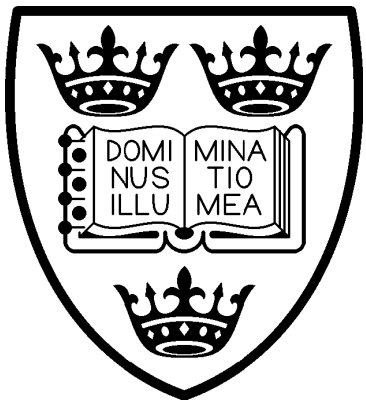

UNIVERSITY OF OXFORD

Discussion Papers in Economic and Social History

Number 47, August 2002

PRODUCTIVITY IN GERMAN AGRICULTURE: ESTIMATES OF AGRICULTURAL PRODUCTIVITY FROM REGIONAL ACCOUNTS FOR 21 GERMAN REGIONS: 1880/4, 1893/7 AND 1905/9

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PRODUCTIVITY IN GERMAN AGRICULTURE: ESTIMATES OF AGRICULTURAL PRODUCTIVITY FROM REGIONAL ACCOUNTS FOR 21 GERMAN REGIONS: 1880/4, 1893/7 AND 1905/9

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This discussion paper is based on material in chapter 5 of my D.Phil. thesis (Grant 2000). I am most grateful to my supervisors, Professors Charles Feinstein and Hartmut Pogge von Strandmann for much encouragement and many helpful suggestions. I would also like to thank my examiners, Professors Niall Ferguson and Albrecht Ritschl for useful comments and a stimulating discussion. Seminar participants at an earlier presentation of this material at All Souls College, Oxford made constructive contributions. The accounts were put together using statistical materials found, to a large extent, on the open access shelves of the library of the London School of Economics. This facility resulted in a massive saving of time and effort. For access to this, I am truly grateful.

Abstract

This paper presents estimates of agricultural productivity (net value added per full-time labour unit) for 21 German regions for the years 1880/4, 1893/7 and 1905/9. The estimates are derived from regional accounts for agricultural production and costs. The methods used to draw up these accounts are discussed, and there is also an analysis of Hoffmann's national agricultural accounts. The estimates show that productivity in East-Elbian agriculture was growing rapidly in the period, and tending to converge on the German average. Productivity in southern Germany was not growing so fast. The reasons for this improvement east of the Elbe are examined using a *Kreis*-level data set. This shows that yield improvements were not limited to large farms and estates, but that smaller holdings also had access to new technology and improved husbandry methods.

In short, East-Elbian agriculture should not be seen as backward or bound by tradition: it was a modern sector capable of rapid improvements in techniques and methods of production.

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I. Introduction

The state of German agriculture in the late nineteenth century has long been a important issue in the historiography of the Kaiserreich. The links between agrarian conservatism and the rise of radical right-wing ideas has been an aspect of Wilhelmine politics which has attracted attention. The part that "pre-industrial" elites played in blocking the evolution of German politics in a more democratic direction has been a central issue in the debate over the German *Sonderweg*. Agrarian issues, such as the agitation over the Caprivi trade treaties, exposed deep divisions in German politics and society, and also revealed that the structure of the German political system was not conducive to the resolution of contentious issues by reasoned debate.

Yet, despite this interest in agrarian issues, there has been a lack of some basic information on the state of German agriculture in the period, particularly at the regional level. This is important because regional divisions were a major factor in the structure of German agriculture. The Junkers, aristocratic owners of larger farms and estates, were mainly found east of the Elbe. Conditions in these regions were well-suited to arable farming on a large scale. In the rest of Germany farms tended to be smaller, and systems were more mixed. There was also an important difference in inheritance norms: northern Germany mostly followed the practice of primogeniture, while partible inheritance was the dominant system in the south.

Given these differences, it would be of interest to have information on the relative performance of agriculture in the various regions. If primogeniture favoured a more efficient agricultural structure, avoiding the splitting of holdings into small parcels, then it should be possible to find a connection between productivity levels (or productivity growth) and inheritance systems. If large eastern farms were better suited to modern agricultural methods, or, conversely, if

the conservatism of East-Elbian society was detrimental to technological progress, then these factors might also be expected to affect productivity performance. It would also be of interest to know if the problems of German agriculture in the period were largely due to external causes, the effect of low world prices for grain for example, or if there were internal reasons, such as a failure to adapt to new market conditions, or to take advantage of new technology.

There are various possible ways to study agricultural productivity. One is to look for estate records and other documentary evidence of agricultural performance. This "micro" approach has several potential advantages. It can provide a full picture of how a particular farm or estate responded to new challenges and opportunities. It can show the effect of changes in ownership, and of new generations with new ideas. But it has also some important drawbacks. There is the problem of representativeness: one farm or estate may not be typical of the sector as a whole. There is a potential bias in the sample, even if a large number of records could be obtained: larger farms and estates were more likely to preserve archives with the necessary documentary evidence. And not all records are fully comparable, so that it may be difficult to compare the performance of different regions or different types of farming.

This paper presents the results of a different approach which derives estimates of productivity from regional accounts, prepared on a similar basis to Hoffmann's national accounts for the agricultural sector. The accounts were built up from estimates of production for the different crops and livestock products. Deductions of intermediate inputs were made to produce estimates of value added for each region. These were then divided by the labour input to produce figures for value added per full-time labour unit (an adjustment which allows for the effect of part-time farming). This provides a basic measure of productivity in the various regions, and, as the exercise was repeated for three five-year periods (1880–4, 1893–7 and 1905–9), measures of productivity growth can be derived and compared.

This exercise should be regarded as complementary to analysis based on estate records. These can provide much more detail. But the performance of regions considered as whole units is best measured by aggregate accounts. These are complete records, and should be unaffected by sampling bias.

II. Hoffmann's agricultural accounts

The regional accounts presented in this paper are themselves decompositions of Hoffmann's national accounts.[1] Hoffmann's national totals are allocated between 21 regional units. Concerns have been raised by Fremdling, and others, about Hoffmann's methods, so it seems advisable to start with a discussion of these national accounts and the ways that Hoffmann derived his estimates from the available materials.[2] If the national accounts are unreliable, then this will have an adverse effect on the regional estimates.

Hoffmann's sources are, firstly, data from official publications of the period, secondly, unofficial estimates by contemporary authors, and thirdly, other studies available at the time when he and his collaborators were drawing up the accounts. Each section of *Das Wachstum der Deutschen Wirtschaft* is preceded by a list of the sources used for the estimates contained within that section. The procedure is generally a transparent one, and the process whereby estimates of cropped areas and yields, minus various deductions, are combined to produce figures for total production, is given in some detail, as is the approach used for the conversion to value added. There are, however, occasions when reference is made to unpublished work, such as the theses of Hoffmann's collaborators, Franz Grumbach and Alfred Hesse, and this can obscure the detail of some calculations.

There are areas of some uncertainty, and there are points on which official figures are inadequate. One important problem was the use of crops as animal fodder (an input for the livestock sector) rather than for human consumption (counting as part of final net production). Hoffmann admitted that there was little evidence on this, which may have remained relatively constant (in the case of oats) or tended to rise (as for potatoes). Contemporary sources were sometimes used to make deductions for animal consumption (as for potatoes), or a balance was drawn up, with animal feed as the residual (this was the procedure used for oats and barley). This in turn depends on accurate assessments of items such as the use of barley for brewing (derived from statistics on the production of malt) and the use of oats as feed for horses outside agriculture, or for human consumption.

Other areas which might give rise to concern include the level of milk yields, livestock slaughter weights and the size of the agricultural labour force. Milk yields are a particularly difficult problem: much production was consumed

[1] Hoffmann (1965).

[2] Fremdling (1988) and (1995).

within the farm household, some was fed to calves, and a considerable amount was turned into butter or cheese on the farm. Hence, deliveries to dairies (where these can be found) are not a good guide to production per cow. So estate records have to be used, and these show quite wide fluctuations. Hoffmann made use of contemporary estimates, and this produced figures which are not out of line with those for other European countries.

Slaughter weights were derived from Saxon statistics and adjusted to reflect estimated differences between Saxony and the rest of Germany. This procedure produces quite a substantial rise: from 163kg to 250kg for adult cattle between 1850 and 1900, and from around 60kg to 90kg for pigs. Such a rise is not inconceivable as improved supplies of animal feedstuffs made it possible to keep more animals alive through the winter rather than slaughtering them prematurely in the autumn.

In general, Hoffmann and his collaborators made sensible use of the available statistical sources and there is no material which they ignored which was clearly superior to their own data sources. It is certainly possible that other approaches might have yielded different result. Table 1 gives the results of some possible changes, considering the effect of different variants on the overall rate of growth of agricultural net value added at 1913 prices.

Table 1. Analysis of the sensitivity of Hoffmann's figures to changes in some of the component estimates

Hoffman's estimated annual increase in agricultural net value added 1850/2 to 1911/13	+1.50%
Variants on this:	
a. Raising oats fed to non-farm animals in 1911/13 from 5% of total supplies to 15%	+1.64%
b. Cutting the increase in slaughter weights for cattle and pigs 1850–1900 by half	+1.41%
c. Cutting the increase in milk yields 1852–1912 by half	+1.35%
d. Combining b. and c.	+1.27%

The first line gives the results of a different allowance for the feeding of oats to non-farm animals. Hoffmann estimated that 5% of total production went to non-farm animals and left this figure unchanged for the whole period. But, be-

tween 1850 and 1913, Germany went from being a predominantly agricultural society to one where the majority of the population worked in non-agricultural sectors. Motive power for many of theses activities was provided by horses, and it therefore seems likely that the provision for feeding to non-farm animals should have been increased. Oat production was relatively high, it was the second most important cereal after rye, and the result of this change (which has the effect of reducing estimated consumption within agriculture) is to raise the estimated growth rate of net value added by about a tenth.

The next two variants consider the effect of more moderate rises in slaughter weights and in milk yields. These produce a slowing down of the estimated rise in net value added, and, when combined, a total reduction of about 15% in the overall rate of growth.

An exercise of this type can be repeated virtually *ad infinitum*. These few examples show that, so long as the errors are uncorrelated, in other words there is no systematic bias upwards or downwards, the likelihood of off-setting errors is quite high. Hoffmann may have under-estimated the feeding requirements of non-farm livestock, his figures for the increases in slaughter weights and milk yields were quite high, but the combined effect was reduced by the way that these errors (if they are indeed errors) operated in different directions.

Hoffmann may have made some assumptions which were incorrect, given the nature of the data it would be virtually inconceivable for this not to have occurred, but on the whole there is no reason to suspect a systematic bias towards errors in one direction or another. And it is also important to recognise that the foundations of his figures showing a substantial increase in total value added rest on the official figures for total arable areas, for yields of the major crops, and for total livestock numbers. It is the increases recorded for these categories which drives up total value added.

III. Drawing up regional accounts

A similar procedure to that used by Hoffman can be employed to produce regional accounts. The data sources he used are in many cases also available at the regional level. There are certain additional problems with regional accounts (mainly due to inter-regional trade in inputs such as animal feedstuffs) but, if these are dealt with carefully, then the resulting errors should not be unacceptably large.

a. Sources

The agricultural accounts used for the productivity estimates made use of the following sources:

A.	**Occupational censuses (*Berufszählungen*):**	1882	*Statistik des Deutschen Reichs* n.f. 2–7
		1895	As above n.f. 102–111
		1907	As above n.f. 202–211
B.	**Surveys of land use (*Landwirtschaftliche Bodenbenutzung*):**	1878	*Statistik des Deutschen Reichs* a.f. 43
		1883	*Monatsheft zur Statistik des Deutschen Reichs* 1885.I
		1893	*Vierteljahrsheft zur Statistik des Deutschen Reichs* 1894.IV
		1900	As above 1902.III
		1913	As above 1915.II
C.	**Fruit tree surveys (*Obstbaumzählungen*)**	1900	*Vierteljahrsheft zur Statistik de Deutschen Reichs* 1902.II
		1913	As above 1915.II
D.	**Annual harvest figures:***	1880–4	*Statistik des Deutschen Reichs* a.f. 48,53,59, *Monatsheft zur Statistik des Deutschen Reichs*
	i. major crops	1893–7	*Vierteljahrsheft zur Statistik des Deutschen Reichs* (annual)
	ii. other crops	1905–9	As above
E.	**Livestock censuses (*Viehzählungen*)**	1883	*Monatsheft zur Statistik des Deutschen Reichs* 1884.VI
		1892 & 1893	*Vierteljahrsheft zur Statistik des Deutschen Reichs* 1894.I
		1897	As above 1898.II
		1900	*Ergänzungsheft zur Vierteljahrsheft zur Statistik des Deutschen Reichs* 1903.I
		1904	As above 1905.IV
		1907	As above 1909.I
		1913	As above 1914.IV

* Annual figures given in *Statistisches Jahrbuch für das Deutsche Reich*

b. Notes on individual items

1. **Regional units.** Pre-1914 German statistics recognised 39 regions, which ranged considerably in size, and included a number of small states. The largest (Bavaria excluding Pfalz) had a total agricultural area in 1900 of 4.3 million hectares; the smallest (Reuβ-älterer Linie) had just 19,000 hectares. To produce a more rational and consistent division, the smaller states were amalgamated with contiguous regions to produce a total of 21 regional units. These are described in Appendix A.

2. **Choice of years.** The years were chosen to centre on the occupational census years of 1882, 1895 and 1907. This minimised the need for extrapolation. It was thought desirable to use more than one livestock census in each case so as to reduce the effect of annual fluctuations (1893 was a drought year for example). So, the 1880–4 figures make use of the Livestock census returns for 1873, 1882 and 1892; those for 1893–7 the Livestock returns for 1892, 1895 and 1897; those for 1905-9 the censuses of 1904, 1907 and 1912.

3. **Relationship to Hoffmann.** The exercise is an allocation of Hoffmann's figures for Net Value Added per head of occupied population in 1913 prices by region. All figures from Hoffmann are five year averages. The decomposition of Hoffmann's accounts followed the procedure he set out.

4. **Wheat, spelt, barley, oats, potatoes.** Production figures for these major crops were available. Deductions followed Hoffmann's procedures. Seed rates were allocated to areas sown by region. Losses were deducted on a uniform basis. The only required adjustment was to 1905–9 barley production. For some reason the authorities ceased to record production of autumn-sown barley after 1900. The pre-1900 relationship between the two crops was used to adjust the post-1900 figures (it was not an important crop outside a few regions).

5. **Mixed cereals**. Following Hoffmann yields were taken to be an average of the wheat and rye figures. Areas were estimated using the regional breakdowns provided by the soil surveys of 1882, 1900 and 1913 (interpolated where necessary). The figures were adjusted to allow for the production of

Buckwheat (Hoffmann combines the two categories) using production figures for the 1890s.

6. **Sugar Beet**. Production figures are available for the 1880–4 and 1893–7 periods, but the 1905–9 production figures are incomplete. The relationship between the production of sugar beet and the use of sugar beet in sugar refineries (figures for this are available by region) was used to fill the gaps. This was also Hoffmann's procedure.

7. **Tobacco, hops, wine**. Regional production figures were available for these categories. For wine and tobacco the regional breakdown used value figures not volumes, on the grounds that price variations by region for these commodities are likely to reflect genuine differences in the quality of production not just transport and other trading costs.

8. **Other minor crops (pulses and peas, field beans, flax and hemp, linseed**). The reporting of yield figures for field beans, pulses and peas was not continued after 1900. Areas can be estimated using the soil surveys, and these were combined with the regional yield figures for the 1890's. This effectively assumes that the regional yield pattern remained unchanged. There are no yield figures for flax and hemp or linseed (the seed of the flax plant), these categories were allocated according to the flax area.

9. **Fruit**. There were fruit tree censuses in 1900 and 1912. These provided interpolated figures for 1905–9 and extrapolated figures (using the rate of change 1900–12) for the earlier years. The rates of change were slow, so the effect of the extrapolations is not great. The 1900 figures were adjusted to allow for the exclusion of figures for walnut trees.

10. **Vegetables**. The allocation was by area using interpolated soil survey figures. There are some pre-1900 yield figures (carrots and cabbages) but these were not sufficiently complete to be used. One problem is production by non-agricultural households. A proportion of the area recorded by the soil surveys as being under vegetables was in allotments cultivated by non-agricultural households. This would lead to a tendency to overestimate agricultural productivity in areas where there was substantial production by non-agricultural households.

11. **Meat production.** Hoffmann's figures are estimates of slaughterings. Adding to these his figures for the value of the increase in livestock numbers produces a gross output figure. It was decided not to make use of regional slaughtering figures either for numbers or weights. The reasons were, firstly, that there was considerable movement of animals prior to slaughter (this is evident both from slaughtering figures for Berlin and from movement figures in the Breslau Statistical Yearbook), and secondly, that slaughter weights are only useful if the age at slaughter is also known (it is annual gain that is needed). Instead, estimates of average liveweights for cattle, sheep and pigs at different ages produced by the local agricultural authorities for use in the livestock censuses of 1882, 1892 and 1900 (there are no figures after 1900, so the 1900 figures were used for 1905–9). These were used to produce estimates of annual liveweight gains by region and by class and age of livestock. These were then applied to the census returns for 1882, 1892 and 1907 to produce output figures. There was a further adjustment to allow for the movement of livestock numbers between these dates and the years of the other censuses incorporated in the estimates (see above, note 2. This procedure was used to estimate the regional breakdown of the production of beef, veal, pork and mutton. Goatmeat was allocated in line with the breakdown of the total goat population.

12. **Seasonal variations**. The livestock censuses were carried out in the winter (generally December). These numbers may not be representative of the whole year and this would cause problems if there were large scale seasonal movements of livestock between regions. Fortunately in 1907 there are figures both for December (livestock census) and June (occupational census). Comparison of these showed that inter-regional seasonal movement was only a problem for sheep. There was a substantial movement of sheep out of East Prussia in the autumn for example. The sheep figures were adjusted to allow for this.

13. **Non-agricultural production**. The two 1907 censuses can also be compared to see if there had been significant non-agricultural livestock production. The livestock census recorded total numbers; the occupational census gives numbers held by agricultural enterprises. In general there is no great discrepancy (any household which kept a cow was likely to be regarded as engaged in part-time farming at the very least), but it appears

that 10–15% of the pig population was kept by non-agricultural households.

14. Milk yields. There are no pre-1914 figures. There are figures for 1928 from a survey which was not repeated for several years. These were used in the following regression:[3]

MILK = 3667.9 – 607.9 D1ARBEIT (15.1) – 9.76 FROSTD (7.3) – 163.2 STEMP (6.2) + 4.08C WEIGHTS (7.4) + 289.0 LUINTENS (2.8)

adj. R^2 = .762, N = 143, estimation was OLS weighted by cow numbers, t-ratios are in brackets.

Variables:

MILK is 1928 annual average yield in litres by *Regierungsbezirke* for two classes of cow:

1. *Arbeitskuhe* - also used for draught work
2. Other cows.

D1ARBEIT is a dummy for the *Arbeitskuhe*

FROSTD is average numbers of days with below zero temperatures by *Regierungsbezirke* 1881–1930

STEMP is average summer temperature by *Regierungsbezirke* 1881–1930

CWEIGHTS is average cow weights in 1900 (there are no later figures)

LUINTENS is livestock intensity measured by Livestock Units per hectare (usable agricultural area) 1930.

This regression was then used to predict milk yields for 1895-1900 using the livestock intensity for that period, 1895 figures for the numbers of *Arbeitskuhe*, together with the climate variables and cow weights used in the regression. These figures were then applied to estimates of total dairy cow numbers obtained from the livestock censuses (these applied the 1907 relationship between dairy cow numbers and total cow numbers to the earlier censuses).

The regression results reflect the impact of breeding (on cow weights), of regular differences in climate (length of the growing season, likelihood of summer droughts), and of livestock intensity (which affects feeding de-

[3] Data from *Vierteljahrsheft zur Statistik des Deutschen Reichs* (1930) ii.

cisions). All these are structural factors, expected to affect milk yields over the medium term.

These regional breakdowns were then applied to Hoffmann's figures which are in turn derived from Wagner's 1896 work, which argued for a close relationship between yield and cow weights.

15. **Goat milk**. Allocated on the basis of the total goat population.

16. **Wool**. Most wool is obtained by shearing adult sheep in the spring. It was therefore allocated on the basis of the adult sheep population revealed by the December censuses.

17. **Eggs and poultry meat.** Only the 1913 livestock census gave poultry numbers. This was then used for all three periods (for meat and eggs).

18. **Honey.** There are production figures for 1900 and 1912. In view of the variability of this item extrapolation seemed unwise. So production in all three periods was allocated on the basis of the regional distribution of production calculated from these figures.

19. **Cereals fed to livestock.** Using Hoffmann's procedures an estimate of the total value of this item was obtained. This was then allocated on the basis of the numbers of livestock (in Livestock Units using Wagner's weighting system) to whom cereals might be expected to be fed (horses, cattle and pigs).[4]

20. **Purchased fertilisers.** Allocated on the basis of the total arable area.

21. **Other costs.** Allocated in relation to production net of all costs deducted up to this point.

22. **Transition to net value added.** Allocated in relation to net production. The main items are the rental value of agricultural housing and depreciation and repairs on buildings and machinery.

[4] Wagner (1895) suggests 1 cow = 6 pigs = 10 sheep = 12 goats, and 3 cows = 2 horses.

23. Labour force. This is expressed in full-time labour units to allow for the effect of part-time farming[5]. The calculation is:

1.0 ×	Total numbers occupied in agriculture full-time with no part-time employment outside agriculture.
+ 0.65 ×	Total numbers with a principal occupation in agriculture and a secondary occupation outside.
+ 0.35 4 ×	Total numbers with a part-time secondary occupation in agriculture (includes those with no full-time principal occupation).

= Labour Force in FLU

This breakdown was then applied to Hoffmann's estimate of the total population occupied in agriculture, which does not allow for part-time occupation outside agriculture, but which does adjust the figures for 1882 and 1895 upwards to allow for the apparent under-recording of the contribution of other family members in these years.

IV. Calculating the effect of possible errors

There are various problems with the accounts, most of which should be apparent from the notes on the individual items. Some are of minor importance (figures for honey production for example) but some are potentially much more serious. This latter category includes the allocation of cereals fed to livestock, the labour force estimates and the figures for milk yields.

Like many estimates, these are a combination of figures, some of which are relatively reliable, with others which are less soundly based. The question is: how large is the impact of these uncertainties on the final figures? Are they large enough to invalidate the overall regional picture?

[5] This system is similar to that used in modern E.U. agricultural statistics; see Helling (1966) for a discussion of the contribution of part-time or *nebenberuflich* workers.

Table 2. Productivity in German Agriculture

Estimates from regional agricultural accounts in 1913 prices (95% confidence intervals in brackets)

	Net Value Added per FLU (Full-time Labour Unit)			Annual % rates of growth
	1880–4 (Marks)	**1893–7 (Marks)**	**1905–9 (Marks)**	**1880/4–1905/9**
East Prussia	480 (454–506)	745 (703–786)	934 (877–992)	2.71 (2.87–2.54)
West Prussia	648 (615–680)	923 (879–967)	1078 (1022–1134)	2.07 (2.18–1.95)
Berlin/Brandenburg	731 (697–764)	1001 (957–1045)	1222 (1163–1280)	2.08 (2.19–1.97)
Pomerania	852 (811–893)	1175 (1121–1229)	1433 (1363–1503)	2.11 (2.22–1.99)
Posen	636 (607–664)	891 (850–932)	1179 (1124–1234)	2.51 (2.63–2.38)
Silesia	550 (521–579)	765 (728–802)	960 (911–1009)	2.26 (2.38–2.13)
Pr. Saxony/Anhalt	1089 (1046–1131)	1356 (1304–1407)	1388 (1330–1445)	0.98 (1.03–0.93)
Schleswig-Holstein	1145 (1072–1218)	1323 (1243–1403)	1709 (1600–1819)	1.62 (1.74–1.50)
Hannover/Oldenburg/Brunswick	779 (737–821)	1075 (1023–1126)	1136 (1075–1197)	1.53 (1.62–1.43)
Westfalia	579 (544–614)	865 (822–908)	834 (787–881)	1.48 (1.58–1.37)
Hesse-Nassau	524 (497–552)	798 (760–837)	769 (727–811)	1.55 (1.65–1.45)
Rhineland	535 (504–565)	761 (723–799)	757 (713–800)	1.41 (1.50–1.31)
Bavaria excl. Pfalz	510 (484–536)	691 (654–729)	667 (623–712)	1.08 (1.16–1.00)
Pfalz	480 (458–501)	791 (756–826)	699 (664–735)	1.53 (1.61–1.44)
Saxony	789 (744–834)	1052 (999–1105)	1395 (1316–1474)	2.32 (2.46–2.17)
Wurttemberg/Hoh.	594 (565–622)	641 (608–674)	661 (619–704)	0.44 (0.47–0.41)
Baden	517 (492–543)	631 (601–661)	635 (599–671)	0.83 (0.88–0.77)
Hesse	685 (654–716)	949 (908–990)	1016 (965–1067)	1.60 (1.68–1.5)
Mecklenburg	1267 (1211–1323)	1442 (1380–1505)	1716 (1632–1801)	1.23 (1.3–1.16)
Thuringia	750 (717–783)	1029 (984–1075)	1088 (1034–1142)	1.50 (1.59–1.42)
Alsace-Lorraine	596 (571–622)	609 (580–638)	676 (639–713)	0.51 (0.54–0.47)
Germany	672	855	982	1.53

An attempt has been made to answer these questions by calculating confidence intervals for the estimates of productivity levels and of rates of growth. The results of this exercise were incorporated in Table 2, which gives productivity estimates derived from regional agricultural accounts. The procedure followed is that set out by Bowley in Chapter 4 of *Elements of Statistics*, and advocated more recently by Feinstein and Thomas.[6]

The first step was to estimate variances for the different component series. There were two items for which direct calculations could be made: milk yields, which were estimates based on regressions run on 1928 data (which could be used to calculate expected errors), and animal weights, where there was data on annual variations in slaughter weights from a number of German towns. The milk variance was also used for other livestock products where there was little evidence about yields. But thereafter some assumptions had to be made. The census data was regarded as fairly reliable and a 95% confidence interval of ± 1.0% was attributed to crop areas, and one of ± 2.0% to livestock numbers. Cereal yields were estimated from annual returns sent in by the local chambers of agriculture, and a 95% confidence interval of ± 2.5% was applied to these annual figures for the major cereals, and ± 5.0% to the legumes, minor cereals and root crops.

Direct estimates of confidence intervals were made for a number of items, by comparing estimates using the preferred procedure with an alternative approach. The difference between these two figures was used to calculate a confidence interval for these items. The alternative estimate approach was applied to purchased fertilisers (use related to yield not area), use of cereals as animal feed (all production for feed consumed within the region), "other costs" (related to area not total net production), vegetable production (deducting production by the non-agricultural population) and the labour force (using the total occupied population instead of a weighted index allowing for part-time farming).

This produced a table of variances, which has been standardised so that the average of every item is 100. Table 3 shows variances and confidence intervals both for the five year averages (the figures used in the accounts) and for annual figures where appropriate. The advantage of using five year averages is clear. All calculations assumed uncorrelated errors.

To show how this procedure works in practice, Table 4 gives the results obtained for East Prussia in 1905–9. The calculated confidence interval repre-

[6] Feinstein and Thomas (2002), which draws on the work of Bowley (1946).

Table 3 . Table of standardised variances (all items have average of 100)

	Annual variance	Annual confidence interval (±)	5-year average variance	5-year confidence interval (±)
Milk:				
Yield	156.70	24.54	31.34	10.97
Cow numbers	5.20	4.47	1.04	2.00
Milk production	161.98	24.95	32.40	11.16
Meat:				
Livestock weights			2.28	2.96
Livestock numbers	5.20	4.47	1.04	2.00
Meat production			3.33	3.57
Major cereals:				
Yields	1.63	2.50	0.33	1.12
Areas	1.31	2.24	0.26	1.00
Production	2.94	3.36	0.59	1.50
Other crops:				
Yields	6.50	5.00	1.30	2.23
Areas	1.31	2.24	0.26	1.00
Production	7.81	5.48	1.56	2.45
Vegetables			51.75	14.10
Cereals fed to livestock			39.38	12.30
Purchased fertilisers			12.39	6.90
Other costs			15.43	7.70
Labour force in FLU (full-time labour units)			2.50	3.10

sents a range of ± 6.6% compared to the mean. This is low, but not unrealistically low. Reviewing the procedure, it is clear that most of the calculated variance came from two sources: milk yields and the amount of cereals fed to livestock. The main reason why the total was low was the high reliability attributed to the census results for areas and livestock. Coupled with the effect of the five year averaging procedure, this meant that the major cereal categories contributed little to total variance.

If estimates of this type are combined to produce an estimate of productivity growth, the combined variance produces a confidence interval of ± 9.4%, which gives a range of between 89.1% and 107.5% for the increase in productivity in East Prussia 1880/5 to 1905/9. The variances were combined using the assumption that the errors were independent. For growth rates the assumption of uncorrelated errors is a neutral one. High positive correlation of errors would produce a narrower range for the growth figures. High negative correlation of errors would create problems, if a large error in one direction in the first period were to combine with a large error in the opposite direction in the next.

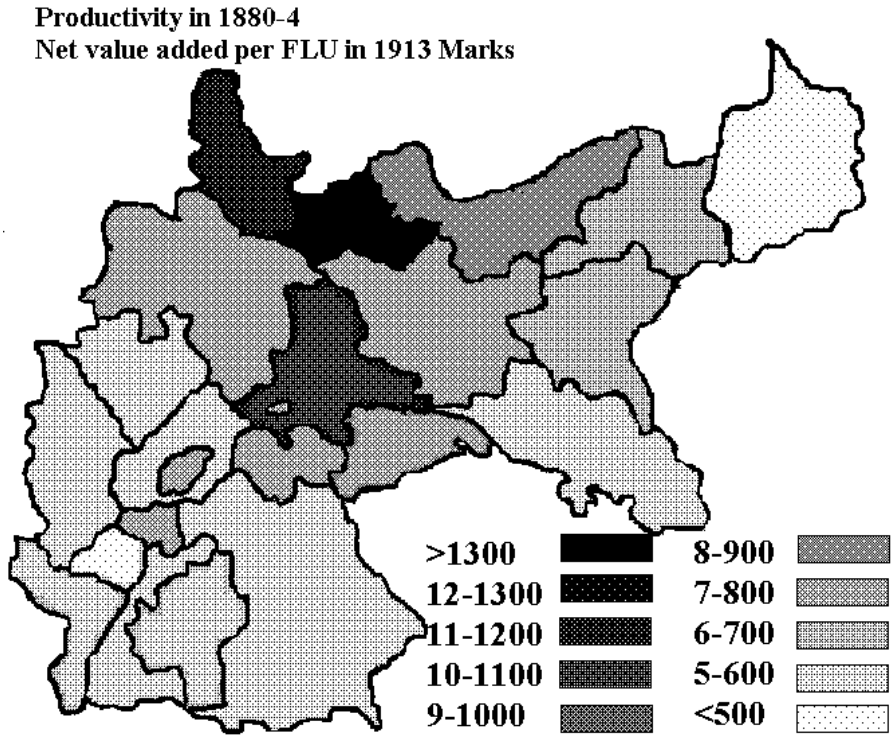
The value of the procedure applied in this section is that it attempts to give a value to the impact of the assumptions used when constructing the accounts. One reason why the confidence intervals shown in Table 4 are relatively narrow is that the productivity differences shown are mainly caused by a few large items: livestock intensity, crop areas, yields of the major crops and the number of persons occupied in agriculture. These are relatively secure figures, established by the various censuses and the official calculations of average yields.

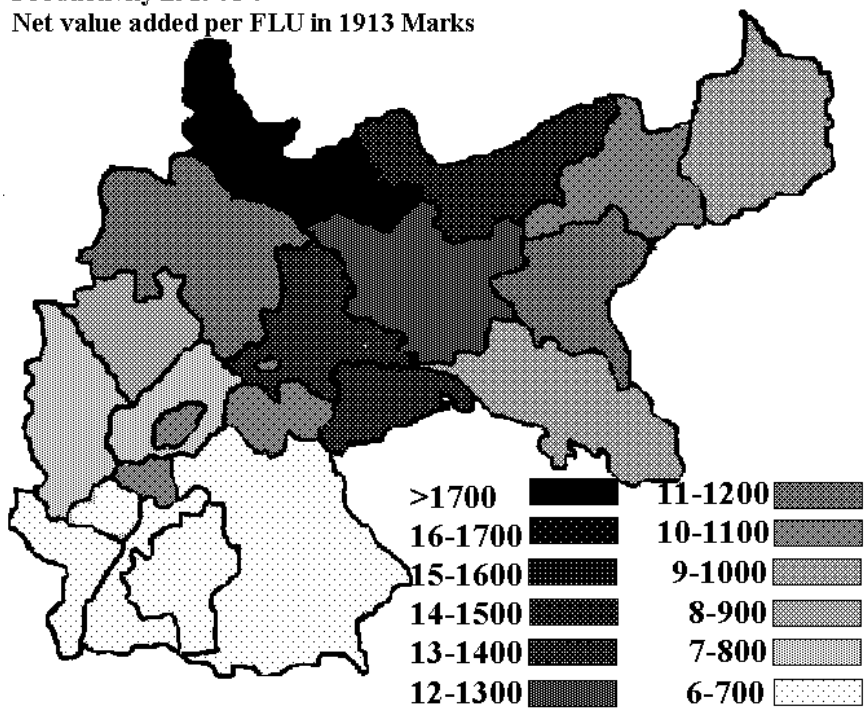
A few examples show the impact of these important items. Starting with the high productivity regions: Mecklenburg had just 1.5% of the total agricultural population but accounted for 3.0% of the output of major crops and 2.4% of total livestock numbers. It is highly probable from these figures that productivity in this region was going to be well above average. The figure given in Table 4 is 175% of the national average (a 95% confidence interval of 166%–183%). Schleswig-Holstein had 2.6% of the agricultural population but 5.2% of total livestock numbers and 3.2% of crop output. Estimated productivity was 174% of the national average. At the other extreme, Baden had 4.3% of the agricultural labour force, but only 3.0% of livestock numbers and produced just 1.9% of major crop output. Estimated productivity was 65% of the national average.

Table 4 An example: estimation of confidence intervals for net value added per FLU, East Prussia 1905–9

Base estimates (Mill.M)		Standardised variance (calculations in brackets)	Estimated variance
Wheat	24.60	0.59	0.0357
Rye	95.34	0.59	0.5363
Barley	24.62	0.59	0.0358
Oats	77.38	0.59	0.3533
Mixed cereals	6.90	1.56	0.0074
Potatoes	65.71	1.56	0.6736
Pulses and peas	7.86	1.56	0.0096
Sugar beet	1.42	1.56	0.0003
Tobacco	0.05	1.56	0.0000
Hops	0.15	1.56	0.0000
Field beans	0.18	1.56	0.0000
Flax and hemp	0.82	1.56	0.0001
Linseed	0.80	1.56	0.0001
Rape & other oilseeds	0.62	1.56	0.0001
Fruit	2.67	1.56	0.0011
Vegetables	7.34	51.75	0.2785
Beef	102.25	3.33	3.4819
Veal	24.43	3.33	0.1988
Pork	128.99	3.33	5.5402
Mutton	2.31	3.33	0.0018
Goatmeat	0.38	3.33	0.0000
Poultrymeat	7.71	3.33	0.0198
Cows milk	120.94	32.4	47.3929
Goat milk	1.13	32.4	0.0041
Wool	2.76	32.4	0.0247
Honey	2.43	32.4	0.0192
Eggs	13.74	32.4	0.6114
Deductions:			
Cereals fed to livestock	177.64	31.38	99.0175
Purchased fertilisers	38.78	17.6	2.6469
Other costs	13.82	7.7	0.1470
Net production	493.33		161.04
Conversion to NVA	26.29	7.7	0.53
NVA current prices	467.04	(7.41)	161.57
Labour force in 1000 FLU (in 1000 full-time labour units)	500.17	2.50	62.54
Net Value Added per FLU (1913 prices)	934	(9.91)	864.00
Upper 95% confidence interval	992		
Lower 95% confidence interval	876		

Figure 1. Agricultural productivity by region





V. Productivity in German agriculture: the regional pattern

Looking at the maps of regional productivity (Figure 1) it is evident that, in the first period, there was a small group of central regions with high productivity: Schleswig-Holstein, Mecklenburg and Prussian Saxony. By 1905–9 these regions were still amongst the leaders, but the gap with regions to the west and east had closed. The south and southwest, on the other hand, were still lagging. In short, there was a process of convergence, but one from which the areas of partible inheritance in southern Germany were excluded.

Table 5 provides a summary of the changes in the relative position of the East-Elbian provinces. Their share in the total labour force was relatively static, as was the share in livestock production. The factor which increased the share of total value added, and thus produced faster than average productivity growth, was the gain in the share of total production of major roots and cereals (sugar beet, potatoes, wheat, barley, spelt, oats and rye).

Table 5. East-Elbian share in total production and value added

	1880–4	1893–7	1905–9
Production of:			
Major roots and cereals	33.5	37.7	43.3
Other crops	31.6	27.7	27.8
Livestock produce	33.0	32.2	33.3
Total net value added	32.8	33.7	37.6
Labour force in FLU	32.7	32.7	32.2

Table 6 provides a decomposition of the increase in the production of major roots and cereals, comparing the East-Elbian provinces with the rest of Germany. The major part of the shift in the balance of production in favour of the East came about as a result of a faster increase in yields. There was a contribution from an increase in areas, and another from a composition effect (the substitution of higher yielding, or higher value, crops for others which were less productive or less valuable).

Table 6. Decomposition of change in production of major roots and cereals 1880/4–1905/9

Calculations use 1905–9 prices

	East-Elbian Germany	Rest of Germany
Total % increase in production	118.5	48.0
Increase in production per hectare	95.5	39.7
Increase in areas	11.8	5.9
Decomposition of increase in production per hectare:		
Composition effect	2.9	0.9
Weighted increase in yields	89.8	38.1

In an attempt to explain the increase in the east's share, regressions were run in which the dependent variable was the increase in the value of arable production per hectare at constant prices for each of the 21 regional units. The results showed a strong process of convergence. In all the estimated equations the coefficient on yield in the first period is strongly negative.

What was the cause of this convergence? Clapham suggests that sugar beet cultivation played a crucial role in making producers aware of the importance of artificial fertilisers. One source which confirms this is a survey of fertiliser production and use in Prussia published in the 1887 *Landwirtschaftliche Jahrbucher*. This brought together reports from 16 regional research stations. It showed that, typically, fertiliser use was 2 or 3 times as high for sugar beet as for other crops. It also showed that most fertiliser was supplied from firms within the region. This suggests that sugar beet may have stimulated the use of fertilisers in other ways besides the "demonstration effect" mentioned by Clapham. The introduction of sugar beet into a region would raise demand, and this might then lead to the construction of additional fertiliser factories. Having a fertiliser factory nearby would then reduce transport costs and so lead to increased use on other crops.

The estimated equations therefore include the change in sugar beet area in percentage points relative to the total arable area 1880/4 to 1905/9 (%ΔSUGARBEET). This has a positive influence on the change in arable

Table 7. Regressions of arable production per hectare, 21 regional units[7]

Dependent variable is change in total production of major roots and cereals per hectare 1880/4 to 1905/9 (constant prices)

	Dependent variable includes sugar beet			Dependent variable excludes sugar beet	
	a.	b.	c.	d.	e.
constant	182.1	180.9	164.1	195.6	180.85
ARABLEYIELD80/4	–7.03	–6.98	–6.55	–7.78	–7.30
	(10.97)	(8.94)	(7.57)	(11.76)	(8.10)
%ΔSUGARBEET	+14.58	+14.15	+12.87	+12.42	+11.58
	(4.02)	(2.80)	(2.21)	(3.38)	(2.05)
LAND>100HA	–	+.031	–.010	–	–.140
		(0.12)	(0.18)		(0.27)
%ΔLEGUMES	–	–	–.071	–	–.168
			(0.18)		(0.42)
%ΔLUINTENSITY	–	–	+.323	–	+.123
			(0.71)		(0.26)
N	21	21	21	21	21
S	14.49	14.91	15.12	14.47	15.37
R^2	.883	.883	.894	.903	.909
adj.R^2	.870	.862	.859	.892	.878
F-test of regression	67.93	42.81	25.29	83.64	29.84

yields. The predicted effect is a substantial one. Table 8 illustrates this by analysing the convergence of arable yields in eastern Germany with the rest of Germany. The effects are calculated using the coefficients given in column a of Table 7.

[7] See Appendix C for a description of regression variables and sources.

Table 8. Explaining the convergence of arable yields
East-Elbian Germany compared to the rest of Germany, 1880–4 to 1905–9

	Value of arable production per hectare (German average 1880–4 = 100)		Convergence effect	Sugar beet effect	Predicted gain
	1880–4	1905–9			
East	78.7	172.0	+27.6%	+24.0%	+103.9
Rest	116.7	172.8	-21.7%	+12.5%	+43.0

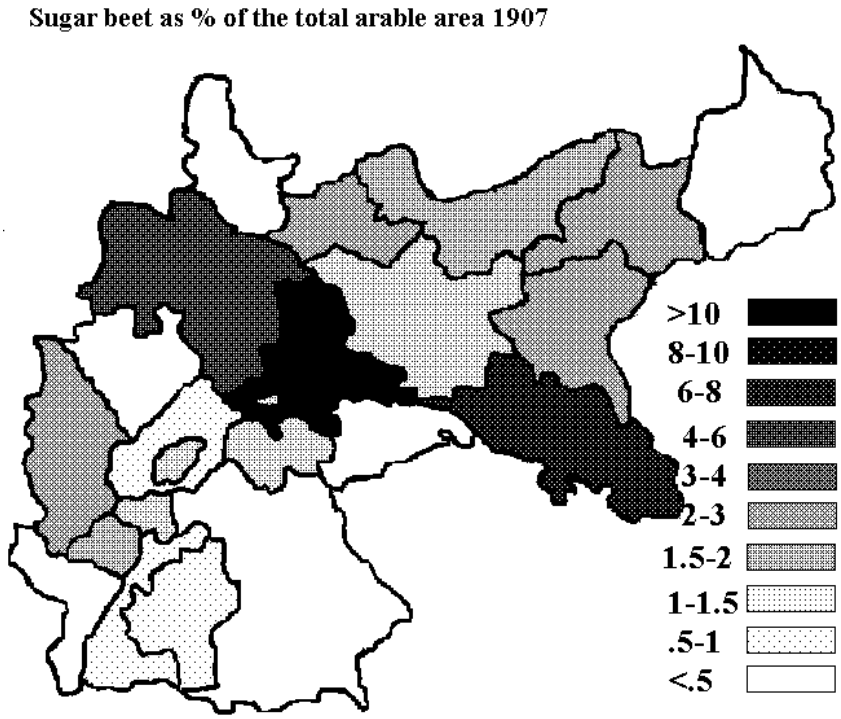
Eastern Germany caught up from a position well below the national average in 1880–4. Sugar beet rose from 0.6% of the eastern arable area in 1880–4 to 2.2% in 1905–9, which was a larger increase than in the rest of Germany (1.7% to 2.5%). So the sugar beet effect is one which promoted convergence. But the general convergence effect explained much more. Only 20% of predicted convergence is attributable to sugar beet.

The reasons for this can be seen by looking at the pattern of sugar beet cultivation (Figure 2) This was limited to areas with suitable soil and climate. Initially, the centre of cultivation was Prussian Saxony, especially the Magdeburg region. From there it spread west and east. But certain regions never had much. These included the regions of southern Germany, which had relatively low productivity, but also more successful regions: Westphalia, Schleswig-Holstein and the Kingdom of Saxony. East Prussia, which recorded the fastest productivity increase, had little sugar beet cultivation. The spread of sugar beet cultivation was only part of the convergence story.

The second column of Table 7 adds a farm size distribution variable to the basic equation. This is not significant. Contrary to Clapham's opinion, there is no evidence from these regressions that larger farms and estates led in the introduction of new technology. This is perhaps surprising. There is documentary evidence which suggests that larger farms were more likely to use artificial fertilisers. For example, a report on conditions in a Gutsbezirk in Kreis Stolp in 1890–1 observed: "Kunstdünger und konzentrierte Futtermittel sind nur im Grossbetrieb, hier sowohl als in der ganzen Gegend, im Gebrauch".[8]

[8] *In this area, as in the whole region, it is only the large farms and estates that make use of artificial fertilisers and concentrated livestock feed*; from *Landwirtschaftliche Jahrbucher,*

Figure 2. The sugar beet regions:[9]



There are a number of possible explanations. One is that the analysis at the level of the 21 regional units is too aggregated to pick up a relationship which might exist at a lower level. Another is that those who contributed to these reports tended to under-estimate the progress made on small and medium sized farms. A third is that these holdings were deriving more nutrients from animal sources and so had less need of artificial fertilisers. The livestock censuses show that the value of livestock per hectare was higher on smaller farms. They also show that the total value of livestock kept was rising faster on smaller holdings. Between 1882 and 1895 the total value of livestock on all German holdings of less than 20 hectares rose by 17.7%, but it only rose by 9.5% on holdings of over 100 hectares.

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xix, erg. 4 (1891). Every year this publication included a series of reports on conditions in various parts of Prussia, which are a useful source of information on the state of agriculture.

[9] Data from agricultural part of the 1907 occupational census, *Statistik des Deutschen Reichs* n.f. 212.

However, when a variable for the change in livestock intensity (%ΔLUINTENSITY – column c, Table 7) is introduced, it does not prove to be significant, nor is the change in the acreage of legumes as a proportion of the total arable acreage, which would have been another possible source of additional nutrients (%ΔLEGUMES).

The regressions in columns d and e of Table 7 use a different dependent variable, removing sugar beet from the calculation of arable yield. The effect of the introduction of sugar beet has two components. The first is the direct effect, the substitution of a high value crop for a less valuable one. The second is indirect, the effect that it has on the yield of other crops. This is a "spill-over": a benefit from the use of one crop that can be measured through an increase in the yield of others. The results in columns d and e remove the direct effect, leaving only the indirect. They show that there is indeed a positive spillover: the coefficient on the change in the sugar beet acreage is still significant, even if somewhat reduced.

VI. Analysis of cereal yields in the Prussian *Kreise*

The analysis in previous section operated at a level of aggregation which made it difficult to disentangle the factors which were driving the convergence of arable yields.

Analysis at a lower level makes it possible to look at the effect of soil type and remoteness, to consider ways in which conditions in the individual *Kreise* affected decisions about fertiliser use and the introduction of new technology. In particular, it is possible to examine the relationship and farm size more carefully. It is a commonly held belief that advanced agricultural technology has more to offer the larger holdings: mechanisation is more profitable for large scale operators; they have better access to skills, to urban markets and to sources of finance. Smaller holdings may be directly disadvantaged if their larger neighbours are, as a result, able to out-bid them for vacant land and other resources.

The data set prepared for this analysis made use of yield data for the Prussian *Kreise.* These were collected by the local agricultural authorities and published annually in *Preußische Statistik*. There are some problems of compara-

bility due to changes in the *Kreis* boundaries, but these can be solved by amalgamation of the affected units. It is a matter of importance that the yield data should be an accurate reflection of conditions in the *Kreis*, and not biased towards holdings of a particular size or type. If there was a bias of this type it would tend to reduce the importance of the farm size variables in the estimated regressions. For example, if yield data had been collected only from larger holdings of over 100 hectares, regardless of whether these were the dominant holdings in the *Kreis* or not, and no results had been obtained from smaller farms, then the estimated coefficients on the farm size variables should tend to zero as the sample size increases.

Provided that the yield data are reliable, regressions can be run with average yield for the various *Kreise* as the dependent variable and the farm size distribution amongst the dependent variables, which should then pick up any tendency for larger holdings to have higher yields. It is, however, important to control for the influence of soil type and quality. This would be expected to affect yields, but it might also influence the size distribution, either because the larger estates were more successful at gaining control of better land, or alternatively because richer soils encouraged the division of holdings on inheritance. So, there is a danger of omitted variable bias if this is not included.

The best source of information on soil type and quality was provided by a survey of Prussian agriculture, carried out in the 1860's under the aegis of the agricultural historian and statistician, August Meitzen.[10] This covered the original post-1815 Prussian provinces: Brandenburg, Posen, Pomerania, Silesia, East and West Prussia, *Provinz* Saxony, the Rhineland and Westfalia. It included data on soil type for each *Kreis.* It also gave the average level of *Grundsteuerreinertrag* per hectare: the assessment of land value for tax purposes based on anticipated net margins (*Reinertrag*) for different soil types. This provides a reasonably good indication of soil quality. The survey also included data on the distribution of the *Kreis* area by soil type: moorland, loam, sandy loam and sand, together with the area under water. The information provided by these variables should have been incorporated in the *Grundsteuerreinertrag* assessment, but as this was rarely altered and may have become out of date, it was thought desirable to include other soil variables as a check. It was discovered that two of these variables, %SAND and %SANDYLOAM (the percentages of the total area not under water in these categories) did add to the explanatory power of the estimated regressions.

[10] Meitzen (1868).

For similar reasons, a set of variables were added which provided information on access to urban markets. In *Kreise* with good market access, the incentives to invest in new technology and higher inputs would be better than in more remote areas. This should have led to a rise in yields. But, it might also be expected that in the more remote areas there would be a predominant number of larger holdings, since they would be better able to bear the higher marketing costs and fluctuating earnings associated with these areas. In which case, there would be a danger of a spurious result without the inclusion of variables to control for this effect.

The most valuable markets are those within the *Kreis* itself, and this can be measured by including the proportion of the population engaged in agriculture as an explanatory variable (the expected coefficient would be negative as yields should rise with increased demand from the non-agricultural population). Other variables were created by measuring the distance from the *Kreis* mid-point to the nearest major cities. The two measures which were found to have the greatest explanatory power were CITYDISTANCE(a) and CITYDISTANCE(c): the distances in kilometres to the nearest cities with at least 200,000 inhabitants and at least 50,000 inhabitants respectively.

The results of these regressions are given in Table 9. Yield data were collected for four years: 1878, 1883, 1897 and 1900. For this initial analysis, the dependent variables were averages of these four years. Columns a. and c. give the basic results for rye and wheat. The importance of soil quality as measured by the *Grundsteuerreinertrag* is confirmed, though, as indicated, the soil variables do convey some additional information. In the case of rye, the estimated coefficients are negative on both %SAND and %SANDYLOAM, but only the latter is significant at the 5% level; for wheat, the estimated coefficient on %SANDYLOAM is negative and significant, but there is positive, though not significant, coefficient on %SAND. As relatively little wheat was grown on the sandy soils, this result can be disregarded.

The three “market access” variables have a high joint significance (as measured by a Wald test on the option of dropping all three variables) and the estimated coefficients are correctly signed, but the individual t-statistics are low. This is mainly due to collinearity problems between the three variables. As the main purpose of these variables is to control for the effect of market access, so as to remove a potential source of bias, all three were retained in the estimated regressions.

Table 9. Regression analysis of yields in the Prussian *Kreise*[11]

Dependent variables are averages of yields for 1878, 1883, 1897 and 1900. T-statistics in brackets.

	Dependent variable is:			
	Average rye yield		Average wheat yield	
	a.	b.	c.	d.
Constant	11.00	11.21	10.84	11.17
LAND20-100HA	+0.0093	+0.0080	+0.0268	+0.0243
	(1.31)	(1.15)	(3.34)	(3.26)
LAND>100HA	+0.0239	+0.0135	+0.0594	+0.0380
	(4.58)	(2.29)	(10.20)	(6.10)
CITYDISTANCE(a)	-0.0046	-0.0042	-0.0018	-0.0004
	(1.86)	(1.73)	(0.64)	(0.16)
CITYDISTANCE(c)	-0.0073	-0.0062	-0.0069	-0.0052
	(1.91)	(1.65)	(1.61)	(1.30)
%AGOCCUP82	-0.0111	-0.0127	-0.0240	-0.0260
	(1.71)	(1.98)	(3.29)	(3.79)
GRUNDSTREIN	+0.0477	+0.0373	+0.0597	+0.0384
	(12.75)	(7.95)	(13.90)	(7.64)
%SANDYLOAM	-0.0069	-0.0019	-0.0152	-0.0047
	(1.51)	(0.41)	(2.96)	(0.93)
%SAND	-0.0287	-0.0265	+0.0092	+0.0132
	(6.34)	(5.91)	(1.79)	(2.73)
%SUGARBEET		+0.129		+0.269
		(3.50)		(6.95)
N	317	315	310	308
S	1.611	1.582	1.785	1.663
R-sqd	0.662	0.675	0.631	0.683
adj R-sqd	0.653	0.665	0.621	0.673
F-test	75.3	70.3	64.4	71.3
RSS	2361.9	2345.5	2600.1	2598.3

[11] See Appendix C for a description of regression variables and sources.

The main points of interest are the coefficients on the farm size variables. These show that, both for wheat and for rye, larger farms had a substantial advantage over all other holdings, and that medium sized holdings had an advantage over smaller ones, although this coefficient is only significant in the case of wheat. The differences are larger for wheat than for rye.

Columns b. and c. repeat these regressions with the addition of a variable (%SUGARBEET) giving the percentage of the total arable area which was used for the cultivation of sugar beet. This has a positive effect on the yields of these other crops, indicating that sugar beet was associated with a general improvement in technology and with investments which raised yields on other arable crops. The introduction of this term has the effect of reducing the estimated coefficient on LAND>100HA by a half in the case of rye, and a third in the case of wheat. This indicates that part of the advantage found for the larger holdings came about as a result of the fact that they were more likely to have moved into sugar beet cultivation.

The regressions were then run using yield data for individual years. The results are reported in Table 10 in a simplified form, without including the coefficients for the "soil quality" variables or the "market access" variables. The first part gives the results for rye, and the first line gives the estimated coefficients on LAND>100HA, when this was added to an estimated equation containing the "soil quality" variables and the "market access" variables. The first four columns give the results for the different years: these show a decline in the advantage of the larger holdings, to the extent that there is no longer a significant difference by 1900. For the final column, the dependent variable was the percentage change between an average of 1878 and 1883 and the 1897-1900 average. The estimated coefficient for LAND>100HA is negative in this equation, confirming that the yield increase was lower in *Kreise* where larger holdings predominated.

The next line repeats the analysis for medium-sized holdings of between 20 and 100 hectares. The results for this category are not significant, indicating that they were not so different to from the average for all other holdings. The third line gives the results for the smaller holdings, of less than 20 hectares. These are the converse of those for the over 100 hectare category: a strong disadvantage in the earlier years was found to have substantially disappeared by 1900.

Table 10. Regression analysis of yields in the Prussian *Kreise.*
Estimated equations included three "soil quality" variables plus three "market access" variables plus one additional variable; only the coefficients and t-statistics for the additional variable are reported.

a. Rye

Additional variable is:	**Dependent variable is: Level of yield in individual years:**				**% Change**
	1878	**1883**	**1897**	**1900**	**1878/83–1897/1900**
LAND>100HA	+0.0317	+0.0316	+0.0169	+0.0109	–0.225
	(5.43)	(4.84)	(2.88)	(1.22)	(3.76)
LAND20–100HA	–0.0108	+0.0176	+0.0031	+0.0040	–0.033
	(1.30)	(1.93)	(0.39)	(0.33)	(0.40)
LAND<20HA	–0.0203	–0.0318	–0.0146	–0.0102	+0.191
	(3.85)	(5.65)	(2.81)	(1.30)	(3.60)
%SUGARBEET	+0.252	+0.256	+0.220	–0.049	–1.624
	(7.01)	(6.43)	(6.13)	(0.87)	(4.30)

b. Wheat

Additional variable is:	**Dependent variable is: Level of yield in individual years**				**% Change 1878/83–1897/1900**
	1878	**1883**	**1897**	**1900**	
LAND>100HA	+0.0379	+0.0500	+0.0684	+0.0614	+0.035
	(6.10)	(8.02)	(8.63)	(6.20)	(0.56)
LAND20-100HA	-0.0145	+0.0109	+0.0174	+0.0231	+0.156
	(1.62)	(1.16)	(1.44)	(1.60)	(1.82)
LAND<20HA	-0.0239	-0.0444	-0.0619	-0.0588	-0.094
	(4.20)	(7.98)	(8.78)	(6.70)	(1.69)
%SUGARBEET	+0.0290	+0.339	+0.471	+0.401	+0.133
	(7.58)	(8.72)	(9.60)	(6.40)	(0.34)

c. Sugar beet area

Additional variable is:	Dependent variable is: Sugar beet as % of total arable area	
	1883	**1897**
LAND>100HA	+0.0710	+0.0847
	(8.87)	(10.67)
LAND20–100HA	–0.0120	–0.0071
	(1.00)	(0.56)
LAND<20HA	–0.0510	–0.0635
	(6.84)	(8.59)

The final line gives results when the additional variable is %SUGARBEET. In the first three years this has a strong effect on yields, but by 1900 there was no effect. The final column shows that yields rose fastest in *Kreise* with less sugar beet.

The story told by these regressions is consistent with the view that larger holdings had a leadership role, partly because they were earlier adopters of sugar beet cultivation, but it also suggests that this knowledge of improved techniques did diffuse to smaller holdings after an interval. It also spread outside the sugar beet areas.The second part of the table repeats the analysis for wheat. Wheat was a less important crop (total production was around 45% of the level for rye) and it was grown on market-orientated holdings for sale in urban markets, not for consumption on the holding by the farmer and his family. The results show that the advantage of the larger holdings remained a substantial one over the 1878–1900 period, and it may even have increased. The association between sugar beet cultivation and high wheat yields was, likewise, a significant one for all four years.

The final section considers the relationship between holding size and sugar beet cultivation using data from the soil surveys for 1883 and 1897. This confirms that, when controlling for soil quality and market access, there was a significant increase in the likelihood of adoption for holdings of over 100 hectares, and a decrease for holdings of less than 20 hectares. There was no reduction in this gap between 1883 and 1897; indeed it may have increased.

The size of the estimated coefficients is best illustrated by calculating the implied difference between yields on holdings of different sizes compared to the *Kreis* average (Table 11). There is one point to note about these estimates.

Table 11. Results of statistical analysis of yields in 325 Prussian *Kreise*

Estimated yields of farms of different sizes relative to the average for the *Kreis* (allowing for the effect of soil type and the location of the *Kreis*

	1878	1883	1897	1900
a. Analysis of rye yields (% difference from the average)				
Holdings of between 20 and 100 hectares	–6.8	+14.0	+1.9	+2.0
Holdings of less than 20 hectares	–8.9**	–17.6**	–6.3**	–3.6
b. Analysis of wheat yields				
Holdings of 100 hectares and over	+18.4**	+33.9**	+33.4**	+23.5**
Holdings of between 20 and 100 hectares	–7.6	+7.9	+9.1	+9.5
Holdings of less than 20 hectares	8.7**	22.5**	22.6**	16.8**

** indicates a result significant at the 99% level
* indicates a result significant at the 95% level

The assumption behind these figures is that there is no learning effect running from large holdings to small. This means that the effect of larger holdings on average yields is entirely direct, due to increases in yields on such holdings. But if larger holdings had an indirect effect on yields on neighbouring holdings even if these were smaller farms, then the estimates given in Table 11 will be too high. The significance of the result remains: the presence of larger holdings has a positive effect on *Kreis* yields, and this effect tended to decline in the case of rye. However, it would not then be possible to make a direct estimate of the gap between yields on different classes of holdings.

VII. Conclusions

The main purpose of this paper has been to make available estimates of agricultural productivity for the German regions, and to provide a description of the methods used to produce these estimates. It is hoped that these estimates will provoke other lines of enquiry and the investigation of other aspects of the position of German agriculture in the late nineteenth and early twentieth centuries. For example, it should be possible to derive estimates of profits or farmers' incomes given regional price data.

The main conclusion to emerge from this analysis is that there was a strong process of convergence which brought productivity up in the rural east to levels equal to or above the national average. This convergence mechanism was associated with the spread of more advanced agricultural techniques led by sugar beet cultivation. Although large farms and estates had a leadership role, there were also significant gains on smaller and medium-sized holdings.

The south and south-west lagged behind. The splitting of holdings due to partible inheritance may well have been a factor in this. But, more careful analysis of data sources for these regions would be required before this conclusion could be stated with any certainty.

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Appendix A. Regions and regional groupings

Regional grouping:	Regional unit used in Table 2:	Includes the following regional units used in German statistical publications:
East of the Elbe	East Prussia	East Prussia
	West Prussia	West Prussia
	Pomerania	Pomerania
	Posen	Posen
	Silesia	Silesia
	Mecklenburg	Mecklenburg-Schwerin and -Strelitz
	Berlin/Brandenburg	Berlin and Brandenburg
Rest of Germany	Pr. Saxony/Anhalt	*Provinz* Saxony and Anhalt
	Thuringia	Saxony-Weimar, -Altenburg, -Meiningen and -Coburg-Gotha, both Reuβ and both Schwarzburgs
	Saxony	Saxony (Kingdom of)
	Schleswig-Holstein	Schleswig-Holstein, Hamburg and Lübeck
	Hannover/Oldenburg/ Brunswick	Hannover, Oldenburg, Brunswick and Bremen
	Westfalia	Westfalia, Waldeck and both Lippes
	Hesse-Nassau	Hesse-Nassau
	Rhineland	Rhineland
	Hesse	Hesse
	Bavaria excl. Pfalz	Bavaria excl. Pfalz
	Pfalz	Pfalz
	Baden	Baden
	Württemberg/Hoh.	Württemberg and Hohenzollern
	Alsace-Lorraine	Alsace-Lorraine

APPENDIX B: REGIONAL ACCOUNTS. A. ACCOUNTS FOR 1880–4

Hoffmann's accounts: Production (in million Marks)		**Allocation of Hoffmann's figures by region (ratios to national total):**									
		EPruss	**WPruss**	**B/Brand**	**Pomm**	**Posen**	**Silesia**	**Pr.Sax**	**Sch-Hol**	**Hann**	**Westf**
Wheat	**448.5**	0.0337	0.0369	0.0246	0.0302	0.0341	0.0748	0.0935	0.0325	0.0731	0.0357
Spelt	**100.0**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000
Rye	**873.2**	0.0552	0.0466	0.0751	0.0563	0.0600	0.0890	0.0756	0.0333	0.0961	0.0438
Barley	**366.5**	0.0303	0.0309	0.0353	0.0301	0.0289	0.0809	0.1520	0.0338	0.0374	0.0137
Oats	**650.5**	0.0464	0.0288	0.0394	0.0487	0.0224	0.0835	0.0674	0.0619	0.0805	0.0342
Mixed cereals	**79.2**	0.0642	0.0413	0.0537	0.0648	0.0470	0.0330	0.0328	0.1403	0.0637	0.0464
Potatoes	**695.0**	0.0238	0.0373	0.0990	0.0519	0.0578	0.0849	0.0799	0.0098	0.0583	0.0262
Pulses and peas	**111.1**	0.1140	0.1168	0.0834	0.1084	0.1157	0.0446	0.0954	0.0375	0.0584	0.0159
Sugar beet	**159.1**	0.0017	0.0173	0.0304	0.0124	0.0161	0.1382	0.4972	0.0062	0.1789	0.0029
Tobacco	**19.8**	0.0087	0.0200	0.0716	0.0344	0.0036	0.0142	0.0171	0.0000	0.0241	0.0000
Hops	**48.2**	0.0069	0.0013	0.0030	0.0014	0.0316	0.0001	0.0330	0.0001	0.0058	0.0000
Wine	**77.8**	0.0000	0.0000	0.0013	0.0000	0.0006	0.0031	0.0038	0.0000	0.0000	0.0000
Field beans	**6.3**	0.0595	0.0345	0.0181	0.0197	0.0203	0.0286	0.0774	0.0815	0.3531	0.0693
Flax and hemp	**25.7**	0.1710	0.0292	0.0614	0.0734	0.0382	0.0687	0.0188	0.0081	0.0908	0.0548
Linseed	**11.1**	0.1710	0.0292	0.0614	0.0734	0.0382	0.0687	0.0188	0.0081	0.0908	0.0548
Rape & other oilseeds	**37.7**	0.0417	0.0679	0.0432	0.0584	0.0136	0.1498	0.0496	0.1398	0.0596	0.0105
Fruit	**84.5**	0.0238	0.0197	0.0566	0.0215	0.0246	0.0720	0.1044	0.0152	0.0698	0.0315
Vegetables	**115.0**	0.0426	0.0315	0.0649	0.0368	0.0439	0.0847	0.0552	0.0431	0.1134	0.0662
Beef	**816.5**	0.0633	0.0317	0.0434	0.0184	0.0415	0.0901	0.0483	0.0530	0.0695	0.0200
Veal	**172.5**	0.0633	0.0317	0.0434	0.0184	0.0415	0.0901	0.0483	0.0530	0.0695	0.0200
Pork	**1071.3**	0.0498	0.0304	0.0640	0.0446	0.0574	0.0531	0.0899	0.0588	0.1051	0.0450
Mutton	**221.0**	0.0264	0.0474	0.0833	0.1258	0.0844	0.0826	0.1032	0.0153	0.0874	0.0222
Goatmeat	**21.0**	0.0068	0.0235	0.0855	0.0259	0.0302	0.0667	0.1067	0.0185	0.1128	0.0679
Poultrymeat	**120.8**	0.0494	0.0354	0.0640	0.0397	0.0456	0.0586	0.0658	0.0415	0.1051	0.0556
Cows milk	**1644.4**	0.0413	0.0300	0.0476	0.0439	0.0375	0.0850	0.0484	0.0639	0.0928	0.0449
Goat milk	**50.2**	0.0068	0.0235	0.0855	0.0259	0.0302	0.0667	0.1067	0.0185	0.1128	0.0679
Wool	**73.5**	0.0812	0.0695	0.0916	0.1327	0.0939	0.0722	0.0735	0.0182	0.0974	0.0209
Honey	**27.5**	0.0665	0.0508	0.0422	0.0750	0.0610	0.0739	0.0344	0.0555	0.1352	0.0367
Eggs	**159.0**	0.0494	0.0354	0.0640	0.0397	0.0456	0.0586	0.0658	0.0415	0.1051	0.0556
Deductions											
Cereals fed to livestock	**1370.8**	0.0486	0.0407	0.0466	0.0394	0.0326	0.0846	0.0484	0.0648	0.0989	0.0487
Purchased fertilisers	**87.5**	0.0644	0.0356	0.0525	0.0381	0.0444	0.0810	0.0495	0.0471	0.0799	0.0356
Other costs	**212.0**	0.0778	0.0540	0.0689	0.0632	0.0695	0.0853	0.0636	0.0431	0.0652	0.0328
Resulting figures (in million Marks)											
Net production	**6843.4**	**264.5**	**224.6**	**373.7**	**298.4**	**295.4**	**510.4**	**568.8**	**295.8**	**564.0**	**231.3**
Net Value Added	**6479.0**	**250.4**	**212.7**	**353.8**	**282.5**	**279.7**	**483.2**	**538.5**	**280.1**	**534.0**	**219.0**
Labour force (in 1000 full-time labour units)	**9650**	**484**	**305**	**449**	**308**	**408**	**815**	**459**	**227**	**636**	**351**
Net Value Added per FLU (in Marks)											
in 1913 prices	**672**	**480**	**648**	**731**	**852**	**636**	**550**	**1089**	**1145**	**779**	**579**

REGIONAL ACCOUNTS. A. ACCOUNTS FOR 1880–4 (continued)

Allocation of Hoffmann's figures by region (ratios to national total):

	Hess-N	Rhine	Bav	Pfalz	Saxony	Wurtt	Baden	Hesse	Meckl	Thur	A-Lorr
Wheat	0.0272	0.0676	0.1655	0.0111	0.0317	0.0174	0.0198	0.0238	0.0448	0.0273	0.0947
Spelt	0.0000	0.0060	0.2473	0.0359	0.0000	0.4717	0.2145	0.0218	0.0000	0.0008	0.0017
Rye	0.0228	0.0507	0.1153	0.0127	0.0526	0.0082	0.0084	0.0154	0.0528	0.0222	0.0079
Barley	0.0141	0.0198	0.1945	0.0180	0.0261	0.0692	0.0397	0.0399	0.0175	0.0488	0.0391
Oats	0.0310	0.0676	0.1271	0.0082	0.0678	0.0435	0.0160	0.0132	0.0491	0.0335	0.0299
Mixed cereals	0.0021	0.0825	0.0487	0.0051	0.0161	0.0599	0.0661	0.0070	0.0804	0.0250	0.0198
Potatoes	0.0249	0.0529	0.1073	0.0330	0.0514	0.0325	0.0356	0.0343	0.0281	0.0293	0.0418
Pulses and peas	0.0211	0.0166	0.0188	0.0017	0.0142	0.0070	0.0015	0.0081	0.0889	0.0243	0.0076
Sugar beet	0.0029	0.0487	0.0002	0.0022	0.0079	0.0127	0.0036	0.0075	0.0034	0.0089	0.0006
Tobacco	0.0078	0.0333	0.1744	0.0196	0.0001	0.0110	0.3485	0.0451	0.0060	0.0078	0.1526
Hops	0.0050	0.0019	0.4428	0.0027	0.0005	0.1885	0.0909	0.0012	0.0000	0.0022	0.1813
Wine	0.0207	0.0834	0.0646	0.1154	0.0050	0.1342	0.1066	0.0840	0.0000	0.0006	0.3768
Field beans	0.0362	0.0162	0.0149	0.0003	0.0006	0.0180	0.0020	0.0002	0.0473	0.0527	0.0497
Flax and hemp	0.0484	0.0192	0.2024	0.0000	0.0187	0.0432	0.0079	0.0073	0.0220	0.0134	0.0030
Linseed	0.0484	0.0192	0.2024	0.0000	0.0187	0.0432	0.0079	0.0073	0.0220	0.0134	0.0030
Rape & other oilseeds	0.0206	0.0297	0.0129	0.0083	0.0216	0.0214	0.0104	0.0109	0.1717	0.0315	0.0271
Fruit	0.0358	0.0724	0.1400	0.0069	0.0559	0.0712	0.0397	0.0184	0.0111	0.0608	0.0487
Vegetables	0.0269	0.0769	0.1065	0.0092	0.0475	0.0345	0.0235	0.0128	0.0332	0.0185	0.0282
Beef	0.0306	0.0686	0.1854	0.0166	0.0290	0.0705	0.0400	0.0159	0.0125	0.0251	0.0259
Veal	0.0306	0.0686	0.1854	0.0166	0.0290	0.0705	0.0400	0.0159	0.0125	0.0251	0.0259
Pork	0.0285	0.0522	0.0823	0.0092	0.0412	0.0390	0.0349	0.0195	0.0324	0.0331	0.0298
Mutton	0.0320	0.0262	0.0660	0.0041	0.0167	0.0428	0.0180	0.0116	0.0626	0.0322	0.0101
Goatmeat	0.0519	0.0953	0.0694	0.0159	0.0429	0.0226	0.0336	0.0363	0.0117	0.0552	0.0203
Poultrymeat	0.0316	0.0703	0.1132	0.0122	0.0375	0.0410	0.0310	0.0203	0.0199	0.0276	0.0349
Cows milk	0.0297	0.0712	0.1276	0.0137	0.0543	0.0445	0.0307	0.0181	0.0264	0.0221	0.0264
Goat milk	0.0519	0.0953	0.0694	0.0159	0.0429	0.0226	0.0336	0.0363	0.0117	0.0552	0.0203
Wool	0.0297	0.0171	0.0589	0.0016	0.0080	0.0271	0.0073	0.0057	0.0626	0.0230	0.0076
Honey	0.0188	0.0472	0.0922	0.0074	0.0306	0.0417	0.0433	0.0106	0.0252	0.0125	0.0393
Eggs	0.0316	0.0703	0.1132	0.0122	0.0375	0.0410	0.0310	0.0203	0.0199	0.0276	0.0349
Deductions											
Cereals fed to livestock	0.0266	0.0742	0.1206	0.0114	0.0514	0.0406	0.0310	0.0161	0.0287	0.0201	0.0261
Purchased fertilisers	0.0301	0.0580	0.1536	0.0126	0.0391	0.0516	0.0336	0.0174	0.0229	0.0229	0.0301
Other costs	0.0256	0.0477	0.1063	0.0098	0.0321	0.0353	0.0217	0.0143	0.0341	0.0236	0.0259
Resulting figures											
Net production	**172.9**	**386.5**	**796.0**	**101.1**	**283.4**	**307.3**	**211.0**	**136.9**	**229.9**	**187.2**	**232.0**
Net Value Added	**163.7**	**365.9**	**753.6**	**95.7**	**268.3**	**291.0**	**199.7**	**129.6**	**217.6**	**177.3**	**219.7**
Labour force (in 1000 full-time labour units)	**290**	**636**	**1371**	**185**	**316**	**455**	**359**	**176**	**159**	**219**	**342**
Net Value Added per FLU in 1913 prices	**524**	**535**	**510**	**480**	**789**	**594**	**517**	**685**	**1267**	**750**	**596**

REGIONAL ACCOUNTS. B. ACCOUNTS FOR 1893–7

Hoffmann's accounts: Production (in million Marks)		**Allocation of Hoffmann's figures by region (ratios to national total):**									
		EPruss	WPruss	B/Brand	Pomm	Posen	Silesia	Pr.Sax	Sch-Hol	Hann	Westf
Wheat	**595.7**	0.0368	0.0411	0.0278	0.0335	0.0324	0.0921	0.1210	0.0333	0.0950	0.0386
Spelt	**83.5**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0000	0.0000	0.0000
Rye	**1203.2**	0.0593	0.0445	0.0834	0.0536	0.0823	0.0920	0.0751	0.0304	0.1011	0.0479
Barley	**391.4**	0.0344	0.0359	0.0379	0.0299	0.0368	0.0944	0.1482	0.0368	0.0323	0.0115
Oats	**786.8**	0.0529	0.0290	0.0442	0.0505	0.0243	0.0847	0.0745	0.0578	0.0938	0.0395
Mixed cereals	**83.3**	0.0682	0.0417	0.0594	0.0648	0.0560	0.0355	0.0352	0.1371	0.0730	0.0515
Potatoes	**1036.5**	0.0386	0.0506	0.0959	0.0608	0.0816	0.1018	0.0775	0.0094	0.0581	0.0298
Pulses and peas	**83.5**	0.1556	0.1411	0.0589	0.1079	0.1022	0.0319	0.0926	0.0264	0.0539	0.0184
Sugar beet	**246.4**	0.0055	0.0580	0.0314	0.0350	0.0838	0.1133	0.3370	0.0040	0.1781	0.0103
Tobacco	**18.0**	0.0057	0.0204	0.1047	0.0597	0.0024	0.0053	0.0076	0.0000	0.0276	0.0000
Hops	**52.3**	0.0109	0.0013	0.0022	0.0009	0.0693	0.0000	0.0412	0.0001	0.0028	0.0000
Wine	**124.9**	0.0000	0.0000	0.0017	0.0000	0.0006	0.0037	0.0029	0.0000	0.0000	0.0000
Field beans	**4.1**	0.0600	0.0329	0.0155	0.0221	0.0161	0.0307	0.0774	0.0837	0.3557	0.0661
Flax and hemp	**13.0**	0.1595	0.0278	0.0590	0.0725	0.0380	0.1118	0.0180	0.0071	0.0874	0.0503
Linseed	**9.4**	0.1595	0.0278	0.0590	0.0725	0.0380	0.1118	0.0180	0.0071	0.0874	0.0503
Rape & other oilseeds	**30.2**	0.0409	0.0681	0.0428	0.0574	0.0136	0.1503	0.0491	0.1419	0.0584	0.0105
Fruit	**132.7**	0.0220	0.0194	0.0629	0.0215	0.0275	0.0713	0.0991	0.0168	0.0749	0.0346
Vegetables	**145.7**	0.0426	0.0315	0.0649	0.0368	0.0439	0.0847	0.0552	0.0431	0.1134	0.0662
Beef	**1100.3**	0.0664	0.0338	0.0489	0.0326	0.0429	0.0783	0.0522	0.0522	0.0725	0.0254
Veal	**247.5**	0.0664	0.0338	0.0489	0.0326	0.0429	0.0783	0.0522	0.0522	0.0725	0.0254
Pork	**1813.9**	0.0470	0.0282	0.0685	0.0499	0.0369	0.0552	0.0945	0.0389	0.1100	0.0542
Mutton	**160.4**	0.0241	0.0445	0.0766	0.1260	0.0605	0.0511	0.1131	0.0179	0.0955	0.0248
Goatmeat	**31.9**	0.0077	0.0232	0.0823	0.0249	0.0331	0.0652	0.1114	0.0168	0.1132	0.0648
Poultrymeat	**128.8**	0.0494	0.0354	0.0640	0.0397	0.0456	0.0586	0.0658	0.0415	0.1051	0.0556
Cows milk	**2057.3**	0.0442	0.0334	0.0478	0.0459	0.0402	0.0808	0.0477	0.0609	0.0934	0.0443
Goat milk	**74.1**	0.0077	0.0232	0.0823	0.0249	0.0331	0.0652	0.1114	0.0168	0.1132	0.0648
Wool	**54.8**	0.0762	0.0656	0.0847	0.1342	0.0683	0.0455	0.0813	0.0223	0.1088	0.0240
Honey	**31.8**	0.0665	0.0508	0.0422	0.0750	0.0610	0.0739	0.0344	0.0555	0.1352	0.0367
Eggs	**201.8**	0.0494	0.0354	0.0640	0.0397	0.0456	0.0586	0.0658	0.0415	0.1051	0.0556
Deductions											
Cereals fed to livestock	**1735.9**	0.0664	0.0381	0.0523	0.0408	0.0476	0.0782	0.0502	0.0482	0.0844	0.0375
Purchased fertilisers	**272.0**	0.0778	0.0540	0.0689	0.0632	0.0695	0.0853	0.0636	0.0431	0.0652	0.0328
Other costs	**274.8**	0.0465	0.0361	0.0582	0.0461	0.0477	0.0775	0.0821	0.0401	0.0894	0.0390
Resulting figures		**in million Marks**									
Net production	**8660.3**	**379.7**	**318.4**	**533.3**	**421.2**	**425.3**	**689.8**	**771.8**	**346.1**	**809.3**	**352.8**
Net Value Added	**8321.4**	**364.9**	**305.9**	**512.4**	**404.7**	**408.6**	**662.8**	**741.5**	**332.6**	**777.6**	**339.0**
Labour force (in 1000 full-time labour units)	**9743**	**490**	**332**	**512**	**345**	**459**	**867**	**547**	**251**	**724**	**392**
Net Value Added per FLU		**in Marks**									
in 1913 prices	**855**	**745**	**923**	**1001**	**1175**	**891**	**765**	**1356**	**1323**	**1075**	**865**

REGIONAL ACCOUNTS. B. ACCOUNTS FOR 1893–79 (continued)

Allocation of Hoffmann's figures by region (ratios to national total):

	Hess-N	Rhine	Bav	Pfalz	Saxony	Wurtt	Baden	Hesse	Meckl	Thur	A-Lorr
Wheat	0.0305	0.0616	0.1316	0.0097	0.0372	0.0129	0.0154	0.0177	0.0420	0.0293	0.0601
Spelt	0.0000	0.0057	0.2684	0.0210	0.0000	0.4626	0.2225	0.0178	0.0000	0.0007	0.0007
Rye	0.0274	0.0595	0.0893	0.0123	0.0482	0.0063	0.0079	0.0176	0.0345	0.0192	0.0082
Barley	0.0148	0.0207	0.1832	0.0227	0.0239	0.0585	0.0366	0.0466	0.0200	0.0441	0.0316
Oats	0.0361	0.0714	0.1101	0.0083	0.0632	0.0368	0.0158	0.0151	0.0422	0.0270	0.0227
Mixed cereals	0.0025	0.0899	0.0417	0.0053	0.0161	0.0483	0.0602	0.0073	0.0678	0.0228	0.0157
Potatoes	0.0291	0.0578	0.0862	0.0230	0.0489	0.0282	0.0243	0.0245	0.0214	0.0238	0.0289
Pulses and peas	0.0265	0.0201	0.0331	0.0027	0.0071	0.0112	0.0023	0.0093	0.0603	0.0303	0.0083
Sugar beet	0.0113	0.0373	0.0005	0.0050	0.0119	0.0073	0.0025	0.0112	0.0398	0.0158	0.0009
Tobacco	0.0086	0.0239	0.1224	0.0137	0.0000	0.0237	0.4336	0.0306	0.0063	0.0057	0.0980
Hops	0.0072	0.0009	0.4486	0.0095	0.0003	0.1220	0.1064	0.0031	0.0000	0.0003	0.1731
Wine	0.0569	0.1935	0.0414	0.1084	0.0020	0.1083	0.1531	0.0927	0.0000	0.0000	0.2348
Field beans	0.0348	0.0148	0.0185	0.0004	0.0008	0.0228	0.0021	0.0005	0.0482	0.0544	0.0426
Flax and hemp	0.0463	0.0183	0.1930	0.0000	0.0201	0.0408	0.0084	0.0064	0.0192	0.0126	0.0034
Linseed	0.0463	0.0183	0.1930	0.0000	0.0201	0.0408	0.0084	0.0064	0.0192	0.0126	0.0034
Rape & other oilseeds	0.0206	0.0299	0.0131	0.0081	0.0219	0.0212	0.0105	0.0109	0.1734	0.0309	0.0267
Fruit	0.0403	0.0756	0.1225	0.0108	0.0555	0.0674	0.0479	0.0236	0.0112	0.0481	0.0470
Vegetables	0.0269	0.0769	0.1065	0.0092	0.0475	0.0345	0.0235	0.0128	0.0332	0.0185	0.0282
Beef	0.0316	0.0562	0.1770	0.0157	0.0281	0.0627	0.0396	0.0174	0.0148	0.0239	0.0274
Veal	0.0316	0.0562	0.1770	0.0157	0.0281	0.0627	0.0396	0.0174	0.0148	0.0239	0.0274
Pork	0.0329	0.0583	0.0876	0.0107	0.0405	0.0405	0.0381	0.0234	0.0340	0.0360	0.0147
Mutton	0.0375	0.0285	0.0825	0.0048	0.0160	0.0487	0.0201	0.0151	0.0699	0.0324	0.0105
Goatmeat	0.0526	0.0907	0.0675	0.0161	0.0439	0.0244	0.0340	0.0374	0.0116	0.0596	0.0196
Poultrymeat	0.0316	0.0703	0.1132	0.0122	0.0375	0.0410	0.0310	0.0203	0.0199	0.0276	0.0349
Cows milk	0.0304	0.0719	0.1289	0.0135	0.0519	0.0434	0.0303	0.0178	0.0250	0.0225	0.0259
Goat milk	0.0526	0.0907	0.0675	0.0161	0.0439	0.0244	0.0340	0.0374	0.0116	0.0596	0.0196
Wool	0.0360	0.0189	0.0751	0.0018	0.0076	0.0310	0.0080	0.0074	0.0707	0.0244	0.0082
Honey	0.0188	0.0472	0.0922	0.0074	0.0306	0.0417	0.0433	0.0106	0.0252	0.0125	0.0393
Eggs	0.0316	0.0703	0.1132	0.0122	0.0375	0.0410	0.0310	0.0203	0.0199	0.0276	0.0349
Deductions											
Cereals fed to livestock	0.0303	0.0581	0.1473	0.0122	0.0371	0.0487	0.0315	0.0172	0.0233	0.0224	0.0286
Purchased fertilisers	0.0256	0.0477	0.1063	0.0098	0.0321	0.0353	0.0217	0.0143	0.0341	0.0236	0.0259
Other costs	0.0299	0.0610	0.1142	0.0143	0.0412	0.0412	0.0314	0.0210	0.0295	0.0265	0.0272
Resulting figures											
Net production	**269.3**	**554.2**	**972.6**	**132.3**	**376.6**	**357.6**	**280.8**	**193.2**	**269.5**	**243.6**	**237.0**
Net Value Added	**258.7**	**532.5**	**934.6**	**127.1**	**361.8**	**343.6**	**269.8**	**185.7**	**259.0**	**234.1**	**227.7**
Labour force (in 1000 full-time labour units)	**324**	**700**	**1353**	**161**	**344**	**537**	**428**	**196**	**180**	**228**	**374**
Net Value Added per FLU in 1913 prices	**798**	**761**	**691**	**791**	**1052**	**641**	**631**	**949**	**1442**	**1029**	**609**

REGIONAL ACCOUNTS. C. ACCOUNTS FOR 1905–7

Hoffmann's accounts: Production (in million Marks)		**Allocation of Hoffmann's figures by region (ratios to national total):**									
		EPruss	WPruss	B/Brand	Pomm	Posen	Silesia	Pr.Sax	Sch-Hol	Hann	Westf
Wheat	**674.5**	0.0365	0.0376	0.0309	0.0345	0.0411	0.1016	0.1272	0.0335	0.0842	0.0400
Spelt	**80.4**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000
Rye	**1492.0**	0.0639	0.0548	0.0911	0.0681	0.1006	0.0898	0.0643	0.0283	0.0976	0.0440
Barley	**477.7**	0.0515	0.0493	0.0489	0.0387	0.0702	0.0965	0.1278	0.0384	0.0261	0.0089
Oats	**1146.4**	0.0675	0.0364	0.0558	0.0674	0.0343	0.0892	0.0699	0.0586	0.0865	0.0376
Mixed cereals	**91.6**	0.0753	0.0457	0.0655	0.0771	0.0637	0.0367	0.0325	0.1403	0.0707	0.0497
Potatoes	**1371.8**	0.0479	0.0569	0.1046	0.0629	0.1035	0.1102	0.0755	0.0091	0.0572	0.0278
Pulses and peas	**49.7**	0.1583	0.1501	0.0481	0.1048	0.0859	0.0258	0.1174	0.0198	0.0496	0.0184
Sugar beet	**331.3**	0.0043	0.0550	0.0371	0.0466	0.1056	0.1317	0.3065	0.0023	0.1450	0.0085
Tobacco	**13.1**	0.0038	0.0356	0.1164	0.0626	0.0017	0.0039	0.0054	0.0193	0.0002	0.0000
Hops	**45.0**	0.0033	0.0005	0.0011	0.0005	0.0182	0.0000	0.0144	0.0000	0.0016	0.0000
Wine	**98.6**	0.0000	0.0000	0.0006	0.0000	0.0002	0.0014	0.0011	0.0000	0.0000	0.0000
Field beans	**3.0**	0.0608	0.0305	0.0116	0.0256	0.0099	0.0340	0.0772	0.0869	0.3596	0.0614
Flax and hemp	**6.3**	0.1294	0.0242	0.0528	0.0702	0.0373	0.2248	0.0158	0.0045	0.0785	0.0383
Linseed	**6.2**	0.1294	0.0242	0.0528	0.0702	0.0373	0.2248	0.0158	0.0045	0.0785	0.0383
Rape & other oil-seeds	**19.3**	0.0323	0.0698	0.0383	0.0465	0.0127	0.1561	0.0425	0.1659	0.0454	0.0101
Fruit	**131.1**	0.0204	0.0189	0.0677	0.0214	0.0299	0.0699	0.0942	0.0182	0.0787	0.0370
Vegetables	**172.0**	0.0426	0.0315	0.0649	0.0368	0.0439	0.0847	0.0552	0.0431	0.1134	0.0662
Beef	**1456.4**	0.0702	0.0366	0.0465	0.0421	0.0547	0.0848	0.0543	0.0525	0.0872	0.0286
Veal	**348.0**	0.0702	0.0366	0.0465	0.0421	0.0547	0.0848	0.0543	0.0525	0.0872	0.0286
Pork	**2442.3**	0.0528	0.0362	0.0557	0.0590	0.0440	0.0564	0.0805	0.0721	0.1383	0.0516
Mutton	**104.2**	0.0222	0.0423	0.0753	0.1278	0.0466	0.0425	0.1271	0.0221	0.0886	0.0230
Goatmeat	**31.2**	0.0122	0.0285	0.0656	0.0268	0.0421	0.0758	0.0912	0.0177	0.1104	0.0627
Poultrymeat	**156.2**	0.0494	0.0354	0.0640	0.0397	0.0456	0.0586	0.0658	0.0415	0.1051	0.0556
Cows milk	**2573.4**	0.0470	0.0355	0.0472	0.0480	0.0410	0.0780	0.0464	0.0622	0.0963	0.0438
Goat milk	**92.8**	0.0122	0.0285	0.0656	0.0268	0.0421	0.0758	0.0912	0.0177	0.1104	0.0627
Wool	**39.8**	0.0695	0.0642	0.0863	0.1393	0.0535	0.0381	0.0938	0.0265	0.1011	0.0220
Honey	**36.6**	0.0665	0.0508	0.0422	0.0750	0.0610	0.0739	0.0344	0.0555	0.1352	0.0367
Eggs	**278.2**	0.0494	0.0354	0.0640	0.0397	0.0456	0.0586	0.0658	0.0415	0.1051	0.0556
Deductions											
Cereals fed to livestock	**2646.5**	0.0671	0.0405	0.0516	0.0444	0.0506	0.0742	0.0507	0.0539	0.0944	0.0392
Purchased fertilisers	**498.2**	0.0778	0.0540	0.0689	0.0632	0.0695	0.0853	0.0636	0.0431	0.0652	0.0328
Other costs	**262.9**	0.0525	0.0409	0.0597	0.0532	0.0579	0.0810	0.0750	0.0470	0.0946	0.0385
Resulting figures		**in million Marks**									
Net production	**10395.0**	**493.3**	**419.0**	**635.0**	**569.3**	**613.1**	**854.8**	**847.2**	**471.0**	**995.8**	**400.0**
Net Value Added	**9841.0**	**467.0**	**396.6**	**601.1**	**539.0**	**580.4**	**809.3**	**802.0**	**445.9**	**942.7**	**378.7**
Labour force (in 1000 full-time labour units)	**10031**	**500**	**368**	**492**	**376**	**493**	**843**	**578**	**261**	**830**	**454**
Net Value Added per FLU		**in Marks**									
in 1913 prices	**982**	**934**	**1078**	**1222**	**1433**	**1179**	**960**	**1388**	**1709**	**1136**	**834**

REGIONAL ACCOUNTS. C. ACCOUNTS FOR 1905–7 (continued)

Allocation of Hoffmann's figures by region (ratios to national total):

	Hess-N	Rhine	Bav	Pfalz	Saxony	Wurtt	Baden	Hesse	Meckl	Thur	A-Lorr
Wheat	0.0370	0.0552	0.1199	0.0062	0.0372	0.0165	0.0178	0.0178	0.0315	0.0347	0.0592
Spelt	0.0000	0.0128	0.2482	0.0031	0.0000	0.5022	0.2178	0.0131	0.0000	0.0005	0.0020
Rye	0.0283	0.0504	0.0783	0.0113	0.0418	0.0060	0.0078	0.0146	0.0343	0.0163	0.0084
Barley	0.0131	0.0205	0.1697	0.0206	0.0170	0.0483	0.0291	0.0371	0.0189	0.0388	0.0307
Oats	0.0391	0.0664	0.0875	0.0078	0.0509	0.0286	0.0142	0.0142	0.0401	0.0263	0.0216
Mixed cereals	0.0027	0.0840	0.0364	0.0043	0.0142	0.0408	0.0541	0.0063	0.0630	0.0218	0.0152
Potatoes	0.0278	0.0464	0.0789	0.0166	0.0398	0.0254	0.0207	0.0204	0.0205	0.0245	0.0235
Pulses and peas	0.0295	0.0193	0.0397	0.0015	0.0076	0.0182	0.0034	0.0105	0.0467	0.0354	0.0100
Sugar beet	0.0073	0.0380	0.0019	0.0054	0.0117	0.0061	0.0145	0.0109	0.0394	0.0160	0.0064
Tobacco	0.0037	0.0146	0.1331	0.0150	0.0000	0.0244	0.4202	0.0174	0.0040	0.0038	0.1151
Hops	0.0023	0.0006	0.5568	0.0065	0.0001	0.1385	0.0639	0.0003	0.0000	0.0003	0.1912
Wine	0.0232	0.1527	0.0273	0.1634	0.0017	0.0982	0.1773	0.0909	0.0000	0.0001	0.2619
Field beans	0.0326	0.0126	0.0239	0.0005	0.0010	0.0300	0.0023	0.0010	0.0496	0.0569	0.0322
Flax and hemp	0.0409	0.0160	0.1683	0.0000	0.0239	0.0346	0.0097	0.0040	0.0121	0.0104	0.0044
Linseed	0.0409	0.0160	0.1683	0.0000	0.0239	0.0346	0.0097	0.0040	0.0121	0.0104	0.0044
Rape & other oilseeds	0.0206	0.0318	0.0152	0.0063	0.0251	0.0185	0.0121	0.0114	0.1932	0.0240	0.0223
Fruit	0.0439	0.0775	0.1089	0.0153	0.0546	0.0639	0.0550	0.0286	0.0112	0.0397	0.0453
Vegetables	0.0269	0.0769	0.1065	0.0092	0.0475	0.0345	0.0235	0.0128	0.0332	0.0185	0.0282
Beef	0.0294	0.0529	0.1606	0.0118	0.0252	0.0535	0.0315	0.0149	0.0176	0.0225	0.0227
Veal	0.0294	0.0529	0.1606	0.0118	0.0252	0.0535	0.0315	0.0149	0.0176	0.0225	0.0227
Pork	0.0293	0.0539	0.0717	0.0091	0.0396	0.0310	0.0277	0.0162	0.0296	0.0274	0.0180
Mutton	0.0337	0.0230	0.0945	0.0053	0.0170	0.0570	0.0181	0.0158	0.0724	0.0344	0.0113
Goatmeat	0.0561	0.0849	0.0738	0.0205	0.0401	0.0289	0.0361	0.0379	0.0101	0.0598	0.0188
Poultrymeat	0.0316	0.0703	0.1132	0.0122	0.0375	0.0410	0.0310	0.0203	0.0199	0.0276	0.0349
Cows milk	0.0298	0.0708	0.1274	0.0128	0.0501	0.0442	0.0301	0.0167	0.0246	0.0225	0.0257
Goat milk	0.0561	0.0849	0.0738	0.0205	0.0401	0.0289	0.0361	0.0379	0.0101	0.0598	0.0188
Wool	0.0316	0.0155	0.0864	0.0023	0.0086	0.0374	0.0078	0.0081	0.0750	0.0246	0.0086
Honey	0.0188	0.0472	0.0922	0.0074	0.0306	0.0417	0.0433	0.0106	0.0252	0.0125	0.0393
Eggs	0.0316	0.0703	0.1132	0.0122	0.0375	0.0410	0.0310	0.0203	0.0199	0.0276	0.0349
Deductions											
Cereals fed to livestock	0.0300	0.0565	0.1381	0.0112	0.0350	0.0456	0.0289	0.0157	0.0237	0.0220	0.0267
Purchased fertilisers	0.0256	0.0477	0.1063	0.0098	0.0321	0.0353	0.0217	0.0143	0.0341	0.0236	0.0259
Other costs	0.0292	0.0566	0.1050	0.0124	0.0382	0.0367	0.0269	0.0176	0.0274	0.0246	0.0252
Resulting figures											
Net production	**301.8**	**590.6**	**999.5**	**132.9**	**407.5**	**357.6**	**276.6**	**188.8**	**289.8**	**261.7**	**256.8**
Net Value Added	**285.7**	**559.1**	**946.2**	**125.8**	**385.8**	**338.5**	**261.9**	**178.7**	**274.4**	**247.8**	**243.1**
Labour force (in 1000 full-time labour units)	**372**	**739**	**1419**	**180**	**277**	**512**	**413**	**176**	**160**	**228**	**360**
Net Value Added per FLU in 1913 prices	**769**	**757**	**667**	**699**	**1395**	**661**	**635**	**1016**	**1716**	**1088**	**676**

Appendix C. Description of regression variables and sources.

I. Table 7

ΔARABLEYIELD 1880/4–1905/9 (Dependent variable)	Change in percentage points in arable production per hectare in 1913 Marks: estimates of total crop production from the regional accounts given in Appendix B divided by the total arable area, from the occupational censuses (these included an agricultural section which recorded land use).
ARABLEYIELD80/4	As above, level in 1880/4
%ΔLUINTENSITY	Change (in percentage points) of livestock intensity, calculated by weighting numbers from the livestock censuses using Wagner's formula, and dividing by the total agricultural area.
%ΔSUGARBEET	Change (in percentage points) of the sugar beet area as a proportion of the total arable area.
%ΔLEGUMES	Change (in percentage points) of the area under peas, beans and pulses as a proportion of the total arable area.
LAND>100HA	The percentage of the total agricultural area in holdings of over 100 hectares, from 1895 Agricultural Census, Statistik des Deutschen Reichs n.f. 212.

II. Tables 9 and 10

Rye and wheat yields 1878, 1883, 1897, 1900 (dependent variables)	Yields in tons/hectare by *Kreis*, for winter rye and winter wheat, from Preuβische Statistik vol.52 (1880), vol. 81 (1884), vol. 54 (1898) and vol. 165 (1900).
%ΔSUGARBEET	Change (in percentage points) of the sugar beet area (beet for sugar production only), 1883-97, as a proportion of the total arable area, from Preuβische Statistik vol.81(1884), part 1, pp. 20–65 and vol. 54 (1898), pp. 6–163
%ARABLE1883	Arable area as a percentage of the total agricultural area, from Preuβische Statistik vol.81.1884.
LAND>100HA	The percentage of the total agricultural area in holdings of over 100 hectares, from 1895 Agricultural Census, Statistik des Deutschen Reichs n.f. 212.

LAND20-100HA	As above, for holdings of between 20 and 100 hectares.
LAND<20HA	As above, for holdings of between below 20 hectares.
CITYDISTANCE(a)	Distance in kilometres from the Kreis mid-point to the nearest city with at least 200,000 inhabitants in 1900.
CITYDISTANCE(c)	As above, for cities with at least 50,000 inhabitants in 1900.
%AGOCCUP82	The population occupied in agriculture as a percentage of the total occupied population, from the 1882 occupational census, Statistik des Deutschen Reichs n.f. 2.
GRUNDSTREIN	The average level of *Grundsteuerreinertrag* per hectare, for each *Kreis,* from Meitzen (1868), volume 4, part a.
%SANDYLOAM	The percentage of the total *Kreis* area (excluding the area under water) classified as “sandy loam”, source as above.
%SAND	The percentage of the total *Kreis* area (excluding the area under water) classified as “sandy”, source as above.
%SUGARBEET	The percentage of the total arable area which was used for the cultivation of sugar beet, average of 1883 and 1897, data from Preuβische Statistik vol.81(1884) and vol. 54 (1898).

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