculation; for data sources see Appendix.

Notes: *The percentages refer to total growth for the periods 1791/93 - 1803/05, 1803/05 - 1810/12, 1815/17 - 1818/20, and 1818/20 - 1828/30.

Table 15: Regional grain yield fluctuations, 1791-1830*

	rye	wheat	barley	oats
	1791-1812			
Chur Kreis	0.252	0.306	0.142	0.123
Thüringischer Kreis	0.174	0.218	0.133	0.114
Meißnischer Kreis	0.173	0.168	0.058	0.074
Leipziger Kreis	0.189	0.213	0.092	0.088
Erzgebirgischer Kreis	0.206	0.115	0.078	0.092
Oberlausitz	0.185	0.152	0.109	0.096
Saxony	0.174	0.182	0.083	0.082
	1815-1830			
Meissner Kreis	0.139	0.180	0.164	0.208
Erzgebirger Kreis	0.213	0.206	0.227	0.155
Leipziger Kreis	0.185	0.201	0.149	0.175
Vogtländer Kreis	0.170	0.175	0.164	0.106
Oberlausitz	0.128	0.150	0.181	0.204
Saxony	0.156	0.178	0.155	0.170

Sources: Own calculation; for data sources see Appendix.

Notes:*the intensity of grain yield fluctuations is measured by simple variation coefficients of de-trended annual yield-ratios.

Regional disaggregation uncovers stark contrasts between the industrial, densely populated, less fertile *Erzgebirge* and the remainder of Saxony. Already in 1791-1812 sown area increased in the *Erzgebirge* whereas it contracted in other parts of Saxony, including granaries like the *Leipziger Kreis* perfectly suited for grain cultivation (Tables 14b-c). This was mainly due to the fact that the reduction of sown area was less pronounced during the war period 1806-1812 than elsewhere. In 1818-1830 the regional differences became much more accentuated. Whereas the total sown area boosted up by 18.9% in the Erzgebirge it expanded only sluggishly in the *Leipziger Kreis* with 3.2%. Especially the sown area of the demanding bread grains rye and wheat rose in the less fertile Erzgebirge with 23.8% and 38.5%, respectively, compared to 1.8% and 16.1% for the *Leipziger Kreis*. All in all during the period 1818-1830 grain output increased by 24.3% in the hilly and mountainous *Erzgebirge* not well suited for arable farming whereas in the highly fertile plains around Leipzig, which contained one of the world's best soils for grain cultivation grain production only expanded by 7.6%.

Most astonishingly is the fact that wheat, whose cultivation at this time was much more demanding and prone to more extreme yield fluctuations on less fertile soils than rye, experienced a real boom in the *Erzgebirge* but not in the much better suited highly fertile plains. In contrast to rye wheat was indeed only cultivated as a cash crop in Central Germany. That even in the later period 1818-1830 the growing wheat demand of wealthier parts of the industrial population in the uplands did not as much induce a deepening of regional specialization according to naturally given comparative advantage but mainly affected local agriculture does not speak into the direction of improving food market integration during Saxony's early industrialization.

We found earlier that a major part of the extension of sown area is accounted for by developments taking place in the *Erzgebirge* (Table 13 above). Accordingly, in contrast to more fertile parts of Saxony the extension of the sown area surpassed increases in land productivity as a source of output growth in the *Erzgebirge* but not in other parts of Saxony. Nevertheless grain yields developed similar to Saxon trends. This implies that after 1815 only in the *Erzgebirge* peasants were capable to extend significantly the sown area and simultaneously pushing yield ratios back to the pre-war level prevailing during the early 1790s (cf. Figure 6 above). This indicates that the most pronounced outward shift of the production function related to progress in agricultural techniques of all Saxon regions occurred in the *Erzgebirge*. If market integration would have been the driving force of Saxony's agricultural development c. 1790-1830 progress in farming would have been concentrated in the fertile plains much better suited for farming and not in the uplands.

As already mentioned only for wheat and oats both sown area and yields increased simultaneously above average all over Saxony after 1815 (Table 14a). Very probably at the expense of barley (and rye) peasants re-allocated good land, other critical inputs and their own diligence to wheat cultivation in order to satisfy the food demand of a small wealthy minority whose incomes may have fared better than those of the common population at large during the period under observation.

At the same time Saxony lost the *Thüringer Kreis*, which was the most important oats surplus region (Table A.9d). Even if oats was the least tradable grain the identification of clear oats-surplus areas in Saxony 1791-1812 indicates that in contrast to potatoes some interregional trade in oats existed within Saxony. Very likely this trade continued as foreign trade between Prussia and Saxony after 1815 and imports of oats from Bohemia seemed to have strongly increased during the post-war period.[18] Nevertheless, the Saxon rump state was forced to extend its own oats production to feed its rising rural population but probably more important to expand the mainly horse-based draft power necessary to intensify arable farming. Indeed, at least contemporary average oats feeding ratios at the lower bound could be secured for horses by the rising domestic production during the 1820s.[19]

In comparative perspective two salient features of land productivity's development stand out in Saxony. *First*, the depression of yield ratios 1792-1812 is not observable either in other parts of Germany or in England. English grain yields — most importantly those of wheat — fell slightly during the second half of the eighteenth century. Recovery in the 1790s and the 1800s was followed by renewed stagnation in the 1810s. After 1820 English grain yields outstripped the high yield ratios obtained in the mid-eighteenth century and increased steadily until the middle of the nineteenth century (Turner et al. 2001, pp. 129, 163). Studies on the Middle Rhine area (Palatinate and Rhine Hesse) suggest that agricultural intensification started before the middle of the eighteenth century. According to the very few existing studies that combine very heterogeneous sources to construct long time series relating to Southwest German yields tremendous increases up to a doubling only in the quarter century c. 1790-1825 occurred followed by complete stagnation until the 1860s (Mahlerwein 2001, pp. 185-200; Grüne 2011, pp. 145-149). Even if such tremendous yield increases definitely were impossible no signs could be found that Southwest Germany experienced any yield stagnation c. 1790-1830.

We explain the poor performance of Saxon grain yields in 1792-1812, on the one hand, with the heavy dependence of food demand from export income and the adverse effect that the outbreak of war in 1792 had on the access of Saxon proto-

[18] In fact, whereas all Saxon imports of oats equaled to 11,808 Dresden bushels in 1792 they accounted for 33,473 Dresden bushels in 1838 solely from Bohemia (Schröter 1912, p. 10, Kiesewetter 2007, p. 258). This would correspond to an average annual increase of oats imports of at least 2.3% for the period 1792-1838 which already clearly outstrip the increase of Saxon oats production. These figures speak into the direction that the tradability of oats significantly improved after 1815. Bohemia was the by far most important foreign supplier of grain set aside the Saxony regions becoming Prussian in 1815.

[19] Data for 1834-1844 suggests that in Saxony the number of all horses increased by 1.4% p.a. This rate of growth can be assumed as well for the 1820s. Moreover, data for 1847-1858 proves that the bulk of horses – around 80% - were used in agriculture. Horses for transport only made one tenth of farm horses still in 1858 (own calculation, for data see Zeitschrift des Königlich Sächsischen Bureaus 1855ff). Contemporary European sources indicate a daily oats ratio per military and working horse between 2 and 5 kg around 1850 (Bernemann, 2005, p. 8-18). Agricultural handbooks note a daily oats ratio for German farm horses between 5 and 6 kg around 1939 (annual ratio of 18-22 quintals oats per farm horse, Klauder, 1945, p. 37, p. 54). According to own calculations Saxony's oats net production secured daily ratios per horse between 2.9 kg (1818/20) and 3.1 kg (1827/29).

industrial regions to world markets. On the other hand, from 1806 onwards Saxony was directly involved into war events to a greater extent than many other German states, which seems to have diverted critical inputs from grain cultivation.

Second, against the background of the evidence just mentioned stagnating grain yields between the early 1790s and the 1820s suggest a poor growth performance of agriculture even if negative effects on yields of war and of the division of Saxony are put aside. To be sure, the fact that potato, wheat and oats cultivation expanded without any reductions in the area sown with rye at least implies some degree of intensification of the use of arable occurred, particularly in industrial upland regions with ample labour supply. But in no way did Saxony transcend a first stage of a pre-modern agricultural revolution, which is characterized by an expansion of sown area while maintaining yield ratios constant. The transition to a second stage in which intensification of land use went hand in hand with significantly rising yields did not take place in Saxony before 1830 if not 1850. First evidence presented in this and the foregoing section indicate that the absence of mass demand, which in turn emanated from Saxony's low wage-high energy cost path of early industrialization, goes a long way toward accounting for the specific trajectory of agricultural development in this German territory.

6. Regional experiences

We have already noted repeatedly the stark contrast between lowland and highland regions relative to geographical conditions, population growth, and the degree of proto- as well as early industrialization. In this section we explore the implication of changes in area sown and land productivity for regional differences in output levels both of aggregate crop production and of major crops, as well as their development over time. Our main objective is to identify the degree of regional specialization and the extent to which industrialization in the upland regions contributed to its deepening. To this end, Table 16 and Figure A.2 contrast major highly fertile lowland regions, perfectly suited for arable farming and disadvantaged upland regions with respect to the trajectory of output over time. Table 17 and Figure A.3 track the evolution of regional shares in the production of major crops. Appendix Tables A.3 to A.12 provide additional background information on regionally disaggregated crop output.

Natural resource endowment plays an important role in this analysis, since we would expect that a growing market demand for food would provide an incentive to concentrate production in fertile zones. We identify natural resource endowment on the basis of the share of winter wheat in total arable sown with grain in 1913, which was in turn highly correlated with soil quality and productivity as recorded in the Saxon land tax assessment of 1838-1842.[20]

[20] Cf. Arndt (1936, p. 92–93). On average around 14% of Saxony's grain land within the borders of 1792 was sown with winter wheat in 1913 (information provided at the level of counties [*Kreise*] within the administrative organization of the early twentieth century by Engelbrecht 1928, pp. 26-27, 38-39 and

Table 16: Agricultural growth of highly fertile lowland districts and of upland industrial districts in comparison, 1791-1830 (annual exponential trend growth rates, in per cent)

	1791-1812	
	highly fertile lowland districts*	upland industrial districts**
Rye	-1.1	-1.4
Wheat	-1.5	+0.9
Barley	-1.1	-0.2
Oats	-0.2	-0.3
Potatoes	4.1	2.3
gross crop production	-0.6	-0.2
	1818-1830	
	Leipziger Kreis	upland industrial districts**
Rye	-0.2	0.7
Wheat	2.4	3.4
Barley	0.2	0.6
Oats	1.5	2.6
Potatoes	2.3	2.5
gross crop production	0.9	1.8

Sources: Own calculation; for data sources see Appendix.

Notes: *The macro-region 'highly fertile lowland districts' comprises *Thüringer Kreis*, *Leipziger Kreis*, and the cathedral chapters of *Naumburg* and *Merseburg*; **the macro-region 'upland industrial districts' consists of *Erzgebirger Kreis* and *Vogtländer Kreis*.

In 1772 the four most important fertile lowland regions *Thüringer Kreis*, *Leipziger Kreis* and the cathedral chapters *Naumburg* and *Merseburg* produced 40.4 per cent of the total crop harvest on only 21.8 per cent of Saxony's territory at that time (Table A.11). Concerning wheat, barley and oats the respective shares ranged narrowly around 50 per cent whereas rye's share accounted for 38.7 per cent (Table A.9a-d). Only the weight of potatoes in total output was slightly below the share of these regions in total area (19.7 per cent, Table A.10). All this suggests that within Saxony some degree of regional specialization with respect to agricultural production had been established prior to 1770 in connection with early proto-industrial development.

Blaschke, Jäschke 2009). The region 'highly fertile lowland districts' contains administrative districts with an average share of winter wheat in total arable area above 19 per cent. These were the *Thüringer Kreis* (six counties: 17-30%, two counties: 5-10%), the *Leipziger Kreis* (five counties: 18-27%, two counties: 9-15%), and the cathedral chapters *Naumburg* and *Merseburg* (three counties: 24-32%). Average shares of winter wheat in total arable between 10 and 17 per cent were recorded in the *Oberlausitz* (three counties: 10-14%, one county: 6%), and the *Meissner Kreis* (3 counties: 15-31%, 5 counties: 2%-10%). Disadvantaged regions with shares of winter wheat in total arable below 10 per cent were the *Kurkreis* (three counties: 4-10%, one county: 16%), the *Erzgebirge* (all counties: 0.4 -8%) and the *Vogtland* (all counties: 3-9%). Due to the fact that *Kurkreis* was a sparsely mainly agricultural lowland district the less fertile but densely populated macro-region 'upland industrial districts' contains only *Erzgebirge* and *Vogtland*.

Table 17: Trends in regional specialization of agricultural production in Saxony, 1791-1830 (linear trend growth rates of the variation coefficient, in per cent)

	1791-1812	1818-1830
Rye	-0.04	-0.10
Wheat	-0.25	-0.31
Barley	-0.34	+0.11
Oats	-0.24	-0.09
Potatoes	-0.64	-0.08
gross crop production	+0.04	+0.12

Sources: Own calculation; for data sources see Appendix.

Notes: *for 1791-1812 the variation coefficient is based on seven units: *Chur Kreis*, *Thüringer Kreis*, *Meissner Kreis*, *Leipziger Kreis*, *Erzgebirger* and *Vogtländer Kreis* combined, the the cathedral chapters *Merseburg* and *Naumburg* combined, *Oberlausitz* and *Niederlausitz* combined; **for 1818-1830 the variation coefficient is based on four units: Meissner Kreis, Leipziger Kreis, Erzgebirger and Vogtländer Kreis combined, and Oberlausitz.

Over time, the spatial distribution of agricultural production changed little between highland and lowland regions. Thus, in 1810/12 the four fertile lowland districts mentioned above accounted still for 41.0 per cent in total crop output (Table A.11). Only the potatoes' share jumped from 19.7 per cent to 28.1 per cent (Table A.10). These results do not suggest a deepening of inter-regional labour division in the wake of proto-industrial development after 1770. To be sure, there were changes in the output shares of individual administrative districts, but during 1772-1791/93 changes of regional shares within the two groups of surplus producing lowland areas on the one hand and upland areas on the other hand neutralized each other, whereas macro-regional shares of grain production hardly changed between 1791/93 and 1810/12 (Table A.9- A.11).

After 1815 only the *Erzgebirgischer Kreis* increased its share in total crop production from 21.8 to 24.0 per cent. All remaining four districts experienced slight losses (Table A.12). Looking at the annual exponential growth rates for major crops and total gross crop production reveals that upland industrial districts fared only slightly better than the rest during 1791-1812 but showed a significantly better performance after 1815 (Table 16, Figure A.2a-b). This points to a tendency towards intensification of agriculture in upland areas rendered possible by an increase in population density resulting from proto-industrial and early industrial development.

A simple variation coefficient based on seven large regions in 1791-1812 and four units in 1818-1830 is used to test whether regional specialization advanced (positive sign) or regressed (negative sign) (Table 17, Figure A3.a-b). Indeed it appears that regional specialization regressed or at best stagnated during the first period but could have gained some momentum during the second period. Taking into consideration additionally the year 1772 the tendency of weakened regional specialization is

strengthened for the first period (Figure A.3a). In addition, only looking at the variation coefficients after 1820 it seems as well that regional specialization did not advance (Figure A3.b).

During the first period 1791-1812 the variation coefficient of potatoes experienced the strongest decline of all crops (Table 17). This documents the universal spread of subsistence oriented potato production in Saxony. Until the third quarter of the eighteenth century potatoes had been introduced mainly in upland regions with poor conditions for grain cultivation. Thus, in 1772 36.4 per cent of total potato production was concentrated in just two upland districts, namely, *Erzgebirgischer Kreis* and *Vogtland*. By 1810 the weight of these two districts had shrunk to 24.5 per cent whereas the combined share of the four fertile lowland districts *Thüringischer Kreis*, *Leipziger Kreis* and the cathedral chapters of *Merseburg* and *Naumburg* had grown from 19.7 to 28.1 per cent (Table A.10). Thus, agricultural growth in the lowland areas during the late eighteenth and the beginning of the nineteenth century meant to a large part the expansion of subsistence crops' production, rather than intensifying grain production. Interestingly wheat production's share of the upland industrial districts increased 1772-1810/12 from 6.1 per cent to 9.3 per cent whereas the best suited areas lost 2.6 percentage points (Table A.9b). Against the theorem of comparative advantage the less fertile industrial areas' share in wheat production increased the strongest. The same tendency can be observed for all other grains as well.

In essence our spatial analysis of crop production supports that regional specialization according to natural comparative advantage did not advance c. 1790-1830, as one would expect as a consequence of proto-industrial and early industrial growth and a concomitant development of food markets. In particular, no concentration of grain cultivation in the highly fertile lowland areas occurred. Indeed, to a certain degree quite the opposite seemed to have happened. Regional growth of agriculture took place to a significant extent in the form of expanding cultivation of subsistence crops: Between 1772 and 1812 potato cultivation spread to the fertile lowlands, and after 1815 grain production seemed to have intensified in the upland areas. Thus, on the regional level farming responded basically on increases in local population rather than exploiting supra-regional market opportunities.

Of course, these very general trends hide a number of specific regional developments which cannot all be considered within the framework of this study. For the remainder of this section we only pick out two adjacent industrial areas in Saxony's south-western upland, namely, *Vogtland* and the *Erzgebirge* (Table 18). Due to the fact that the territory of the administrative unit *Erzgebirge* slightly changed after 1815 a comparison between the second captaincy (*Amthauptmannschaftsbezirk II*) of the *Erzgebirge* (in the following *Erzgebirge II*) and the *Vogtland* has been added for supportive purposes.[21] The borders of these two latter administrative units did not change at all

[21] After 1815 the large *Erzgebirger Kreis* consisted mainly out of four larger units, the so called *Amtshauptmannschaften*, which resembled a Prussian *Regierungsbezirk* and embraced various *Ämter* or counties. Located at *Vogtland*'s eastern border the *II. Amtshauptmannschafts-Bezirk Erzgebirger Kreis*

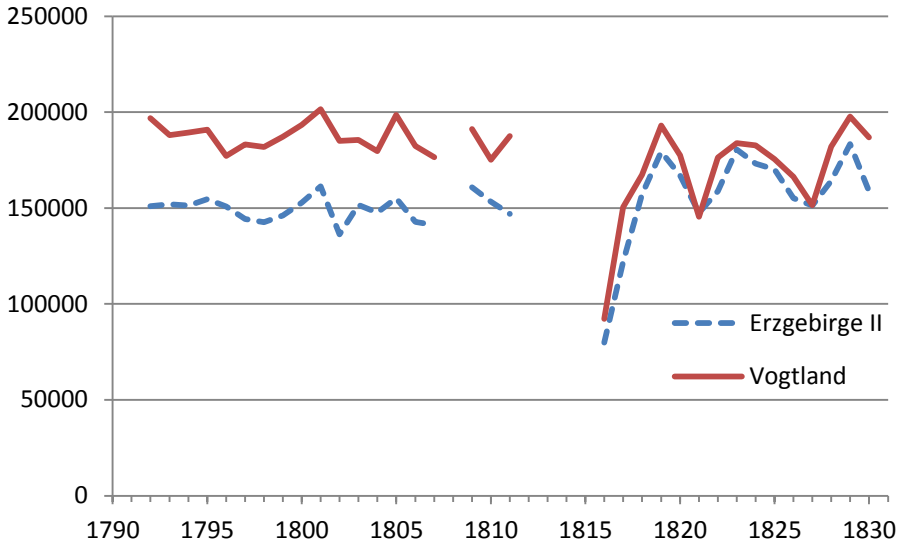
over the entire period. As far as possible a continuous series of grains' and potatoes' gross output has been constructed for 1792-1830 (Figure 8).

Table 18: Agricultural growth in *Erzgebirger Kreis* and *Vogtländer Kreis* in comparison, 1791-1830 (exponential trend growth rate of gross output, in per cent)

	1791-1812			1818-1830		
	Vogtland	Erzgebirge	Saxony	Vogtland	Erzgebirge	Saxony
Rye	-1.5	-1.4	-1.2	-0.4	+0.9	-0.1
Wheat	-1.2	+1.1	-1.0	+2.2	+3.6	+2.4
Barley	-0.9	+0.1	-0.8	-1.1	+1.2	+0.3
Oats	-0.7	-0.3	-0.0	-0.4	+3.0	+2.2
Potatoes	+1.8	+2.5	+3.2	+2.0	+2.7	+2.5
Gross crop prod.	-0.5	-0.2	-0.5	+0.4	+2.1	+1.2

Source: Own calculation; for data sources see Appendix.

Figure 9: Total grain and potato production in the Amtshauptmannschaft Erzgebirge II and in the Vogtland, 1792-1830 (in grain equivalents)



Source: Own calculation; for data sources see Appendix.

Even if both regions were centres of textile production, consisted mainly of upland areas, showed similar soil qualities and the highest population densities within Saxony, *Erzgebirge* performed distinctly better than the *Vogtland*. Concerning agriculture the *Erzgebirge* achieved in general growth rates above the Saxon average. Just the opposite occurred in the much smaller *Vogtland* (Table 18, Map 1). Moreover, divergence between both regions significantly strengthened after 1815. It appears that during the second period the *Vogtland* not only lost the connection to the dynamic agricultural development of the Erzgebirge but to the entire rest of Saxony. According to Figure 9 the *Vogtland* reached its pre-war level of grain and potato output only by the late

comprised of the former *Ämter* Zwickau, two thirds of Wildenfels, Wiesenburg and Schwarzenberg with Schneeberg.

1820s, whereas *Erzgebirge II* surpassed this threshold already around 1818. All in all, given the similarity of the two adjacent regions with respect to natural conditions and economic structure the divergent trajectory relative to agricultural growth appears difficult to explain. Already contemporary observers regarded agrarian institutions as a key to resolve the puzzle.

As already mentioned in section 2 seigniorial merino sheep husbandry strongly expanded in Saxony. Concurrently a mainly peasant-driven intensification of farming has gained strong momentum. As a reaction to rising food prices during the last decades of the eighteenth century the diffusion of mixed farming and land saving stable feeding based on the cultivation of forage crops strongly accelerated all over Saxony. A severe obstacle to peasants' intensification efforts was the landlords' aim to enlarge their highly profitable sheep husbandry by strictly reinforcing traditional grazing rights on peasant land — commons and fallow land in the open fields. However, supported by an enlightened state bureaucracy the severe land conflicts could be resolved by considering peasant demands in many parts of Saxony well before the general agrarian reforms of 1832, but apparently much less so in the *Vogtland*.

Indeed, the landlords of the *Vogtland* tenaciously defended their extensive and highly profitable entitlements to sheep grazing rights against the peasantry. During the *Landtag* (the diet of the estates; cf. Matzerath 2006) of 1817/18 the nobility of this district launched a massive campaign against the liberally minded judiciary of the central administration to stop the very successful promotion of voluntary agreements between peasants and landlords intended to abolish manorial grazing rights on peasant arable land by redemption payments. Indeed, the enlightened Saxon bureaucracy — eager to increase food production in order to avoid food riots and believing in intense mixed farming a la mode in the English style — fostered voluntary agreements to remove grazing rights. According to the literature these 'Coase-solutions' enforced by the courts to satisfy the demands of the peasants strongly increased in numbers especially after the violent peasant riots of 1790. This peasant uprising could only be quelled by the intervention of military forces (Stulz, Opitz 1956, pp. 25-27; Gross 1968, p. 77, 82).[22] The Saxon bureaucracy wanted to prevent such an escalation in the future.

All this indicates that consensual redemption of grazing rights occurred less frequently prior to the agrarian reforms of the early 1830s in the *Vogtland* than elsewhere in Saxony. Consequently, this restricted the potential for agricultural intensification in the *Vogtland*. Seigneurial grazing rights obstructed the cultivation of fallow land and investments into melioration projects on common land. In quantitative terms, Ta-

[22] Since the end of the eighteenth century liberal Saxon courts appointed to a so called secret law which never had to be announced publicly to justify their enforcing of 'Coase solutions' against the will of the landlords. Secret laws were a peculiarity of all European absolutist states. Indeed, after the severe rural riots the Saxon cabinet had intensively discussed a secret law to foster enclosures which were demanded by the peasants. A detailed law was drafted but never enacted even not as a non-public secret law! However, tolerated by the Central authorities Saxon courts treated the draft law as an existing law. Until the diet of 1817/18 over more than two decades no open resistance occurred against this very successful practice.

bles 12 and 13 demonstrate that especially 1818-1830 the area sown expanded at a significantly slower rate in the *Vogtland* compared to the *Erzgebirge*. In the two periods 1791-1805 and 1818-1830 the growth of *Vogtland*'s area sown ranged below the Saxon average (Table 12b and 13b). During the years 1806-1812 only the *Vogtland* and to a certain extent the *Erzgebirge* managed to hold constant their cultivated area. However, the reason was that after 1805 war related damages and requisitions mainly affected fertile areas in the plain. Looking at growth rates of total gross crop production the *Vogtland* showed the lowest ones during the period 1818/20-1828/30 and only the *Oberlausitz* performed worse during the period 1791/93-1803/05. The gap to the rest of Saxony strongly enlarged after 1815 (Tables A.5 and A.8). Much lower yield fluctuations in the *Vogtland* after 1815 compared to the *Erzgebirge* indicate that the extension of arable on marginal land took place in a less dynamic way if at all in the *Vogtland* (Table 15).

Due to the reason that the diffusion of new crop rotations and farming systems was obstructed by the strict enforcement of seigneurial grazing rights it is also of no wonder that yield ratios developed less favourably in the *Vogtland* than in most parts of Saxony (Tables A. 13 and A.14). This is particularly true for spring grain, namely, barley and oats, which were sown after rye and wheat in most rotation systems. In fact, contemporary experts noted the diligence of farmers in the *Erzgebirge* with respect to expanding arable and grassland through incessant efforts to improve the quality of marginal land. This included labour intensive investments like terracing, melioration via ditches, the layout of artificial meadows and the return transport of soil that had been washed away to fight erosion. At the same time, they attributed the absence of such practices in the *Vogtland* to the tenacity with which landlords in this region clung to grazing rights. In the case of the *Vogtland* at least agrarian institutions implying distributed property rights seem to have obstructed progress in farming techniques (Anonymus 1809; Geyer 1866).

This short regional case study implies that while agricultural development in Saxony as a whole was primarily shaped by demand forces and by changes in labour supply agrarian institutions mattered in determining regional trajectories in certain areas. The example of the *Vogtland* also suggests *ex negativo* the existence of Coase-solutions to solve harsh land use conflicts between peasants and their landlords in most parts of Saxony. These conflicts emerged in the wake of industrial development and population growth as well as the diffusion of labour-intensive agricultural innovations that were most profitable within an ownership pattern characterized by peasant family farms. In most parts of Saxony voluntary redemptions of seigneurial grazing rights constituted a mean to redistribute property rights without radical agrarian reforms in a way that was conducive to the improvement of farming techniques and agricultural growth. Functioning institutions to cut transaction costs of market-oriented Coase-solutions in order to maintain agricultural growth were provided by an efficient central government and bureaucracy that curbed the particularism of local landed elites. In early nineteenth century Germany only the rising enlightened bureaucracy

had the power to enforce reforms of traditional agrarian institutions against the vested interests of the nobility.

7. Food standards between subsistence production and market

In the final part of this study we examine the effect that agricultural development during the late eighteenth and early nineteenth century had on the food standard of Saxony's population. Primary attention will be given to changes in food supply provided by domestic production and to its composition in terms of market vs. subsistence crops. This allows analysing whether the food standard of a growing population became more dependent on the operation of markets or whether it was secured by employing the expanding local labour force to cultivate subsistence crops. To this end we identify the part of grain and potato harvests that was disposable for human consumption and compare per capita levels of these figures for net output with diverse benchmarks.

In 1756 Saxon state officials estimated the food supply required to feed the population in units of rye, which was the basic staple food. They worked with the assumption that three *Dresdner Scheffel* (bushels) rye per capita and year were necessary to secure a reasonable food standard on average (Schröter 1912, p. 7). This quantity corresponded to approximately 240 kg of rye or 2.42 grain equivalents, which implies a food ration of 2,052 calories per day. This comes very close to the crucial nutritional benchmark of a daily intake of 2,000 calories per capita, which often defines the poverty line in caloric terms in less developed countries in the tropics today (Dasgupta, Ray 1986, 1987a, pp. 2-9, 1987b, p. 177). A caloric intake below this threshold would endanger the capability to work and is defined as malnutrition. Having in mind that a colder climate demands a slightly higher caloric intake to secure the biological capacity to work an annual food standard of 2.5 grain equivalents (GE) per capita for Saxony during our period of observation is a reasonable assumption.[23] This food standard equals a daily intake of 2,233 calories per capita and comes close to estimates of food consumption in Germany around 1800.

Information collected by Saalfeld (1975, p. 252) suggests average annual staple food consumption per capita ranging between 2 and 2.7 grain equivalents at the beginning of the nineteenth century. Our benchmark of 2.5 GE is close to the upper limit of this span. However, Saalfeld considers only rye, wheat and potatoes and neglects human consumption of barley and oats. Contemporary sources and later scholarship suggest that up to about 1830 at least wheat, rye and potatoes were more or less completely used for human consumption. In addition, a substantial share of output in barley and oats, which are typically regarded as feed grains, served for human con-

[23] During the Second World War an annual standard of 2.5 GE per capita was calculated by the food-administration of Nazi-Germany as minimum food requirement to preserve the capacity for work of the population. This standard was more or less secured for the German population until 1944. In 1943 English and German daily food ratios per capita laid between 2.200 and 2.300 calories (Aly 2006, pp. 203-205, Corni 1997, pp. 570-573).

sumption as well, mainly in the form of beer and mush; porridge was common not only in the UK but in Germany as well. Specifically, a contemporary estimate for Prussia places average annual consumption per capita for the period 1833-1853 at 14.1 kg for barley and 6.5 kg for oats; in rural areas consumption was placed a bit higher, namely, at 17.3 and 8.4 kg, respectively (Schröter 1912, p. 7; Kopsidis 1996, pp. 192-201, 515-526). Given the low levels of urbanization and income in pre-1830 Saxony, the latter figures are probably more suitable to serve as a benchmark with an equivalent of 0.25 GE. This benchmark is supported by information on Bern in the 1790s, which suggests that oats consumption alone could contribute 10 per cent — that is, an equivalent of about 0.25 GE — to total grain consumption (Brandenberger 2003, pp. 123-126).

Taken together, these data suggest that annual human oats consumption per capita assumingly ranged between 0.1 and 0.25 GE. Since oats production in the 1820s and 1830s was at the order of magnitude of the minimum ration to sustain Saxony's horse stock (see footnote 18 above) human consumption of oats may have tended to the lower rather than to the higher bound. However, it is reasonable to assume that the horse-land ratio and the feed rations given to horses grew little during the period under consideration. Thus, we tentatively conclude that an increase of oats output beyond the growth rate of seeding quantities of all types of grain (+0.2 per cent p.a. during 1791-1805, -0.9 per cent p.a. during 1805-1812 [Table 12b] and 0.4 per cent p.a. during 1818-1830 [Table 13b]) at least in part indicates growing human consumption of oats.

Our analysis, though limited to the study of major staple crops, covers the overwhelming part of contemporary diet since meat, the principal animal food, contributed only a minor part to nutrition: The annual per capita meat consumption of 16 kg prevailing in Saxony during the 1830s (Table 4 above) implies a contribution of only 100 to 200 calories or less than 0.25 GE to the daily food intake. Finally, we ignore supply of pulses and minor grains like buckwheat. To a large part these crops were used as animal feed, which renders their classification difficult (Achilles 1993, pp. 55-56, 63, 166-167). Having in mind that up to 1830 at least in some areas of Saxony potatoes were partly used as feed as well (Herz 1964, p. 44) the neglect of legumes and minor grains as human food corrects this effect. Note also that legumes and minor grains contributed a stable share of only five per cent to total crop output (Figure 4 above) so that our conclusions regarding changes in consumption patterns are not affected by this omission.

To compare actual output figures with these general benchmarks we have to determine that part of output that was disposable for human consumption. In the case of grain we start from the quantities remaining after threshing and subtract the amount of seed used for the next harvest; both types of information are given in the original source (section 2 above). This quantity is defined as net output. Since notations of seed quantities in our sources refer to the subsequent harvest our analysis of food standards based on net output ends in 1811 and 1829, respectively. Information on seed quantities lacks for potatoes, however. For this reason we apply a constant ratio of

retained seed to output of 14 per cent (Kopsidis 1996, p. 517). Output net of threshing and seed represents an upper bound of the quantity disposable for human consumption as we are incapable to take account of storage damages and transportation losses.[24] Table 19 displays the resulting per capita values in grain equivalents (GE) for key years, Figure 9 shows time series for different crops and total net crop output per capita for the entire period.

The following four salient results stand out from these data: *First*, in 1791/93 the Electorate of Saxony was by and large self-sufficient. Per capita quantities available for human consumption of rye, wheat and potatoes added up to 2.14 GE. Allowing for additional human consumption of barley and oats of 0.25 GE after a normal harvest, which is equivalent to one fifth of these two grains' total net output in 1791/93, domestic supply of vegetable foodstuffs in these years came close to our benchmark of 2.5 GE (Table 19a). This is consistent with the fact that in 1792 net trade in rye and wheat accounted for only 0.9 per cent of net production of these two bread grains (own calculation based on Schröter 1912, p. 10). Even if urban grain markets in Saxony were better integrated into wider networks than in many other parts of Germany during the second half of the eighteenth century, net cross-border trade must have been small in normal harvest years.

Second, domestic food supply shrank during the war period c. 1793-1813. Since grain markets in Germany as a whole disintegrated during these years (cf. section 2) imports very likely were incapable to fill the gap, implying a serious deterioration of food standards. Specifically, rye and wheat output per capita available for human consumption shrank by 0.41 GE during 1791/93-1803/05 and by another 0.06 GE during 1803/05-1810/11. A rising net potato output per capita of 0.14 GE over the whole period only partially compensated for the decline in bread grain. Hence, until 1810/11 bread grain and potato supply per capita combined had fallen by 15% from 2.14 GE to 1.82 GE. Nearly all of the deterioration of food standards occurred until 1805. A further reduction was prevented by the reduction of population growth from 0.6 per cent p. a. (1791-1805) to 0.4 per cent p. a. (1805-1812, Table 8).

As noted in earlier sections production of oats fared better during the war period than output of other grains. Specifically, net output of oats per capita increased by 0.08 GE between 1791/93 and 1803/05. Since arable land expanded little during this period only a minor part of the incremental output of oats was required for feeding horses, suggesting an increase of human consumption of this grain. As per capita supply of feed grain shrank largely in parallel with bread grain between 1803/05 and 1810/12 the potential for further substitution was limited in the years when Saxony itself became a theatre of war. Taken together, the decline of bread grain output and the highly probable shift of some feed grain from animal foodstuffs to human consumption imply a deterioration of food standards during the Revolutionary and Napo-

[24] However, the Saxon harvest statistics tended to slightly underestimate the real seed and harvest (see section 3). Hence, storage and transportation losses are at least implicitly considered in calculating net output per capita.

leonic Wars c. 1792-1815 that goes a long way toward explaining the decline of the biological standard of living during the first one-and-a-half decades of the nineteenth century detected by Ewert (2006, Figure 10).

Table 19a: Net output per capita 1791/93-1809/11 (grain equivalents)

	1791/93	1803/05	1809/11	1803/05	1809/11
				1791/93 = 100	
Rye	1.62	1.27	1.21	79	75
Wheat	0.30	0.24	0.25	79	83
Barley	0.63	0.63	0.52	101	82
Oats	0.61	0.69	0.56	113	91
Potatoes	0.22	0.32	0.36	147	163
Legumes, minor grains[1]	0.17	0.20	0.17	119	102
Total crop net production	3.55	3.36	3.07	95	86
different staple crop food standards					
Rye, potatoes	1.84	1.60	1.57	87	85
Rye, wheat, potatoes	2.14	1.83	1.82	86	85
Human cons. o&b[2]	*0.25*	*0.24*	*0.22*	94	86
r, w, p, o & b hc[3]	2.39	2.07	2.04	87	85

Source: Own calculation; for data sources see Appendix.

Notes: 1 = legumes and minor grains contain peas, lentils, millet, buckwheat, vetches, and maslin. To calculate the net output of legumes and minor grains a seeding quota of 30% has been assumed to not overestimate net output; 2 = estimated food ratio of oats and barley for human consumption. The annual 'norm ratio' per capita of 10 kg oats and 15 kg barley refers to a normal harvest. Human feed grain consumption is assumed to fluctuate with oat's and barley's harvests; 5 = rye, wheat, potatoes, and feed grains for human consumption.

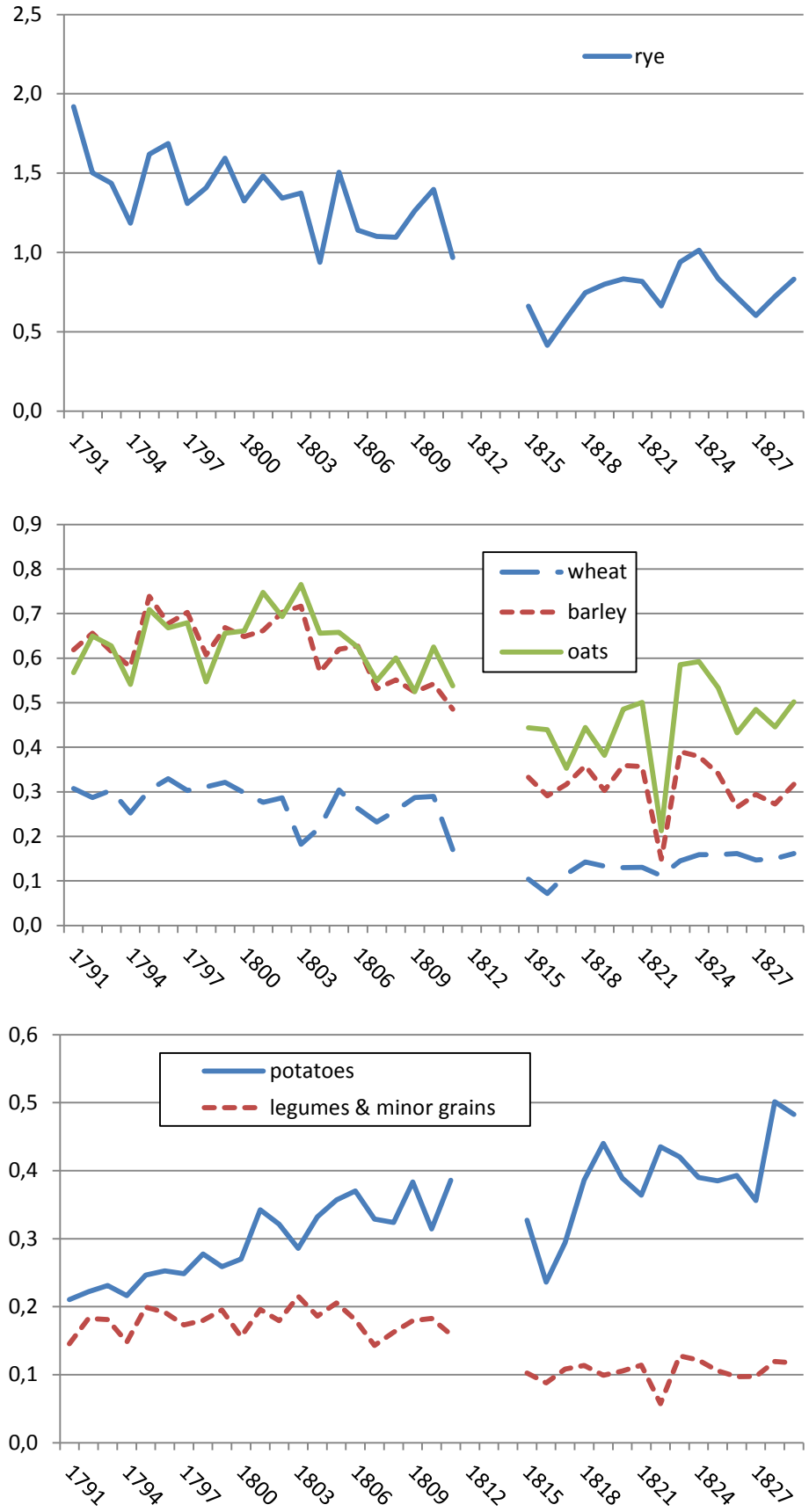
Table19b: Net output per capita 1815/17-1827/29 (grain equivalents)*

	1815/17	1818/20	1827/29	1815/17	1818/20	1827/29
				1791/93 = 100		
Rye	0.55	0.79	0.72	34	49	44
Wheat	0.10	0.14	0.15	32	45	51
Barley	0.31	0.34	0.29	50	54	47
Oats	0.41	0.44	0.48	67	71	78
Potatoes	0.29	0.41	0.45	129	183	202
legumes, minor grains	0.10	0.11	0.11	59	62	66
total crop net production	1.76	2.22	2.20	50	62	62
different staple crop food standards						
rye, potatoes	0.65	0.93	0.87	35	50	47
rye, wheat, potatoes	0.94	1.33	1.32	44	62	62
human con. o&b	0.18	0.23	0.25	71	92	98
r, w, p, o & b hc	1.12	1.57	1.57	47	65	66

Source: Own calculation; for data sources see Appendix.

Notes: see Table 19a.

Figure 10: **Net output per capita, 1791-1829 (grain equivalents)**



Source: Own calculation; for data sources see Appendix.

Notes: Legumes and minor grains comprise peas, lentils, millet, buckwheat, vetches, and maslin.

Third, after 1815 the remaining Saxon rump state depended structurally on imports, even if the catastrophic episode of 1815/17 is set aside. On average, during the period 1818-1829 domestic supply of rye, wheat, and potatoes provided only about 1.33 GE. Oats contributed another unspecifiable, but at best only minor part to staple crop intake. It is reasonable to assume that during the 1820s aggregate consumption of staple crops per capita was similar to the level prevailing during the early 1790s (Kopsidis, Pfister 2013), that is close to 2.5 GE. Thus, between a third and forty per cent of total food supply needed to be imported regularly (cf. Pfister, Kopsidis 2013). The drastic decline in self-sufficiency resulted from the fact that the strongly reduced Saxon state had inherited all the industrial upland areas with high population densities. Indeed, the ratio of the share of retained land to retained population is only 0.68 (cf. beginning of section 2), which lies close to the estimated average degree of self-sufficiency in 1818-1830. Abstracting from the changes in territorial boundaries occurring in 1815 implies as well that agricultural growth in 1790-1830 was sufficient to keep the level of domestic food supply per capita roughly stable, at least in terms of all sources of staple crops combined.

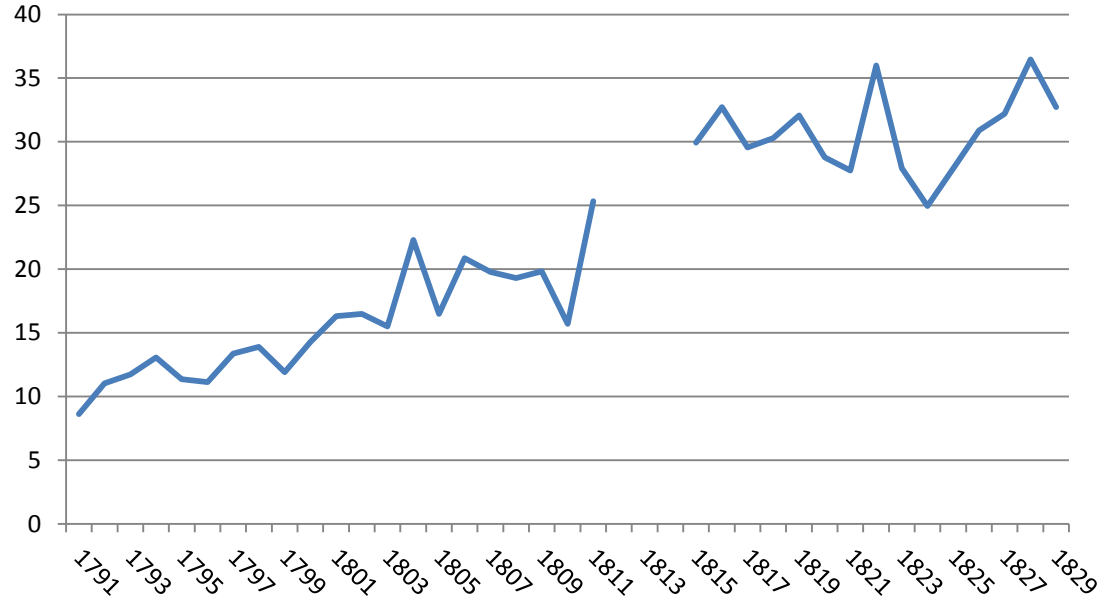
Fourth, the wartime shift towards subsistence crops continued even after post-war reconstruction and the positive income shock occurring during the late 1810s. That Saxony could not survive without substantial imports after 1815 should not be interpreted as a sign of rising market orientation of Saxon consumers and agricultural producers. Indeed, most of Saxony's food imports during the post-war era were nothing else than the continuation of the long established intense pre-war interregional trade within the former borders of the much larger Saxon state.

Table 20: Net share of potatoes in staple crop production per capita, 1791-1829 (per cent)*

year	Saxony	Leipziger Kreis	Erzgebirger Kreis	Vogtländischer Kreis
1791/93	10.3	7.6	20.2	34.0
1803/05	17.7	14.7	28.2	47.6
1809/11	19.9	16.0	32.3	48.8
1815/17	30.5	25.8	47.5	62.3
1818/20	30.4	23.9	46.6	61.7
1827/29	33.9	27.2	47.2	64.5

Source: Own calculation; for data sources see Appendix.
Notes: *staple crop production comprises rye, wheat and potatoes.

Figure 11: Share of potatoes in staple crop production per capita, 1791-1829 (per cent)*



Source: Own calculation; for data sources see Appendix.
Notes: *staple crop production comprises rye, wheat and potatoes.

Rye supply per capita out of domestic production decreased between 1818/20 and 1828/29 by 0.07 GE, and the exponential time trend over all thirteen years 1818-1830 of gross rye production is slightly negative (Table 19b, Table 8). The contribution of wheat supply increased by only 0.01 GE per capita, but this crop was out of the reach of the poorer segments of the population. However, decreasing domestic supply of rye was mainly compensated by increasing cultivation of subsistence crops, namely, potatoes and to a limited extent oats. Note that the increase of per capita net output in potatoes by 0.4 GE during 1818/20-1828/30 failed to compensate fully for the reduction in rye supply per capita (-0.7 GE). The moderate expansion of oats output per capita (+0.4 GE), which exceeded the growth of arable land and, hence, the growth of horse stocks, suggests a reorientation of the use of oats from serving as feed grain to human consumption.[25] Thus, per capita supply of staple crops remained constant or in fact may have slightly increased during the 1820s. However, declining terms of trade for livestock products (Figure 1) suggests that the consumption of protein-rich animal foodstuffs fell. Thus, the nutritional standard of the population at large declined, which is consistent with the finding that body heights of adult recruits, after a stabilization between the birth cohorts 1815/19 and 1820/24, fell again among the birth cohorts of the second half of the 1820s (Ewert 2006, p. 63).

Whereas the tradability of oats seemed to have improved significantly after 1815 potatoes remained a non-tradable over the entire period under consideration. Thus, the evolution of potato cultivation serves as a useful indicator of the subsistence sector's growth. Looking at the share of potatoes in staple crop production, narrowly de-

[25] See the end of section 5 on rising Saxon imports of oats after 1815.

fined as rye, potatoes and wheat, reveals that the weight of the subsistence sector in agricultural production increased in 1791-1829 all over Saxony. However, the relative importance of potatoes did not continuously rise following a constant trend (Table 19 and Figure 10). After the catastrophic war years 1812-1813 and the severe reduction of Saxony's territory in 1815 the share of potatoes jumped up immediately by half for the entire remaining Saxon territory. Even in industrial upland districts where shares of potatoes were already very large before 1815 they suddenly boosted up between a quarter (*Vogtland*) and a half (*Erzgebirger Kreis*). This structural break took place even in larger administrative units whose borders did not change at all in 1815, like the *Vogtland*. All in all, a lot of evidence speaks into the direction that after 1815 the low-income industrial population was not able to attract sufficient foreign food imports to fully compensate for the loss of important Saxon surplus areas, which probably deflected parts of their food trade to high-income Berlin. Even if the dynamics of the subsistence sector's expansion significantly slowed down, the trend remained positive between 1818 and 1830 (Table 8, Figure 10).

The evolution of food supply after 1818 suggests that the development of industrial regions characterized by strong population growth did not lead to an increase of food distribution through inter-regional markets. Rather, innovations in farming techniques were mainly applied to intensify arable farming in order to increase local production of non-tradable subsistence crops. The wide-spread phenomenon of *Arbeiterbauern* (industrial worker-farmers) suggests that small scale farming in pluriactive household economies of the industrial lower classes encouraged this process (Quataert 1985; Friedeburg 1996; Trossbach, Zimmermann 2006, pp. 205-206). The low income level of the population was simply inadequate to fuel increasing specialization between industrial and agricultural regions according to their comparative advantage. As a consequence, impulses to strengthen the existing market integration failed to appear.

Table 21a: Net output per capita 1791/93-1809/11 in the *Erzgebirger Kreis* (grain equivalents)

	1791/93	1803/05	1809/11	1803/05	1809/11
				1791/93 = 100	
Rye	0.78	0.60	0.59	77	75
Wheat	0.08	0.09	0.09	108	117
Barley	0.23	0.21	0.22	95	99
Oats	0.47	0.49	0.43	105	90
Potatoes	0.22	0.27	0.32	124	150
Legumes, minor grains	0.13	0.14	0.13	105	101
Total crop net production	1.90	1.80	1.78	94	94
different staple crop food standards					
Rye, potatoes	1.00	0.87	0.91	87	91
Rye, wheat, potatoes	1.08	0.96	1.00	89	93

Source: Own calculation; for data sources see Appendix.

Table21b: Net output per capita 1791/93-1809/11 in the *Leipziger Kreis* (grain equivalents)

	1791/93	1803/05	1809/11	1803/05	1809/11
				1791/93 = 100	
Rye	2.20	1.77	1.70	80	77
Wheat	0.50	0.40	0.43	80	86
Barley	0.84	0.85	0.76	102	91
Oats	1.06	1.22	0.98	115	92
Potatoes	0.22	0.36	0.39	166	179
Legumes, minor grains	0.17	0.23	0.20	133	115
Total crop net production	4.99	4.83	4.46	97	89
different staple crop food standards					
Rye, potatoes	2.42	2.13	2.09	214	210
Rye, wheat, potatoes	2.92	2.53	2.52	235	234

Source: Own calculation; for data sources see Appendix.

We conclude this section with a brief comparative case study of the densely populated, industrial upland district *Erzgebirge* and the less densely populated, highly fertile, lowland district *Leipziger Kreis*, which adds some nuances to previous conclusions. Whereas the dependency on food imports of Saxony in total remained roughly stable over the period of observation if the drastic changes of territorial borders in 1815 are set aside, this was not the case in the industrializing areas of Saxony (Tables 21a, 22a). In the *Erzgebirge* domestic supply of rye and wheat per capita declined from 0.86 GE in 1791/93 to 0.47 GE per capita in 1827/29 (-0.39 GE). Over the same time span the net potato output per capita increased from 0.22 to 0.43 GE (+0.21 GE), which only compensated for a bit more than half of the reduction in rye supplies. After 1815 local oats production hardly if at all contributed to fill the 'calorie gap', since oats output production per capita declined from 0.47 GE to 0.37 GE whereas during the 1820s intensification of agriculture and growth of the non-agricultural sectors simultaneously demanded urgently for more horse power. Thus, in the leading industrial region of Saxony, even under the assumption of a narrowly defined subsistence sector restricted to potatoes only, 55 per cent of the rising 'calorie gap' caused by the fall of rye output per head was filled by subsistence sector's expansion and only 45 per cent by rising supplies via markets. Moreover, despite the fact that soils were not suited for wheat cultivation huge efforts were undertaken in the *Erzgebirge* to raise domestic wheat production even if wheat was a highly marketable cash crop (Table 18, Figure A.6).

Table 22a: Net output per capita 1815/17-1827/29 in the Erzgebirger Kreis (grain equivalents)

	1815/17	1818/20	1827/29	1815/17	1818/20	1827/29
				1791/93 = 100		
Rye	0.25	0.41	0.40	32	52	51
Wheat	0.04	0.06	0.07	54	81	94
Barley	0.14	0.16	0.15	61	71	65
Oats	0.31	0.32	0.37	67	69	78
Potatoes	0.25	0.41	0.43	116	192	199
Legumes, minor grains	0.10	0.12	0.11	79	90	87
Total crop net production	1.10	1.47	1.54	58	77	81
different staple crop food standards						
rye, potatoes	0.50	0.82	0.83	50	82	83
rye, wheat, potatoes	0.54	0.88	0.91	50	82	84

Source: Own calculation; for data sources see Appendix.

Table22b: Net output per capita 1815/17-1827/29 in the *Leipziger Kreis* (grain equivalents)

	1815/17	1818/20	1827/29	1815/17	1818/20	1827/29
				1791/93 = 100		
Rye	0.90	1.31	1.21	41	60	55
Wheat	0.16	0.24	0.27	33	49	55
Barley	0.57	0.59	0.51	69	70	61
Oats	0.81	0.87	0.90	76	82	84
Potatoes	0.36	0.49	0.55	162	223	253
Legumes, minor grains	0.11	0.12	0.13	65	70	77
Total crop net production	2.91	3.63	3.58	58	73	72
different staple crop food standards						
Rye, potatoes	1.25	1.80	1.76	52	74	73
Rye, wheat, potatoes	1.42	2.04	2.03	49	70	70

Source: Own calculation; for data sources see Appendix.

Looking at the development of crop output per capita in the *Leipziger Kreis* as a potential surplus area reveals why the weight of subsistence production in agriculture and human food consumption increased during early industrialization. According to all standards this district was a grain surplus area at the end of the eighteenth century, but it lost this favourable position definitely during the 1820s (Tables 21b and 22b). Indeed, huge differences in crop production per capita existed within Saxony in 1791-1812 as well as in 1815-1830, but these differences remained more or less stable and did not increase as could be expected in a process of accelerated market driven regional specialization (Figures A.7a- A.8d).

Indeed, population in Saxony's industrial regions expanded so rapidly that dependency on grain imports from other parts of the Kingdom, lost in 1815, and from Bohemia increased over time. However, the greater part of the 'food-gap' that resulted from declining regional per capita supply of bread grain was filled by local produc-

tion of subsistence crops, namely, potatoes and probably some oats. Thus, during the first phase of Saxony's early industrialization c. 1815-1830 integration of grain markets advanced marginally at best, and regional specialization did only deepen to a limited extent if at all. According to the Saxon experience it appears that until the 1850s in industrializing Germany at least in a low-wage context the greater part of the challenge of feeding a growing industrial population was met by employing innovations in farming techniques to expand most of all local production of subsistence crops. In addition, any market demand induced impact on agricultural production seemed to have been narrowly restricted to local crop production.

8. Conclusion

Explaining agricultural development in the Prussian province of Westphalia c. 1835-1865 the famous Saxon statistician Ernst Engel, who formulated Engel's law, wrote in 1867: "Thanks to all the new railway tracks the coal, iron, steel and zinc production advanced strongly in this province during the last years, which makes for good wages for a number of people enabling them to consume more" (own translation; Engel 1867, p. 108). In his statement Engel identified a critical variable for agricultural growth that performed rather poor in Saxony before the 1830s if not until the 1850s: food demand from a spatially concentrated urban-industrial work force earning high wages relative to pre-industrial wage labourers. To be sure, we find evidence of considerable output growth in the agricultural sector of early industrializing Saxony. However, the low wage-high energy cost path of industrialization based mainly on dispersed textile manufacturing followed by this part of Germany meant that incomes earned by the mass of the population barely sufficed to maintain a stable nutritional standard in caloric terms — war shocks and harvest failures put aside. In qualitative terms the nutritional standard deteriorated, since the weight of subsistence staple crops increased over time; indirect evidence also points to a declining consumption of superior livestock products. Due to the low level and slow rise of working class incomes the purchasing power of Saxony's consumers was insufficient to spur food market integration and to deepen specialization between industrial and agricultural regions according to their comparative advantage. Improvements in farming techniques linked to the First Agricultural Revolution were not employed to develop market production in naturally favoured regions and to support the transition to mixed farming. Rather, they served to intensify arable farming and to expand the local production of subsistence crops, mainly potatoes and oats. Thus, the dominance of a specific industrialization path characterized by low wages and high energy costs and its depressing impact on effective food demand goes a long way to explain the sluggishness of agricultural growth in Saxony.[26] Indeed, c. 1770-1830 Saxony's food standard declined from a full grain to a partial potato-standard (Abel 1966, pp. 240-242).

[26] About the depressing impact of a weak effective market demand for food on agricultural growth as a result of low incomes in developing economies see Lipton (1990). In a worst case scenario even a

Specifically, by drawing on a new dataset of regionally disaggregated crop output and seed quantities for Saxony 1791-1830, our study contributes to deepen the understanding of Saxony's agricultural development during early industrialization. Our major findings are:

(1) After war-related decline during 1791-1812 and post-war recovery until 1818 total crop output increased between 1818 and 1830 at an annual rate of 1.15 per cent. This fell marginally short of population growth (1.22 per cent). Output growth resulted from the recovery of yield ratios complemented by an expansion of the area sown. The latter did not as much indicate a wave of land reclamation (*Landesausbau*) but a reduction of fallow land on the given arable. However, for most parts of Saxony, yield growth after 1815 meant only a return to pre-war levels of land productivity and a modest expansion of area sown. This combination speaks not in favour of strongly rising total factor productivity. Only in the less fertile industrial *Erzgebirge* sustained productivity growth occurred in the sense that the restoration of pre-war yield ratios was accompanied by a vigorous expansion of sown area. This constitutes indirect evidence of an accelerated implementation of new farming techniques in this upland area that permitted productivity-enhancing intensification of (arable) farming.

(2) Output decline during the Revolutionary and Napoleonic Wars 1792-1813 occurred in two phases: Until 1803/05 adverse demand forces prevailed; disruptions in world trade presumably depressed earnings from industrial exports and reduced food demand of export-depended textile workers. Whereas yield ratios of rye declined area sown and yield ratios of feed grain, particularly of oats, increased; potato output expanded as well. Assuming that feed requirements for horses grew parallel with total area sown, at least some parts of the incremental output in oats must have been used for human consumption. These findings imply that in a context of faltering market demand input resources in agriculture were shifted from cash crops to cheaper subsistence crops. In the second phase, that is, after 1805 Saxony became a theatre of war and was forced to contribute food and manpower to Napoleon's War efforts. Diversion of critical inputs, mainly of labour, manure producing livestock, and draught animals manifested themselves in a parallel decline of yield ratios and sown area for all major crops.

(3) Already in 1772 there existed a considerable regional concentration of agricultural production, but regional output shares remained by and large stable over the subsequent period up to 1830. Indeed, there is no evidence indicating a deepening of regional specialization, which was the engine of Smithian growth in agriculture in industrializing Westphalia c. 1840-1880 and other parts of Europe. Moreover, set aside the massive changes of territorial borders in 1815 nothing indicates substantial alterations in the degree of self-sufficiency for Saxony concerning staple crops. These results are consistent with recent research showing that major grain mar-

'Boserupian response' on population growth could not take place in agriculture. However, this kind of most extreme immiserizing growth did not occur in early industrializing Saxony.

kets of Saxony were well integrated into wider market networks already by the middle of the eighteenth century and that subsequently the level of market integration changed only little up to the mid-nineteenth century, apart from temporary market disintegration during the Napoleonic Wars. Taking all this together, a modest development of agricultural markets and inter-regional specialization must have occurred during an early phase of proto-industrial development until the outbreak of the Seven-Years-War in 1756. For our period of observation c. 1790-1830 nothing speaks in favour of a further substantial deepening of regional specialization according to comparative advantage driven by demand articulated through markets.

(4) Even after post-war reconstruction and a positive income shock the weight of potatoes and to a lesser extent of oats in total crop output increased during 1818-1830. Both crops were by and large non-tradables even if the tradability of oats seemed to have improved slightly during the 1820s. Intensification of land use must have been accompanied by an expansion of the stock of farm horses consuming oats. However, again oats output growth developed so dynamically that at least parts of these increases probably were used for human consumption. By contrast, the domestic supply of rye fell on a per capita basis, particularly in the industrial parts of Saxony, despite a strong expansion of the area sown with this crop. Only a minor part of the gap in bread grain supply opening in the industrial regions was closed by increased supplies via foreign or domestic markets. Rather, expanded cultivation of subsistence crops, namely, potatoes and possibly oats, made an important contribution. This adds evidence to the thesis that improved farming techniques and intensification of arable farming mainly contributed to the expansion of local subsistence production in areas characterized by high population density, often in the context of petty farming carried out by industrial workers on their household plots, rather than by the expansion of market oriented full time-farming. This development occurred under the condition of renewed declines of the relative prices of meat, butter and beer: Obviously, incomes of the mass of population were too low to afford processed and traded foodstuffs.

(5) Wheat constitutes a side-story adding interesting nuances. Wheat production grew almost as fast as potato output after 1815. It was the only grain whose sown area expanded significantly outside the industrialized parts of Saxony. Wheat cultivation did not expand at the detriment of rye, but yield ratios of rye developed less favourably than those of all other main grains. Apparently farmers turned their best land and an increasing part of their efforts and diligence over to wheat cultivation and relegated rye cultivation to soils of lesser quality; only because of the intensification of arable farming the area sown with rye expanded, too. At a first glance the development of wheat cultivation seems to be consistent with a model of market-driven regional specialization and agricultural development. However, wheat cultivation expanded most vigorously in the *Erzgebirge* and not in the highly fertile plains provided with one of world's best soils for wheat farming.

In addition, even at the end of the period under study the share of wheat in total output amounted to only 6 per cent of total crop output. Because of its high price relative to rye consumption of wheat must have been limited to the more affluent segments of society. Strong output growth of wheat may thus reflect an increase in income inequality during early industrialization. Absence of mass demand precluded the extension of market-driven regional specialization beyond the narrow confines of producing agricultural goods destined for upper-class consumption.

(6) Sweeping land reforms which fully individualized land property rights were enacted only in 1832 after the end of our period of observation. However, 'traditional' agrarian institutions did not inhibit agricultural growth and development before 1832. The foregoing summary of results demonstrates that changes in the practices of land use and farming in pre-1830 Saxony primarily reflect incentives that farmers were exposed to. Growth was slow relative to population growth because farmers had only weak demand signals to react to. To be sure, intensification of arable farming undertaken by peasants interfered with endeavours by landlords to expand lucrative merino sheep husbandry on the basis of a reactivation and extension of traditional manorial grazing rights on peasant land. In most regions of Saxony, however, the resulting land conflicts could be resolved by redemption contracts — a solution strongly supported by the central government and the liberal minded bureaucracy. The example of the *Vogtland* and its comparison with a neighbouring region demonstrates *ex negativo* that there existed ample scope for successful Coase-solutions to solve land use conflicts between 'cattle raisers' and 'farmers' within the framework of the given manorial system and management of commons. All in all, Saxony represents an additional example that traditional early modern agrarian institutions provided sufficient flexibility to allow the introduction of land-saving innovations without radical enclosures or full privatization of land (Allen 2001). Indeed, agricultural growth did not accelerate in Saxony immediately after the agricultural reforms but only two to three decades later after industrial real incomes had started to rise (Pfister, Kopsidis 2013).

To conclude, at best only the first stage of a first agricultural revolution had been reached in pre-1830 Saxony. Indeed, around 1830 yields were not higher than four decades ago. Only the sown area could be extended without risking diminishing yields. However, a fully developed first agricultural revolution would have implied that yields achieved a new level hitherto unknown despite the extension of area sown.

Saxony's path of agricultural development, which depended heavily on the intensification of local subsistence production or production for local demand in general, emanated from its low wage-high energy cost path of early industrialization, and contrasts with the trajectory of Westphalia. At least since the 1840s a high wage-low energy cost path of industrialization dominated in this Prussian province. This had far reaching consequences for agricultural growth having in mind that during the eighteenth and nineteenth centuries agricultural development was mainly a demand induced process. As already noticed by Ernst Engel the boosting demand for superior

high value added (animal) foodstuffs in the *Ruhr area* promoted market integration, regional specialization and the expansion of intense livestock farming. Vigorous productivity growth in farming took place (Kopsidis 2002, 2006c, pp. 277-374; Kopsidis, Hockmann 2010; Kopsidis, Wolf 2012). To be sure, Westphalia's take-off took place from the 1830s or 1840s onwards, that is, after the end of the time period under consideration of this study, which opens up the possibility that the experiences of the two regions may actually represent two stages of a longer process. In fact, from the 1850s onwards railway construction improved Saxony's supply with coal; this facilitated the modernization of industry as well as its spatial concentration. Railway networks also improved integration of both industrial and agricultural markets. The single most telling indicator of an improvement of mass demand in this period is the strong increase in meat consumption per capita occurring at the end of the 1850s (Table 4). All in all, Allen's distinction between low wage-high energy costs and high wage-low energy costs paths of industrialization (Allen 2009) presents a useful concept not only to study contrasting patterns of early industrialization but also for the analysis of differing regional trajectories of agricultural development during the era of the First Agricultural Revolution.

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Appendix

Archival Sources for output and population statistics

Hauptstaatsarchiv Dresden, Bestand 10026 Geheimes Kabinett, Ernte- und Konsumentenverzeichnisse. 1755, 1772, 1791-1793: Loc. 563/1; 1789-1790: Loc. 561/1; 1794-1797: Loc. 564/2; 1798-1801: Loc. 564/3; 1802-1805: Loc. 564/4; 1806-1812: Loc. 564/5; 1815-1826: Loc. 564/6; 1827-1830: Loc. 2450/7.

Conversion rules

Conversion of bushels (*Dresdner Scheffel*) into kilogram and grain equivalents (GE)

	kg per bushel	GE per 100 kg
Rye	80	1.01
Wheat	85	1.07
Barley	70	1.00
Oats	50	0.85
Peas	80	1.04
Lentils	80	0.36
Millet	90	0.84
Buckwheat	80	1.17
Vetches	80	0.92
Maslin	80	1.01
Potatoes	85	0.22

Source: http://www.tll.de/ainfo/pdf/ge_schl.pdf, Kiesewetter (2007, p. 231), http://www.bv-net.de/deutsch/080_service/08600_schuettguttabelle.htm.
Note: 1 kilogram of barley corresponds to 3,260 calories. Thus 100 kilogram of barley (= 1 grain equivalent) corresponds to 326,000 calories.

The standard for grain equivalents based on feed barley as used here has been introduced in 1988. For the crops considered in this study conversion ratios differ only marginally between this standard and earlier rules (cf. Finckenstein 1960, pp. 5-9; Schulze Mönking, Klapp 2010, p. 7-9).

Tables and Figures

Table A.1 Regional population growth and density, 1755-1830

Population	**Area (km^2)**	**1755**	**1772**	**1791**	**1812**	**1815**	**1818**	**1830**
Chur Kreis	5.178	116,491	109,857	128,810	134,737	--	--	--
Thüringischer Kreis	3.409	165,056	168,045	175,287	181,962	--	--	--
Meißnischer Kreis	*6.654*	*289,318*	*289,689*	*277,170*	*296,359*	*239,856*	*319,502*	*343,445*
Leipziger Kreis	*3.421*	*206,238*	*196,912*	*224,301*	*250,099*	*207,701*	*214,865*	*244,014*
Erzgebirgischer Kreis	*4.632*	*303,117*	*278,884*	*399,002*	*452,464*	*440,454*	*389,696*	*483,314*
Vogtländischer Kreis	*1.380*	*89,884*	*61,705*	*81,331*	*90,139*	*88,162*	*88,389*	*101,285*
Markgrafschaft Ober-Lausitz	5.700	263,400	259,175	296,093	321,465	--	--	--
Markgrafschaft Nieder-Lausitz	4.725	105,785	104,922	116,018	133,948	--	--	--
Population growth p.a. (per cent)	**1755-1772**	**1772-1791**	**1791-1812**	**1812-1815**	**1815-1818**	**1818-1830**	**1772-1812**	**1772-1830**
Chur Kreis	-0.34	0.84	0.21	--	--	--	*0.51*	--
Thüringischer Kreis	0.11	0.22	0.18	--	--	--	*0.20*	--
Meißnischer Kreis	*0.01*	*-0.23*	*0.32*	*-6.81*	*10.03*	*0.60*	*0.06*	*0.29*
Leipziger Kreis	*-0.27*	*0.69*	*0.52*	*-6.00*	*1.14*	*1.07*	*0.60*	*0.37*
Erzgebirgischer Kreis	*-0.49*	*1.90*	*0.60*	*-0.89*	*-4.00*	*1.81*	*1.22*	*0.95*
Vogtländischer Kreis	*-2.19*	*1.46*	*0.49*	*-0.74*	*0.09*	*1.14*	*0.95*	*0.86*
Markgrafschaft Ober-Lausitz	-0.10	0.70	0.39	--	--	--	*0.54*	--
Markgrafschaft Nieder-Lausitz	-0.05	0.53	0.69	--	--	--	*0.61*	--
Population density (pop / km^2)		**1755**	**1772**	**1791**	**1812**	**1815**	**1818**	**1830**
Chur Kreis		22	21	25	26	--		--
Thüringischer Kreis		48	49	51	53	--		--
Meißnischer Kreis		*43*	*44*	*42*	*45*	*36*	*48*	*52*
Leipziger Kreis		*60*	*58*	*66*	*73*	*61*	*63*	*71*
Erzgebirgischer Kreis		*65*	*60*	*86*	*98*	*95*	*84*	*104*
Vogtländischer Kreis		*65*	*45*	*59*	*65*	*64*	*64*	*73*
Markgrafschaft Ober-Lausitz		46	45	52	56	--	--	--
Markgrafschaft Nieder-Lausitz		22	22	25	28	--	--	--

Source: Own calculation; for data sources see Appendix and Stams (2007, p. 49). — *Note*: Names of administrative units in italics refer to units whose territory remained largely unchanged in 1814/1815.

Table A.2: Change of the share of bread grain and potatoes in total gross crop production (GCP) by using different output measures

Share in crop production (per cent)	1755	1772	1791/93	1803/05	1810/12	1815/17	1818/20	1828/30
			Electorate of Saxony				Kingdom of Saxony	
Rye in bushel	40	33	34	26	26	21	21	18
Rye in grain equivalents	49	44	46	39	40	35	37	34
Wheat in bushel	4	5	5	4	4	3	3	3
Wheat in grain equivalents	5	8	8	7	7	5	6	6
Bread grain in bushel	44	38	39	31	30	23	24	21
Bread grain in grain equivalents	52	57	54	46	48	40	43	40
Potatoes in bushel	3	13	18	25	30	35	41	45
Potatoes in grain equivalents	1	4	6	9	11	14	17	19

Source: Own calculation; for data sources see Appendix.

Note: Bread grain includes rye and wheat.

Table A.3a: Output and annual growth rates of gross rye production (GCP) in grain equivalents, 1772-1812

Administrative units	Production in GE				Annual growth rates (per cent)		
	1772	1791/1793	1803/1805	1810/1812	1772-1791/93	1791/93-1803/05	1803/05-1810/12
Chur Kreis	206,269	341,822	302,190	267,757	2.6	-1.0	-1.7
Thüringischer Kreis	507,805	603,752	615,140	499,985	0.9	0.2	-2.9
Meißnischer Kreis	461,531	571,894	500,045	461,933	1.1	-1.1	-1.1
Leipziger Kreis	367,361	596,089	526,388	481,408	2.4	-1.0	-1.3
Erzgebirgischer Kreis	168,362	400,614	348,911	315,772	4.4	-1.1	-1.4
Vogtländischer Kreis	60,880	81,718	64,902	60,809	1.5	-1.9	-0.9
Neustädtischer Kreis	39,609	69,246	57,809	48,381	2.8	-1.5	-2.5
Stift Merseburg	100,101	152,159	156,738	127,475	2.1	0.2	-2.9
Stift Naumburg	53,301	65,420	59,575	52,341	1.0	-0.8	-1.8
Grafschaft Henneberg	--	17,861	15,942	15,299	--	-0.9	-0.6
Markgrafschaft Ober-Lausitz	440,053	634,048	460,380	497,906	1.8	-2.6	1.1
Markgrafschaft Nieder-Lausitz	193,846	295,925	252,816	206,056	2.1	-1.3	-2.9
Bergämter	--	431	427	185	--	-0.1	-11.3
Saxony	2,654,796	3,839,522	3,369,997	3,074,877	1.9	-1.1	-1.3

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.3b: Output and annual growth rates of gross wheat production (GCP) in grain equivalents, 1772-1812

Administrative units	Production in GE				Annual growth rates (per cent)		
	1772	1791/1793	1803/1805	1810/1812	1772-1791/93	1791/93-1803/05	1803/05-1810/12
Chur Kreis	52,040	75,640	62,396	54,078	1.9	-1.6	-2.0
Thüringischer Kreis	121,951	148,262	132,909	113,079	1.0	-0.9	-2.3
Meißnischer Kreis	77,245	95,390	86,629	85,684	1.1	-0.8	-0.2
Leipziger Kreis	81,267	129,671	113,999	104,009	2.4	-1.1	-1.3
Erzgebirgischer Kreis	23,605	40,999	49,023	45,835	2.8	1.5	-1.0
Vogtländischer Kreis	7,113	5,739	4,599	4,269	-1.1	-1.8	-1.1
Neustädtischer Kreis	11,808	16,255	14,769	11,270	1.6	-0.8	-3.8
Stift Merseburg	23,017	38,620	31,876	27,535	2.6	-1.6	-2.1
Stift Naumburg	20,250	20,155	17,022	14,909	0,0	-1.4	-1.9
Grafschaft Henneberg	--	4,283	3,903	3,894	--	-0.8	0.0
Markgrafschaft Ober-Lausitz	39,355	51,161	41,029	48,746	1.3	-1.8	2.5
Markgrafschaft Nieder-Lausitz	28,801	40,020	26,833	25,989	1.7	-3.3	-0.5
Bergämter	--	119	71	28	--	-4.2	-12.4
Saxony	497,417	668,615	586,929	544,330	1.5	-1.1	-1.1

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.3c: Output and annual growth rates of gross barley production (GCP) in grain equivalents, 1772-1812

	Production in GE				Annual growth rates (per cent)		
Administrative units	**1772**	**1791/1793**	**1803/1805**	**1810/1812**	**1772-1791/93**	**1791/93-1803/05**	**1803/05-1810/12**
Chur Kreis	84,202	123,219	125,921	83,629	1.9	0.2	-5.7
Thüringischer Kreis	352,072	397,189	446,764	305,620	0.6	1.0	-5.3
Meißnischer Kreis	164,825	217,037	221,498	200,407	1.4	0.2	-1.4
Leipziger Kreis	153,052	226,814	242,918	214,108	2.0	0.6	-1.8
Erzgebirgischer Kreis	58,718	117,908	122,006	120,704	3.5	0.3	-0.2
Vogtländischer Kreis	42,766	46,397	43,144	38,430	0.4	-0.6	-1.6
Neustädtischer Kreis	29,188	39,559	37,749	31,780	1.5	-0.4	-2.4
Stift Merseburg	52,378	65,531	76,578	57,232	1.1	1.3	-4.1
Stift Naumburg	40,037	49,063	53,638	46,813	1.0	0.7	-1.9
Grafschaft Henneberg	--	3,255	2,365	2,101	--	-2.6	-1.7
Markgrafschaft Ober-Lausitz	118,196	112,835	124,702	113,898	-0.2	0.8	-1.3
Markgrafschaft Nieder-Lausitz	44,317	47,008	44,848	31,476	0.3	-0.4	-4.9
Bergämter	--	249	246	18	--	-0.1	-30.9
Saxony	1,168,873	1,451,836	1,547,920	1,250,200	1.1	0.5	-3.0

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.3d: Output and annual growth rates of gross oats production (GCP) in grain equivalents, 1772-1812

	Production in GE				Annual growth rates (per cent)		
Administrative units	**1772**	**1791/1793**	**1803/1805**	**1810/1812**	**1772-1791/93**	**1791/93-1803/05**	**1803/05-1810/12**
Chur Kreis	46,176	64,361	82,289	63160	1.7	2.1	-3.7
Thüringischer Kreis	281,532	314,972	352,992	281446	0.6	1.0	-3.2
Meißnischer Kreis	171,376	150,776	201,082	184168	-0.6	2.4	-1.2
Leipziger Kreis	185,613	289,496	345,121	302059	2.2	1.5	-1.9
Erzgebirgischer Kreis	167,903	274,052	303,734	268277	2.5	0.9	-1.8
Vogtländischer Kreis	30,318	28,328	27,843	23865	-0.3	-0.1	-2.2
Neustädtischer Kreis	13,103	18,981	21,122	18594	1.9	0.9	-1.8
Stift Merseburg	87,067	111,003	130,767	105769	1.2	1.4	-3.0
Stift Naumburg	24,154	31,451	36,793	33936	1.3	1.3	-1.1
Grafschaft Henneberg	--	3,105	2,978	3483	--	-0.3	2.3
Markgrafschaft Ober-Lausitz	95,528	132,496	161,411	144713	1.6	1.7	-1.5
Markgrafschaft Nieder-Lausitz	28,645	37,987	48,480	24347	1.4	2.1	-9.4
Bergämter	--	336	335	147	--	0.0	-11.1
Saxony	1,160,057	1,459,562	1,717,205	1460126	1.2	1.4	-2.3

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.4: Output and annual growth rates of potato production (GCP) in grain equivalents, 1772-1812

Administrative units	Production in GE				Annual growth rates (per cent)		
	1772	1791/1793	1803/1805	1810/1812	1772-1791/93	1791/93-1803/05	1803/05-1810/12
Chur Kreis	11,323	30,294	54,129	51,527	5.0	5.0	-0.7
Thüringischer Kreis	13,317	35,587	73,923	82,385	5.0	6.3	1.6
Meißnischer Kreis	26,935	59,669	100,479	107,988	4.1	4.4	1.0
Leipziger Kreis	26,716	56,837	100,975	109,698	3.8	4.9	1.2
Erzgebirgischer Kreis	52,809	100,176	135,385	152,672	3.3	2.5	1.7
Vogtländischer Kreis	37,431	37,781	48,968	48,433	0.0	2.2	-0.2
Neustädtischer Kreis	14,963	24,438	33,006	32,767	2.5	2.5	-0.1
Stift Merseburg	3,980	10,897	18,806	22,196	5.2	4.7	2.4
Stift Naumburg	4,759	8,929	14,356	16,923	3.2	4.0	2.4
Grafschaft Henneberg	--	12,168	14,804	18,818	--	1.6	3.5
Markgrafschaft Ober-Lausitz	36,314	56,958	96,932	114,494	2.3	4.5	2.4
Markgrafschaft Nieder-Lausitz	13,227	37,682	54,531	53,912	5.4	3.1	-0.2
Bergämter	--	809	1,011	1,368	--	1.9	4.4
Saxony	248,147	472,961	749,174	821,778	3.3	3.9	1.3

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.5: Output and annual growth rates of total crop production (GCP) in grain equivalents, 1772-1812

Administrative units	Production in GE				Annual growth rates (per cent)		
	1772	1791/1793	1803/1805	1810/1812	1772-1791/93	1791/93-1803/05	1803/05-1810/12
Chur Kreis	445,039	695,101	716,469	579,369	2.3	0.3	-3.0
Thüringischer Kreis	1.316,364	1,550,570	1,689,731	1,321,316	0.8	0.7	-3.5
Meißnischer Kreis	975,512	1,171,161	1,217,612	1,141,740	0.9	0.3	-0.9
Leipziger Kreis	844,943	1,354,685	1,408,622	1,277,856	2.4	0.3	-1.4
Erzgebirgischer Kreis	509,257	1,008,460	1,044,310	981,640	3.5	0.3	-0.9
Vogtländischer Kreis	185,295	203,302	191,812	177,617	0.5	-0.5	-1.1
Neustädtischer Kreis	119,480	183,039	180,899	155,443	2.2	-0.1	-2.1
Stift Merseburg	274,302	389,852	429,562	352,884	1.8	0.8	-2.8
Stift Naumburg	149,737	184,426	190,656	171,688	1.0	0.3	-1.5
Grafschaft Henneberg	--	41,724	41,727	44,976	--	0.0	1.1
Markgrafschaft Ober-Lausitz	764,744	1,025,716	925,360	962,347	1.5	-0.9	0.6
Markgrafschaft Nieder-Lausitz	352,469	505,712	479,392	379,025	1.8	-0.4	-3.3
Bergämter	--	1,963	2,190	1,748	--	0.9	-3.2
Saxony	6,074,692	8,337,837	8,542,226	7,617,914	1.6	0.2	-1.6

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.6a: Output and annual growth rates of total gross rye production (GCP) in grain equivalents, 1815-1830

Administrative units	Production in GE			Growth p.a. (per cent)	
	1815-17	1818-20	1828-30	1815/17-1818/20	1818/20-1828/30
Meissner Kreis	345,655	453,736	463,523	9.5	0.2
Erzgebirger Kreis	153,524	217,907	247,537	12.4	1.3
Leipziger Kreis	264,381	360,755	365,780	10.9	0.1
Vogtländer Kreis	39,252	49,952	48,468	8.4	-0.3
Markgrafschaft Ober-Lausitz	205,831	243,735	237,638	5.8	-0.3
Saxony	1,008,725	1,326,231	1,363,119	9.6	0.3

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.6b: Output and annual growth rates of total gross wheat production (GCP) in grain equivalents, 1815-1830

Administrative units	Production in GE			Growth p.a. (per cent)	
	1815-17	1818-20	1828-30	1815/17-1818/20	1818/20-1828/30
Meissner Kreis	59,337	77,185	90,793	9.2	1.6
Erzgebirger Kreis	24,602	33,699	47,986	11.1	3.6
Leipziger Kreis	44,210	62,856	79,278	12.4	2.3
Vogtländer Kreis	3,069	4,377	5,285	12.6	1.9
Markgrafschaft Ober-Lausitz	23,778	29,720	36,119	7.7	2.0
Saxony	155,007	207,855	259.474	10.3%	2.2%

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.6c: Output and annual growth rates of total gross barley production (GCP) in grain equivalents, 1815-1830

Administrative units	Production in GE			Growth p.a. (per cent)	
	1815-17	1818-20	1828-30	1815/17-1818/20	1818/20-1828/30
Meissner Kreis	184,216	204,345	204,843	3.5	0.0
Erzgebirger Kreis	76,222	85,085	95,953	3.7	1.2
Leipziger Kreis	150,399	155,235	155,846	1.1	0.0
Vogtländer Kreis	28,475	36,889	32,130	9.0	-1.4
Markgrafschaft Ober-Lausitz	60,714	59,707	55,478	-0.6	-0.7
Saxony	500,040	541,279	544.261	2.7	0.1

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.6d: Output and annual growth rates of total gross oats production (GCP) in grain equivalents, 1815-1830

Administrative units	Production in GE			Growth p.a. (per cent)	
	1815-17	1818-20	1828-30	1815/17-1818/20	1818/20-1828/30
Meissner Kreis	177,726	199,394	246,849	3.9	2,2
Erzgebirger Kreis	189.882	193.816	256.177	0.7	2.8
Leipziger Kreis	211,230	231,331	261,985	3.1	1,3
Vogtländer Kreis	22,496	26,242	24,274	5.3	-0,8
Markgrafschaft Ober-Lausitz	79,663	76,281	90,870	-1.4	1,8
Saxony	681,099	727,209	880.306	2.2	1.9

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.7: Output and annual growth rates of total gross potato production (GCP) in grain equivalents, 1815-1830

Administrative units	Production in GE			Growth p.a. (per cent)	
	1815-17	1818-20	1828-30	1815/17-1818/20	1818/20-1828/30
Meissner Kreis	88,997	129,244	178,532	13.2	3.3
Erzgebirger Kreis	117,183	189,218	254,167	17.3	3.0
Leipziger Kreis	86,953	123,010	168,019	12.3	3.2
Vogtländer Kreis	39,740	63,081	79,920	16.7	2.4
Markgrafschaft Ober-Lausitz	62,224	72,166	103,361	5.1	3.7
Saxony	396,130	578,244	785,820	13.4	3.1

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.8: Output and annual growth rates of total gross crop production (GCP) in grain equivalents, 1815-1830

Administrative units	Production in GE			Growth p.a. (per cent)	
	1815-17	1818-20	1828-30	1815/17-1818/20	1818/20-1828/30
Meissner Kreis	899,154	1,110,310	1,244,292	7.3	1.1
Erzgebirger Kreis	602,796	766,056	959,780	8.3	2.3
Leipziger Kreis	781,011	959,561	1,065,668	7.1	1.1
Vogtländer Kreis	133,993	181,850	191,074	10.7	0.5
Markgrafschaft Ober-Lausitz	441,390	490,474	533,764	3.6	0.8
Saxony	2,859,597	3,511,656	3,996,765	7.1	1.3

Source: Own calculation; for data sources see Appendix.

Note: The total sum for Saxony slightly differs from the sum of all administrative units because some smaller units are missing.

Table A.9a: Spatial distribution of gross rye production, 1772-1812

Administrative units		Regional share in total production (per cent)			
	Total area	1772	1791/93	1803/05	1810/12
Chur Kreis	13.8	7.8	9.0	8.9	8.7
Thüringischer Kreis	9.1	19.1	15.7	18.4	16.2
Meißnischer Kreis	17.8	17.4	14.9	14.8	15.0
Leipziger Kreis	9.2	13.8	15.5	15.6	15.6
Erzgebirgischer Kreis	12.4	6.3	10.5	10.4	10.3
Vogtländischer Kreis	3.6	2.3	2.1	1.9	2.0
Neustädtischer Kreis	2.0	1.5	1.8	1.7	1.6
Stift Merseburg	2.7	3.8	3.9	4.7	4.1
Stift Naumburg	0.8	2.0	1.7	1.8	1.7
Grafschaft Henneberg	1.0	0.0	0.5	0.5	0.5
Markgrafschaft Ober-Lausitz	15.1	16.6	16.5	13.6	16.3
Markgrafschaft Nieder-Lausitz	12.5	7.3	7.7	7.5	6.7
Bergämter	0.0	0.0	0.0	0.0	0.0

Source: Own calculation; for data sources see Appendix.

Table A.9b: Spatial distribution of gross wheat production, 1772-1812

Administrative units		Regional share in total production (per cent)			
	Total area	1772	1791/93	1803/05	1810/12
Chur Kreis	13.8	10.5	11.3	10.5	9.9
Thüringischer Kreis	9.1	24.5	22.2	23.3	20.7
Meißnischer Kreis	17.8	15.5	14.3	14.5	15.8
Leipziger Kreis	9.2	16.3	19.4	19.3	18.9
Erzgebirgischer Kreis	12.4	4.7	6.1	8.5	8.5
Vogtländischer Kreis	3.6	1.4	0.9	0.8	0.8
Neustädtischer Kreis	2.0	2.4	2.4	2.5	2.1
Stift Merseburg	2.7	4.6	5.8	5.5	5.0
Stift Naumburg	0.8	4.1	3.0	2.9	2.7
Grafschaft Henneberg	1.0	0.0	0.6	0.7	0.7
Markgrafschaft Ober-Lausitz	15.1	7.9	7.7	6.7	9.1
Markgrafschaft Nieder-Lausitz	12.5	5.8	6.0	4.5	4.8
Bergämter	0.0	0.0	0.0	0.0	0.0

Source: Own calculation; for data sources see Appendix.

Table A.9c: Spatial distribution of gross barley production, 1772-1812

Administrative units		Regional share in total production (per cent)			
	Total area	1772	1791/93	1803/05	1810/12
Chur Kreis	13.8	8.3	8.5	8.2	6.7
Thüringischer Kreis	9.1	27.0	27.4	28.8	24.5
Meißnischer Kreis	17.8	14.9	14.9	14.3	16.0
Leipziger Kreis	9.2	16.0	15.6	15.7	17.1
Erzgebirgischer Kreis	12.4	8.6	8.1	7.9	9.6
Vogtländischer Kreis	3.6	3.0	3.2	2.8	3.1
Neustädtischer Kreis	2.0	2.6	2.7	2.5	2.5
Stift Merseburg	2.7	4.7	4.5	4.9	4.6
Stift Naumburg	0.8	3.4	3.4	3.5	3.7
Grafschaft Henneberg	1.0	0.2	0.2	0.2	0.2
Markgrafschaft Ober-Lausitz	15.1	8.4	7.8	8.1	9.1
Markgrafschaft Nieder-Lausitz	12.5	3.1	3.2	2.9	2.5
Bergämter	0.0	0.0	0.0	0.0	0.0

Source: Own calculation; for data sources see Appendix.

Table A.9d: Spatial distribution of gross oats production, 1772-1812

Administrative units		Regional share in total production (per cent)			
	Total area	1772	1791/93	1803/05	1810/12
Chur Kreis	13.8	4.5	4.4	4.8	4.3
Thüringischer Kreis	9.1	20.9	21.6	20.5	19.3
Meißnischer Kreis	17.8	11.5	10.3	11.7	12.6
Leipziger Kreis	9.2	20.0	19.8	20.1	20.7
Erzgebirgischer Kreis	12.4	18.2	18.8	17.7	18.4
Vogtländischer Kreis	3.6	1.8	1.9	1.6	1.6
Neustädtischer Kreis	2.0	1.3	1.3	1.2	1.3
Stift Merseburg	2.7	7.4	7.6	7.6	7.2
Stift Naumburg	0.8	2.2	2.2	2.1	2.3
Grafschaft Henneberg	1.0	0.2	0.2	0.2	0.2
Markgrafschaft Ober-Lausitz	15.1	9.3	9.0	9.4	9.9
Markgrafschaft Nieder-Lausitz	12.5	2.6	2.6	2.8	1.6
Bergämter	0.0	0.0	0.0	0.0	0.0

Source: Own calculation; for data sources see Appendix.

Table A.10: Spatial distribution of gross potato production, 1772-1812

		Regional share in total production (per cent)			
Administrative units	**Total area**	**1772**	**1791/1793**	**1803/1805**	**1810/1812**
Chur Kreis	13.8	4.6	6.4	7.2	6.3
Thüringischer Kreis	9.1	5.4	7.5	9.9	10.0
Meißnischer Kreis	17.8	10.9	12.6	13.4	13.1
Leipziger Kreis	9.2	10.8	12.0	13.5	13.3
Erzgebirgischer Kreis	12.4	21.3	21.2	18.1	18.6
Vogtländischer Kreis	3.6	15.1	8.0	6.5	5.9
Neustädtischer Kreis	2.0	6.0	5.2	4.4	4.0
Stift Merseburg	2.7	1.6	2.3	2.5	2.7
Stift Naumburg	0.8	1.9	1.9	1.9	2.1
Grafschaft Henneberg	1.0	--	2.6	2.0	2.3
Markgrafschaft Ober-Lausitz	15.1	14.6	12.0	12.9	13.9
Markgrafschaft Nieder-Lausitz	12.5	5.3	8.0	7.3	6.6
Bergämter	0.0	--	0.2	0.1	0.2

Source: Own calculation; for data sources see Appendix.

Table A.11: Spatial distribution of total gross crop production (GCP), 1772-1812

Administrative units	Total area	Regional share in total production (per cent)			
		1772	1791-1793	1803-1805	1810-1812
Chur Kreis	13.8	7.3	8.3	8.4	7.6
Thüringischer Kreis	9.1	21.7	18.6	19.8	17.3
Meißnischer Kreis	17.8	16.1	14.0	14.3	15.0
Leipziger Kreis	9.2	13.9	16.2	16.5	16.8
Erzgebirgischer Kreis	12.4	8.4	12.1	12.2	12.9
Vogtländischer Kreis	3.6	3.1	2.4	2.2	2.3
Neustädtischer Kreis	2.0	2.0	2.2	2.1	2.0
Stift Merseburg	2.7	4.5	4.7	5.0	4.6
Stift Naumburg	0.8	2.5	2.2	2.2	2.3
Grafschaft Henneberg	1.0	--	0.5	0.5	0.6
Markgrafschaft Ober-Lausitz	15.1	12.6	12.3	10.8	12.6
Markgrafschaft Nieder-Lausitz	12.5	5.8	6.1	5.6	5.0
Bergämter	0.0	--	0.0	0.0	0.0

Source: Own calculation; for data sources see Appendix.

Table A.12: Spatial distribution of gross crop production (GCP), 1815-1830

Administrative units	Regional share in total production (per cent)	
	1818-1820	1828-1830
	Rye	
Meissner Kreis	33.9	34.0
Erzgebirger Kreis	16.4	18.2
Leipziger Kreis	26.9	26.8
Vogtländer Kreis	3.7	3.6
Markgrafschaft Ober-Lausitz	18.2	17.4
	Wheat	
Meissner Kreis	36.9	35.0
Erzgebirger Kreis	16.2	18.5
Leipziger Kreis	30.0	30.6
Vogtländer Kreis	2.1	2.0
Markgrafschaft Ober-Lausitz	14.2	13.9
	Barley	
Meissner Kreis	37.4	37.6
Erzgebirger Kreis	15.7	17.6
Leipziger Kreis	28.4	28.6
Vogtländer Kreis	6.7	5.9
Markgrafschaft Ober-Lausitz	10.9	10.2
	Oats	
Meissner Kreis	27.1	28.0
Erzgebirger Kreis	26.7	29.1
Leipziger Kreis	31.5	29.8
Vogtländer Kreis	3.6	2.8
Markgrafschaft Ober-Lausitz	10.4	10.3
	Potatoes	
Meissner Kreis	22.2	22.7
Erzgebirger Kreis	32.7	32.3
Leipziger Kreis	21.2	21.4
Vogtländer Kreis	10.8	10.2
Markgrafschaft Ober-Lausitz	12.4	13.2
	Gross Crop Production	
Meissner Kreis	31.3	31.1
Erzgebirger Kreis	21.8	24.0
Leipziger Kreis	27.1	26.7
Vogtländer Kreis	5.1	4.8
Markgrafschaft Ober-Lausitz	13.8	13.4

Source: Own calculation; for data sources see Appendix.

Table A.13: Yield ratios for main types of grain, 1772-1812/30

			Rye				
Yield ratios	**1772**	**1791/93**	**1803/05**	**1810/12**	**1815/17**	**1818/20**	**1828/30**
Chur Kreis	2.6	3.6	3.0	3.0			
Thüringischer Kreis	5.1	6.0	6.1	5.5			
Meißnischer Kreis	3.2	3.9	3.5	3.3			
Leipziger Kreis	3.8	5.7	5.0	4.6	3.5	4.8	4.8
Erzgebirgischer Kreis	3.5	4.5	3.9	3.6	2.6	4.1	3.7
Vogtländischer Kreis	2.9	3.6	2.9	2.8			
Neustädtischer Kreis	2.9	4.3	3.6	3.1			
Stift Merseburg	4.1	5.9	6.1	4.4			
Stift Naumburg	5.0	6.1	5.8	4.9			
Grafschaft Henneberg	--	3.1	2.7	3.5			
Markgrafschaft Ober-Lau.	3.1	3.9	2.9	3.4			
Markgrafs. Nieder-Lausitz	2.4	3.3	2.8	2.8			
Bergämter	--	5.1	4.6	4.0			
Saxony	3.4	4.4	3.9	3.7	2.9	3.7	3.7
Indices (1791/93=100)	**1772**	**1791/93**	**1803/05**	**1810/12**	**1815/17**	**1818/20**	**1828/30**
Chur Kreis	73	100	84	84			
Thüringischer Kreis	84	100	101	91			
Meißnischer Kreis	82	100	88	83			
Leipziger Kreis	66	100	88	81	62	84	84
Erzgebirgischer Kreis	77	100	86	80	57	91	83
Vogtländischer Kreis	81	100	81	77			
Neustädtischer Kreis	68	100	83	72			
Stift Merseburg	70	100	104	75			
Stift Naumburg	83	100	96	81			
Grafschaft Henneberg	--	100	89	114			
Markgrafschaft Ober-Lau.	80	100	75	87			
Marggrafs. Nieder-Lausitz	74	100	85	84			
Bergämter	--	100	91	78			
Saxony	78	100	88	84	67	86	84

Table A.13 (continuation)

			Wheat				
Yield ratios	**1772**	**1791/93**	**1803/05**	**1810/12**	**1815/17**	**1818/20**	**1828/30**
Chur Kreis	4.6	4.8	3.4	3.5			
Thüringischer Kreis	6.3	7.0	6.0	5.6			
Meißnischer Kreis	4.4	5.5	4.5	4.5			
Leipziger Kreis	5.1	7.3	6.1	5.6	4.8	6.3	6.8
Erzgebirgischer Kreis	3.9	4.7	4.7	4.0	3.1	4.5	4.6
Vogtländischer Kreis	4.0	4.3	4.0	3.2			
Neustädtischer Kreis	4.1	5.0	4.3	3.3			
Stift Merseburg	5.7	8.0	7.0	5.9			
Stift Naumburg	9.5	9.5	7.7	6.4			
Grafschaft Henneberg	--	3.1	2.7	4.2			
Markgrafschaft Ober-Lau.	4.2	5.0	4.1	4.3			
Markgrafs. Nieder-Lausitz	3.5	4.2	3.1	3.6			
Bergämter	--	5.5	4.2	5.9			
Saxony	4.9	5.9	4.9	4.6	4.0	5.0	5.4
Indices (1791/93=100)	**1772**	**1791/93**	**1803/05**	**1810/12**	**1815/17**	**1818/20**	**1828/30**
Chur Kreis	94	100	71	72			
Thüringischer Kreis	90	100	86	80			
Meißnischer Kreis	81	100	82	82			
Leipziger Kreis	69	100	83	77	67	86	94
Erzgebirgischer Kreis	84	100	100	84	66	96	98
Vogtländischer Kreis	94	100	92	73			
Neustädtischer Kreis	83	100	86	66			
Stift Merseburg	71	100	87	73			
Stift Naumburg	100	100	82	67			
Grafschaft Henneberg	--	100	88	134			
Markgrafschaft Ober-Laus.	84	100	82	86			
Markgrafs. Nieder-Lausitz	83	100	74	86			
Bergämter	--	100	76	107			
Saxony	84	100	83	79	69	85	91

Table A.13 (continuation)

			Barley				
Yield ratios	**1772**	**1791/93**	**1803/05**	**1810/12**	**1815/17**	**1818/20**	**1828/30**
Chur Kreis	3.2	4.1	4.2	3.7			
Thüringischer Kreis	6.3	7.3	7.7	6.7			
Meißnischer Kreis	3.4	4.5	4.6	4.3			
Leipziger Kreis	3.5	5.4	6.2	5.8	5.2	5.6	5.9
Erzgebirgischer Kreis	3.3	4.2	4.3	4.1	3.2	4.2	4.3
Vogtländischer Kreis	3.3	3.3	3.0	2.8			
Neustädtischer Kreis	3.7	4.1	4.0	3.4			
Stift Merseburg	5.3	6.7	7.7	6.1			
Stift Naumburg	6.0	7.4	8.1	7.3			
Grafschaft Henneberg	--	5.3	4.5	4.4			
Markgrafschaft Ober-Lau.	3.5	3.3	3.8	3.7			
Markgrafs. Nieder-Lausitz	2.8	3.3	3.3	3.1			
Bergämter	--	5.6	7.5	4.0			
Saxony	4.1	4.9	5.3	4.7	4.0	4.3	4.6
Indices (1791/93=100)	**1772**	**1791/93**	**1803/05**	**1810/12**	**1815/17**		**1828/30**
Chur Kreis	80	100	103	90			
Thüringischer Kreis	86	100	105	91			
Meißnischer Kreis	75	100	102	96			
Leipziger Kreis	65	100	114	106	95	103	109
Erzgebirgischer Kreis	79	100	103	97	76	100	103
Vogtländischer Kreis	101	100	92	86			
Neustädtischer Kreis	90	100	97	83			
Stift Merseburg	78	100	115	90			
Stift Naumburg	81	100	109	99			
Grafschaft Henneberg	--	100	85	84			
Markgrafschaft Ober-Lau.	108	100	116	113			
Markgrafs. Nieder-Lausitz	87	100	102	95			
Bergämter	--	100	133	71			
Saxony	83	100	107	96	82	88	94

Table A.13 (continuation)

			Oats				
Yield ratios	**1772**	**1791/93**	**1803/05**	**1810/12**	**1815/17**	**1818/20**	**1828/30**
Chur Kreis	2.8	3.6	3.9	3.2			
Thüringischer Kreis	5.9	7.0	7.9	6.9			
Meißnischer Kreis	3.4	3.9	4.5	4.1			
Leipziger Kreis	3.7	5.6	6.3	5.6	5.1	5.6	6.0
Erzgebirgischer Kreis	3.0	3.2	3.5	3.1	2.8	3.1	3.4
Vogtländischer Kreis	3.2	3.2	3.1	2.6			
Neustädtischer Kreis	3.1	4.2	4.2	4.5			
Stift Merseburg	5.7	7.0	8.3	6.8			
Stift Naumburg	5.1	7.2	8.3	7.7			
Grafschaft Henneberg	--	2.9	2.8	3.6			
Markgrafschaft Ober-Lau.	2.5	3.4	3.7	3.6			
Markgrafs. Nieder-Lausitz	2.6	3.2	3.6	2.2			
Bergämter	--	5.7	4.7	3.5			
Saxony	3.3	4.5	5.0	4.4	3.6	3.8	4.2
Indices (1791/93=100)	**1772**	**1791/93**	**1803/05**	**1810/12**	**1815/17**	**1818/20**	**1828/30**
Chur Kreis	78	100	107	90			
Thüringischer Kreis	85	100	114	100			
Meißnischer Kreis	86	100	114	105			
Leipziger Kreis	66	100	113	101	91	100	107
Erzgebirgischer Kreis	92	100	108	97	87	97	106
Vogtländischer Kreis	102	100	98	83			
Neustädtischer Kreis	73	100	99	106			
Stift Merseburg	83	100	120	98			
Stift Naumburg	71	100	115	106			
Grafschaft Henneberg	--	100	99	123			
Markgrafschaft Ober-Lau.	74	100	110	107			
Markgrafs. Nieder-Lausitz	82	100	114	68			
Bergämter	--	100	83	62			
Saxony	73	100	111	98	80	84	94

Source: Own calculation; for data sources see Appendix.

Table A.14: Yield ratios for main types of grain, 1816-1830

	RYE					
	Yield ratios			Indices (1818/20 = 100)		
	1815/17	1818/20	1828/30	1815/17	1818/20	1828/30
I.ter Amtshpt-Bezirk Meissner Kreis	2.5	3.2	3.5	76	100	108
II.ter Amtshpt.-Bezirk Meissner Kreis	3.7	4.7	4.7	79	100	100
III.ter Amtshpt.-Bezirk Meissner Kreis	2.2	2.5	2.6	86	100	104
IV.ter Amtshpt.-Bezirk Meissner Kreis	2.6	2.8	2.7	92	100	95
V.ter Amtshpt.-Bezirk Meissner Kreis	3.3	3.8	--	87	100	--
Meissner Kreis	2.9	3.5	3.6	85	100	103
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	3.1	4.3	3.7	73	100	87
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	2.6	3.6	3.0	72	100	84
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	2.9	4.1	3.8	71	100	94
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	3.3	4.4	4.3	74	100	99
Amt Grüllenburg	--	3.6	3.8	--	100	105
Erzgebirger Kreis	3.0	4.1	3.7	72	100	91
I.ter Amtshpt.-Bezirk Leipziger Kreis	3.7	5.3	5.3	71	100	101
II.ter Amtshpt.-Bezirk Leipziger Kreis	3.4	4.3	4.0	79	100	93
III.ter Amtshpt.-Bezirk Leipziger Kreis	3.7	4.6	4.8	80	100	102
Leipziger Kreis	3.6	4.8	4.8	76	100	99
Vogtländer Kreis	2.0	2.5	2.4	78	100	95
Berg-Aemter	3.2	4.4	4.0	72	100	92
Ober-Lausitz, Markgrafschaft, Land-Kreis	2.9	3.3	3.2	88	100	97
Saxony	3.0	3.7	3.7	81	100	99

Table A.14 (continuation)

WHEAT						
	Yield ratios			Indices (1818/20 = 100)		
	1815/17	1818/20	1828/30	1815/17	1818/20	1828/30
I.ter Amtshpt-Bezirk Meissner Kreis	3.5	4.1	4.8	87	100	117
II.ter Amtshpt.-Bezirk Meissner Kreis	5.5	6.6	6.8	84	100	103
III.ter Amtshpt.-Bezirk Meissner Kreis	3.2	3.6	4.2	90	100	118
IV.ter Amtshpt.-Bezirk Meissner Kreis	3.7	4.1	3.9	91	100	95
V.ter Amtshpt.-Bezirk Meissner Kreis	4.2	5.0	--	85	100	--
Meissner Kreis	4.4	4.9	5.4	89	100	110
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	3.1	4.4	4.5	72	100	101
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	3.0	4.4	4.3	68	100	99
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	2.9	4.2	3.6	69	100	87
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	3.9	5.0	5.8	78	100	116
Amt Grüllenburg	--	--	4.3	--	--	--
Erzgebirger Kreis	3.1	4.5	4.6	69	100	103
I.ter Amtshpt.-Bezirk Leipziger Kreis	4.2	6.7	7.2	63	100	107
II.ter Amtshpt.-Bezirk Leipziger Kreis	4.8	6.0	6.3	79	100	106
III.ter Amtshpt.-Bezirk Leipziger Kreis	4.8	6.1	6.6	78	100	108
Leipziger Kreis	4.8	6.4	6.8	76	100	107
Vogtländer Kreis	2.8	3.5	3.6	79	100	102
Berg-Aemter	3.0	4.1	3.6	73	100	90
Ober-Lausitz, Markgrafschaft, Land-Kreis	3.6	4.5	4.4	81	100	98
Saxony	4.0	5.1	5.4	79	100	105

Table A.14 (continuation)

BARLEY						
	Yield ratios			Indices (1818/20 = 100)		
	1815/17	1818/20	1828/30	1815/17	1818/20	1828/30
I.ter Amtshpt-Bezirk Meissner Kreis	3.8	4.1	4.6	91	100	112
II.ter Amtshpt.-Bezirk Meissner Kreis	4.9	5.3	5.7	92	100	108
III.ter Amtshpt.-Bezirk Meissner Kreis	2.7	3.0	2.9	92	100	97
IV.ter Amtshpt.-Bezirk Meissner Kreis	3.4	3.3	3.8	101	100	115
V.ter Amtshpt.-Bezirk Meissner Kreis	4.7	4.5	--	105	100	--
Meissner Kreis	4.1	4.2	4.6	98	100	110
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	3.1	4.1	4.4	74	100	106
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	2.4	4.2	3.8	57	100	91
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	3.4	4.2	3.9	79	100	92
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	3.8	4.8	4.9	80	100	103
Amt Grüllenburg	--	5.1	4.4	--	100	86
Erzgebirger Kreis	3.2	4.2	4.3	75	100	102
I.ter Amtshpt.-Bezirk Leipziger Kreis	5.7	6.3	7.0	90	100	111
II.ter Amtshpt.-Bezirk Leipziger Kreis	4.2	4.8	4.9	87	100	103
III.ter Amtshpt.-Bezirk Leipziger Kreis	5.3	5.6	6.0	95	100	106
Leipziger Kreis	5.2	5.6	5.9	93	100	107
Vogtländer Kreis	2.3	3.0	2.7	78	100	90
Berg-Aemter	4.1	4.7	4.2	87	100	89
Ober-Lausitz, Markgrafschaft, Land-Kreis	3.7	3.7	3.8	100	100	103
Saxony	4.0	4.3	4.6	92	100	105

Table A.14 (continuation)

OATS						
	Yield ratios			Indices (1818/20 = 100)		
	1815/17	1818/20	1828/30	1815/17	1818/20	1828/30
I.ter Amtshpt-Bezirk Meissner Kreis	3.0	3.6	4.3	84	100	119
II.ter Amtshpt.-Bezirk Meissner Kreis	4.2	4.8	5.7	87	100	119
III.ter Amtshpt.-Bezirk Meissner Kreis	2.6	2.5	2.9	101	100	113
IV.ter Amtshpt.-Bezirk Meissner Kreis	3.6	3.1	3.7	117	100	119
V.ter Amtshpt.-Bezirk Meissner Kreis	4.5	4.3	--	103	100	--
Meissner Kreis	3.6	3.7	4.3	99	100	118
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	3.3	3.9	3.9	84	100	100
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	2.7	3.5	3.9	77	100	111
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	2.5	2.7	2.7	95	100	100
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	2.6	2.8	3.5	92	100	123
Amt Grüllenburg	--	4.1	4.4	--	100	107
Erzgebirger Kreis	2.8	3.1	3.4	92	100	112
I.ter Amtshpt.-Bezirk Leipziger Kreis	5.4	6.3	6.5	86	100	103
II.ter Amtshpt.-Bezirk Leipziger Kreis	4.2	4.7	5.4	89	100	114
III.ter Amtshpt.-Bezirk Leipziger Kreis	4.6	5.3	5.6	88	100	107
Leipziger Kreis	5.1	5.6	6.0	90	100	106
Vogtländer Kreis	2.5	2.9	2.6	88	100	90
Berg-Aemter	3.3	3.8	3.6	86	100	95
Ober-Lausitz, Markgrafschaft, Land-Kreis	3.5	3.4	3.7	102	100	109
Saxony	3.6	3.8	4.2	94	100	110

Source: Own calculation; for data sources see Appendix

Table A.15: Regional variation in yield ratios (Saxony = 100), 1791-1812

	Rye			*Wheat*		
	1791/93	**1803/05**	**1810/12**	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	82	79	81	83	70	75
Thüringischer Kreis	137	158	148	120	124	121
Meißnischer Kreis	89	89	87	93	92	96
Leipziger Kreis	129	129	124	124	124	121
Erzgebirgischer Kreis	102	100	97	80	96	85
Vogtländischer Kreis	81	75	74	74	82	68
Neustädtischer Kreis	98	93	84	85	88	70
Stift Merseburg	133	159	118	137	144	127
Stift Naumburg	137	151	132	162	159	137
Grafschaft Henneberg	69	71	94	53	56	90
Markgrafschaft Ober-Lausitz	88	75	91	85	85	93
Markgrafschaft Nieder-Lausitz	75	72	74	71	64	78
Bergämter	114	118	106	94	86	127
Saxony	100	100	100	100	100	100
	Barley			*Oats*		
	1791/93	**1803/05**	**1810/12**	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	82	79	77	80	77	73
Thüringischer Kreis	148	145	140	155	159	158
Meißnischer Kreis	91	87	91	87	90	94
Leipziger Kreis	110	117	121	124	126	128
Erzgebirgischer Kreis	85	82	86	72	70	71
Vogtländischer Kreis	66	57	59	70	62	60
Neustädtischer Kreis	83	75	71	95	84	103
Stift Merseburg	136	146	128	155	167	155
Stift Naumburg	150	152	155	160	166	174
Grafschaft Henneberg	106	84	93	64	57	81
Markgrafschaft Ober-Lausitz	66	71	77	76	75	82
Markgrafschaft Nieder-Lausitz	66	63	66	70	72	49
Bergämter	114	141	84	128	95	80
Saxony	100	100	100	100	100	100

Source: Own calculation; for data sources see Appendix.

Table A.16: Regional variation in yield ratios (Saxony = 100), 1816-1830

	Rye		*Wheat*	
	1818/20	**1828/30**	**1818/20**	**1828/30**
I.ter Amtshpt-Bezirk Meissner Kreis	87	95	81	89
II.ter Amtshpt.-Bezirk Meissner Kreis	126	127	130	127
III.ter Amtshpt.-Bezirk Meissner Kreis	68	71	70	79
IV.ter Amtshpt.-Bezirk Meissner Kreis	75	72	80	73
V.ter Amtshpt.-Bezirk Meissner Kreis	102	--	98	--
Meissner Kreis	92	96	97	101
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	115	101	86	83
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	96	82	86	81
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	108	103	83	68
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	117	117	98	108
Amt Grüllenburg	96	102	--	80
Erzgebirger Kreis	110	101	88	86
I.ter Amtshpt.-Bezirk Leipziger Kreis	141	144	131	134
II.ter Amtshpt.-Bezirk Leipziger Kreis	114	108	118	118
III.ter Amtshpt.-Bezirk Leipziger Kreis	124	128	121	124
Leipziger Kreis	128	129	126	128
Vogtländer Kreis	68	65	70	67
Berg-Aemter	118	109	80	68
Ober-Lausitz, Markgrafschaft, Land-Kreis	87	86	88	82
	Barley		*Oats*	
	1818/20	**1828/30**	**1818/20**	**1828/30**
I.ter Amtshpt-Bezirk Meissner Kreis	96	102	94	101
II.ter Amtshpt.-Bezirk Meissner Kreis	123	126	126	136
III.ter Amtshpt.-Bezirk Meissner Kreis	69	63	67	68
IV.ter Amtshpt.-Bezirk Meissner Kreis	77	84	80	87
V.ter Amtshpt.-Bezirk Meissner Kreis	103	--	114	--
Meissner Kreis	97	101	96	103
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	96	96	101	92
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	96	83	92	92
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	98	86	70	63
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	111	108	73	82
Amt Grüllenburg	119	97	108	104
Erzgebirger Kreis	98	95	81	82
I.ter Amtshpt.-Bezirk Leipziger Kreis	147	155	166	155
II.ter Amtshpt.-Bezirk Leipziger Kreis	110	108	124	129
III.ter Amtshpt.-Bezirk Leipziger Kreis	131	131	138	134
Leipziger Kreis	129	130	148	142
Vogtländer Kreis	69	58	75	61
Berg-Aemter	109	91	99	86
Ober-Lausitz, Markgrafschaft, Land-Kreis	86	84	89	88

Source: Own calculation; for data sources see Appendix.

Table A.17: Regional seeding quota of main types of grain in Saxony, 1791-1812

Rye			
Seeding quota (per cent)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	30	34	33
Thüringischer Kreis	17	17	17
Meißnischer Kreis	28	30	30
Leipziger Kreis	19	22	20
Erzgebirgischer Kreis	24	27	25
Vogtländischer Kreis	29	36	34
Neustädtischer Kreis	25	30	29
Stift Merseburg	18	17	16
Stift Naumburg	17	19	29
Grafschaft Henneberg	35	38	45
Markgrafschaft Oberlausitz	28	36	29
Markgrafs. Niederlausitz	34	37	36
Bergämter	18	26	23
Saxony	*24*	*27*	*26*
Index 1 (1791/93 = 100)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	100	113	110
Thüringischer Kreis	100	102	101
Meißnischer Kreis	100	107	106
Leipziger Kreis	100	116	108
Erzgebirgischer Kreis	100	114	106
Vogtländischer Kreis	100	125	119
Neustädtischer Kreis	100	122	119
Stift Merseburg	100	96	90
Stift Naumburg	100	111	169
Grafschaft Henneberg	100	109	128
Markgrafschaft Oberlausitz	100	131	106
Markgrafs. Niederlausitz	100	106	103
Bergämter	100	142	127
Saxony	*100*	*112*	*107*
Index 2 (Saxony=100)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	123	124	127
Thüringischer Kreis	70	63	66
Meißnischer Kreis	117	112	117
Leipziger Kreis	78	80	78
Erzgebirgischer Kreis	99	101	98
Vogtländischer Kreis	118	132	133
Neustädtischer Kreis	102	111	113
Stift Merseburg	73	62	62
Stift Naumburg	71	70	112
Grafschaft Henneberg	144	141	174
Markgrafschaft Oberlausitz	116	135	114
Markgrafs. Niederlausitz	143	135	138
Bergämter	76	96	90
Saxony	*100*	*100*	*100*

Table A.17 (continuation)

Wheat			
Seeding quota (per cent)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	23	31	26
Thüringischer Kreis	15	16	17
Meißnischer Kreis	21	25	21
Leipziger Kreis	15	18	16
Erzgebirgischer Kreis	25	24	22
Vogtländischer Kreis	24	26	28
Neustädtischer Kreis	22	24	25
Stift Merseburg	13	14	10
Stift Naumburg	11	14	21
Grafschaft Henneberg	34	41	39
Markgrafschaft Oberlausitz	22	31	22
Markgrafs. Niederlausitz	27	39	27
Bergämter	18	21	18
Saxony	*19*	*21*	*20*
Index 1 (1791/93 = 100)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	100	134	112
Thüringischer Kreis	100	110	113
Meißnischer Kreis	100	115	97
Leipziger Kreis	100	116	104
Erzgebirgischer Kreis	100	96	88
Vogtländischer Kreis	100	106	115
Neustädtischer Kreis	100	112	118
Stift Merseburg	100	106	77
Stift Naumburg	100	127	190
Grafschaft Henneberg	100	122	114
Markgrafschaft Oberlausitz	100	136	99
Markgrafs. Niederlausitz	100	143	99
Bergämter	100	113	101
Saxony	*100*	*115*	*105*
Index 2 (Saxony=100)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	123	144	131
Thüringischer Kreis	79	76	85
Meißnischer Kreis	114	114	105
Leipziger Kreis	81	82	80
Erzgebirgischer Kreis	133	111	111
Vogtländischer Kreis	131	121	142
Neustädtischer Kreis	115	112	129
Stift Merseburg	72	66	53
Stift Naumburg	59	65	106
Grafschaft Henneberg	181	192	196
Markgrafschaft Oberlausitz	120	142	113
Markgrafs. Niederlausitz	144	180	136
Bergämter	97	96	93
Saxony	*100*	*100*	*100*

Table A.17 (continuation)

Barley			
Seeding quota (per cent)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	26	24	27
Thüringischer Kreis	14	13	15
Meißnischer Kreis	27	21	23
Leipziger Kreis	20	16	17
Erzgebirgischer Kreis	28	23	23
Vogtländischer Kreis	33	33	35
Neustädtischer Kreis	28	25	27
Stift Merseburg	16	12	16
Stift Naumburg	14	12	13
Grafschaft Henneberg	19	24	32
Markgrafschaft Oberlausitz	37	27	27
Markgrafs. Niederlausitz	34	30	29
Bergämter	13	13	31
Saxony	22	18	20
Index 1 (1791/93 = 100)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	100	92	102
Thüringischer Kreis	100	92	108
Meißnischer Kreis	100	78	85
Leipziger Kreis	100	76	81
Erzgebirgischer Kreis	100	81	82
Vogtländischer Kreis	100	102	106
Neustädtischer Kreis	100	90	96
Stift Merseburg	100	75	105
Stift Naumburg	100	86	93
Grafschaft Henneberg	100	128	172
Markgrafschaft Oberlausitz	100	72	72
Markgrafs. Niederlausitz	100	89	85
Bergämter	100	99	242
Saxony	*100*	*84*	*94*
Index 2 (Saxony=100)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	119	129	130
Thüringischer Kreis	63	69	73
Meißnischer Kreis	123	114	111
Leipziger Kreis	94	85	81
Erzgebirgischer Kreis	129	123	113
Vogtländischer Kreis	149	182	169
Neustädtischer Kreis	129	137	132
Stift Merseburg	72	64	81
Stift Naumburg	66	67	65
Grafschaft Henneberg	86	131	159
Markgrafschaft Oberlausitz	169	144	130
Markgrafs. Niederlausitz	157	165	142
Bergämter	58	69	151
Saxony	*100*	*100*	*100*

Table A.17 (continuation)

Oats			
Seeding quota (per cent)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	32	27	31
Thüringischer Kreis	15	12	15
Meißnischer Kreis	34	22	25
Leipziger Kreis	21	16	18
Erzgebirgischer Kreis	37	28	31
Vogtländischer Kreis	35	33	36
Neustädtischer Kreis	30	24	23
Stift Merseburg	15	12	15
Stift Naumburg	16	12	13
Grafschaft Henneberg	37	35	37
Markgrafschaft Oberlausitz	41	27	29
Markgrafschaft Niederlausitz	41	30	32
Bergämter	14	25	27
Saxony	*26*	*20*	*23*
Index 1 (1791/93 = 100)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	100	85	96
Thüringischer Kreis	100	84	101
Meißnischer Kreis	100	66	75
Leipziger Kreis	100	75	88
Erzgebirgischer Kreis	100	76	84
Vogtländischer Kreis	100	94	104
Neustädtischer Kreis	100	81	79
Stift Merseburg	100	80	99
Stift Naumburg	100	75	83
Grafschaft Henneberg	100	95	99
Markgrafschaft Oberlausitz	100	66	70
Markgrafschaft Niederlausitz	100	72	79
Bergämter	100	180	196
Saxony	*100*	*78*	*90*
Index 2 (Saxony=100)	**1791/93**	**1803/05**	**1810/12**
Chur Kreis	126	137	134
Thüringischer Kreis	58	62	64
Meißnischer Kreis	132	111	110
Leipziger Kreis	82	79	80
Erzgebirgischer Kreis	147	142	136
Vogtländischer Kreis	136	163	158
Neustädtischer Kreis	116	120	102
Stift Merseburg	60	61	66
Stift Naumburg	63	60	58
Grafschaft Henneberg	145	175	160
Markgrafschaft Oberlausitz	162	135	125
Markgrafs. Niederlausitz	160	148	141
Bergämter	54	124	118
Saxony	*100*	*100*	*100*

Source: Own calculation; for data sources see Appendix.

Table A.18: Regional seeding quota of main types of grain in Saxony, 1815-1830

	Seeding quota (per cent)		Index 1 (1818/20=100)		Index 2 (Saxony=100)	
Rye	**1818/20**	**1828/30**	**1818/20**	**1828/30**	**1818/20**	**1828/30**
I.ter Amtshpt-Bezirk Meissner Kreis	33	32	100	96	112	116
II.ter Amtshpt.-Bezirk Meissner Kreis	23	21	100	95	77	78
III.ter Amtshpt.-Bezirk Meissner Kreis	42	40	100	95	144	147
IV.ter Amtshpt.-Bezirk Meissner Kreis	38	37	100	97	130	136
V.ter Amtshpt.-Bezirk Meissner Kreis	29	--	100	--	98	--
Meissner Kreis	31	29	100	93	105	106
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	27	25	100	90	93	91
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	32	30	100	95	109	111
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	30	27	100	93	101	101
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	26	23	100	90	89	86
Amt Grüllenburg	--	30	--	--	--	109
Summa Erzgebirger Kreis	30	26	100	87	102	95
I.ter Amtshpt.-Bezirk Leipziger Kreis	22	19	100	89	73	70
II.ter Amtshpt.-Bezirk Leipziger Kreis	25	24	100	95	86	89
III.ter Amtshpt.-Bezirk Leipziger Kreis	23	22	100	93	79	79
Summa Leipziger Kreis	23	21	100	91	79	77
Vogtländer Kreis	42	41	100	97	144	150
Berg-Aemter	28	30	100	107	94	109
Ober-Lausitz, Markgrafschaft, Land-Kreis	30	33	100	109	103	121
Saxony	29	27	100	93	100	100
Wheat	**1818/20**	**1828/30**	**1818/20**	**1828/30**	**1818/20**	**1828/30**
I.ter Amtshpt-Bezirk Meissner Kreis	25	22	100	88	117	116
II.ter Amtshpt.-Bezirk Meissner Kreis	16	14	100	88	74	73
III.ter Amtshpt.-Bezirk Meissner Kreis	33	24	100	72	156	126
IV.ter Amtshpt.-Bezirk Meissner Kreis	25	24	100	98	118	129
V.ter Amtshpt.-Bezirk Meissner Kreis	20	--	100	--	97	--
Meissner Kreis	21	18	100	86	100	96
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	25	24	100	94	120	126
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	25	24	100	98	118	129
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	27	29	100	107	128	153
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	22	18	100	83	103	96
Amt Grüllenburg	--	24	--	--	--	129
Erzgebirger Kreis	26	23	100	89	122	121
I.ter Amtshpt.-Bezirk Leipziger Kreis	16	14	100	89	77	77
II.ter Amtshpt.-Bezirk Leipziger Kreis	18	16	100	87	87	85
III.ter Amtshpt.-Bezirk Leipziger Kreis	17	15	100	89	81	81
Leipziger Kreis	17	15	100	89	80	80
Vogtländer Kreis	30	29	100	96	144	155
Berg-Aemter	39	26	100	66	184	136
Ober-Lausitz, Markgrafschaft, Land-Kreis	22	22	100	100	103	115
Saxony	21	19	100	89	100	100

Table A.18 (continuation)

	Seeding quota (per cent)		Index 1 (1818/20=100)		Index 2 (Saxony=100)	
Barley	**1818/20**	**1828/30**	**1818/20**	**1828/30**	**1818/20**	**1828/30**
I.ter Amtshpt-Bezirk Meissner Kreis	25	23	100	94	102	102
II.ter Amtshpt.-Bezirk Meissner Kreis	19	17	100	89	80	76
III.ter Amtshpt.-Bezirk Meissner Kreis	36	37	100	104	148	163
IV.ter Amtshpt.-Bezirk Meissner Kreis	32	28	100	86	133	122
V.ter Amtshpt.-Bezirk Meissner Kreis	24	--	100	--	100	--
Meissner Kreis	25	22	100	89	103	98
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	26	24	100	91	109	105
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	27	28	100	103	111	121
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	23	27	100	115	96	117
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	22	22	100	100	92	97
Amt Grüllenburg	--	24	--	--	--	104
Erzgebirger Kreis	27	24	100	89	112	106
I.ter Amtshpt.-Bezirk Leipziger Kreis	16	15	100	94	66	66
II.ter Amtshpt.-Bezirk Leipziger Kreis	22	21	100	96	90	92
III.ter Amtshpt.-Bezirk Leipziger Kreis	18	17	100	97	74	77
Leipziger Kreis	18	18	100	96	76	77
Vogtländer Kreis	35	40	100	115	145	177
Berg-Aemter	21	21	100	97	87	90
Ober-Lausitz, Markgrafschaft, Land-Kreis	26	28	100	108	105	121
Saxony	24	23	100	94	100	100
Oats	**1818/20**	**1828/30**	**1818/20**	**1828/30**	**1818/20**	**1828/30**
I.ter Amtshpt-Bezirk Meissner Kreis	30	24	100	80	106	101
II.ter Amtshpt.-Bezirk Meissner Kreis	22	17	100	79	76	72
III.ter Amtshpt.-Bezirk Meissner Kreis	41	36	100	87	144	149
IV.ter Amtshpt.-Bezirk Meissner Kreis	36	28	100	78	124	114
V.ter Amtshpt.-Bezirk Meissner Kreis	27	--	100	--	93	--
Meissner Kreis	29	23	100	80	101	97
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	29	27	100	91	101	111
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	30	27	100	90	106	114
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	39	39	100	101	135	163
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	39	29	100	75	135	121
Amt Grüllenburg	--	23	--	--	--	97
Erzgebirger Kreis	37	30	100	82	127	124
I.ter Amtshpt.-Bezirk Leipziger Kreis	18	16	100	88	63	65
II.ter Amtshpt.-Bezirk Leipziger Kreis	24	18	100	78	82	76
III.ter Amtshpt.-Bezirk Leipziger Kreis	22	18	100	82	75	74
Leipziger Kreis	20	17	100	84	70	70
Vogtländer Kreis	36	41	100	116	123	171
Berg-Aemter	29	28	100	97	101	117
Ober-Lausitz, Markgrafschaft, Land-Kreis	29	28	100	94	103	115
Saxony	29	24	100	84	100	100

Source: Own calculation; for data sources see Appendix.

Table A.19a: Net production of rye per capita (in GE), 1791-1811

	Grain equivalents			Index 1 (1791/93=100)		Growth rates p.a.		Index 2 (Saxony=100)		
	1791/93	1803/05	1809/11	1803/05	1809/11	1791/93-03/05	1803/05-09/11	1791/93	1803/05	1809/11
Chur Kreis	1.92	1.50	1.41	78	73	-2.1%	-1.0%	119	118	117
Thüringischer Kreis	2.82	2.63	2.51	93	89	-0.6%	-0.8%	174	207	207
Meißnischer Kreis	1.56	1.24	1.14	80	73	-1.9%	-1.4%	96	98	95
Leipziger Kreis	2.20	1.77	1.70	80	77	-1.8%	-0.6%	136	139	141
Erzgebirgischer Kreis	0.78	0.60	0.59	77	75	-2.1%	-0.4%	48	47	49
Vogtländischer Kreis	0.72	0.49	0.48	69	66	-3.1%	-0.6%	44	39	39
Neustädtischer Kreis	1.48	1.12	0.99	75	66	-2.3%	-2.1%	91	88	81
Stift Merseburg	3.17	3.13	2.63	99	83	-0.1%	-2.8%	196	246	218
Stift Naumburg	1.79	1.51	1.37	85	77	-1.4%	-1.6%	110	119	113
Grafschaft Henneberg	0.53	0.43	0.48	80	89	-1.8%	1.9%	33	34	39
Markgrafschaft Oberlausitz	1.60	0.96	1.11	60	70	-4.2%	2.5%	99	76	92
Markgrafschaft Niederlausitz	1.78	1.29	1.07	72	60	-2.7%	-3.1%	110	101	88
Bergämter	0.05	0.05	0.02	89	42	-0.9%	-11.8%	3	4	2
Saxony	1.62	1.27	1.21	79	75	-2.0%	-0.8%	100	100	100

Source: Own calculation; for data sources see Appendix.

Table A.19b: Net production of wheat per capita (in GE), 1791-1811

	Grain equivalents			Index 1 (1791/93=100)		Growth rates p.a.		Index 2 (Saxony=100)		
	1791/93	1803/05	1809/11	1803/05	1809/11	1791/93-03/05	1803/05-09/11	1791/93	1803/05	1809/11
Chur Kreis	0.46	0.33	0.35	72	77	-2.8%	1.3%	153	139	142
Thüringischer Kreis	0.71	0.57	0.58	81	82	-1.8%	0.4%	236	242	234
Meißnischer Kreis	0.28	0.23	0.26	83	91	-1.5%	1.6%	94	100	103
Leipziger Kreis	0.50	0.40	0.43	80	86	-1.8%	1.2%	166	169	172
Erzgebirgischer Kreis	0.08	0.09	0.09	108	117	0.7%	1.4%	27	37	38
Vogtländischer Kreis	0.05	0.04	0.04	72	72	-2.7%	-0.2%	18	17	16
Neustädtischer Kreis	0.36	0.30	0.27	83	74	-1.6%	-1.8%	121	127	108
Stift Merseburg	0.85	0.65	0.63	77	75	-2.1%	-0.6%	283	277	253
Stift Naumburg	0.58	0.45	0.43	78	73	-2.1%	-1.0%	195	193	171
Grafschaft Henneberg	0.13	0.11	0.13	81	103	-1.7%	4.1%	43	45	54
Markgrafschaft Oberlausitz	0.14	0.09	0.13	69	92	-3.1%	5.0%	46	40	51
Markgrafschaft Niederlausitz	0.26	0.14	0.16	54	62	-5.0%	2.4%	87	60	65
Bergämter	0.01	0.01	0.00	58	22	-4.4%	-15.1%	5	4	1
Saxony	0.30	0.24	0.25	79	83	-2.0%	0.9%	100	100	100

Source: Own calculation; for data sources see Appendix.

Table A.19c: Net production of barley per capita (in GE), 1791-1811

	Grain equivalents			Index 1 (1791/93=100)		Growth rates p.a.		Index 2 (Saxony=100)		
	1791/93	1803/05	1809/11	1803/05	1809/11	1791/93-03/05	1803/05-09/11	1791/93	1803/05	1809/11
Chur Kreis	0.73	0.70	0.48	96	66	-0.3%	-6.1%	115	110	93
Thüringischer Kreis	1.91	2.00	1.47	104	77	0.3%	-5.0%	304	314	283
Meißnischer Kreis	0.62	0.60	0.54	98	87	-0.2%	-1.9%	98	95	104
Leipziger Kreis	0.84	0.85	0.76	102	91	0.2%	-1.9%	133	134	147
Erzgebirgischer Kreis	0.23	0.21	0.22	95	99	-0.5%	0.8%	36	34	43
Vogtländischer Kreis	0.39	0.33	0.29	84	73	-1.4%	-2.2%	62	52	56
Neustädtischer Kreis	0.83	0.74	0.65	89	78	-0.9%	-2.2%	132	117	126
Stift Merseburg	1.40	1.60	1.14	115	82	1.1%	-5.4%	222	252	221
Stift Naumburg	1.38	1.44	1.24	104	90	0.3%	-2.5%	219	227	239
Grafschaft Henneberg	0.12	0.08	0.08	65	65	-3.5%	-0.1%	19	12	15
Markgrafschaft Oberlausitz	0.26	0.29	0.27	108	102	0.6%	-1.0%	42	45	52
Markgrafschaft Niederlausitz	0.28	0.25	0.19	89	68	-1.0%	-4.2%	44	39	37
Bergämter	0.03	0.03	0.00	97	6	-0.3%	-36.2%	5	5	0
Saxony	0.63	0.63	0.52	101	82	0.1%	-3.4%	100	100	100

Source: Own calculation; for data sources see Appendix.

Table A.19d: Net production of oats per capita (in GE), 1791-1811

	Grain equivalents			Index 1 (1791/93=100)		Growth rates p.a.		Index 2 (Saxony=100)		
	1791/93	1803/05	1809/11	1803/05	1809/11	1791/93-03/05	1803/05-09/11	1791/93	1803/05	1809/11
Chur Kreis	0.36	0.44	0.34	124	94	1.8%	-4.5%	58	64	60
Thüringischer Kreis	1.51	1.58	1.31	105	87	0.4%	-3.1%	245	228	233
Meißnischer Kreis	0.41	0.54	0.46	133	112	2.4%	-2.8%	66	78	81
Leipziger Kreis	1.06	1.22	0.98	115	92	1.2%	-3.6%	173	176	174
Erzgebirgischer Kreis	0.47	0.49	0.43	105	90	0.4%	-2.4%	77	71	76
Vogtländischer Kreis	0.23	0.21	0.18	90	77	-0.9%	-2.7%	38	30	32
Neustädtischer Kreis	0.40	0.42	0.37	106	91	0.5%	-2.4%	65	61	65
Stift Merseburg	2.38	2.75	2.08	115	87	1.2%	-4.5%	387	397	370
Stift Naumburg	0.88	0.99	0.86	113	97	1.0%	-2.4%	143	143	152
Grafschaft Henneberg	0.09	0.08	0.12	91	127	-0.8%	5.8%	15	12	21
Markgrafschaft Oberlausitz	0.31	0.37	0.31	117	99	1.4%	-2.8%	51	53	55
Markgrafschaft Niederlausitz	0.22	0.27	0.18	124	80	1.8%	-7.0%	36	40	32
Bergämter	0.04	0.04	0.02	93	39	-0.6%	-13.5%	7	6	3
Saxony	0.61	0.69	0.56	113	91	1.0%	-3.4%	100	100	100

Source: Own calculation; for data sources see Appendix.

Table A.20: Net production of potatoes per capita (in GE), 1791-1811

	Grain equivalents			Index 1 (1791/93=100)		Growth rates p.a.		Index 2 (Saxony=100)		
	1791/93	1803/05	1809/11	1803/05	1809/11	1791/93-03/05	1803/05-09/11	1791/93	1803/05	1809/11
Chur Kreis	0.20	0.33	0.34	164	170	4.2%	0.6%	91	102	95
Thüringischer Kreis	0.17	0.32	0.37	190	218	5.5%	2.3%	77	100	103
Meißnischer Kreis	0.19	0.30	0.32	161	169	4.0%	0.9%	85	92	88
Leipziger Kreis	0.22	0.36	0.39	166	179	4.3%	1.2%	99	112	108
Erzgebirgischer Kreis	0.22	0.27	0.32	124	150	1.8%	3.2%	97	82	89
Vogtländischer Kreis	0.39	0.48	0.50	121	126	1.6%	0.7%	178	147	138
Neustädtischer Kreis	0.58	0.75	0.76	129	130	2.1%	0.2%	264	231	210
Stift Merseburg	0.24	0.38	0.42	164	179	4.2%	1.5%	106	118	117
Stift Naumburg	0.25	0.38	0.41	151	166	3.5%	1.6%	113	116	115
Grafschaft Henneberg	0.47	0.53	0.68	112	144	1.0%	4.2%	213	163	188
Markgrafschaft Oberlausitz	0.17	0.26	0.31	157	188	3.9%	3.0%	75	80	86
Markgrafschaft Niederlausitz	0.28	0.37	0.37	132	132	2.4%	0.0%	126	113	102
Bergämter	0.11	0.13	0.18	120	169	1.6%	5.8%	49	40	50
Saxony	0.22	0.32	0.36	147	163	3.3%	1.8%	100	100	100

Source: Own calculation; for data sources see Appendix.

Table A.21: Total net production of bread grain (rye & wheat) and potatoes per capita (in GE), 1791-1811

	Grain equivalents			Index 1 (1791/93=100)		Growth rates p.a.		Index 2 (Saxony=100)		
	1791/93	1803/05	1809/11	1803/05	1809/11	1791/93-03/05	1803/05-09/11	1791/93	1803/05	1809/11
Chur Kreis	2.58	2.16	2.11	84	82	-1.5%	-0.4%	121	118	116
Thüringischer Kreis	3.70	3.53	3.46	95	94	-0.4%	-0.3%	173	192	190
Meißnischer Kreis	2.03	1.78	1.72	88	85	-1.1%	-0.6%	95	97	94
Leipziger Kreis	2.92	2.53	2.52	87	86	-1.2%	0.0%	136	138	139
Erzgebirgischer Kreis	1.08	0.96	1.00	89	93	-1.0%	0.8%	50	52	55
Vogtländischer Kreis	1.17	1.01	1.01	87	87	-1.2%	0.0%	55	55	56
Neustädtischer Kreis	2.43	2.17	2.01	89	83	-0.9%	-1.2%	113	118	111
Stift Merseburg	4.26	4.17	3.68	98	87	-0.2%	-2.0%	199	227	202
Stift Naumburg	2.62	2.34	2.21	89	84	-0.9%	-0.9%	122	128	122
Grafschaft Henneberg	1.14	1.06	1.29	94	114	-0.6%	3.3%	53	58	71
Markgrafschaft Oberlausitz	1.91	1.32	1.55	69	82	-3.0%	2.8%	89	72	85
Markgrafschaft Niederlausitz	2.32	1.79	1.60	77	69	-2.1%	-1.9%	109	98	88
Bergämter	0.18	0.19	0.21	106	118	0.5%	1.8%	8	10	11
Saxony	2.14	1.83	1.82	86	85	-1.3%	-0.1%	100	100	100

Source: Own calculation; for data sources see Appendix.

Table A.22: Total net crop production per capita (in GE), 1791-1811

	Grain equivalents			Index 1 (1791/93=100)		Growth rates p.a.		Index 2 (Saxony=100)		
	1791/93	1803/05	1809/11	1803/05	1809/11	1791/93-03/05	1803/05-09/11	1791/93	1803/05	1809/11
Chur Kreis	3.99	3.75	3.24	94	81	-0.5%	-2.4%	112	111	106
Thüringischer Kreis	7.32	7.35	6.40	100	87	0.0%	-2.3%	206	218	208
Meißnischer Kreis	3.25	3.19	2.97	98	91	-0.2%	-1.2%	91	95	97
Leipziger Kreis	4.99	4.83	4.46	97	89	-0.3%	-1.3%	140	144	145
Erzgebirgischer Kreis	1.90	1.80	1.78	94	94	-0.5%	-0.1%	54	53	58
Vogtländischer Kreis	1.82	1.57	1.50	86	82	-1.2%	-0.8%	51	47	49
Neustädtischer Kreis	3.94	3.64	3.28	92	83	-0.7%	-1.7%	111	108	107
Stift Merseburg	8.24	8.76	7.12	106	86	0.5%	-3.4%	232	261	232
Stift Naumburg	5.10	4.98	4.47	98	88	-0.2%	-1.8%	143	148	145
Grafschaft Henneberg	1.38	1.27	1.52	92	110	-0.7%	3.0%	39	38	49
Markgrafschaft Oberlausitz	2.57	2.06	2.23	80	87	-1.8%	1.3%	72	61	73
Markgrafschaft Niederlausitz	3.11	2.60	2.18	84	70	-1.5%	-2.9%	87	77	71
Bergämter	0.25	0.27	0.22	106	90	0.5%	-2.7%	7	8	7
Saxony	3.55	3.36	3.07	95	86	-0.5%	-1.5%	100	100	100

Source: Own calculation; for data sources see Appendix.

Table A.23a: Net production of rye per capita (in GE), 1816-1830

	Grain equivalents			growth p.a. 1818/20-27/29	Index 1 (1818/20=100)		Index 2 (Saxony=100)	
	1816/17	1818/20	1827/29		1816/17	1827/29	1818/20	1827/29
I.ter Amtshpt.-Bezirk Meissner Kreis	0.39	0.58	0.51	-1.5%	67	87	73	71
II.ter Amtshpt.-Bezirk Meissner Kreis	1.17	1.79	2.01	1.3%	65	112	226	280
III.ter Amtshpt.-Bezirk Meissner Kreis	0.38	0.55	0.52	-0.6%	70	94	69	72
IV.ter Amtshpt.-Bezirk Meissner Kreis	1.05	1.21	1.18	-0.3%	87	97	153	164
V.ter Amtshpt.-Bezirk Meissner Kreis	1.38	2.09	--	--	66	--	264	--
Meissner Kreis	0.72	1.02	0.97	-0.6%	70	95	129	135
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.21	0.45	0.40	-1.2%	48	90	56	56
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.17	0.39	0.33	-1.7%	44	86	49	46
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.12	0.31	0.27	-1.6%	38	86	39	37
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.24	0.46	0.62	3.2%	52	133	59	86
Erzgebirger Kreis	0.19	0.41	0.40	-0.1%	46	99	51	56
I.ter Amtshpt.-Bezirk Leipziger Kreis	0.62	1.23	1.15	-0.7%	51	93	155	159
II.ter Amtshpt.-Bezirk Leipziger Kreis	0.69	1.12	0.98	-1.5%	62	87	141	136
III.ter Amtshpt.-Bezirk Leipziger Kreis	1.25	1.86	1.75	-0.7%	67	94	235	244
Leipziger Kreis	0.77	1.31	1.21	-0.9%	58	92	166	168
Vogtländer Kreis	0.18	0.34	0.30	-1.5%	51	87	43	42
Berg-Aemter	0.01	0.02	0.01	-3.1%	41	76	2	2
Oberlausitz	0.68	1.04	0.88	-1.7%	66	85	131	123
Saxony	0.50	0.79	0.72	-1.1%	63	91	100	100

Source: Own calculation; for data sources see Appendix.

Table A.23b: Net production of wheat per capita (in GE), 1816-1830

	Grain equivalents			growth p.a. 1818/20-27/29	Index 1 (1818/20=100)		Index 2 (Saxony=100)	
	1816/17	1818/20	1827/29		1816/17	1827/29	1818/20	1827/29
I.ter Amtshpt.-Bezirk Meissner Kreis	0.13	0.16	0.19	2.1%	81	120	118	126
II.ter Amtshpt.-Bezirk Meissner Kreis	0.27	0.38	0.49	3.1%	71	131	279	324
III.ter Amtshpt.-Bezirk Meissner Kreis	0.03	0.04	0.05	2.0%	73	119	30	32
IV.ter Amtshpt.-Bezirk Meissner Kreis	0.14	0.14	0.16	1.1%	95	110	106	103
V.ter Amtshpt.-Bezirk Meissner Kreis	0.30	0.38	--	--	80	--	278	--
Meissner Kreis	0.15	0.19	0.23	2.0%	79	120	142	150
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.04	0.07	0.08	0.7%	58	106	54	51
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.03	0.06	0.05	-0.4%	54	96	42	35
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.03	0.06	0.05	-1.7%	46	85	41	31
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.05	0.07	0.12	6.0%	64	169	52	79
Erzgebirger Kreis	0.04	0.06	0.07	1.6%	56	116	48	49
I.ter Amtshpt.-Bezirk Leipziger Kreis	0.14	0.28	0.30	0.8%	52	107	205	194
II.ter Amtshpt.-Bezirk Leipziger Kreis	0.11	0.15	0.19	2.6%	72	126	114	127
III.ter Amtshpt.-Bezirk Leipziger Kreis	0.22	0.31	0.35	1.5%	70	114	228	230
Leipziger Kreis	0.15	0.24	0.27	1.3%	61	113	180	180
Vogtländer Kreis	0.02	0.04	0.04	0.3%	57	103	26	24
Berg-Aemter	0.00	0.00	0.00	-5.4%	36	61	1	1
Oberlausitz	0.10	0.13	0.16	2.1%	73	121	96	103
Saxony	0.09	0.14	0.15	1.4%	69	113	100	100

Source: Own calculation; for data sources see Appendix.

Table A.23c: Net production of barley per capita (in GE), 1816-1830

	Grain equivalents			growth p.a. 1818/20-27/29	Index 1 (1818/20=100)		Index 2 (Saxony=100)	
	1816/17	1818/20	1827/29		1816/17	1827/29	1818/20	1827/29
I.ter Amtshpt-Bezirk Meissner Kreis	0.22	0.24	0.21	-1.6%	89	87	71	71
II.ter Amtshpt.-Bezirk Meissner Kreis	0.84	0.95	1.14	2.1%	89	120	280	389
III.ter Amtshpt.-Bezirk Meissner Kreis	0.27	0.31	0.23	-2.9%	87	77	90	80
IV.ter Amtshpt.-Bezirk Meissner Kreis	0.34	0.33	0.33	0.1%	106	101	96	112
V.ter Amtshpt.-Bezirk Meissner Kreis	1.26	1.26	--	--	100	--	370	--
Meissner Kreis	0.46	0.49	0.46	-0.7%	94	94	145	158
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.14	0.21	0.19	-1.1%	68	91	61	64
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.08	0.19	0.14	-3.5%	43	73	56	47
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.04	0.05	0.03	-6.2%	69	56	16	10
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.14	0.18	0.20	1.2%	78	111	54	69
Erzgebirger Kreis	0.10	0.16	0.15	-1.0%	65	91	47	50
I.ter Amtshpt.-Bezirk Leipziger Kreis	0.53	0.50	0.44	-1.5%	105	87	147	149
II.ter Amtshpt.-Bezirk Leipziger Kreis	0.48	0.56	0.50	-1.2%	87	90	164	170
III.ter Amtshpt.-Bezirk Leipziger Kreis	0.85	0.87	0.73	-1.9%	98	84	255	249
Leipziger Kreis	0.57	0.59	0.51	-1.5%	98	87	173	174
Vogtländer Kreis	0.15	0.28	0.18	-4.4%	53	67	81	62
Berg-Aemter	0.00	0.00	0.00	-6.5%	87	54	1	0
Oberlausitz	0.25	0.28	0.24	-1.7%	90	86	81	81
Saxony	0.30	0.34	0.29	-1.6%	89	87	100	100

Source: Own calculation; for data sources see Appendix.

Table A.23d: Net production of oats per capita (in GE), 1816-1830

	Grain equivalents			growth p.a. 1818/20-27/29	Index 1 (1818/20=100)		Index 2 (Saxony=100)	
	1816/17	1818/20	1827/29		1816/17	1827/29	1818/20	1827/29
I.ter Amtshpt-Bezirk Meissner Kreis	0.30	0.36	0.41	1.5%	83	114	83	87
II.ter Amtshpt.-Bezirk Meissner Kreis	0.72	0.83	1.08	3.0%	87	130	190	226
III.ter Amtshpt.-Bezirk Meissner Kreis	0.29	0.26	0.30	1.7%	112	116	60	64
IV.ter Amtshpt.-Bezirk Meissner Kreis	0.42	0.32	0.43	3.2%	131	133	74	90
V.ter Amtshpt.-Bezirk Meissner Kreis	0.72	0.74	--	--	96	--	170	--
Meissner Kreis	0.44	0.46	0.56	2.1%	95	121	105	117
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.20	0.22	0.31	3.5%	88	137	51	64
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.17	0.24	0.25	0.3%	69	103	55	52
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.29	0.33	0.29	-1.5%	88	87	76	60
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.46	0.53	0.70	3.0%	86	131	122	146
Erzgebirger Kreis	0.27	0.32	0.37	1.5%	83	114	74	77
I.ter Amtshpt.-Bezirk Leipziger Kreis	0.86	0.97	0.90	-0.8%	89	93	222	189
II.ter Amtshpt.-Bezirk Leipziger Kreis	0.48	0.55	0.67	2.1%	87	121	127	140
III.ter Amtshpt.-Bezirk Leipziger Kreis	1.05	1.17	1.27	0.9%	90	108	268	265
Leipziger Kreis	0.78	0.87	0.90	0.3%	89	102	200	188
Vogtländer Kreis	0.15	0.19	0.14	-3.9%	77	70	45	29
Berg-Aemter	0.01	0.02	0.02	-0.7%	56	94	4	3
Oberlausitz	0.31	0.31	0.36	1.6%	99	115	72	76
Saxony	0.40	0.44	0.48	1.0%	91	109	100	100

Source: Own calculation; for data sources see Appendix.

Table A.24: Net production of potatoes per capita (in GE), 1816-1830

	Grain equivalents			growth p.a. 1818/20-27/29	Index 1 (1818/20=100)		Index 2 (Saxony=100)	
	1816/17	1818/20	1827/29		1816/17	1827/29	1818/20	1827/29
I.ter Amtshpt.-Bezirk Meissner Kreis	0.15	0.20	0.24	1.7%	71	116	50	53
II.ter Amtshpt.-Bezirk Meissner Kreis	0.27	0.44	0.61	3.8%	61	140	107	136
III.ter Amtshpt.-Bezirk Meissner Kreis	0.31	0.39	0.43	1.2%	79	111	95	96
IV.ter Amtshpt.-Bezirk Meissner Kreis	0.31	0.45	0.51	1.4%	69	113	112	115
V.ter Amtshpt.-Bezirk Meissner Kreis	0.36	0.54	--	--	67	--	133	--
Meissner Kreis	0.24	0.35	0.41	1.8%	70	117	86	92
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.20	0.35	0.42	2.0%	58	120	87	94
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.24	0.45	0.42	-0.7%	53	94	111	95
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.29	0.46	0.46	0.2%	63	102	113	104
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.25	0.41	0.42	0.2%	61	102	102	93
Erzgebirger Kreis	0.24	0.41	0.43	0.4%	58	104	102	96
I.ter Amtshpt.-Bezirk Leipziger Kreis	0.30	0.50	0.57	1.4%	59	113	124	127
II.ter Amtshpt.-Bezirk Leipziger Kreis	0.25	0.38	0.44	1.7%	65	116	94	99
III.ter Amtshpt.-Bezirk Leipziger Kreis	0.43	0.63	0.70	1.2%	69	112	155	157
Leipziger Kreis	0.31	0.49	0.55	1.4%	63	113	120	124
Vogtländer Kreis	0.35	0.61	0.61	0.0%	57	100	151	137
Berg-Aemter	0.14	0.20	0.19	-0.5%	69	96	50	43
Oberlausitz	0.29	0.38	0.48	2.6%	75	126	94	108
Saxony	0.27	0.41	0.45	1.1%	65	110	100	100

Source: Own calculation; for data sources see Appendix.

Table A.25: Net production of bread grain and potatoes per capita (in GE), 1816-1830

	Grain equivalents			growth p.a. 1818/20-27/29	Index 1 (1818/20=100)		Index 2 (Saxony=100)	
	1816/17	1818/20	1827/29		1816/17	1827/29	1818/20	1827/29
I.ter Amtshpt-Bezirk Meissner Kreis	0.66	0.95	0.94	-0.1%	70	99	233	210
II.ter Amtshpt.-Bezirk Meissner Kreis	1.71	2.61	3.12	2.0%	65	120	643	697
III.ter Amtshpt.-Bezirk Meissner Kreis	0.72	0.97	0.99	0.2%	74	102	240	222
IV.ter Amtshpt.-Bezirk Meissner Kreis	1.50	1.81	1.85	0.3%	83	102	446	414
V.ter Amtshpt.-Bezirk Meissner Kreis	2.04	3.00	--	--	68	--	741	--
Meissner Kreis	1.12	1.56	1.61	0.3%	71	103	386	361
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.46	0.87	0.90	0.3%	53	103	215	202
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.44	0.89	0.81	-1.1%	49	91	220	181
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.43	0.82	0.78	-0.6%	52	95	203	174
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.54	0.95	1.15	2.2%	57	122	234	258
Erzgebirger Kreis	0.47	0.88	0.91	0.3%	53	103	218	203
I.ter Amtshpt.-Bezirk Leipziger Kreis	1.07	2.01	2.01	0.0%	53	100	495	450
II.ter Amtshpt.-Bezirk Leipziger Kreis	1.05	1.66	1.62	-0.3%	64	98	408	362
III.ter Amtshpt.-Bezirk Leipziger Kreis	1.90	2.80	2.81	0.0%	68	100	691	628
Leipziger Kreis	1.22	2.04	2.03	-0.1%	60	99	505	455
Vogtländer Kreis	0.55	0.99	0.95	-0.5%	55	96	244	212
Berg-Aemter	0.15	0.22	0.21	-0.7%	66	94	55	47
Oberlausitz	1.07	1.55	1.52	-0.2%	69	98	382	341
Saxony	0.86	1.33	1.32	-0.1%	64	99	329	295

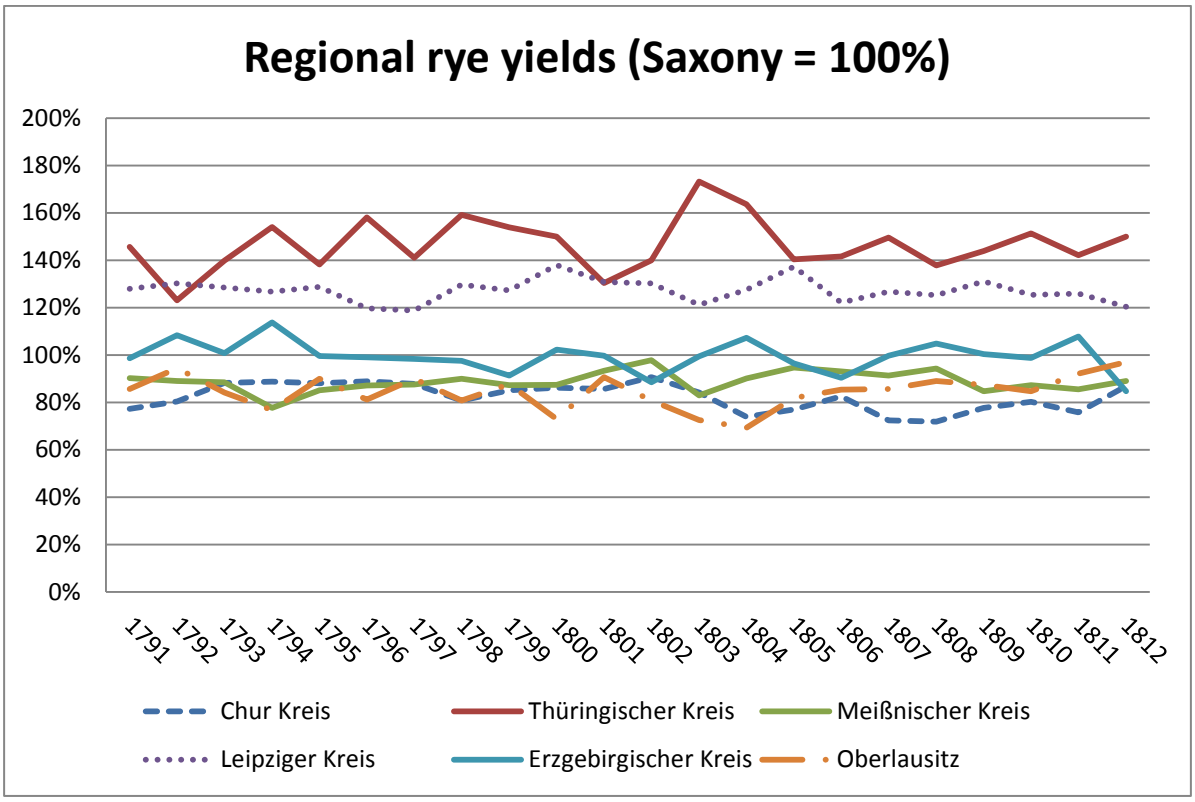
Source: Own calculation; for data sources see Appendix.

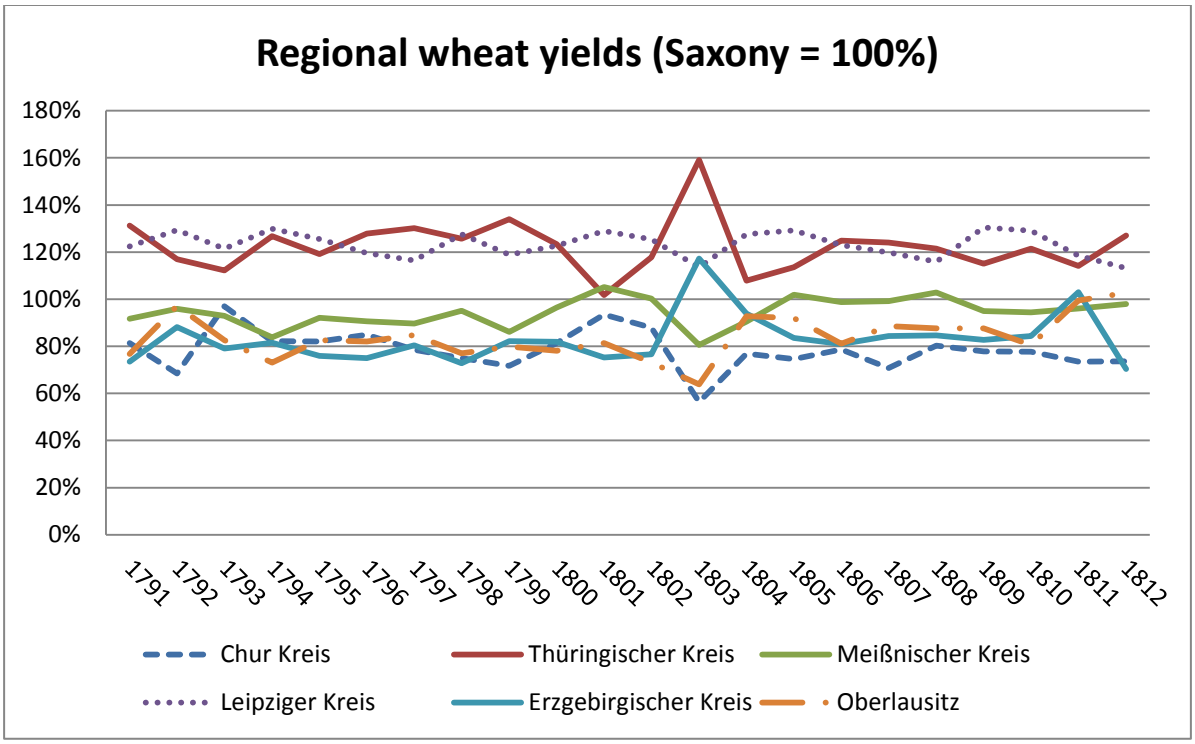
Table A.26: Total net crop production per capita (in GE), 1816-1830

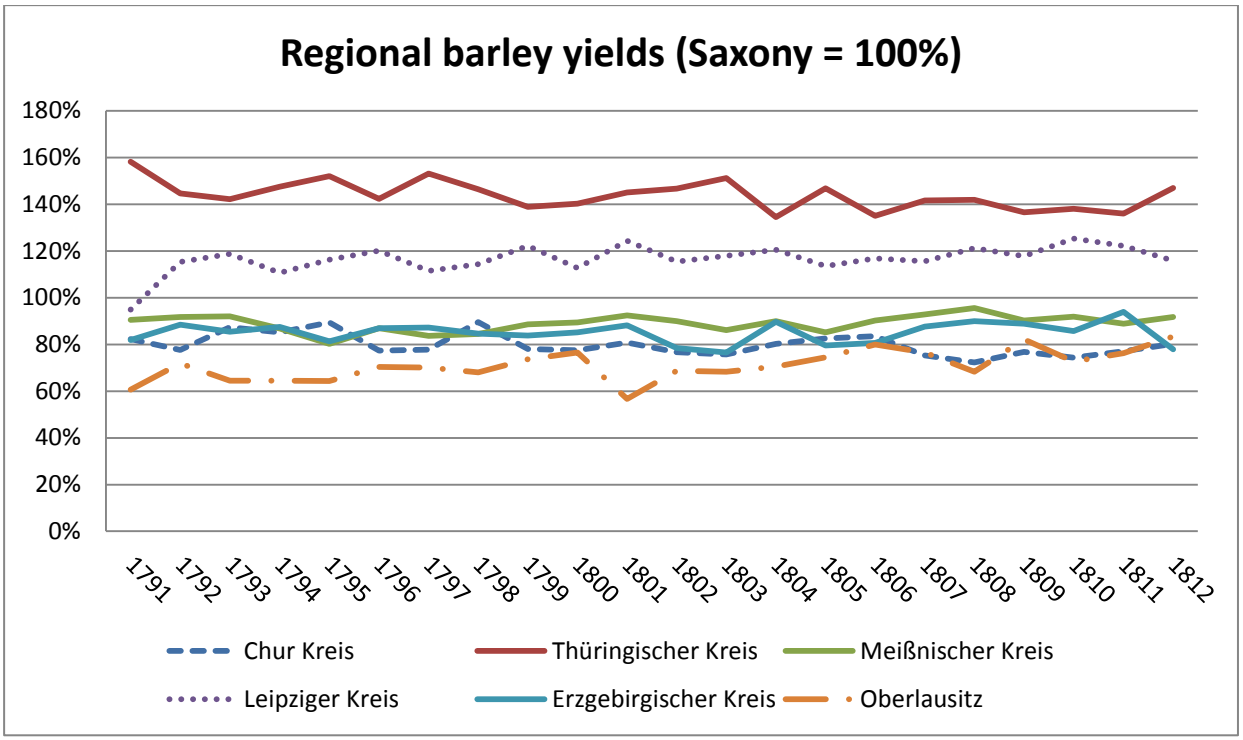
	Grain equivalents			growth p.a. 1818/20-27/29	Index 1 (1818/20=100)		Index 2 (Saxony=100)	
	1816/17	1818/20	1827/29		1816/17	1827/29	1818/20	1827/29
I.ter Amtshpt-Bezirk Meissner Kreis	1.24	1.62	1.63	0.1%	76	101	74	74
II.ter Amtshpt.-Bezirk Meissner Kreis	3.51	4.65	5.67	2.2%	76	122	212	258
III.ter Amtshpt.-Bezirk Meissner Kreis	1.32	1.60	1.59	0.0%	83	100	73	72
IV.ter Amtshpt.-Bezirk Meissner Kreis	2.55	2.76	2.97	0.8%	92	107	126	135
V.ter Amtshpt.-Bezirk Meissner Kreis	4.30	5.24	--	--	82	--	239	--
Meissner Kreis	2.16	2.66	2.80	0.6%	81	105	121	127
I.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.89	1.41	1.52	0.8%	63	108	64	69
II.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.69	1.34	1.21	-1.1%	52	90	61	55
III.ter Amtshpt.-Bezirk Erzgebirger Kreis	0.86	1.32	1.20	-1.1%	65	90	60	54
IV.ter Amtshpt.-Bezirk Erzgebirger Kreis	1.37	1.91	2.29	2.0%	72	120	87	104
Erzgebirger Kreis	0.94	1.47	1.54	0.5%	64	105	67	70
I.ter Amtshpt.-Bezirk Leipziger Kreis	2.54	3.58	3.46	-0.4%	71	97	163	157
II.ter Amtshpt.-Bezirk Leipziger Kreis	2.13	2.89	2.91	0.1%	74	101	132	132
III.ter Amtshpt.-Bezirk Leipziger Kreis	3.97	5.02	5.01	0.0%	79	100	229	228
Leipziger Kreis	2.68	3.63	3.58	-0.2%	74	99	165	162
Vogtländer Kreis	0.85	1.47	1.28	-1.6%	58	87	67	58
Berg-Aemter	0.16	0.24	0.23	-0.7%	66	94	11	10
Oberlausitz	1.67	2.19	2.18	0.0%	76	100	100	99
Saxony	1.66	2.19	2.20	0.0%	75	100	100	100

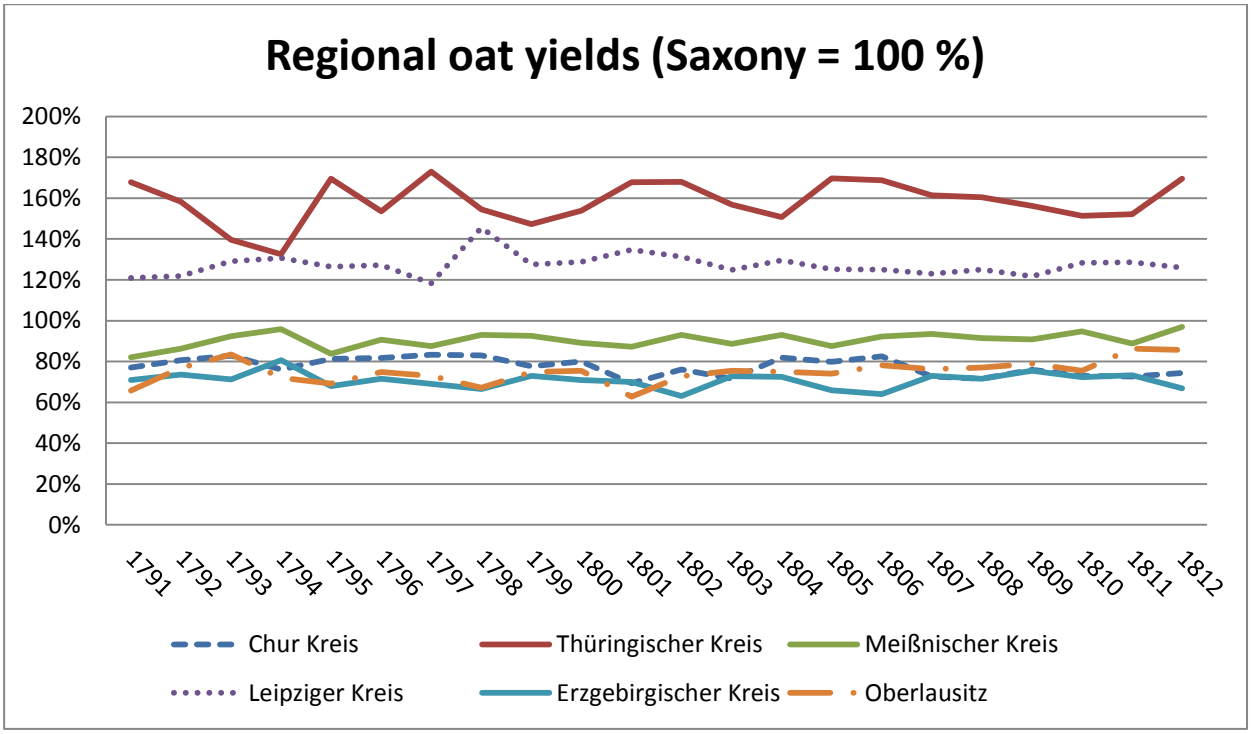
Source: Own calculation; for data sources see Appendix.

Figure A.1a: Regional yields in relation to the Saxon average, 1791-1812 (Saxony = 100%)



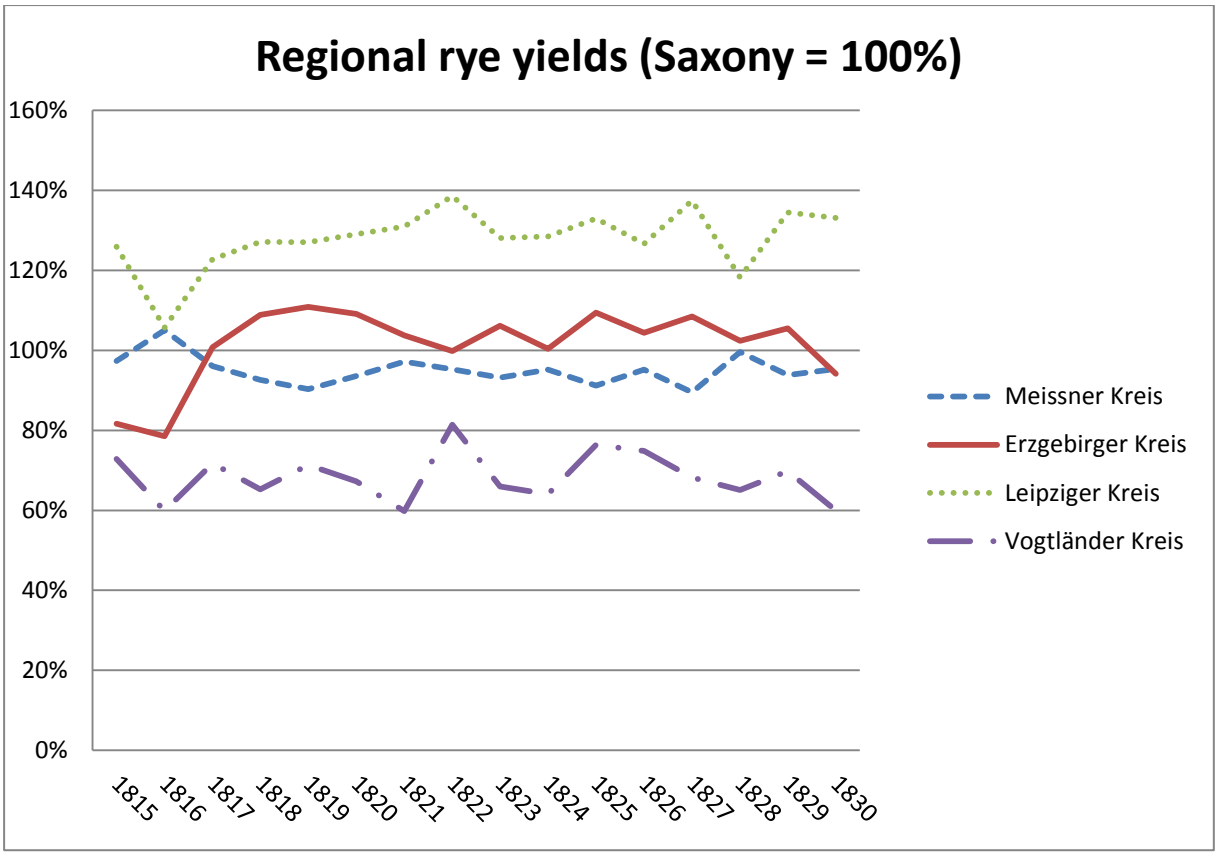


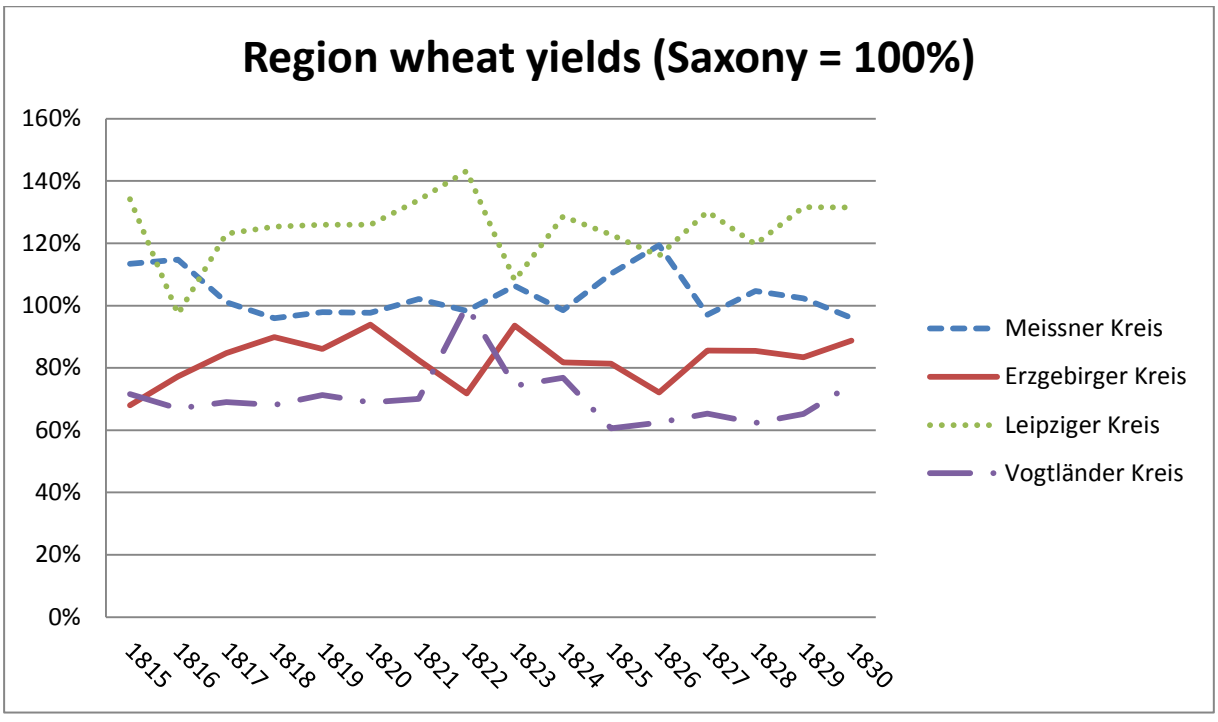




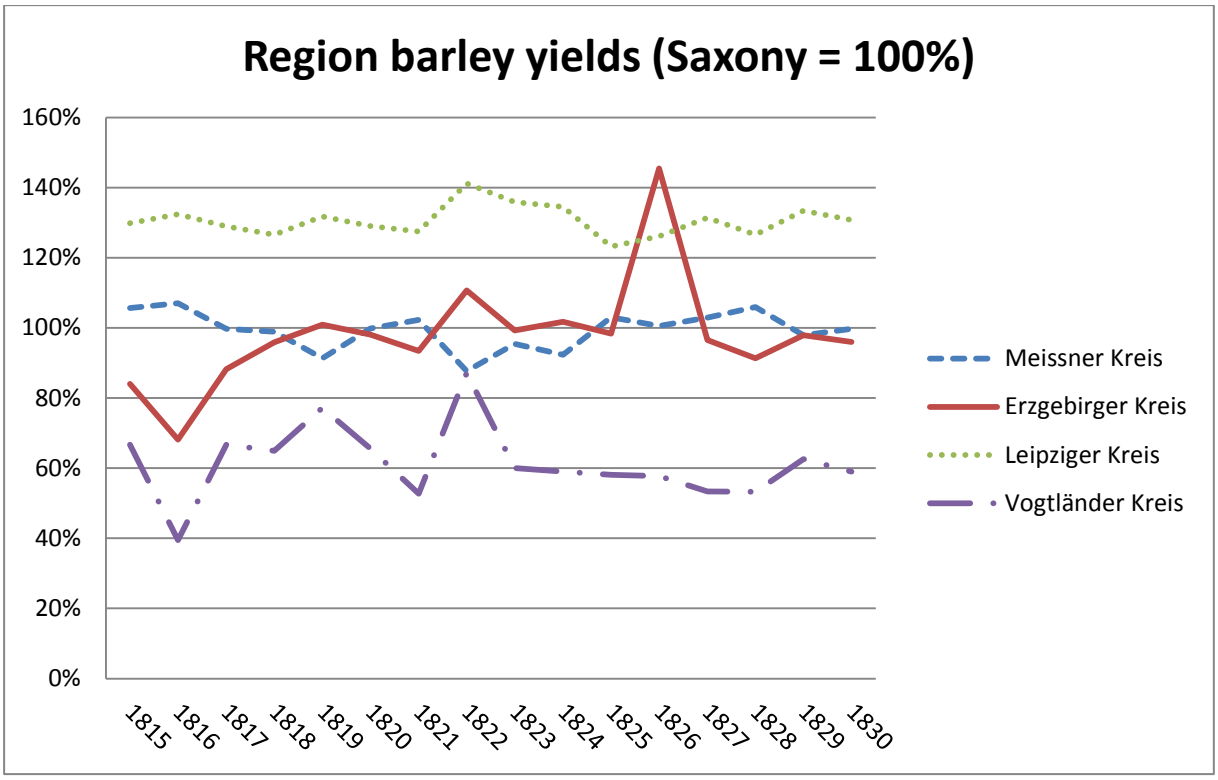
Source: Own calculation; for data sources see Appendix.

Figure A.1b: Regional yields in relation to the Saxon average, 1815-1830 (Saxony = 100%)





Source: Own calculation; for data sources see Appendix.


Region barley yields (Saxony = 100%)
160%
140%
120%
100%
80%
60%
40%
20%
0%
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
Meissner Kreis
Erzgebirger Kreis
Leipziger Kreis
Vogtländer Kreis

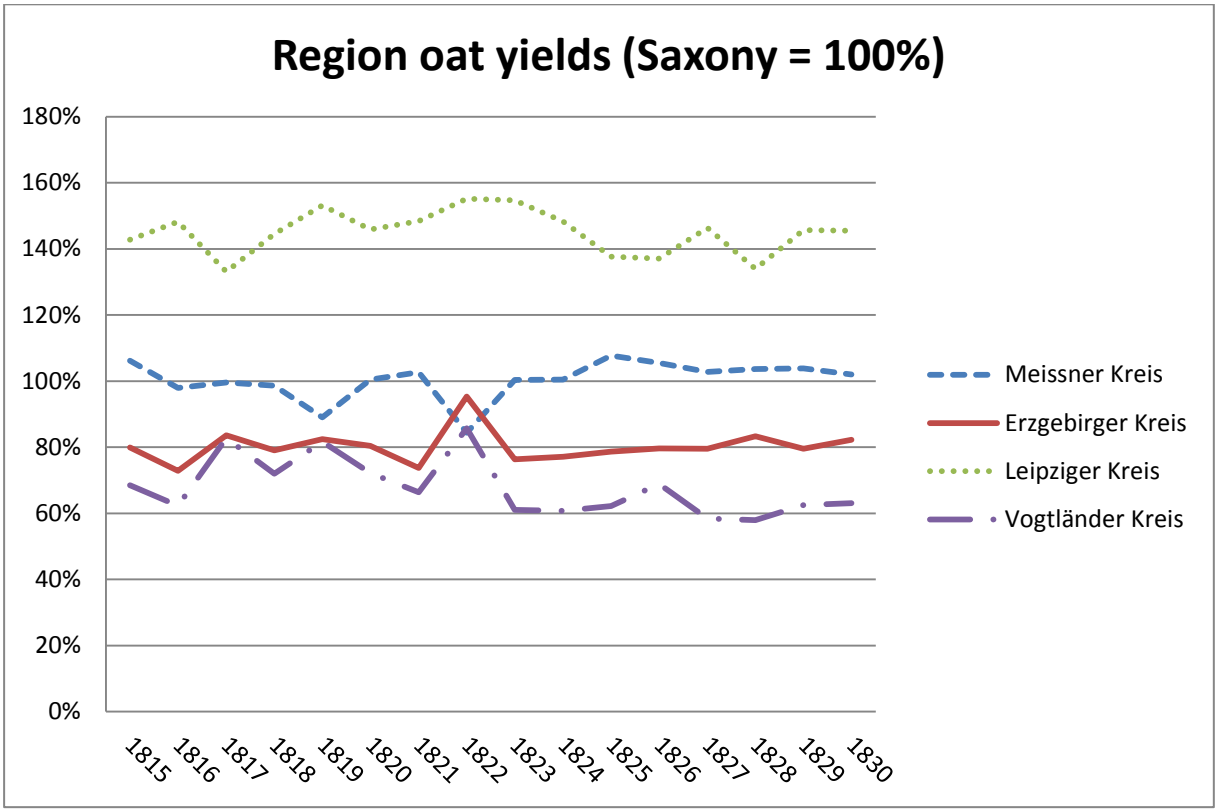
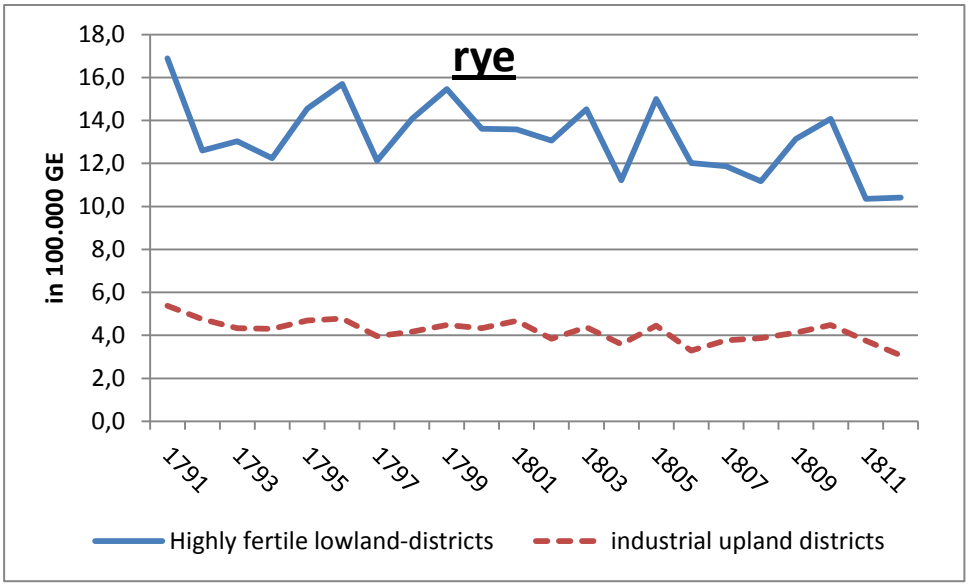
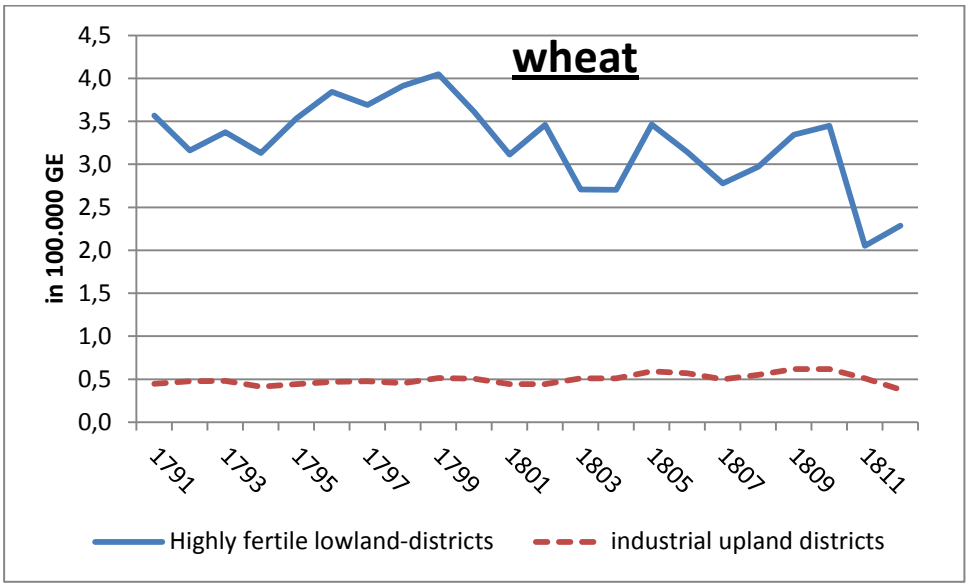
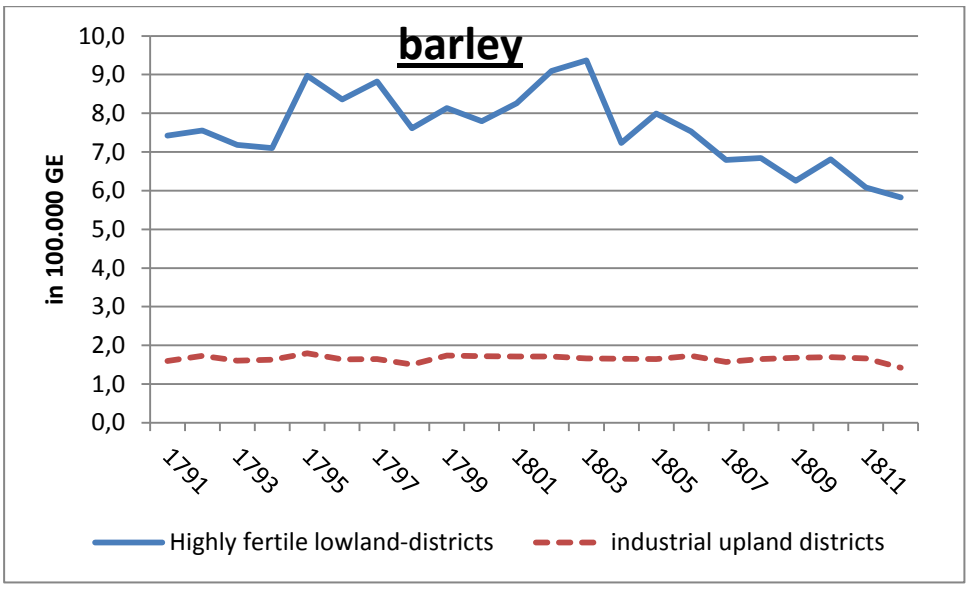
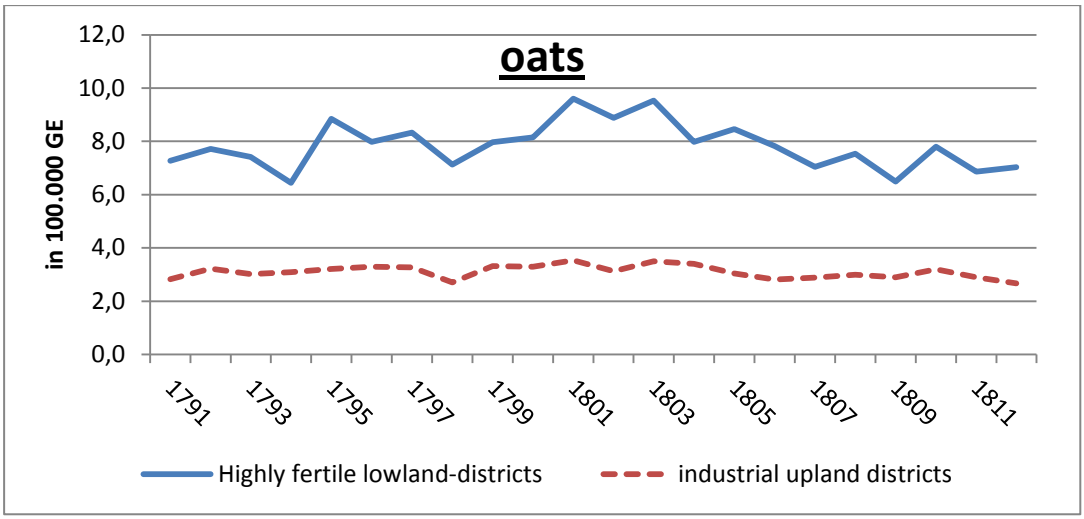

Region oat yields (Saxony = 100%)
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
Meissner Kreis
Erzgebirger Kreis
Leipziger Kreis
Vogtländer Kreis

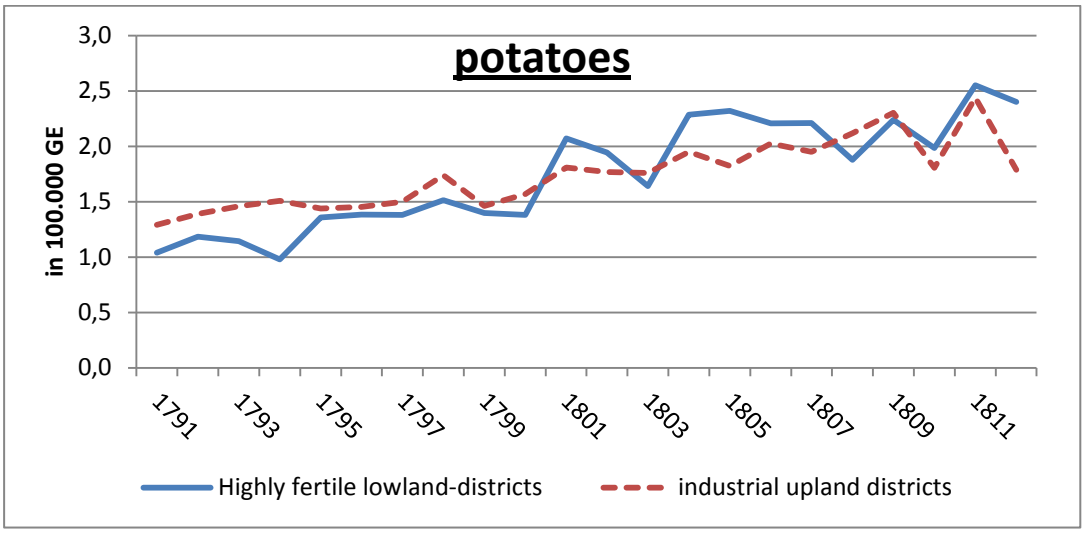
Figure A.2a: Gross production in highly fertile lowland districts and in upland industrial districts, 1791-1812*

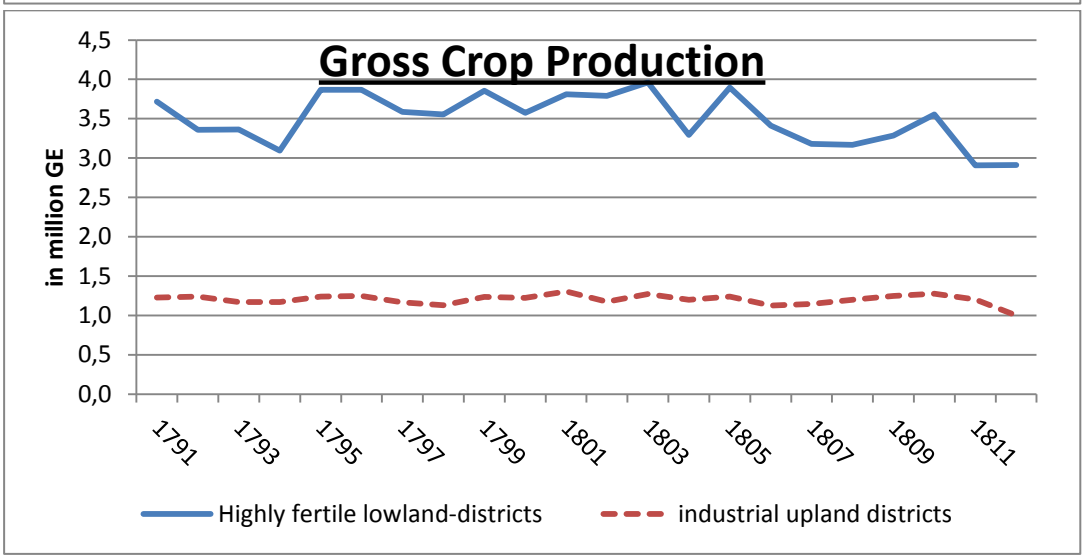






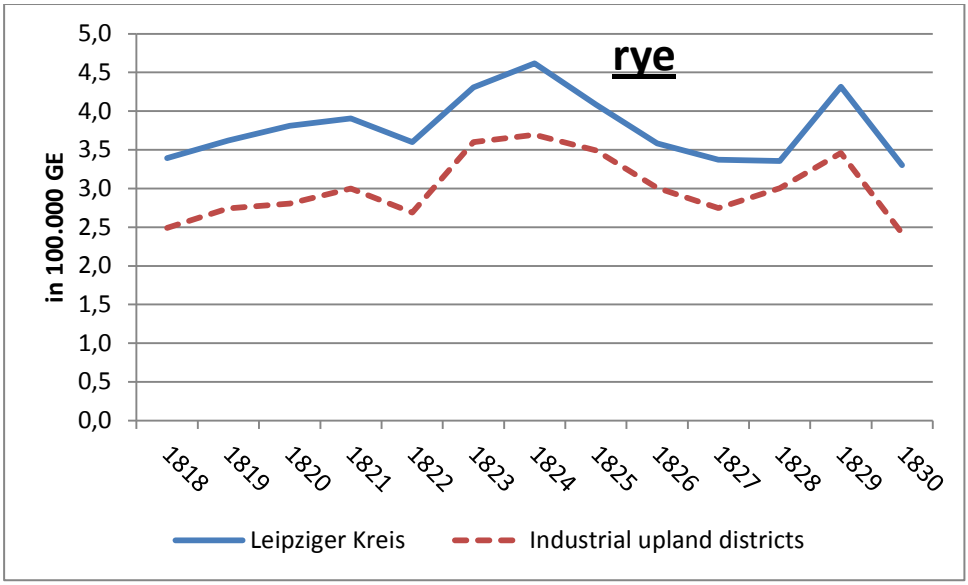


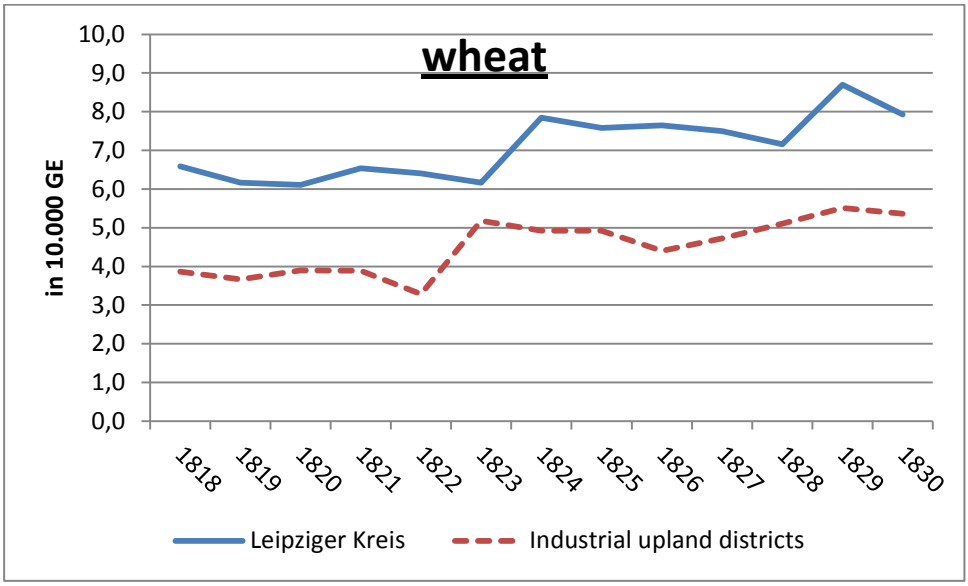


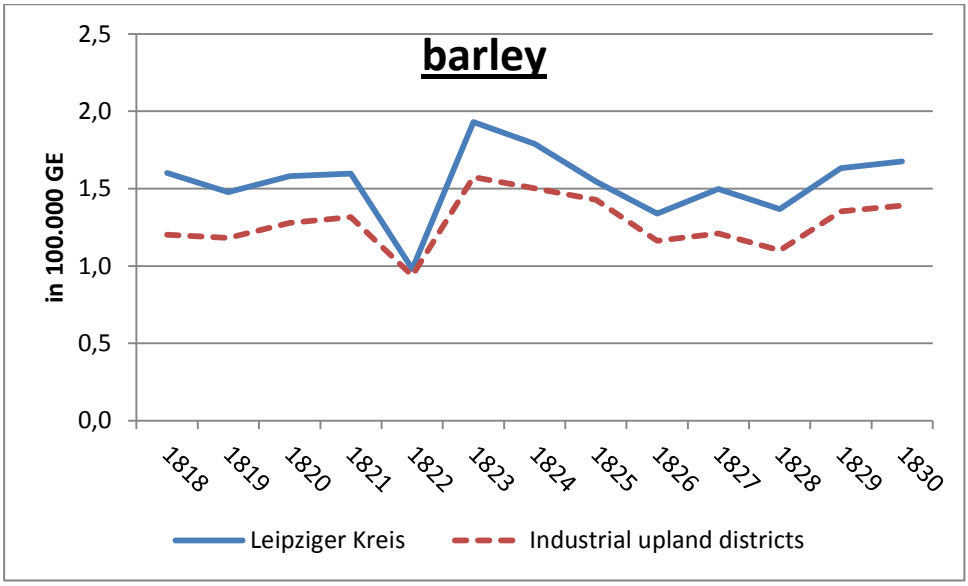


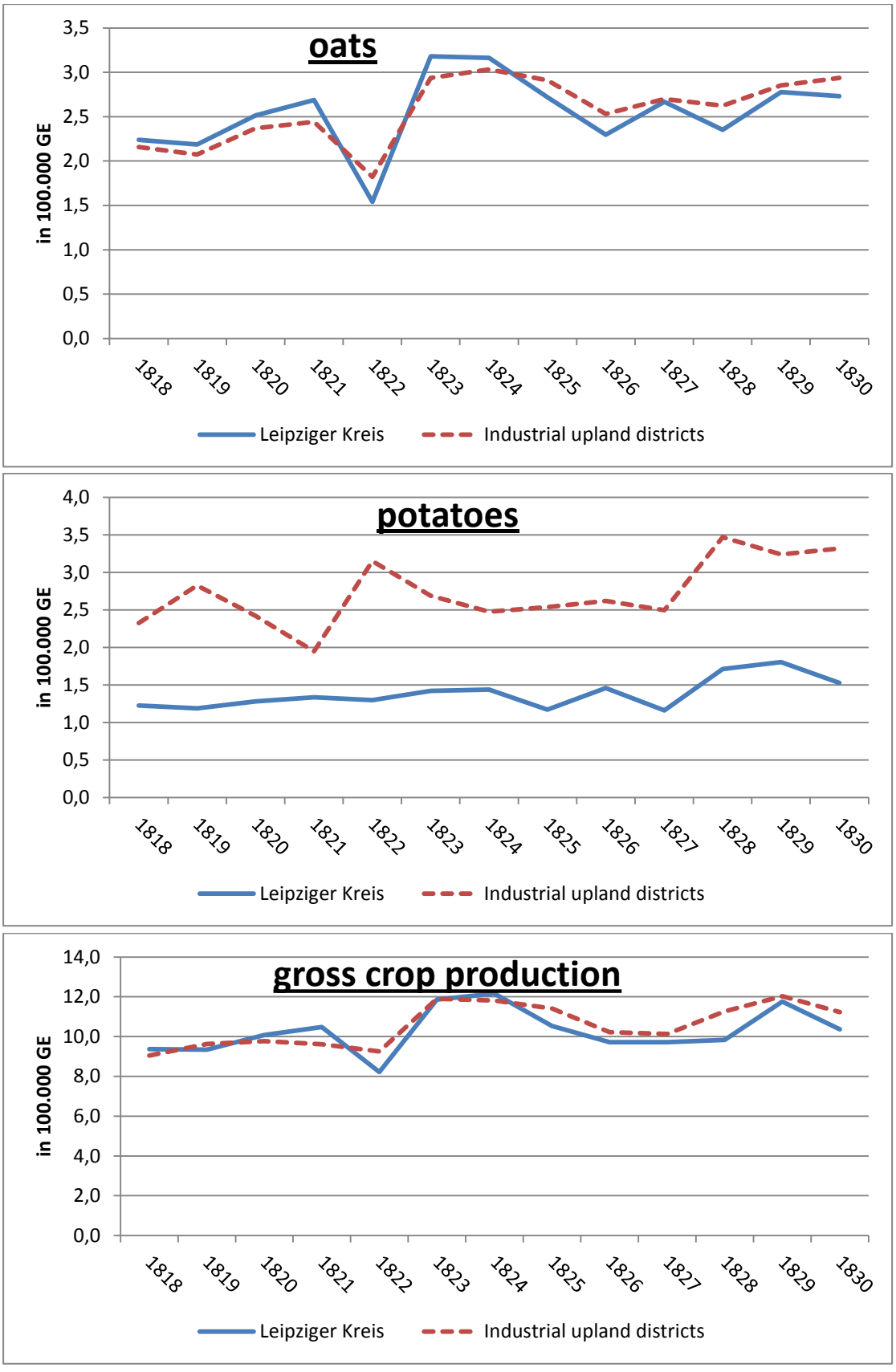
Sources: Own calculation; for data sources see Appendix.
Notes: *the macro-region 'highly fertile lowland districts' contains *Thüringer Kreis*, *Leipziger Kreis*, and the cathedral chapters of Naumburg and Merseburg; *the macro-region 'upland industrial districts' contains *Erzgebirger Kreis* and *Vogtländer Kreis*.

Figure A.2b: Gross production in a highly fertile lowland district (Leipziger Kreis) and in upland industrial districts (Erzgebirger and Vogtländer Kreis), 1818-1830



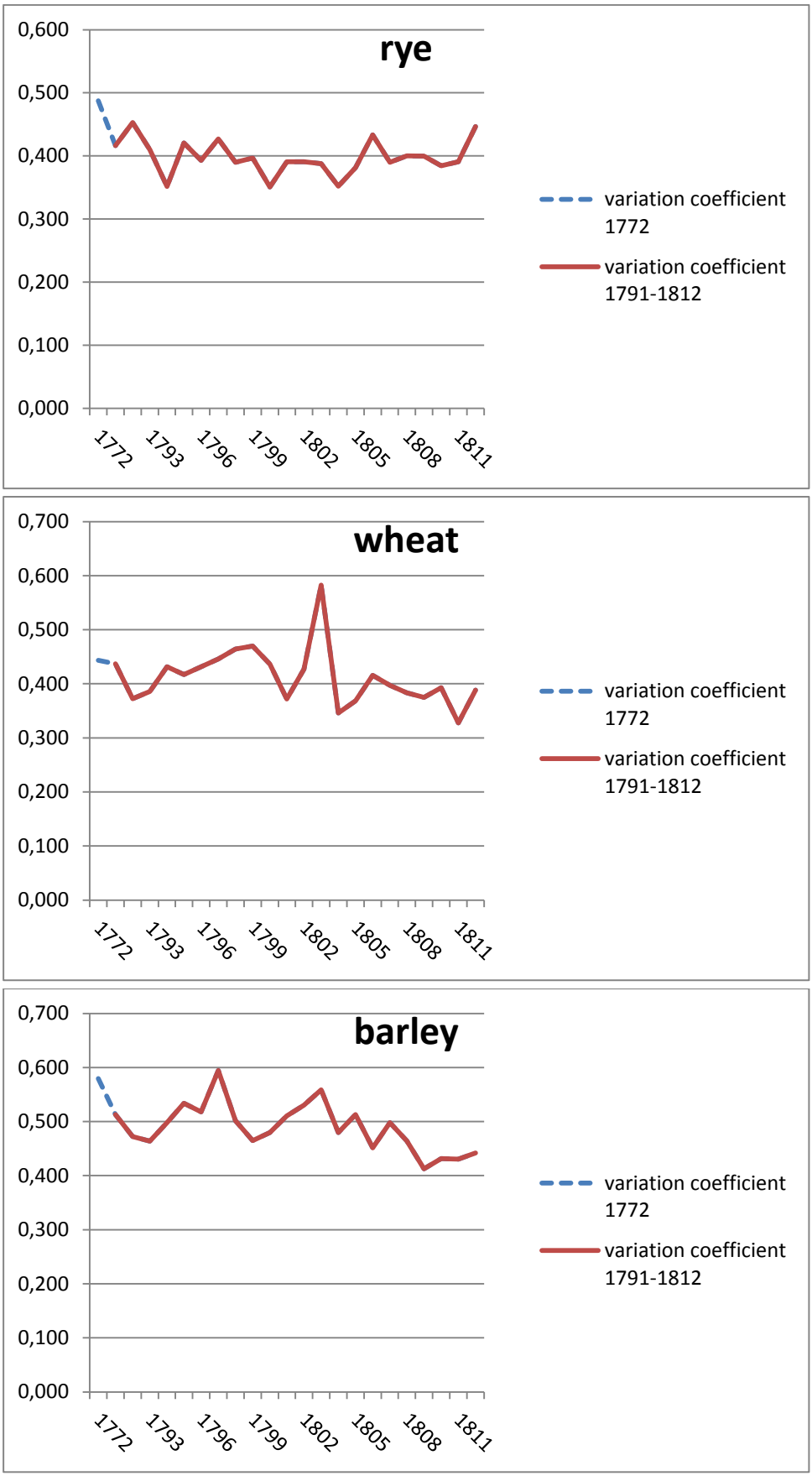


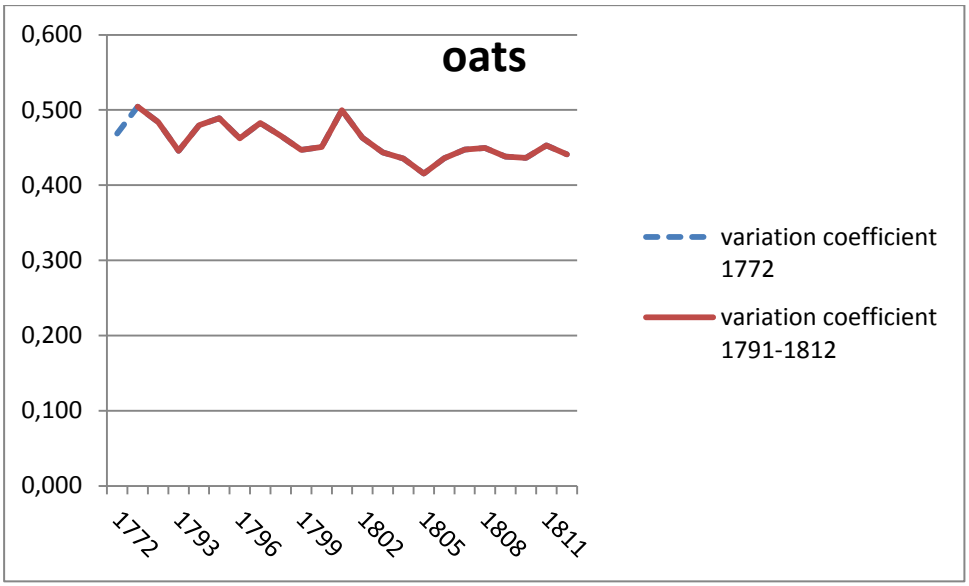


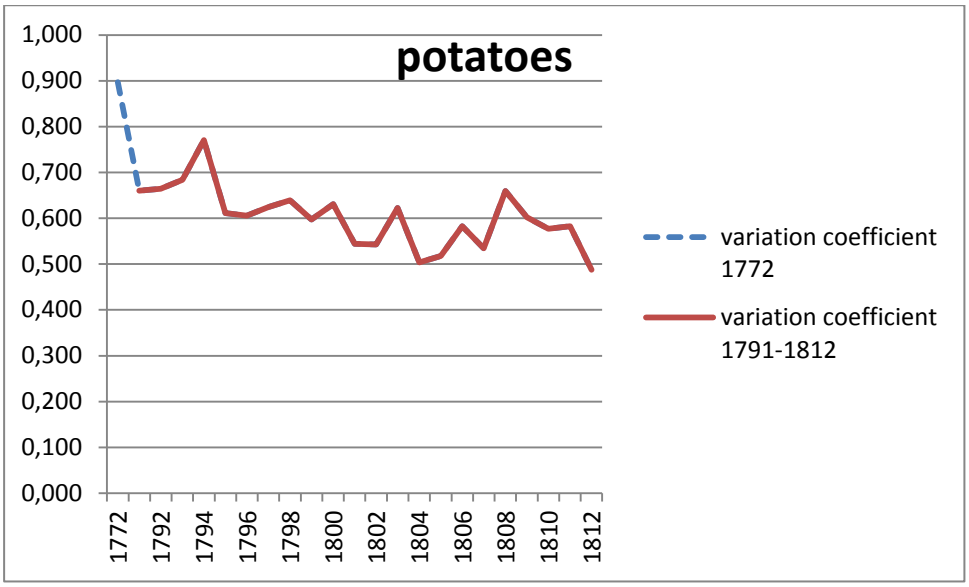


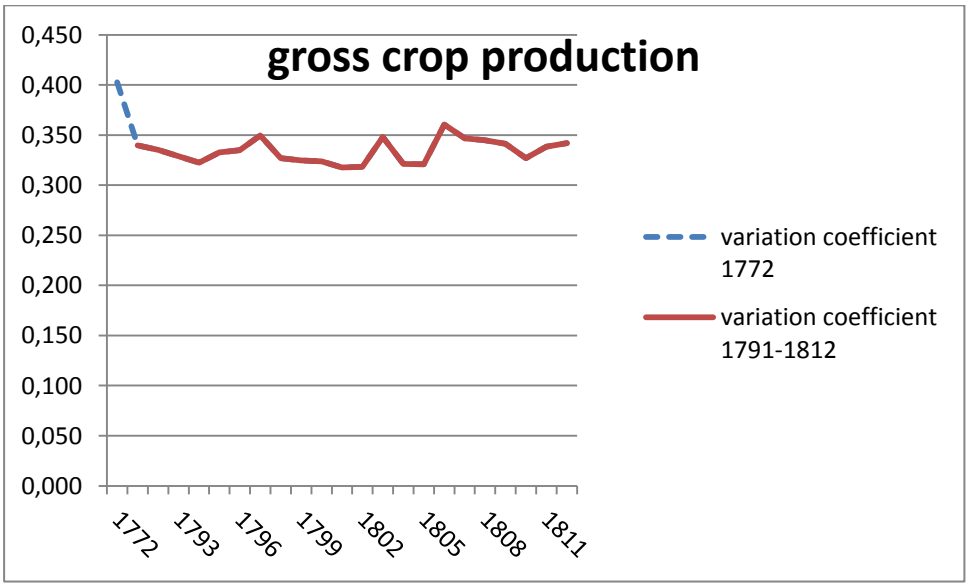
Sources: Own calculation; for data sources see Appendix.

Figure A.3a: Trends in regional specialization (variation coefficient), 1791-1812





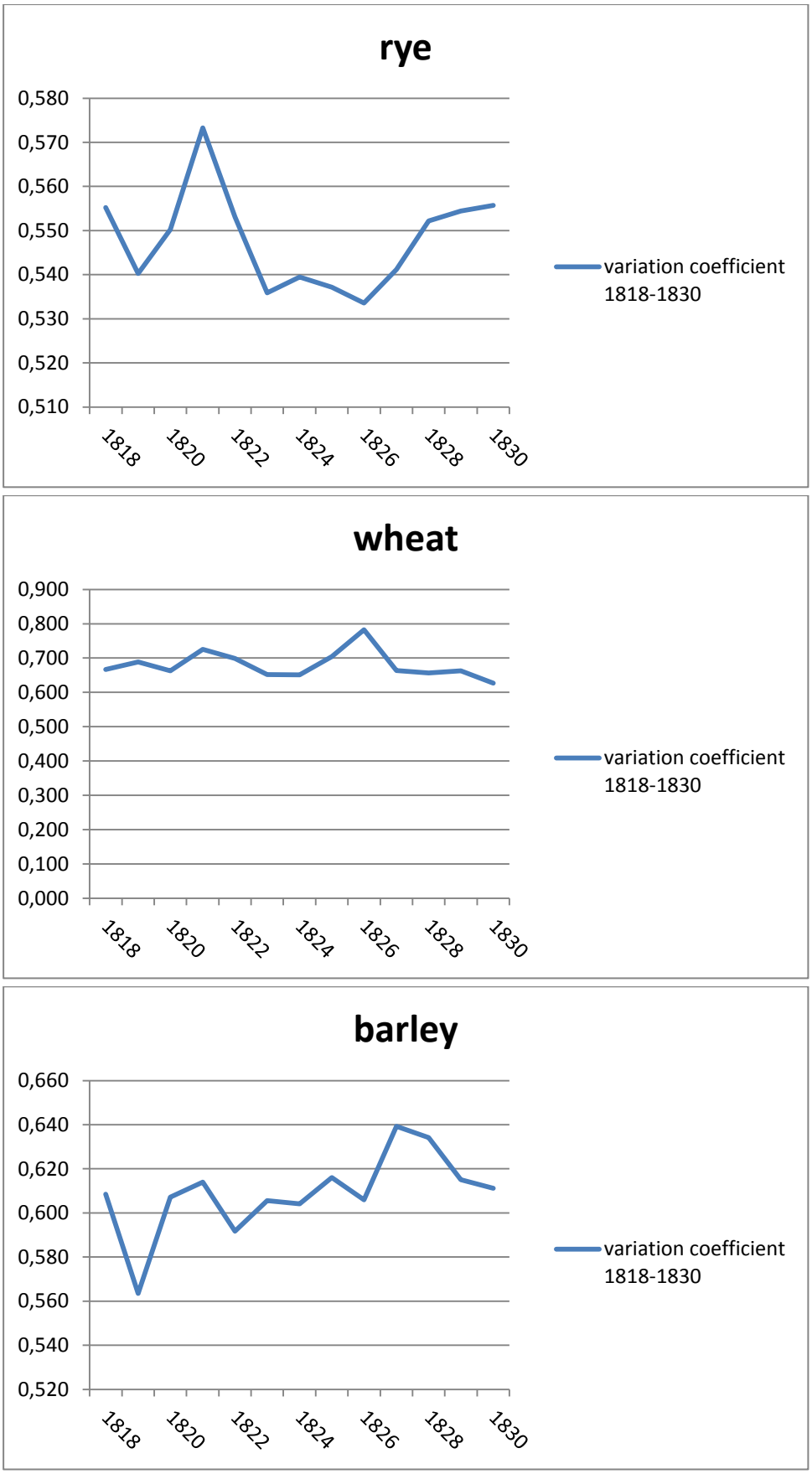


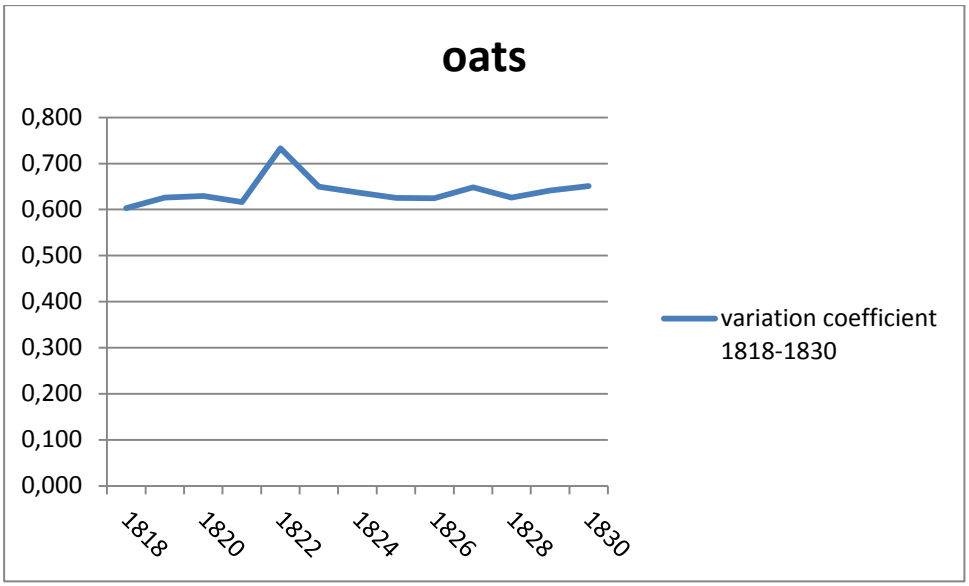


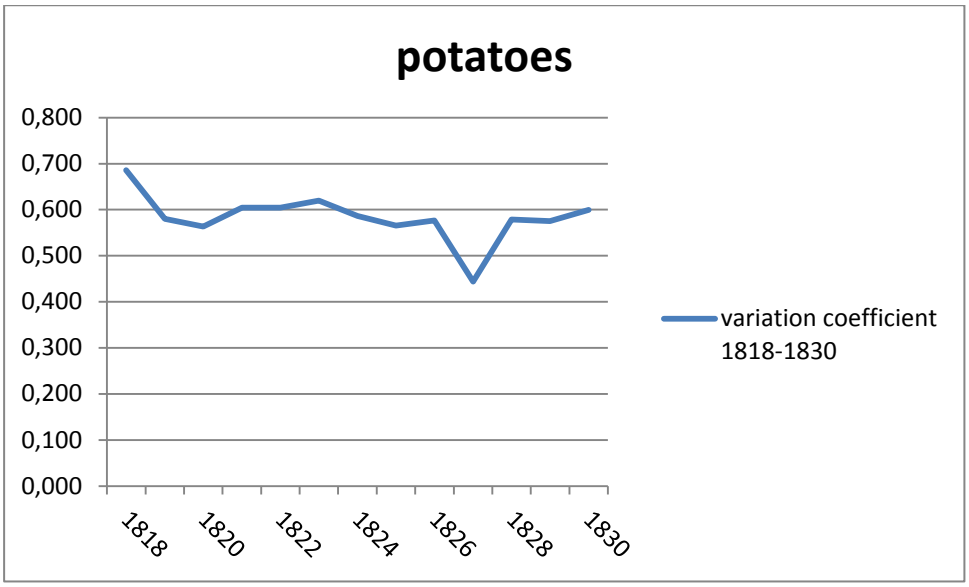
Sources: see table 16

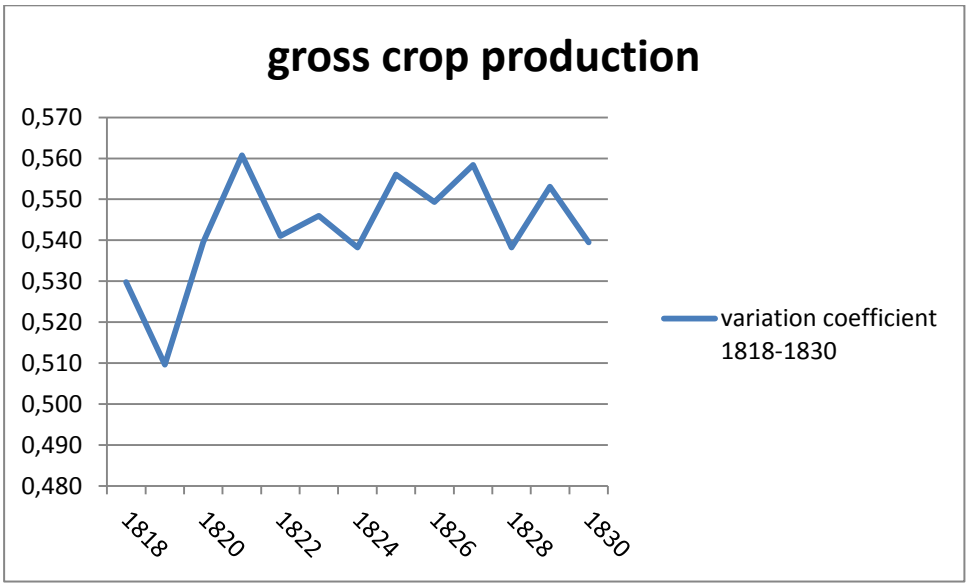
Notes: see table 16.

Figure A.3b: Trends in regional specialization (variation coefficient), 1818-1830





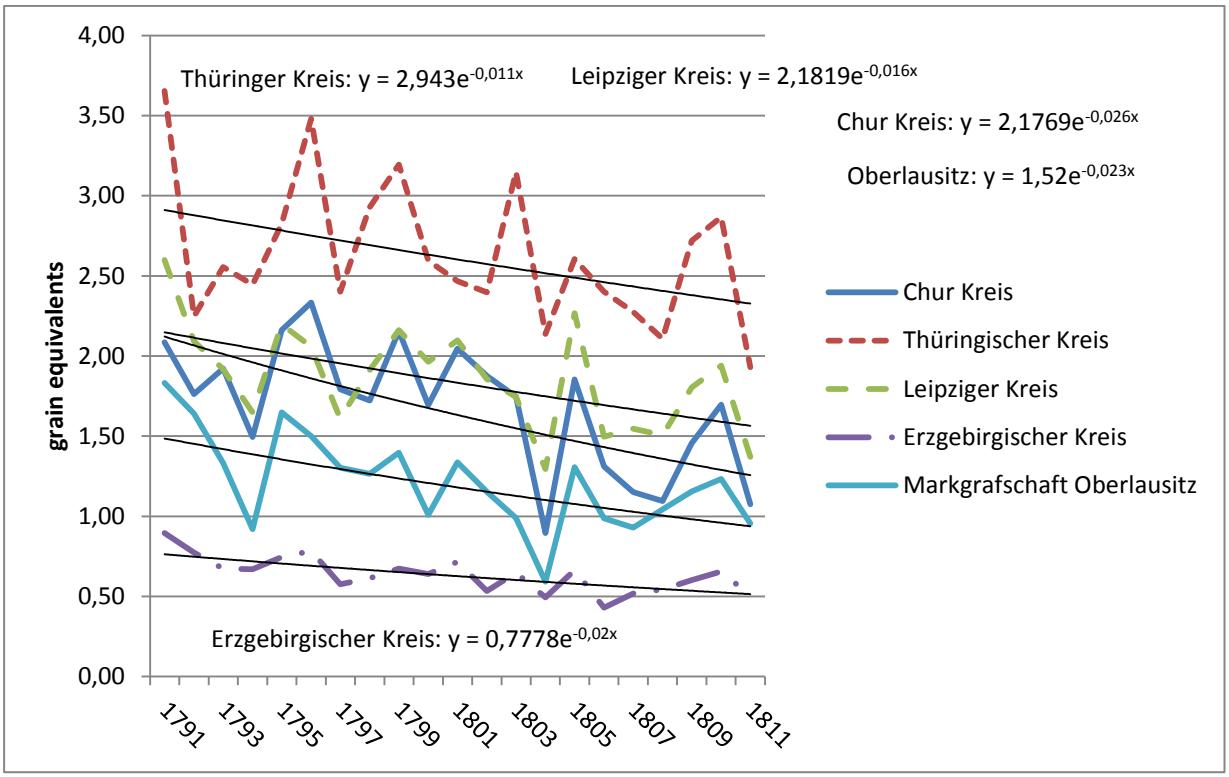




Sources: see table 16

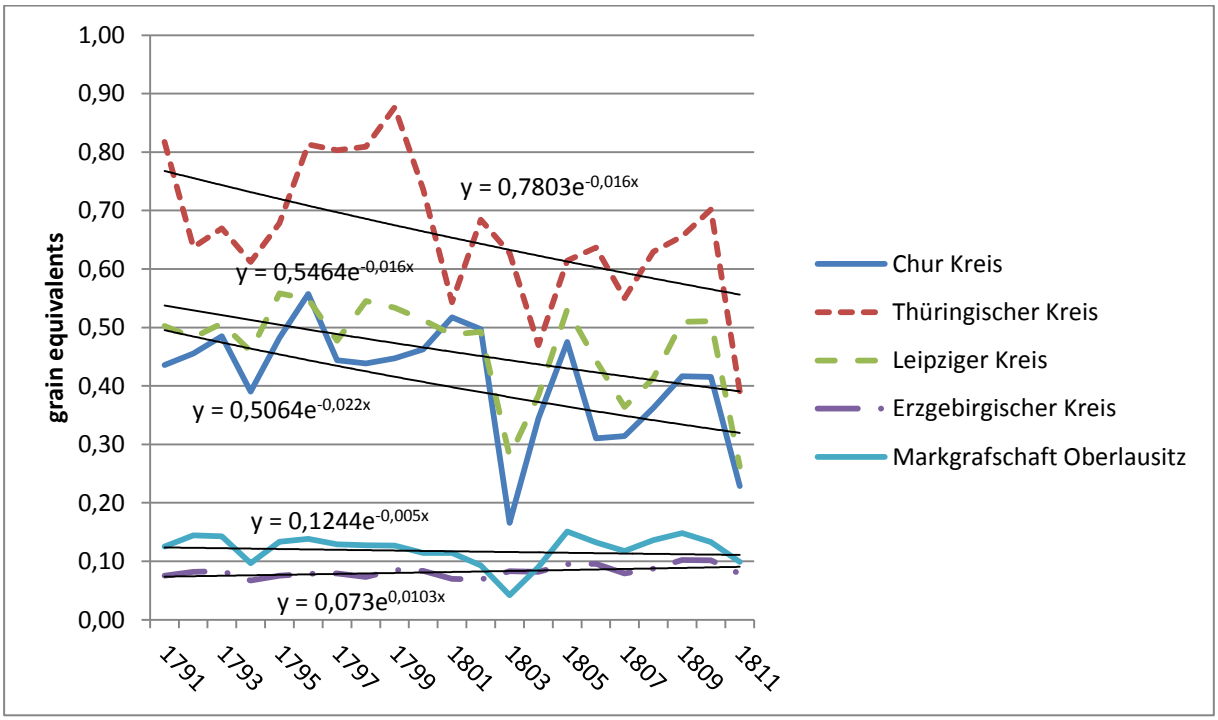
Notes: see table 16.

Figure A.4a: Regional net production of rye per capita (in GE), 1791-1812



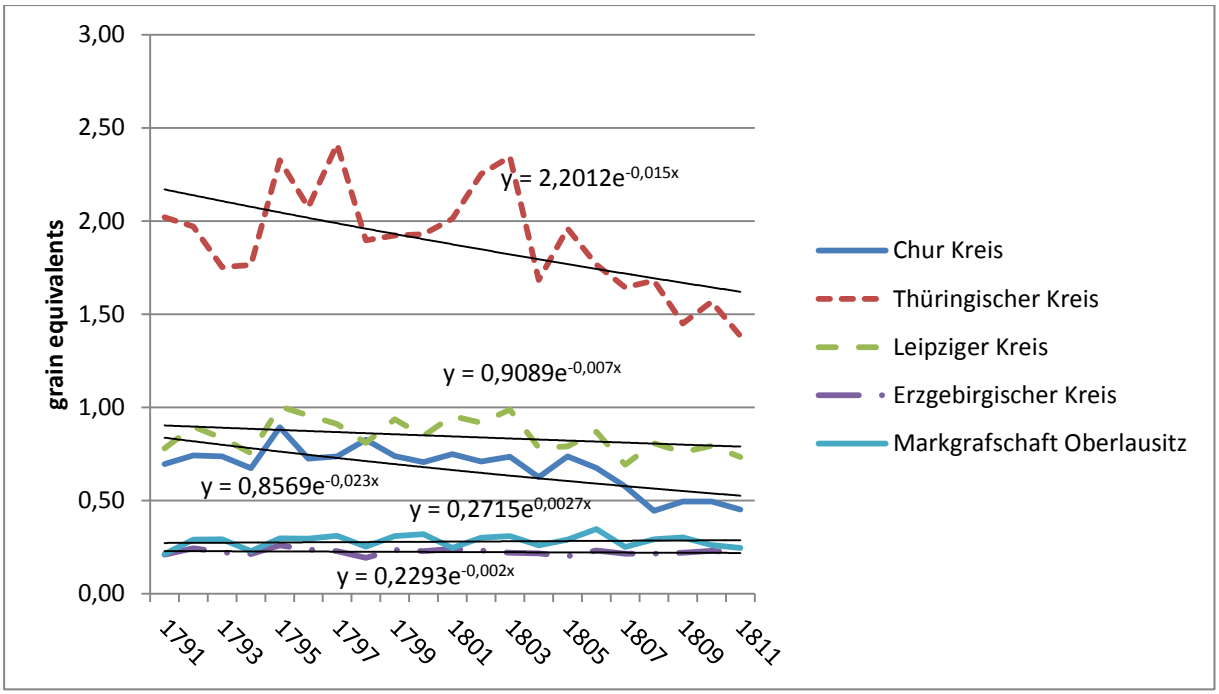
Sources: own calculation, for data see appendix.

Figure A.4b: Regional net production of wheat per capita (in GE), 1791-1812



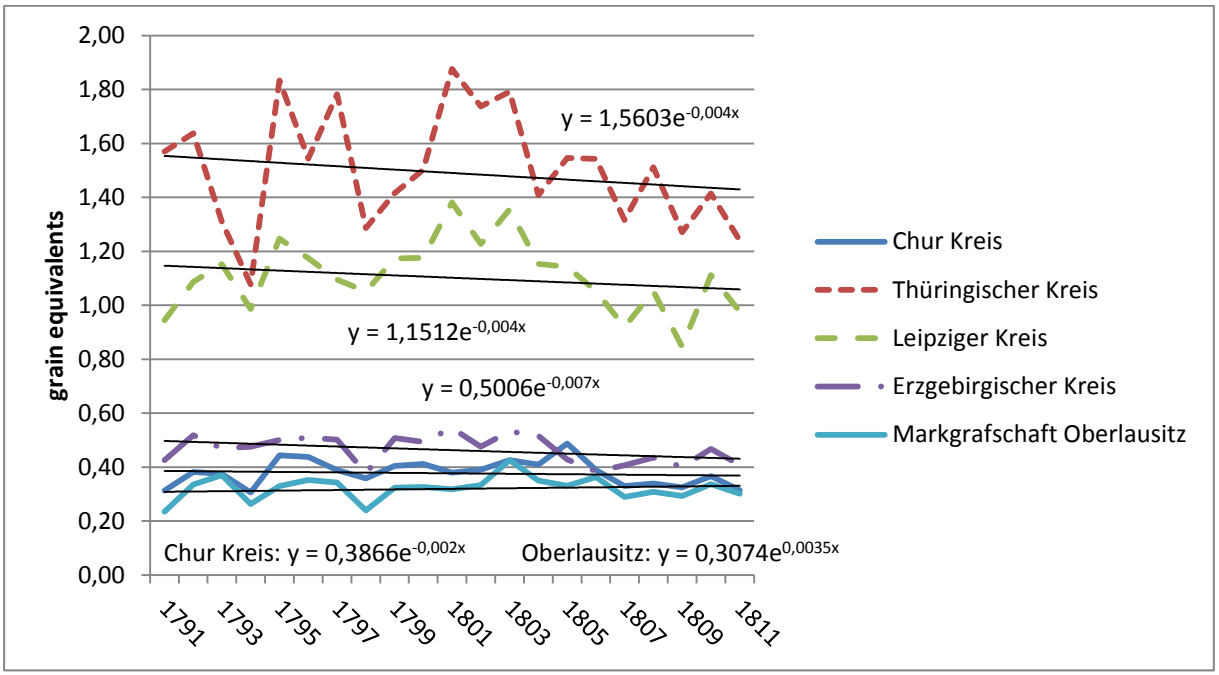
Sources: own calculation, for data see appendix.

Figure A.4c: Regional net production of barley per capita (in GE), 1791-1812



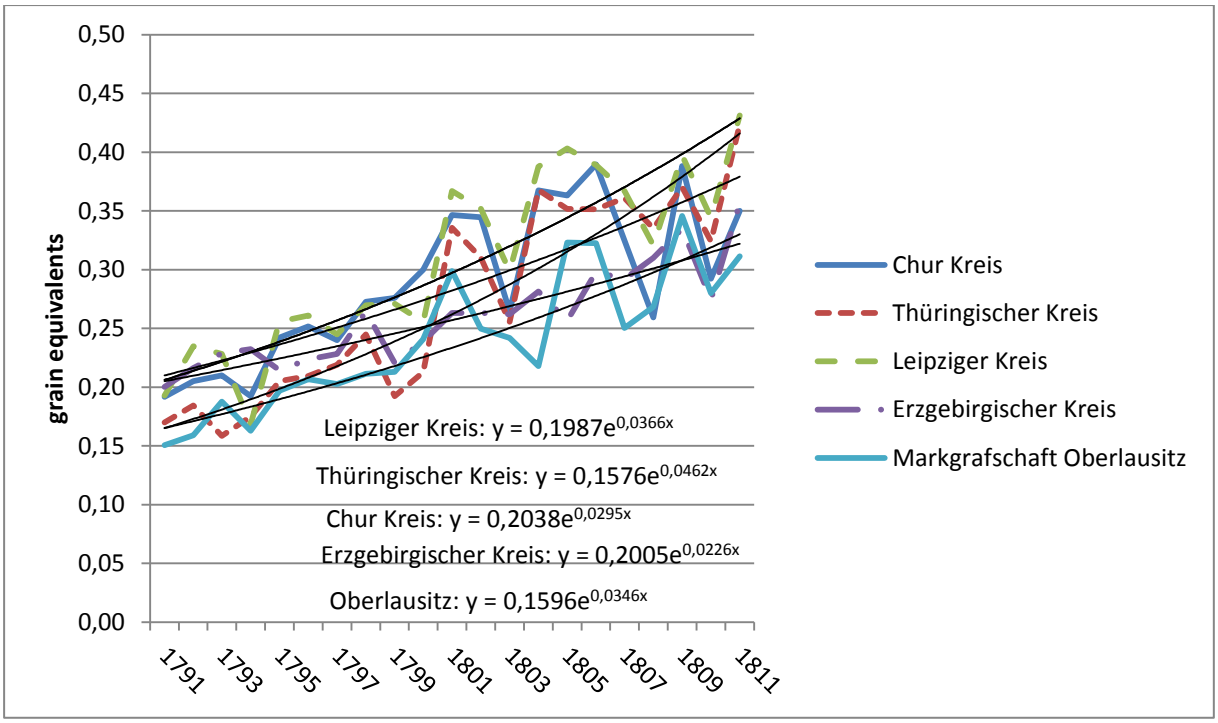
Sources: own calculation, for data see appendix.

Figure A.4d: Regional net production of oats per capita (in GE), 1791-1812



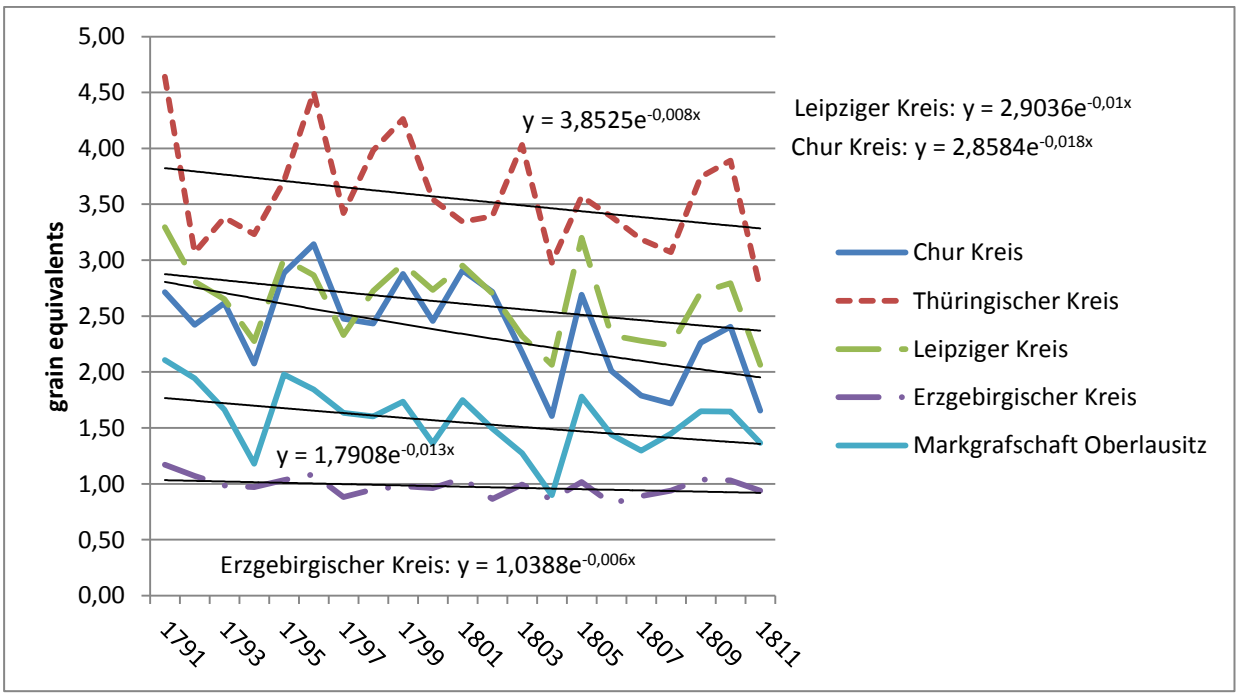
Sources: own calculation, for data see appendix.

Figure A.4e: Regional net potato production per capita (in GE), 1791-1812



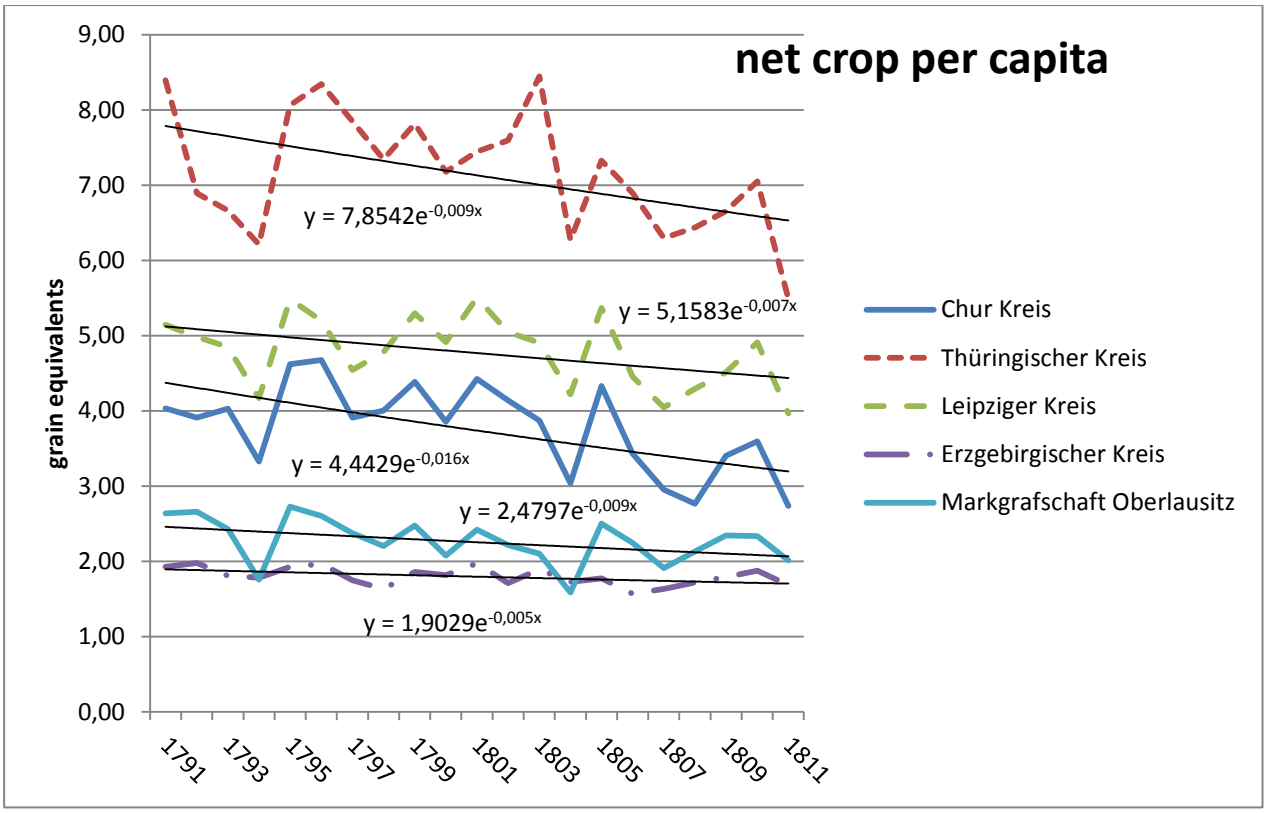
Sources: own calculation, for data see appendix.

Figure A.4f: Regional net staple food production (rye, wheat, and potatoes) per capita (in GE),
1791-1812



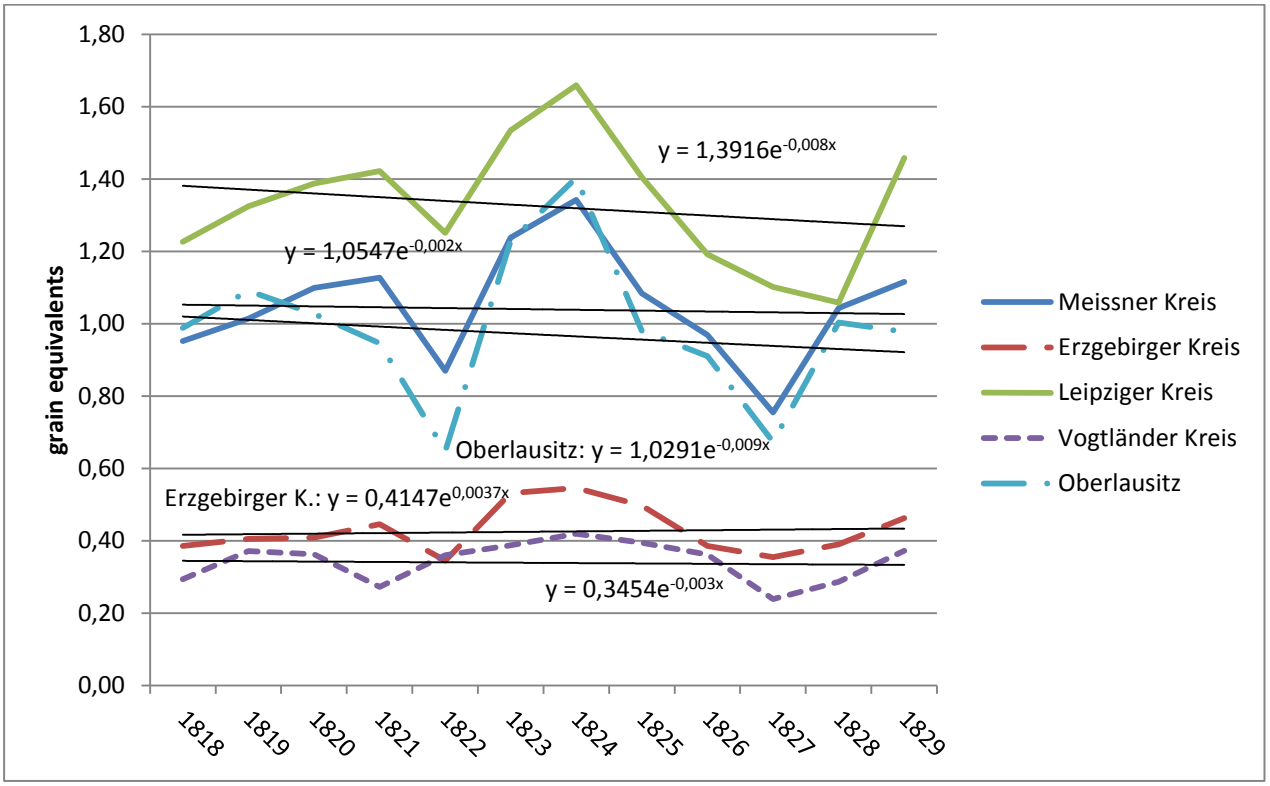
Sources: own calculation, for data see appendix.

Figure A.4g: Regional total net crop production per capita (in GE), 1791-1812



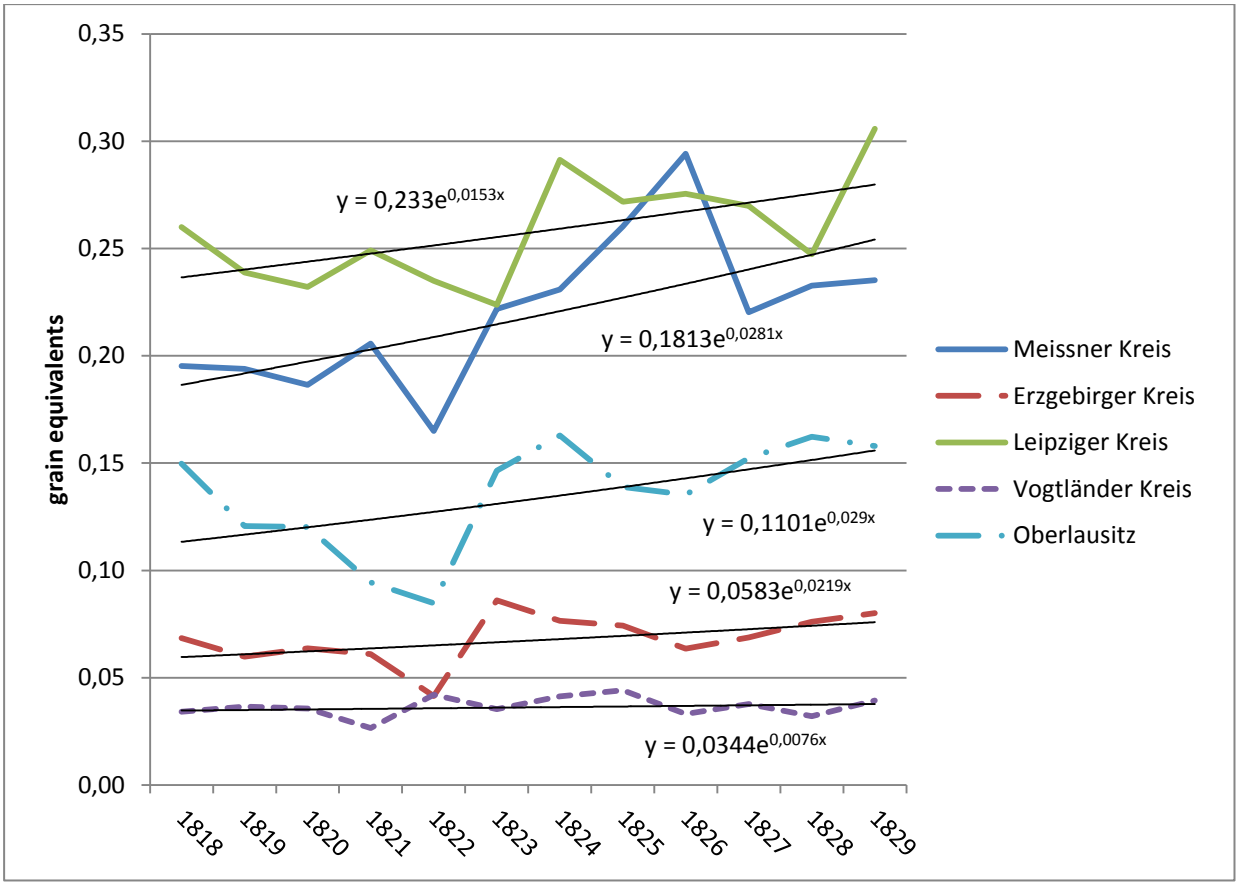
Sources: own calculation, for data see appendix.

Figure A.5a: Regional net rye production per capita (in GE), 1818-1829



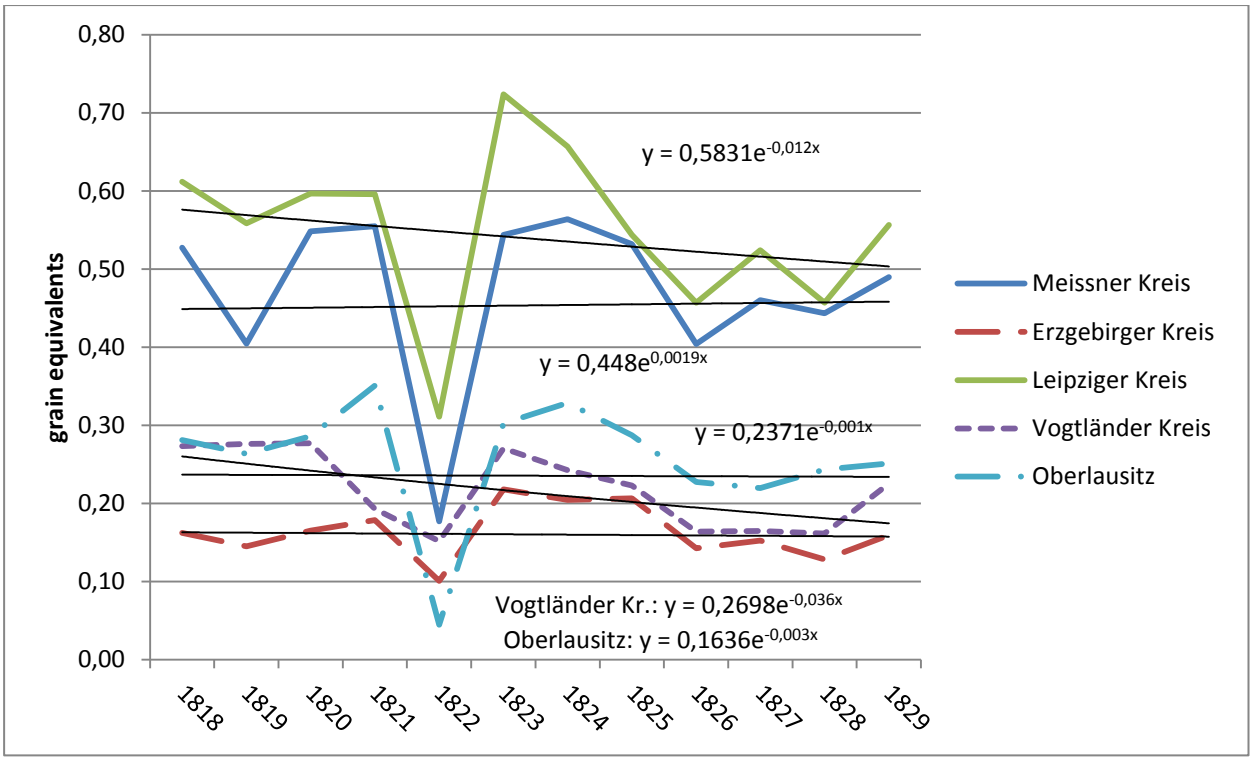
Sources: own calculation, for data see appendix.

Figure A.5b: Regional net wheat production per capita (in GE), 1818-1829



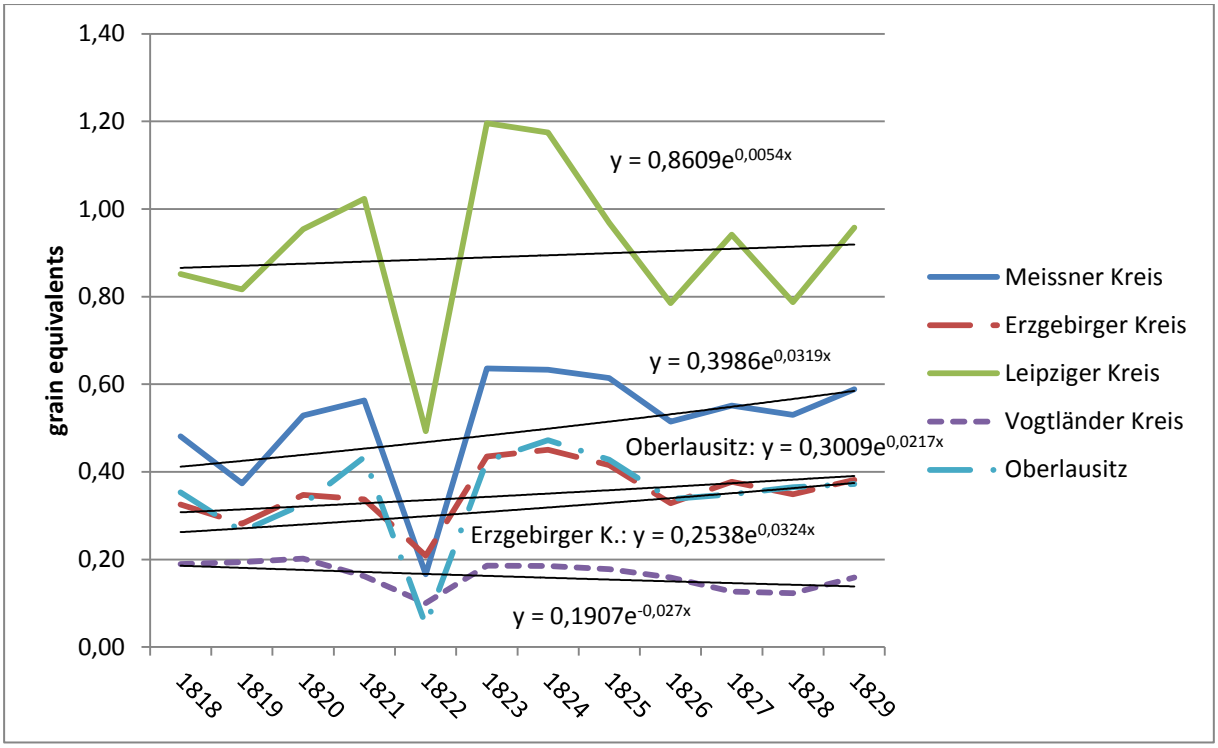
Sources: own calculation, for data see appendix.

Figure A.5c: Regional net barley production per capita (in GE), 1818-1829



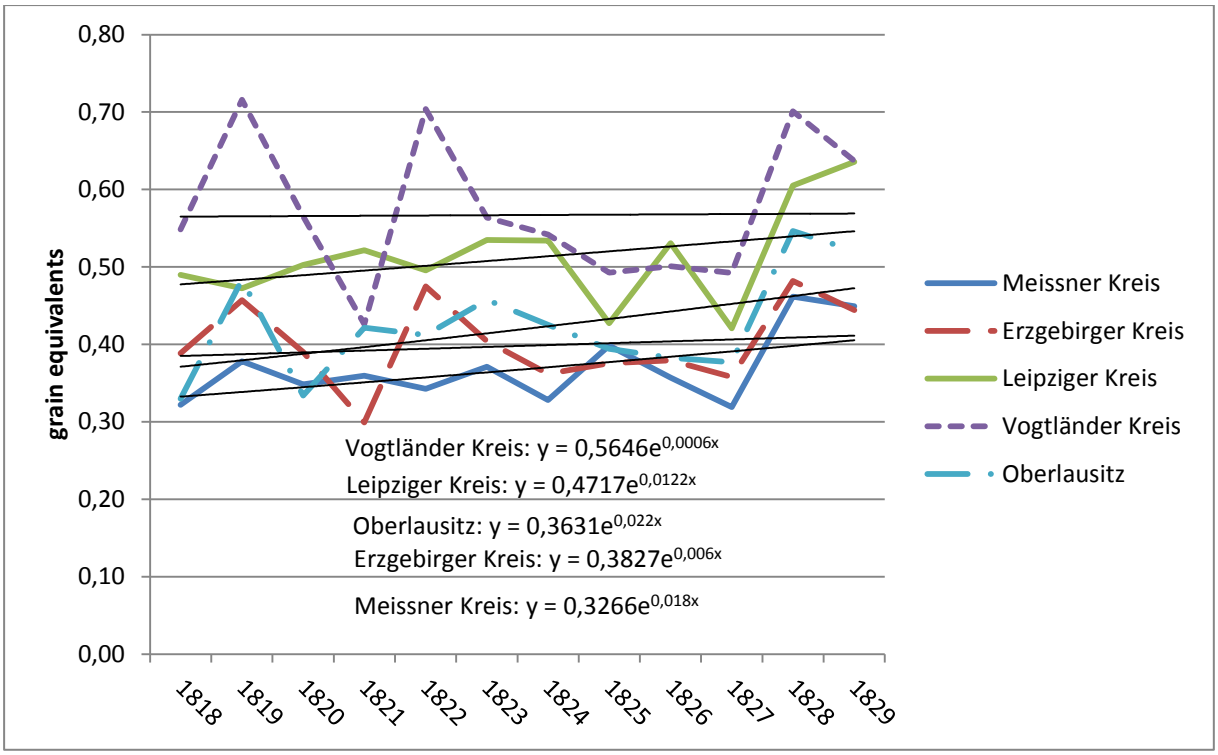
Sources: own calculation, for data see appendix.

Figure A.5d: Regional net oats production per capita (in GE), 1818-1829



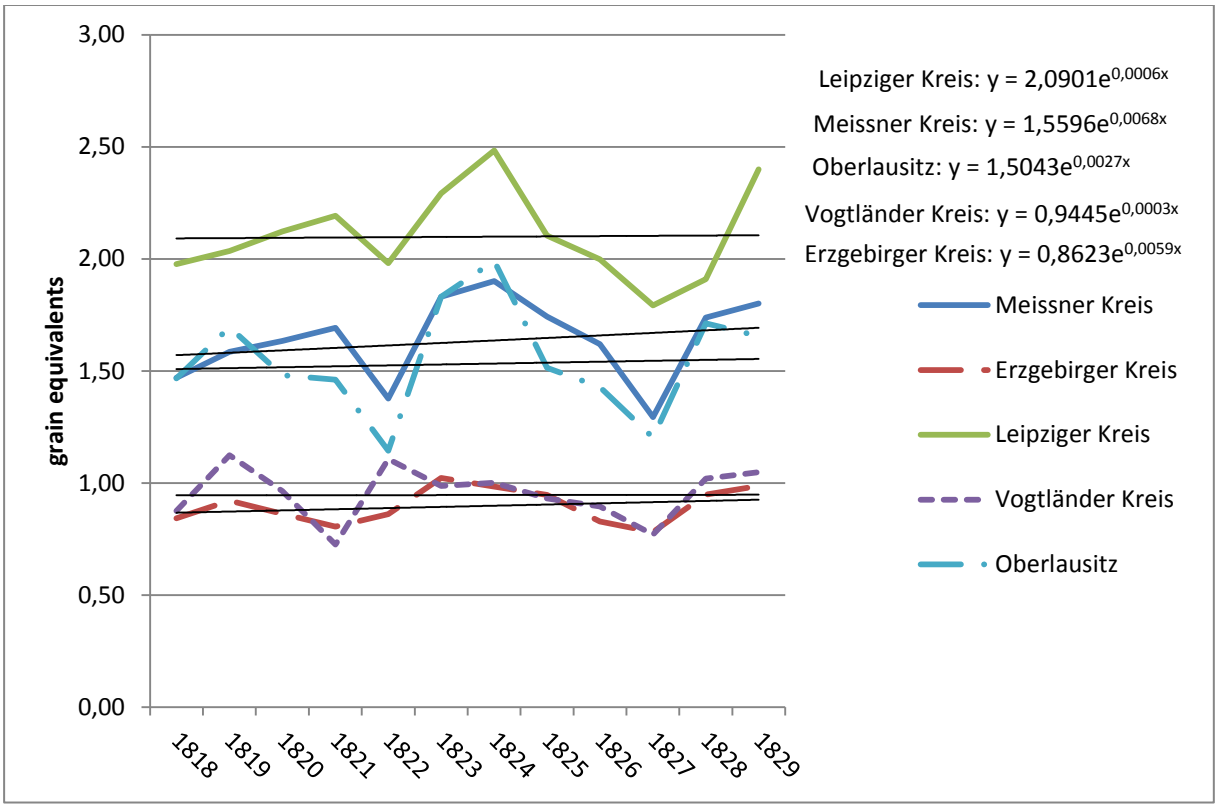
Sources: own calculation, for data see appendix.

Figure A.5e: Regional net potato production per capita (in GE), 1818-1829



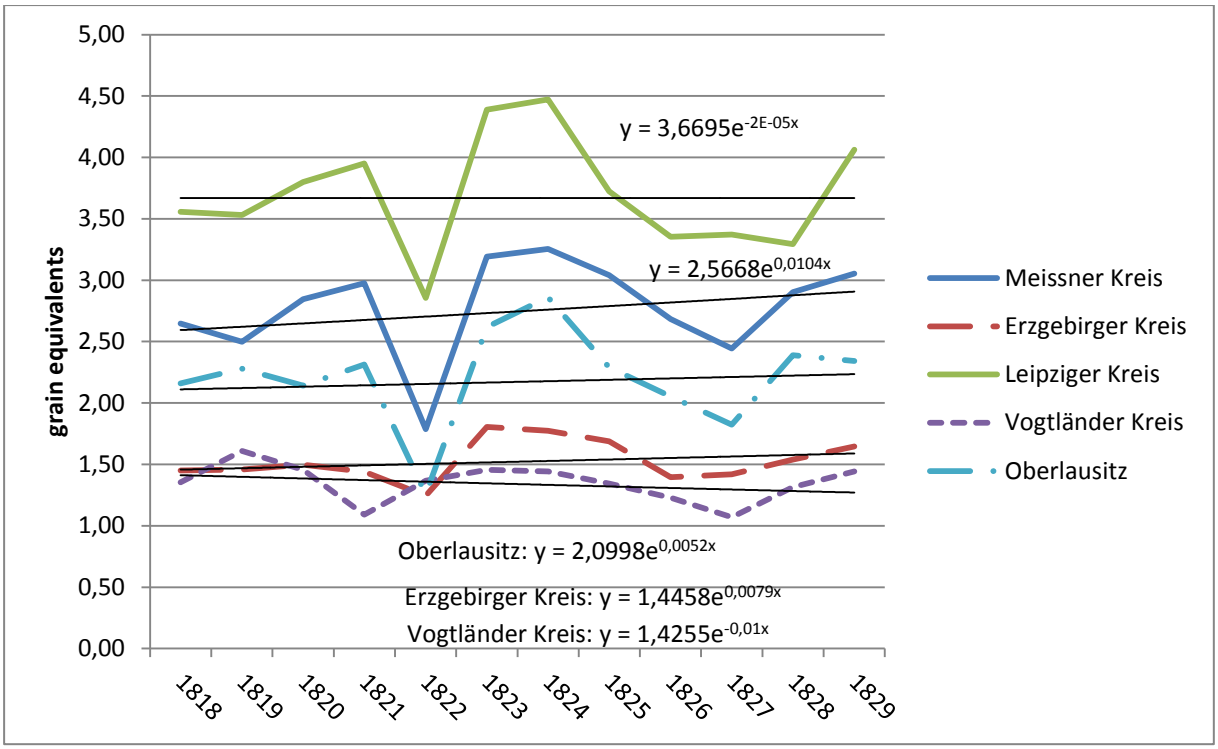
Sources: own calculation, for data see appendix.

Figure A.5f: Regional net staple food production (rye, wheat, and potatoes) per capita (in GE), 1818-1829



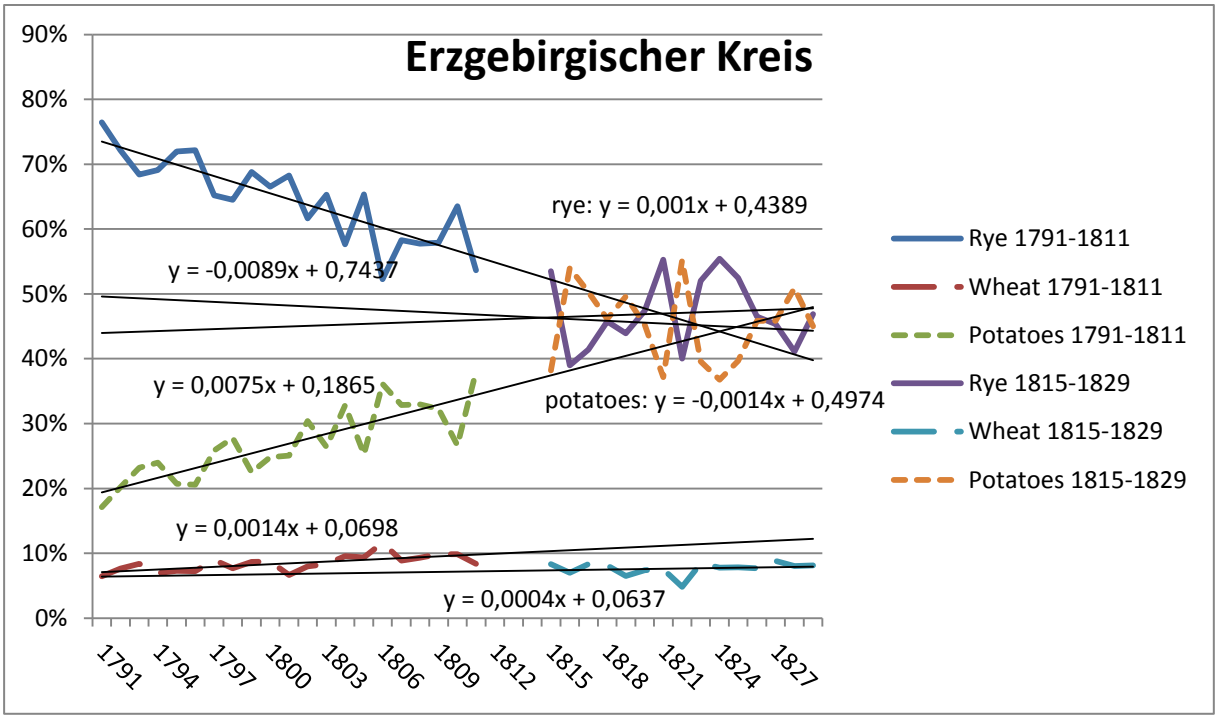
Sources: own calculation, for data see appendix.

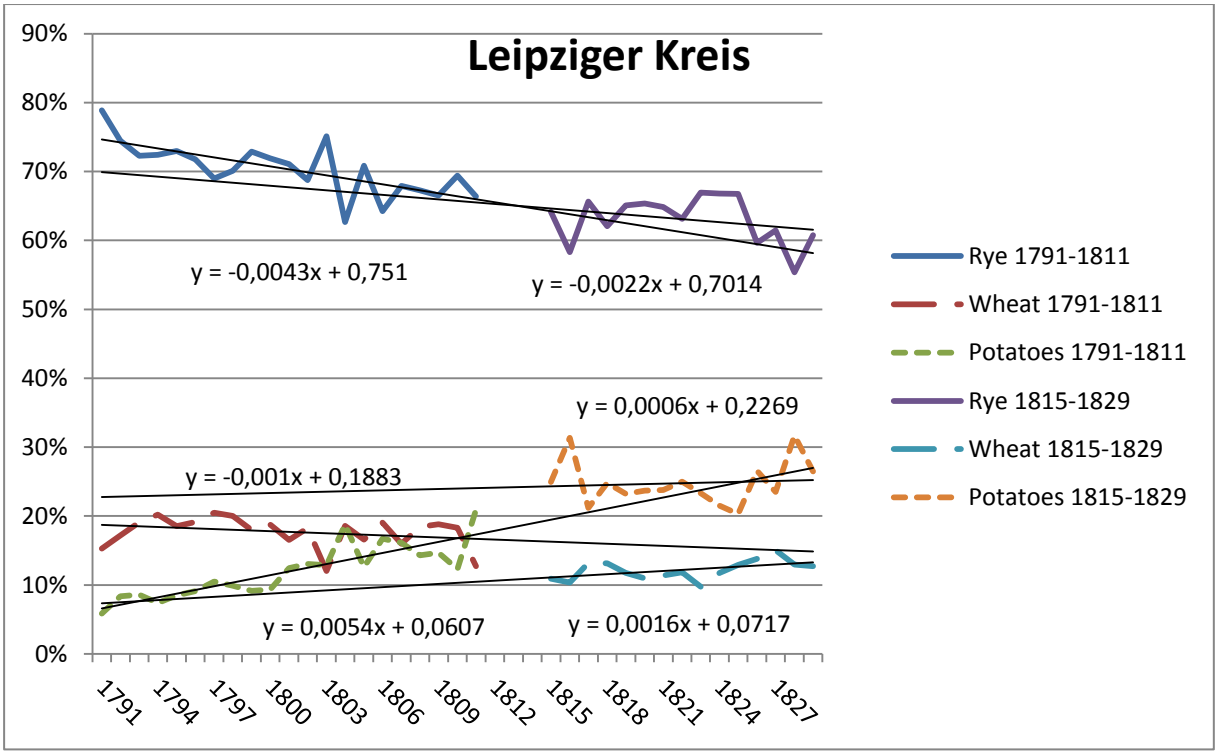
Figure A.5g: Regional net crop production per capita (in GE), 1818-1829



Sources: own calculation, for data see appendix.

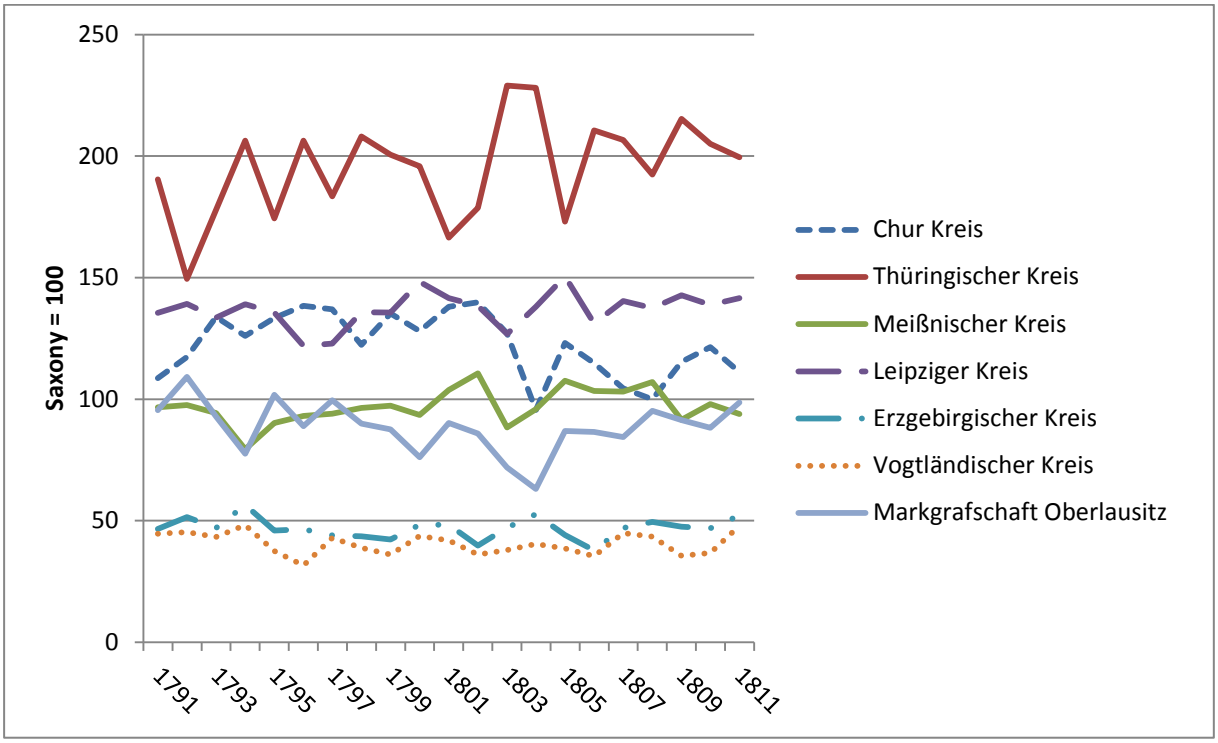
Figure A.6: Share of rye, wheat and potatoes in regional net staple food production, 1791-1829





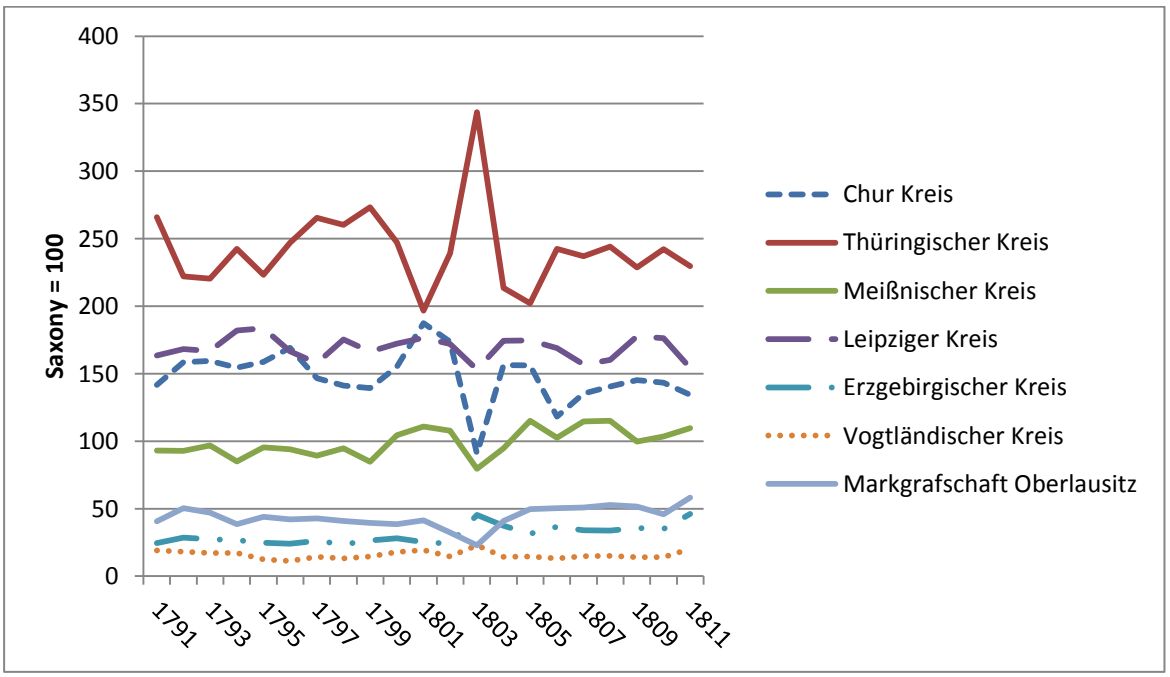
Sources: own calculation, for data see appendix.

Figure A.7a: Net production of rye per capita, 1791-1811 (Saxony = 100)



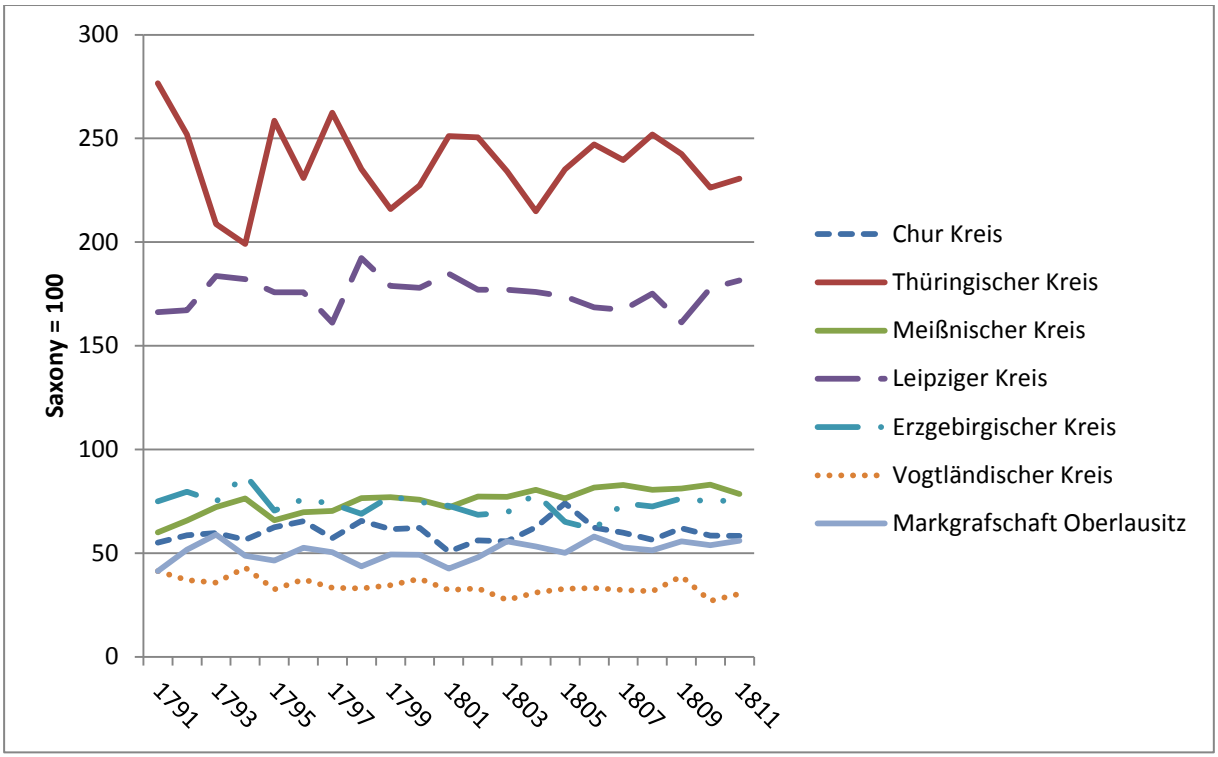
Sources: own calculation, for data see appendix.

Figure A.7b: Net production of wheat per capita, 1791-1811 (Saxony = 100)



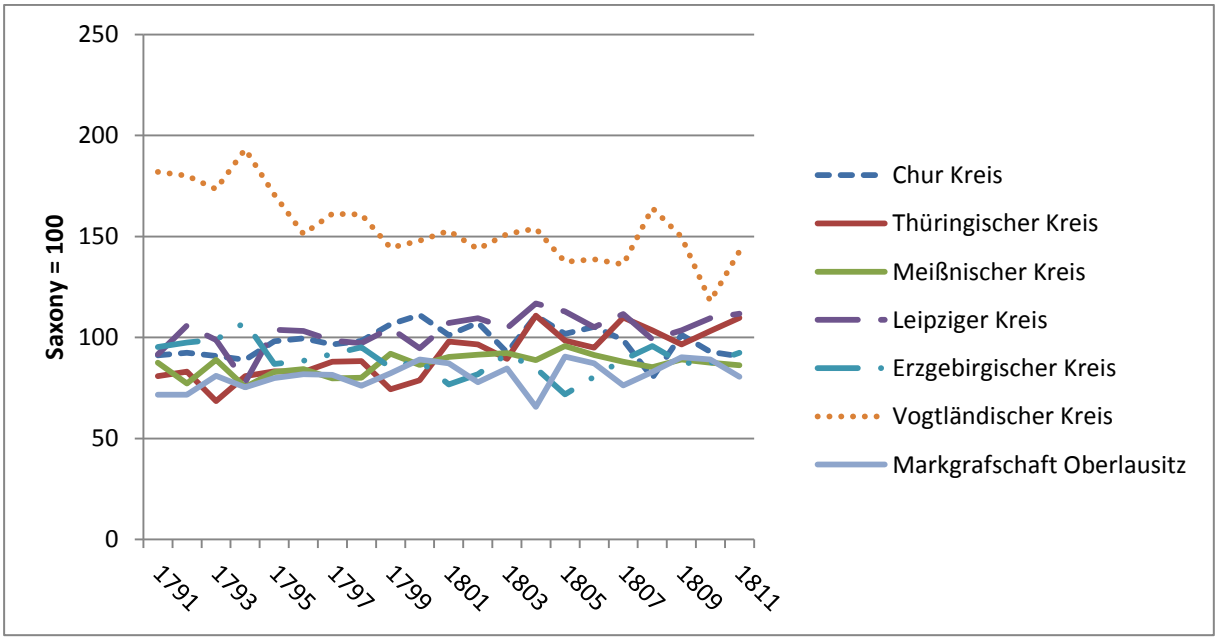
Sources: own calculation, for data see appendix.

Figure A.7c: Net production of oats per capita, 1791-1811 (Saxony = 100)



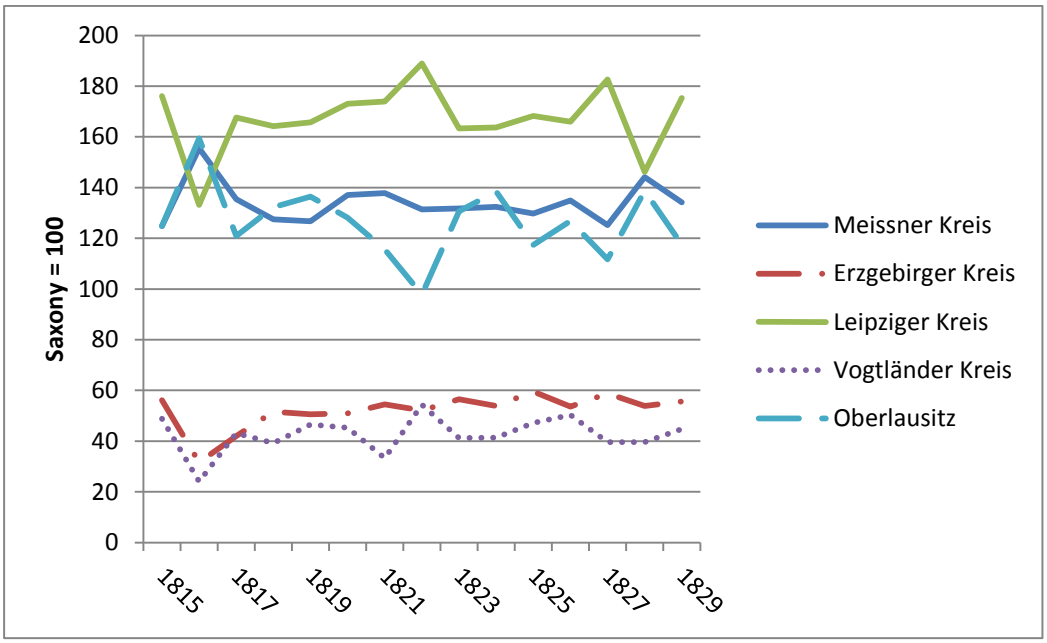
Sources: own calculation, for data see appendix.

Figure A.7d: Net production of potatoes per capita, 1791-1811 (Saxony = 100)



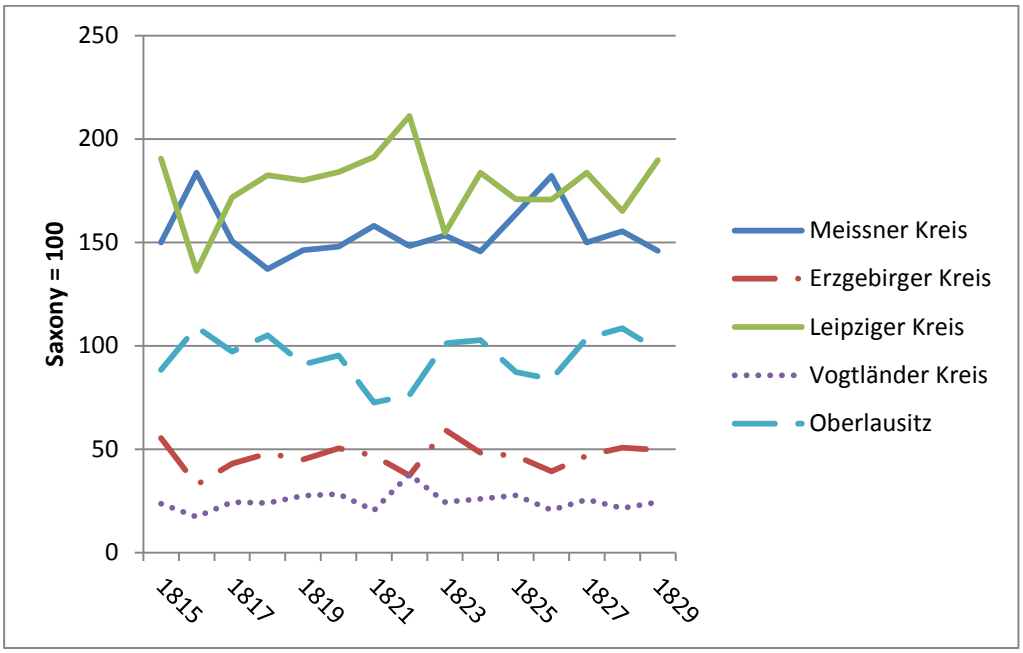
Sources: own calculation, for data see appendix.

Figure A.8a: Net production of rye per capita, 1815-1829 (Saxony = 100)



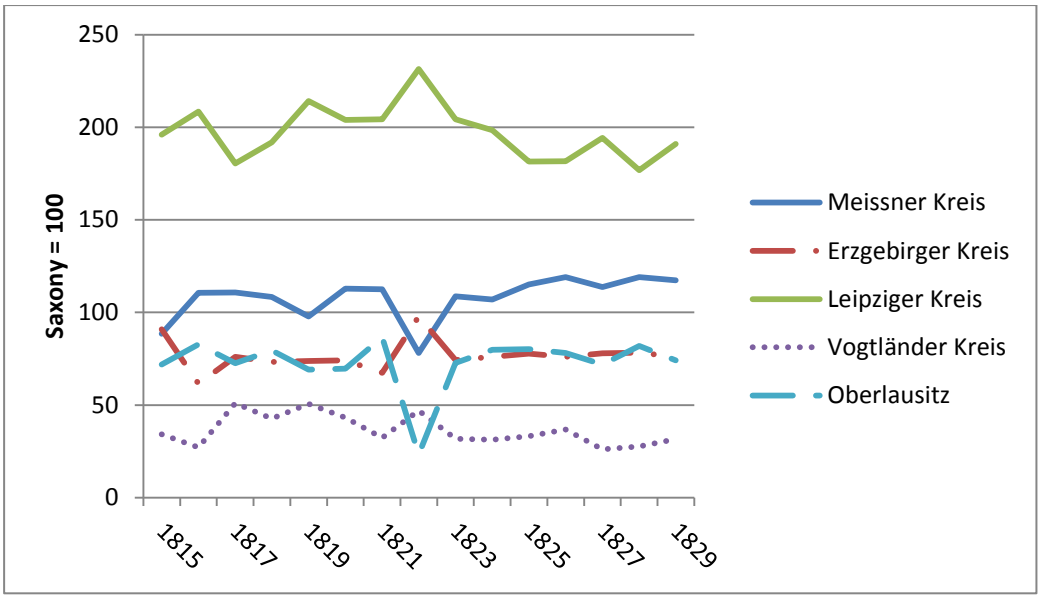
Sources: own calculation, for data see appendix.

Figure A.8b: Net production of wheat per capita, 1815-1829 (Saxony = 100)



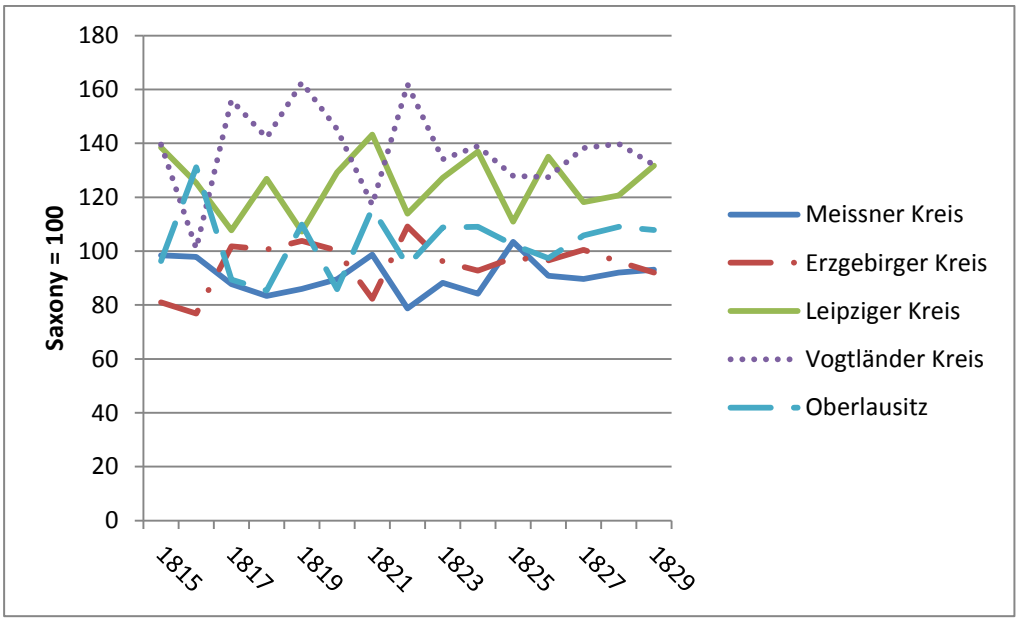
Sources: own calculation, for data see appendix.

Figure A.8c: Net production of oats per capita, 1815-1829 (Saxony = 100)



Sources: own calculation, for data see appendix.

Figure A.8d: Net production of potatoes per capita, 1815-1829 (Saxony = 100)



Sources: own calculation, for data see appendix.

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