Online appendix to:

"Institutions vs. demand: Determinants of agricultural development in Saxony, 1660–1850"

Ulrich Pfister and Michael Kopsidis

Construction of the population series

From 1743 to 1830 public authorities compiled annual lists of the total number of consumers (Schirmer 1996b, pp. 57–8; Kiesewetter 2007, p. 174); from 1832 there exists a series of total population based on census data (Kraus 1980, p. 52). Population figures in 1830 and 1832 differ by 11 per cent, suggesting under-registration of consumers up to 1830. The average rate of population growth in 1825–1830 yields an extrapolation for 1831 and a correction factor of 8.8 per cent for the years prior to 1832. This is close to the correction factor suggested by Stams (2007, p. 21; 9.5 per cent).

Comparison of the indirect estimate with output data, 1792–1830

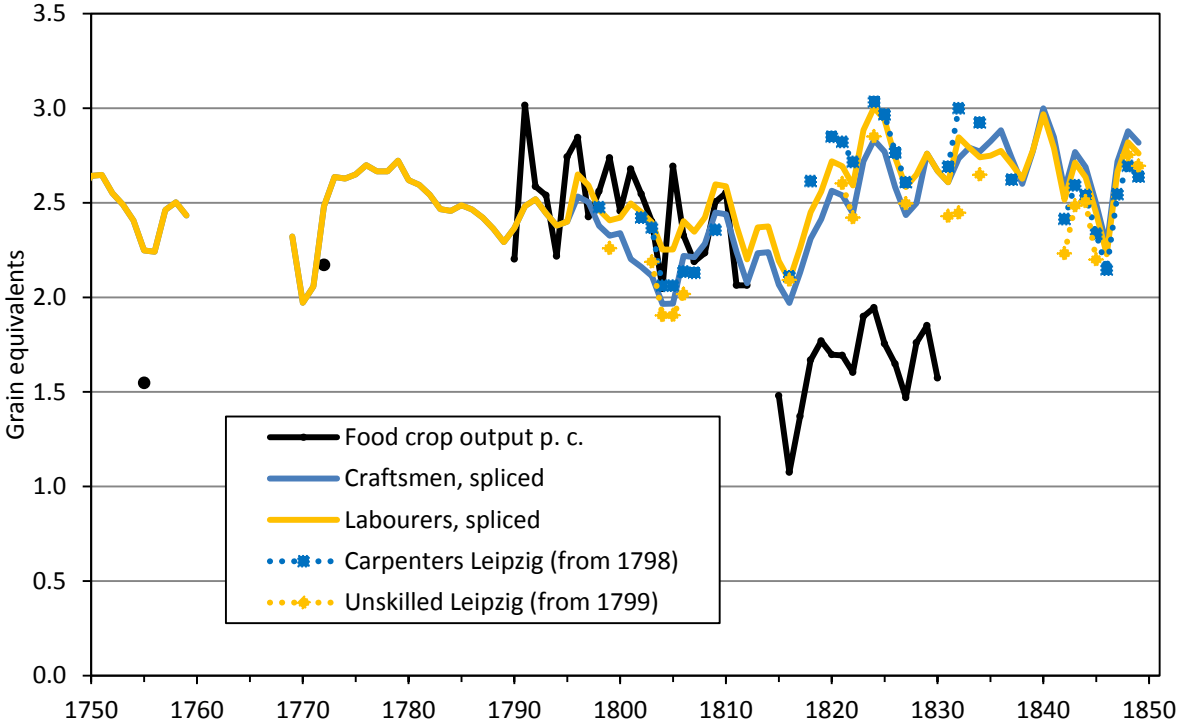
What follows explores the sensitivity of the indirect output estimate with respect to the limitations and imprecisions of this method exposed in section 3 of the main article by comparing it with contemporary output figures for the period 1792–1830. As part of their food security policy state authorities collected annual data on all vegetable output that had the potential to serve human consumption from 1790 to 1830; isolated earlier ledgers reach back until 1755. These data cover the major food crops sown mostly in autumn, that is, rye, wheat and potatoes, as well as the most important summer crops, i. e. barley, which entered human consumption primarily in the form of beer, and oats. Oats were mainly used to feed horses, but complemented the everyday diet of peasants in the form of gruel. Other crops mentioned in this source, mainly legumes and buckwheat, never accounted for more than seven per cent of recorded vegetable output. The sources give neither foodstuff output from animal sources nor output of agricultural commodities serving industrial purposes (Kopsidis and Pfister 2013: 14–6).

The comparison of recorded output of vegetable foodstuffs per capita with projected values is presented in Figure A.1 and Table A.1. Estimated output is lagged by minus one year since the harvest of a year is consumed in the following year.[1] Moreover in Figure A.1 the scaling factor of the estimate (*a* in equation 2 of the paper) is chosen so as to splice estimates with food crop output (i. e., output of rye, wheat and potatoes) per capita in 1792–4. In these years official output records became reliable (see below), and net trade of grain with other territories was close to nil. Per capita output net of retained seed of rye,

[1] There is at best a weak contemporaneous relationship between observed output of food crops and estimated values, both per capita.

wheat and potatoes alone amounted to an equivalent of a little over 1800 calories, which appears as a reasonable figure (Kopsidis and Pfister 2013: 47, 50). Table A.1 provides separate panels for two sub-periods, 1792–1812, when geographical coverage of recorded output refers to the Electorate of Saxony, and 1815–1830, when the observed data refer to the Kingdom of Saxony. In addition, separate analyses are carried out for craftsmen's and workers' wages as income proxies; the resulting projections are compared both with recorded output of food crops (total of rye, wheat and potatoes) and total vegetable production, both per caput. The first column displays trend growth rates of individual series, the second and third columns show Pearson correlation coefficients between the annual growth rates of projections and of the two measures of observed output, all on a per capita basis. The information presented in Figure A.1 and Table A.1 lends itself to the following three sets of conclusions concerning the relationship between observed output in agriculture per capita and the estimates obtained with the demand function:

Figure A.1: Recorded output of food crops per capita and estimates based on different income proxies, 1750–1849 (in grain equivalents)



Note: Estimates of food output per capita are lagged one year and are spliced with observed output values in 1792–1794. For remaining notes and sources, see Figure 4 in the main article.

The first conclusion relates to the reliability of output figures during the incipient stage of the state's effort to record agricultural production. The early ledgers from 1755, 1772 and probably also the one from 1790 under-report actual output since the values for these years are considerably below projected figures (Figure A.1). In fact, during the second half of 1791 state authorities took measures to increase the quality of the harvest statistics (Kopsidis and Pfister 2013: 14–5). Data collection may have been carried out with particular accuracy

during the campaign later that year; in any case recorded output shows a positive outlier in 1791. From 1792 coverage seems to have been maintained at a somewhat lower but stable level. Since population size was also under-estimated by almost 10 per cent previous to 1830 under-reporting of per capita output must have been modest. The trajectory of the output series during the early 1790s justifies both scaling the series of estimates with the observed values of output in 1792–1794 and limiting the comparison to years from 1792.

Table A.1: Comparison of recorded output per capita (in grain equivalents) and estimated output per capita, 1792/93–1812/13 and 1815/16–1830/31

	(1) Exponential trend (per cent)	(2) Pearson r with total output (1st diff. of logs)	(3) Pearson r with food output (1st diff. of logs)
1792/93–1812/13			
Recorded output p. c.			
Total vegetable output	-0.9		
Food crop output	-0.8		
Estimated output p. c.			
Basis: wages of craftsmen	-0.6	0.17	0.20
Basis: wages of labourers	-0.2	0.35	0.37
1815/16–1830/31			
Recorded output p. c.			
Total vegetable output	1.0		
Food crop output	1.4		
Estimated output p. c.			
Basis: wages of craftsmen	1.7	0.76	0.81
Basis: wages of labourers	1.5	0.79	0.84

Note: Food crop output refers to the sum of rye, wheat and potato output in grain equivalents. "Craftsmen" and "labourers" refer to the real wage series shown in Figure 2 of the main article. The Pearson r relates to first differences of natural logs of original values.
Source: Own calculation; for underlying sources, see Figure 4 of the main article.

Second, we examine which component of per capita output is best represented by the indirect estimate. Remember that the indirect method aims at tracking food consumption, which includes foods of animal origin and involves some degree of processing of agricultural goods. Comparison between the second and the third column of Table A.1 shows that the estimate fits better with observed output of food crops than with total vegetable output, at least in so far as annual growth rates are concerned. Trend growth rates over the two sub-periods, reported in column 1, are also more similar between the projection and food crop output than between the former and total vegetable output. There exist two possible explanations for this finding, and both are related to the fact that crops not classified as primary food crops consist mainly of barley and oats. On the one hand, to the extent that

these were not consumed in the form of gruel or an addition to bread both grains are intermediate goods: As fodder for horses, oats entered the capital stock, and processing barley into beer implied a considerable mark-up for processing and distribution. Supply conditions of these intermediate goods thus had only a weak effect on the prices of final foodstuffs used for projecting output. On the other hand, barley and oats were usually sown in spring, whereas the principal food crops — rye, wheat and potatoes — were sown in autumn. Their respective growth periods were subject to different climatic conditions, therefore, so that the correlation between the output of winter and summer crops was not necessarily close. We are unable to determine the relevance of these two explanations with the information at our disposal. For the time being it can be stated that the indirect estimation method tracks food crop output better than other segments of agricultural production, which justifies the limitation to this aggregate in Figure A.1 and the analysis conducted in the main article.

The final and most important observation relates to the magnitude of the fit between observed food crop output and projected output, both per capita. During the second sub-period starting in 1815 the Pearson correlation between the growth rates of the two series is of the order of magnitude of r=0.8, which suggests a good short-term fit. Likewise, trend growth rates over this decade and a half are quite similar, particularly if one focuses on labourers' wages as proxy for income (1.5 vs. 1.4 per cent p. a. for observed output of principal food crops per caput). By contrast, during the war period 1792–1812 — the War of the First Coalition began in 1792, and from 1806 Saxony herself became part of the war theatre — the fit between observed and estimated output is much looser: The Pearson correlation between the annual growth rates of the two series is 0.37 at most, and the projected values underestimate the severe downturn of the output of principal food crops during these two decades (-0.8 vs. -0.6 to -0.2 per cent p. a.). The disintegration of markets during the war period mentioned earlier may render it problematic to infer aggregate figures from price and wage data of just two towns; moreover, increase of the flour extraction rate and consumption of substitutes of grain, such as roots and beets, may have contributed to reducing demand for primary food crops.

In both sub-periods the Pearson correlation between the annual growth rates of observed food crop output and estimated output per capita is higher when labourers' wages rather than pay rates of craftsmen are taken as proxy for income. From 1815, but not during the war period up to 1812, the projection based on day wages of labourers also shows a trend that is more similar to the trend of observed output than estimates based on wages of craftsmen. In most respects, then, wages of unskilled workers are better income proxies for assessing aggregate demand for foodstuffs than craftsmen's wages. Yet, even during the sub-period from 1815 output projected on the basis of the wage of unskilled labourers overestimates somewhat the trend growth of recorded output of principal food crops, although the difference is not large (1.5 vs. 1.4 per cent p. a.). Thus, sources of imprecision of the indirect approach — shifts of consumption patterns following from industrialization and from a decline of the relative prices of imported groceries, a decline of female earning capacity in the wake of the industrialization of cotton spinning, and an increase of the

dependency ratio resulting from an acceleration of population growth — may be of some relevance here. It may also be that the unskilled wage in the industrial boom town of Chemnitz, which underlies the contiguous output estimate from the 1790, is simply not representative for Saxony at large. The scattered diamonds in Figure A.1, which represent projections derived from the unskilled wage in Leipzig, yield a somewhat more pessimistic picture of the evolution of food demand between the 1790s and the 1840s. Thus, despite their fragmentary nature the estimates based on the pay rate of labourers in Leipzig merit careful consideration.

Additional references

KRAUS, A. (1980). *Quellen zur Bevölkerungsstatistik Deutschlands 1815–1875*. Boppard am Rhein: Boldt.

SCHIRMER, U. (1996b). Der Bevölkerungsgang in Sachsen zwischen 1743–1815. *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte* **83**, pp. 25–58.

STAMS, W. (2007). Fläche und Bevölkerung. pp. 18–36 in K. Blaschke and W. Stams, *Das Kurfürstentum Sachsen am Ende des Alten Reiches 1790–1806*. Leipzig: Sächsische Akademie.