"The German empire has been built more truly on coal and iron than on blood and iron" (Keynes, 1919)

How and when did Germany catch up to Great Britain and the US? Results from the official statistics, 1901-1960

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Abstract

This paper presents further evidence on Germany's productivity catch up to Britain and the US studied, among others, by Broadberry and Fremdling. As there exist serious doubts about the intertemporal consistency the German data underlying most previous work, we employ the official statistics instead and thus offer an alternative. Preliminary results show higher productivity in German manufacturing before World War I and a sharp relative decline in the inter-war period. According to our calculations, the main structural shifts explaining Germany's catching-up appear to have occurred across World War II.

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I. Introduction

Conventional wisdom has long seen Germany's productivity catch-up on Britain as a process that took place well before World War I, mainly in manufacturing. Superior use of R & D, large-scale plants, and cartelization were held to have been the major causes. More recent research, however, has revealed a surprisingly stable pattern of German performance with respect to Britain. Using productivity benchmarks for census years in Britain and Germany, Broadberry and Fremdling [1990] have argued that there was no decisive productivity advantage for Germany over Britain in manufacturing until World War II. Broadberry [1993;1997a;b] extrapolates aggregate and sectoral data for both economies from a 1935 benchmark to argue that most of the German catching-up did not come from manufacturing. Instead, Germany's closing of the productivity gap is seen largely as the result of improved performance in services and of the gradual decline of peasant agriculture in Germany.

The methods employed in existing research allow tracking the comparative record of the German economy vis-à-vis the UK and the US in some detail. One potential limitation to the validity of the results lies, however, in the quality of the time series used for extrapolation from the benchmark. It is common in these studies to the data of Hoffmann [1965], which are the internationally most commonly used basis for historical national and sectoral accounts for Germany, see e.g., Maddison [1982;1991;1995]. Over the past decades, these data have met with increasing criticism both for the aggregate and sectoral level, see Lewis [1978], Holtfrerich [1983], and especially Fremdling [1988;1991;1995]. Building on Fremdling's work, Burhop and Wolff [2002] applied a number of corrections to Hoffmann's aggregate data for the 19th century. Ritschl

[1998;2004] and Spoerer [1998] criticized the shortcomings of Hoffmann's aggregate output series for the immediate pre-war years and the inter-war period. Ritschl and Spoerer [1997] have suggested using the official national income series instead, and calculate a GDP/GNP series at constant prices back to 1901. For manufacturing, Ritschl [1998;2004] has argued that in the inter-war period, Hoffmann's index of industrial production exaggerates the level and growth of output with respect to the pre-war period. On the basis of the official data, Broadberry and Ritschl [1995] compared indices of unit wage cost in the German and British inter-war economies and identified very similar cost-push effects. As pointed out by Ritschl [1990], these cost-push effects vanish for Germany if calculated on the basis of Hoffmann's industrial output data. The apparent upward bias in Hoffmann's inter-war output figures would also affect any intertemporal and international comparisons.

The paper attempts to gauge the possible bias by inserting alternative data into the existing international productivity comparisons, both on an aggregate and a sectoral level. Following an emerging mainstream among German economic historians, we employ the official data on industry and agriculture produced by Berlin's semi-official *Institut für Konjunkturforschung* during the inter-war years (see Tooze [2001] for a fascinating account of this institution). Wagenführ [1933] and von der Decken and Wagenführ [1935] extended the index calculations backwards into the pre-war period. While we find little discrepancy between these data and Hoffmann's estimates prior to 1913, serious deviations exist after that date.

In aggregate comparison, the broad picture painted by previous research does not change much before World War I. Germany did partially catch-up to Britain. However, the convergence was only conditional, given the persistence of a large, unproductive peasant agriculture in the German economy. During the inter-war period, the German economy appears to have fallen behind farther than previous studies suggest. We find that in terms of aggregate productivity, the German economy was no closer to Britain on the eve of World War II than thirty years earlier. After World War II, we find that domestic output per capita in Germany converges roughly to the same trend established by the growth of British GDP after the depression of 1921.

At the disaggregate level, however, our results differ. For the years on the eve of World War I, we obtain a markedly higher productivity lead in manufacturing over Britain for 1911, while in the same year, construction and agriculture seem to be less productive than use of the Hoffmann data would imply. However, the German productivity lead in manufacturing appears to have built up only during the last years before the Great War and may partly be due to a phase shift between German and British business cycles.

Our figures indicate a severe setback for the German economy across World War I. German industry forged ahead of Britain before World War I, but fell behind in the post-war turmoils and would not recover to its comparative productivity levels well into the 1970s. Our results confirm the "incomplete reconstruction" view of Weimar's poor economic performance that was diagnosed by Petzina and Abelshauser [1974]. They are also consistent with the position of Borchardt [1979/1991], who identified productivity problems to be at the root of Germany's severe inter-war depression.

This paper is structured as follows. Section II reviews the aggregate evidence and identifies the main comparative trends in national product per capita. Section III turns to the sectoral level and discusses some of the key entries of the sectoral comparison. Section IV puts the various elements together and attempts to obtain a full picture. Section V looks into the proximate causes of Germany's delayed productivity catching-up and focuses on the impact of World War II on physical and human capital in West Germany after World War II. Section VI concludes and sketches avenues for further research.

II. War, delayed reconstruction, and catching-up to the Tommies: the aggregate evidence

This section presents and reviews time-series evidence on German national output and productivity. The widely used output series of Hoffmann [1965] has been interpolated by Maddison [1995] to bridge the war and post-war periods of 1914-24 and 1939-49, for which Hoffmann's series exhibits gaps. As Ritschl [1998;2004] has argued, Hoffmann's series overstates both the level and growth of domestic output in the inter-war period, which is largely due to upward bias in his estimates of capital-goods production. Following earlier work of Maddison [1991], Ritschl and Spoerer [1997] therefore calculated inter-war GDP from the official national income series instead, which they interpolated for the wartime periods using a refined version of Maddison's approach. From existing sources, the conversion from national income to GDP can be carried out with satisfactory reliability back to 1901, see Spoerer [1998]. Fig. 1 calculates GDP per capita from our series and compares the result with Maddison's version of Hoffmann. As we follow Maddison [1995] in using the official national accounts from 1950 on, both series are identical for the post-war period.

(Figure 1)

Both series exhibit a marked slowdown of growth throughout the inter-war period. The pronounced slump during the Great Depression of the 1930s comes out similarly in both series. However, our series, which is based on the official national income accounts, is somewhat below the Maddison [1995] estimate. Note also that the Nazi recovery from 1933 to 1938 looks rather less impressive in the official data; only during World War II does the official series (for which data exist through 1941 on a consistent basis) catch up to Maddison's estimates.

It is also instructive to look at the full time-series evidence on per-capita output to trace the comparative position of Germany further. Figure 2 shows the long-term growth of German (West German after 1945) per-capita product from our series along with Maddison's time series for the UK.

(Figure 2)

What stands out from the D/UK comparison in this figure is a double effect. First, there is a strongly visible structural break in British productivity performance around the trough of the post-war recession of 1920. After that year, British productivity actually grows faster on average than it did since the turn of the century. This is evidenced in Figure 2 by the extrapolated trend line for Britain for 1901-1913, which is crossed again in the mid-1935 and never returned to thereafter. If there was ever a British decline, it was probably over by that time.

In contrast, German output appears rather volatile. The extrapolated trend from the pre-war decade is never reached again before World War II, not even in the early 1940s when the German war economy exploited the resources of continental Europe to the maximum. Again, it is interesting to compare actual developments to the extrapolated trends from the pre-World War I period: Had both German and British aggregate productivity continued to grow at their average pre-war trends, Germany would have caught up to Britain already by the mid-1930s, not just in the 1960s. What prevented this from happening was not just Germany's delayed reconstruction from World War I but also the acceleration of British productivity growth after the 1920 slump.

In the post-war period we see German productivity growing at astounding rates, albeit from a very low starting base. This seemingly fabulous growth story is again about reconstruction, as was emphasised long go by Janossy [1969] and Abelshauser [1975]. German productivity catches up to an earlier historical trend as if drawn back by a magnet to a mystical trend line. Running convergence and catching-up regressions, Dumke [1990] has indeed found reconstruction effects to play an important part in explaining this stunning performance. However, as Eichengreen and Ritschl [1997] note, already in the 1960s the German rates of TFP growth are back down at the very low British levels prevailing at the same time.

The trend comparison implicit in Figure 2 also suggests a possible explanation for Britain's slow productivity growth in the post-war period, which has attracted much scholarly attention (see e.g. Bean and Crafts [1995], and Broadberry and Crafts [1996;2003]). As the data bear out, one reason why Britain's productivity grew more slowly after 1945 was that the war shock to the British economy was much smaller. From around

1960 on when Germany's potential for reconstruction was exhausted, both economies grew from similar levels at similar rates. Seen in the context of British comparative success or failure, Figure 2 suggests that it was actually Germany that oscillated between failure and success. In contrast, there was rather steady growth in the British economy throughout most of the century.

We insert the result into Broadberry [1997a;b] comparison of GDP per employee in Germany, Britain, and the US (Table 1).

(Table 1 about here)

The first three columns in the above table emerge from the Maddison dataset. Here, the inter-war period affects Germany's catching-up process with respect to Britain only slightly; on the eve of World War II the comparative position looks more favourable for Germany than in 1913. Only across World War II do we observe a strong setback for the German economy, which is more than compensated in the post-war "miracle" of West Germany's catching-up growth. Largely the same picture is obtained for the comparison with the US up until 1950. What is notable here is Germany's conditional convergence to a glass ceiling of less than 70% of US productivity. This position is attained in 1913 and again in 1938, and only surpassed in 1973.

This impression changes if we look instead at the revised aggregate figures. Before World War I, the overall productivity comparison comes out somewhat worse. In the inter-war period, Germany fails to catch-up to her pre-war productivity position with respect to Britain. The German recovery of 1933-1938 may have done much to increase

employment, aggregate demand, and the number of tanks in the German economy, but our data suggest that it was definitely not a productivity race. In 1938, Germany's economy had grown back to capacity, but modernisation of the production apparatus itself was clearly still lacking[1]. This is confirmed by looking at the revised German-American productivity comparison in the last column of Table 1. Like Britain, Germany missed the productivity growth that the US experienced in the 1920s. Our revised figures indicate that while Germany maintained its relative productivity position with respect to Britain, it gradually fell behind the U.S. The overall picture again confirms that German reconstruction from World War I was incomplete and interrupted. In terms of aggregate productivity, the inter-war years were lost; Germany never recovered the position of 1913 before World War II.

IV. Lifting the veil of aggregation: the sectoral evidence

In this section we attempt to gain more insight into the proximate causes driving the comparative productivity record of Germany vis-à-vis Britain and the US by looking at the sectoral performance.

(i) Agriculture

Broadberry [1997b] has argued convincingly that contrary to conventional wisdom, the originated not so much in manufacturing but rather in agriculture and services contributed desicively to Germany's productivity catching-up. While free trade in agricultural products had reduced Britain's share of employment in agriculture already in the mid-19th century, German agricultural protectionism since the 1870s preserved an inefficient structure of peasant smallholdings in the West and overstaffed "junker" estates in the East. The dragging effects of these policies on the modernisation of the German econ-

[1] On the skewed modernization of Germany's machinery park during World War II see Tooze [2003].

omy and society have been a constant theme in German historiography, see e.g. Borchardt [1991/1977]. The figures provided by Hoffmann [1965] for agriculture have been criticized by Fremdling [1988]. Alternative calculations produced by von der Decken and Wagenführ [1935] suggest lower levels of German agricultural output up until 1935. In comparative perspective, then, productivity in German agriculture comes out even lower. Results are shown in Table 2.

(Table 2 about here)

Table 2 is again an exercise in conditional convergence. The Hoffmann data would picture a relative decline of German agriculture, interrupted by the autarky policies of the 1930s. According to the alternate estimate, German agriculture remained stalled at slightly more than 50% of U.K. and U.S. productivity levels, again with a spike in 1935. What becomes visible in these estimates is Germany's subsistence farming with its necessarily high degree of hidden unemployment. Sharply increasing agricultural protection after 1933 combined with material incentives for farmers to increase output and bring their produce to the market, see e.g. Corni [1990]. Still, the effects on material and biological living standards seem doubtful, as argued by Baten and Wagner [2003].

(ii) Mining

Beginning in the 1860s, German mining experienced a transition from iron ore and non-ferrous metals to coal and potash, both in relative and absolute terms. While Hoffmann's index puts stronger weight on the latter categories, the older Wagenführ [1933] calculations account more completely for the older, declining subsectors of mining. As a result, they exhibit slightly lower growth rates. Table 3 calculates these data into a productivity comparison with Britain and the United States.

(Table 3 about here)

Naturally, the relative positions fluctuate somewhat, owing to the strong cyclical dependence of mining and the lack of synchronicity of national business cycles. Averaging over Germany's rising coal and lignite mining and her declining traditional mining industries, not much of a trend relative to Britain is visible. Germany's territorial losses of 1920 contributed to an output decline with apparently some effects on productivity. Still, German mining apparently maintained its productivity status relative to Britain. Both countries together lost ground relative to U.S. mining, which greatly gained in productivity through its rich oilfields.

(iii) Construction

Before World War I, German construction industry benefited from generally high economic growth, where growth rates of GNP oscillated around 4-5% per year. The Wagenführ data reflect veritable housing booms in the German economy around 1905 and again in 1911, followed by busts in 1908/09 and again in 1913. Construction in the Weimar Republic never attained the same levels. Hyperinflation until 1923 eroded private capital formation and hampered long-term credit throughout the inter-war period, and privately financed residential construction remained low throughout the 1920s. Holtfrerich [1991] has highlighted the strong role of the public sector in stabilizing the ailing construction sector. Ritschl [2002] calculates a public share in construction of over 50% during the 1920s. Activity in this sector suffered badly from the depression after 1929. During the recovery after 1933, construction was one of the main playing fields of publicly managed work creation, Silverman [1998]. To maximize the number

of workers put back into employment, work creation would often heavily restrict the use of machinery. After 1936, the labor service resorted to conscription and was gradually converted into a paramilitary organization working for military purposes. Again, the effects on productivity were less than favorable. In international comparison, Germany's inter-war depression in construction is clearly visible; it is even more pronounced in the Wagenführ data we use here (Table 4).

(Table 4 about here)

Rearmament in Germany during the 1930s also affected the quality of its industrial statistics. Fremdling and Staeglin [2003] report from archival research that German published industry statistics attempted to hide sensitive armament industries in other categories. The industry census of 1936 lists 1220 million employed in "construction and other branches of industry", see the data in Reichsamt für wehrwirtschaftliche Planung [1939, p. 86]. Unpublished archival documents from the Statistical Office reveal that this total includes about 167 thousand employed in aircraft and firearms industry. This is a third larger than Germany's motor industry at the same time (which casts some doubt on the interpretation of German recovery as a story about cars and roads, as in Overy [1975]. Table 5 provides the details.

(Table 5 about here)

Thus, both output and employment in construction are overestimated by the 1936 benchmark. Subtracting output and employment from the sector total does not change productivity much. Hence, the productivity benchmark used in Broadberry [1997a] is

apparently not affected. What is affected, though, is the backward extrapolation in Table 4. Around the benchmark, output is overestimated relative to the extrapolation by about 10 percent. Correcting, we arrive at the numbers in italics in Table 4.

Manufacturing

Discrepancies also exist between Hoffmann [1965] index of production in manufacturing and the figures of Wagenführ [1933]. While Hoffmann's index is widely used in international comparisons, German standard sources commonly rely on Wagenführ, whose work from the 1930s also formed the basis for the official index of industrial production on a 1936 basis. As laid out in Ritschl [2004], these figures may be preferable to the alternative index of Hoffmann [1965], as the latter appears to overstate output in metal-working industry by a wide margin. Hoffmann's procedure for this sector is to infer output indirectly from employment and wages, assuming the wage share to be constant over time. In this way, he arrives at output estimates that differ strongly from contemporaneous evidence on output and employment in these sectors as well as of iron consumption. Correcting for this bias, Ritschl [2004] finds that for the 1920s, most of the discrepancy between Hoffmann's and Wagenführ's data for the inter-war period disappears. In what follows, we will follow an alternative route and work from the Wagenführ series directly. Table 6 compares both output indices on a 1913 basis.

(Table 6 about here)

As evidenced by the official figures, German output suffered severely during the immediate post-war period, which was characterized by social unrest, failed revolution, occupation of the Ruhr, hyperinflation, and a beerhall *putsch* (see Feldman [1993]). Given

these starting conditions, recovery between 1923 and 1929 was actually remarkable: manufacturing output more than doubled over those six years, equivalent to annual growth at an average rate of 13.9 percent. Calculated on a constant territory basis, manufacturing output in inter-war Germany actually recovered almost to British levels. Table 6 also provides the manufacturing data from Hoffmann. At a first glance, this series reproduces the British evidence: just as in Feinstein's data for manufacturing, output in 1929 is 22% higher than in 1913. However, on a post-war territory basis, this would have implied output growth to over a third beyond the 1913 level, which would almost resemble American data. However, the official output figures seem fully consistent with other data on the German economy at the time. Table 7 compares sectoral evidence from Britain and Germany on industrial output and transport volumes.

(Table 7 about here)

What comes out even more clearly than in previous research is Germany's industrial failure in the inter-war period. German economic historians have spent time and effort describing Weimar as a "sick economy", plagued by low business investment, high degrees of labour market intervention, and previously unknown degrees of macroeconomic instability. German steel output in the inter-war years follows the general pattern of relative industrial decline that we found already in the previous tables. Largely, this is due to the territorial changes of 1920, which reduced Germany's steel-making capacity by about 40%. Evaluated on constant territory, German steel industry hardly performed worse than its British counterpart.

The decline in German steel making carried over to machine building, tied to heavy industry through the backward and forward linkages typical of German iron and coal. Table 7 reproduces estimates of shipbuilding and machinery. We note that the British counterparts of these sectors hardly fared better. Losers in German industry also included clothing, brewing, and paper; here the performance of their British counterparts is remarkably better. Last in Table 7, data on railway freight volumes are provided. This sector had been several times more dynamic than industrial output before World War I. In the inter-war period, it shared the relative decline of German manufacturing. Apparently, the aftermath of World War I operated very much like a class ceiling on the German economy: in an extremely volatile economy, output during most of the time fell far short of pre-war levels, and hardly ever increased beyond that. No doubt, the Weimar Republic was doomed to fail.

As in the previous tables, we splice our revised series to the benchmark estimate for 1935. Relative to 1935, the picture does not change much for the inter-war period. However, we do obtain a markedly higher productivity of the German economy before World War I. The productivity lead apparently emerged some time before the turn of the century, and is particularly strong for 1911, which is also the peak of Germany's pre-war construction boom. West Germany reached a similarly high productivity lead over Britain only in the 1970s.

(Table 8)

Table 8 also offers an alternative estimate that extrapolates the same data from a different benchmark, viz., the comparative productivity estimate by Broadberry [1997] for

1911. To be compatible with a moderate productivity lead over Britain on the eve of World War I, German manufacturing productivity in 1935 would have to be at 85% of Britain instead of the 102% obtained by Broadberry and Fremdling [1990].

There may indeed be reasons why German productivity may be overstated by the Broadberry/Fremdling benchmark. Industrial statistics as well as the 1936 census regularly covered only two thirds of industrial employment. The employment shortfall is particularly pronounced in textile industry, where less than a third of employment at population census years is captured. Given the particular prominence of small-scale *Handwerk* (the traditional trades) or *Mittelstand* (family-owned firms) businesses in the German economy, industry census data of productivity are likely to be upward biased. Similar problems may of course pertain to the annual industry employment figures taken from Feinstein [1972], however probably to a lesser extent. The compromise estimate in Table 6 assumes that comparative productivity in the sectors not covered by the censuses is 10 percent below the benchmark. This tends to lower the German productivity lead somewhat.

The results appear to re-establish conventional wisdom: since the turn of the century, German manufacturing pulled ahead of Britain quite remarkably, only to lose its productivity advantage in the inter-bellum period. While it has now become common to view Germany's catching-up as a process originating from the steady loss of employment in agriculture rather than from manufacturing, our results do not find much change in the relative position of agriculture before World War II. Without much change in the aggregate, the sectoral evidence suggests that prior to World War I, German mining, manufacturing, and construction indeed pulled ahead of Britain quite clearly, while ag-

riculture continued to lag behind. The catching-up through rapidly declining employment shares in agriculture set in only after World War II.

However, we notice that most of the variance in the data is generated, not by the British but rather by the German data. The evidence examined in this section paints the picture of rather growth in the British economy around a satisfactory steady state. In contrast, the German economy exhibits wild swings in both output and productivity, and converges back to near-steady state growth only in the 1970s.

V. On coal and iron: the manufacturing figures across World War I

It is now time to check into the reliability of the two different manufacturing series underlying the previous calculations.

(Table 9)

In Table 9, note the remarkable similarity between Hoffmann's and Wagenfuehr's data on coal and steel production. This effect is not preserved when passing on to metal-processing and aggregate industry. As Hoffmann's figures bear out, coal and steel production in Germany had not yet recovered to their pre-war levels in 1935, while at the same time, he shows output of the industries using steel as an input to have increased by more than two thirds over the 1913 level. In contrast, Wagenfuehr's estimates of machine building remain rather conservative for the inter-war period. This picture would look somewhat more optimistic especially when the more expanding auto industry were

accounted for. Preliminary calculations that we made do however indicate that we are still far below Hoffmann's enthusiastic figures.

Upon closer examination, Hoffmann's estimate of metal-working output turns out to be an estimate from the distribution side. Net value added in that sector is calculated from employment in that sector times a wage estimate, assuming the wage share to be constant for all years from 1851 to 1959 [Hoffmann, 1965, p. 357]. While this assumption is clearly justified under Cobb-Douglas conditions with full employment, it seems less defensible for lower rates of factor substitution and with varying degrees of capacity utilisation.

Across World War I, the wage share may indeed have moved upward systematically. Broadberry and Ritschl [1995] find evidence on this effect for Germany and Britain during the mid-1920s. In fact, wage pressure and lack of productivity growth in Germany during the 1920s is the main theme of a whole debate centered around the work of Borchardt [1979/1991]. Hence, the assumption of constant wage shares in e key sector of German industry across World War I is less than innocuous. To the extent that the wage share is underestimated by this procedure, the output estimate is driven upwards. Hence, it should exhibit a structural break across World War I with respect to the unknown "true" index of industrial production. Ritschl [2004] evaluates Hoffmann´s index of production in metal-processing industry against other contemporary evidence and argues that between the wars, activity in that sector is grossly overstated by Hoffmann´s index.

In the following we will employ a more indirect method of evaluating the validity of Hoffmann's calculations. In the medium run, one should expect the relation between steel production and aggregate industrial activity to be fairly stable, probably exhibiting a trend. If our working hypothesis is correct and Hoffmann's index overstates industrial activity between the World Wars, there should be a structural break in the relation between steel production and industrial output across World War I (Table 10).

(Table 10)

As Hoffmann's series of metal-processing and aggregate industry seem to take off after World War I, we include a dummy variables in the regressions of Table 9 in order to see if there is a structural break in the regressions across World War I. The results show a systematic difference across the estimates: while for Wagenfuehr's estimates, there is no such structural beak, it comes out significantly in the regression of Hoffmann's estimates.

In Table 10, each of the two rivalling indexes has been subjected to regression three times. First, we regress either index on steel production and the deterministic trend components indicated in the table (1) and (4). Note that the coefficients of the steel-making variable are very close to each other. In Hoffmann's index, there is a positive structural break across World War I; it is significant at the 95% confidence level. In contrast, there is no evidence of such a structural break in the Wagenfuehr series, which means that the structural parameters of this regression remain unchanged across World War I.

The next group of estimates, (2) and (5), excludes construction, activities which may be correlated to the steel-making cycle but do not belong to manufacturing in the proper sense. As can be seen from the table, results get even sharper now: in Hoffmann's index there is now an even more pronounced structural break across World War I, while no such change occurs in Wagenfuehr's data.

This result remains unaffected by excluding steel-making from either index, as shown by estimates (3) and (6). This correction we applied in order to eliminate the spurious correlation that might arise from the fact that steel-making itself is a component of the index of industrial production. As can be seen, however, results remain largely unaffected. Still, there is a strongly significant, positive relation between steel-making and industrial production. In Hoffmann´s index, it is disrupted by an upward jump in the aggregate index across World War I, while no such upward jump is present in Wagenfuehr's indices.

As a last check, we regress the indices of Hoffmann and Wagenfuehr directly on one another. Under our working hypothesis, the only major difference between the two should be precisely the structural upward shift across World War I that became visible from the previous regressions. Once again, we choose the adjusted index measures as our standard where construction and steel-making itself have been eliminated. The result, shown in column (7), is indeed consistent with our hypothesis, as there is a strong and significant structural break and a trend is absent. Note also that the regression constant is insignificant and that the coefficient on Wagenfuehr's index is equal to unity: Statistically speaking, both indices are largely identical, except for a structural break across the First World War that shifts the Hoffmann data upwards exogenously.

Drawing the evidence of this section together, there is an upward jump in the level of Hoffmann's index of industrial production, which is largely spurious. Comparing the index to steel production, we see a structural break across World War I, which does not obtain in the Wagenfuehr data collected and elaborated at the time. Hence, the backward extrapolation of the Hoffmann data from the 1935 benchmark is likely to underestimate German comparative productivity in the years prior to World War I.

VI. Conclusions

Recent research has established that, Germany's catching-up to Britain and the US was largely driven by declining shares of employment in its least productive sectors like agriculture, whereas catching-up in manufacturing productivity only played a minor role. In this paper we have examined descriptive and econometric evidence on time series of output in various different sectors of the German economy in order to re-examine this hypothesis.

Our conclusions appear to lean again towards the old orthodoxy. We identify the source of Germany's catching up to be a productivity spurt in manufacturing between 1900 and World War I. During this period, German steel output tripled and thus widened the heavy industry base of the German economy, creating forward linkages to machine and shipbuilding, which were of high military priority.

Across World War I, we see the German economy suffering a major productivity shock. This view is probably consistent with conventional historiography: Economically speaking, Allied victory in World War I was an economic success, if only a transitory one.

Germany lost considerable parts of her most profitable coal and steel capacities and was also deprived of the advantages of inter-regional specialisation patterns that these industries had built up before. As our data bear out, by 1936 German heavy industry had not yet recovered to the levels of 1913, which was one of the motivations for Hitler's Four Years Plan. - As Nazi autarky policies attempted to expand capacities on the existing territory, this may explain why the coal and steel shock striking the German economy after World War II was apparently much less persistent.

Our results are consistent with the traditional views on German industrial advantage before World War I. They also fit well in the German debates on low productivity and high wage aspiration levels during the Weimar years. Given that Germany's coal and steel capacities had been diminished deliberately after World war I and that forced coal exports continued to diminish the energy base of the German economy for some more years, our evidence of a downward productivity should probably not be too surprising. Further research in this field should be directed towards establishing more reliable benchmark estimates for the pre-war period, including a careful re-examination of the employment series used for Germany and a more than superficial look at the balance of trade of the German economy at the time.

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Figure 1: German GDP Per Capita in Constant Prices

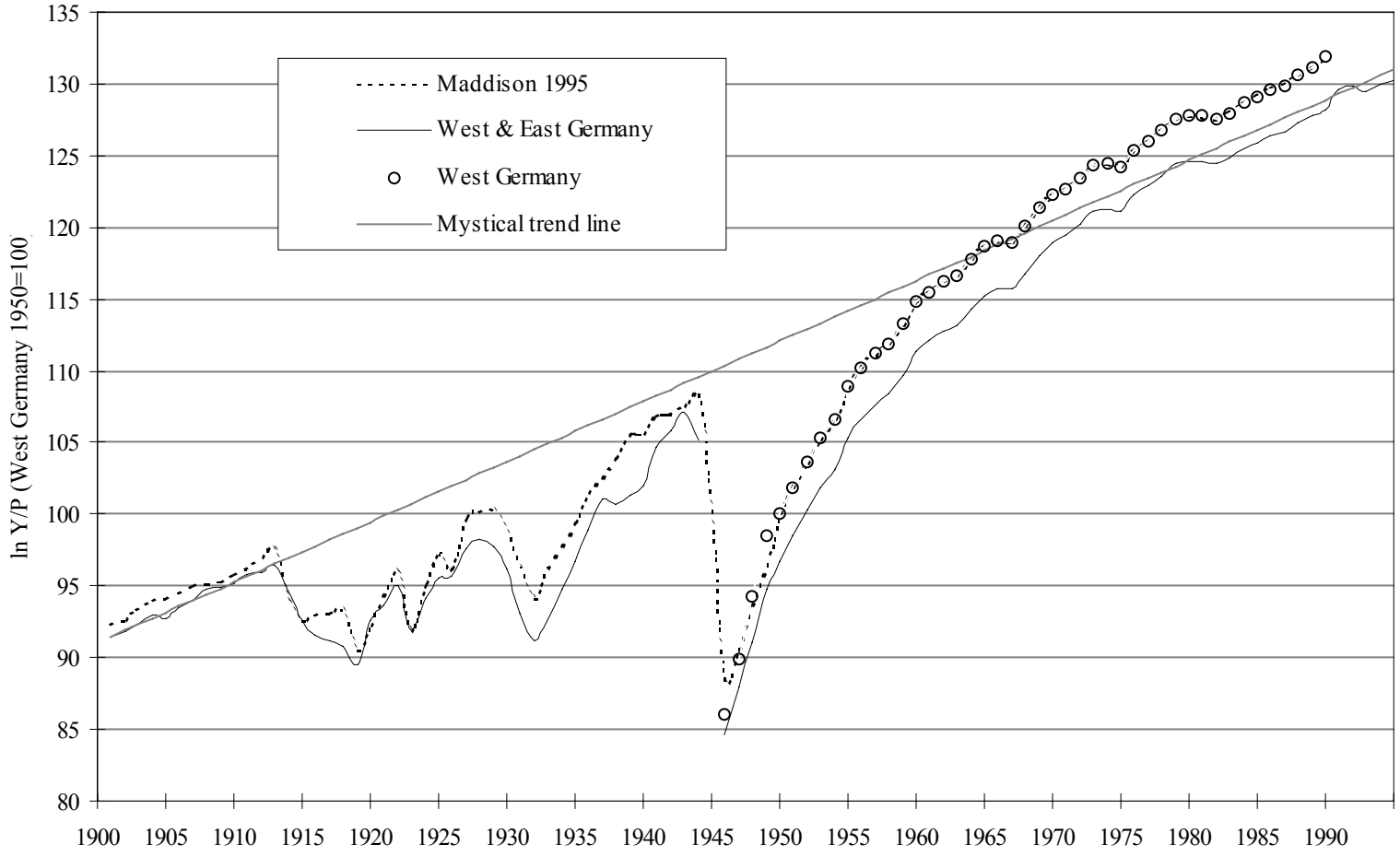

Figure 2: Growth of GDP Per Capita in Britain and Germany, 1901-1993

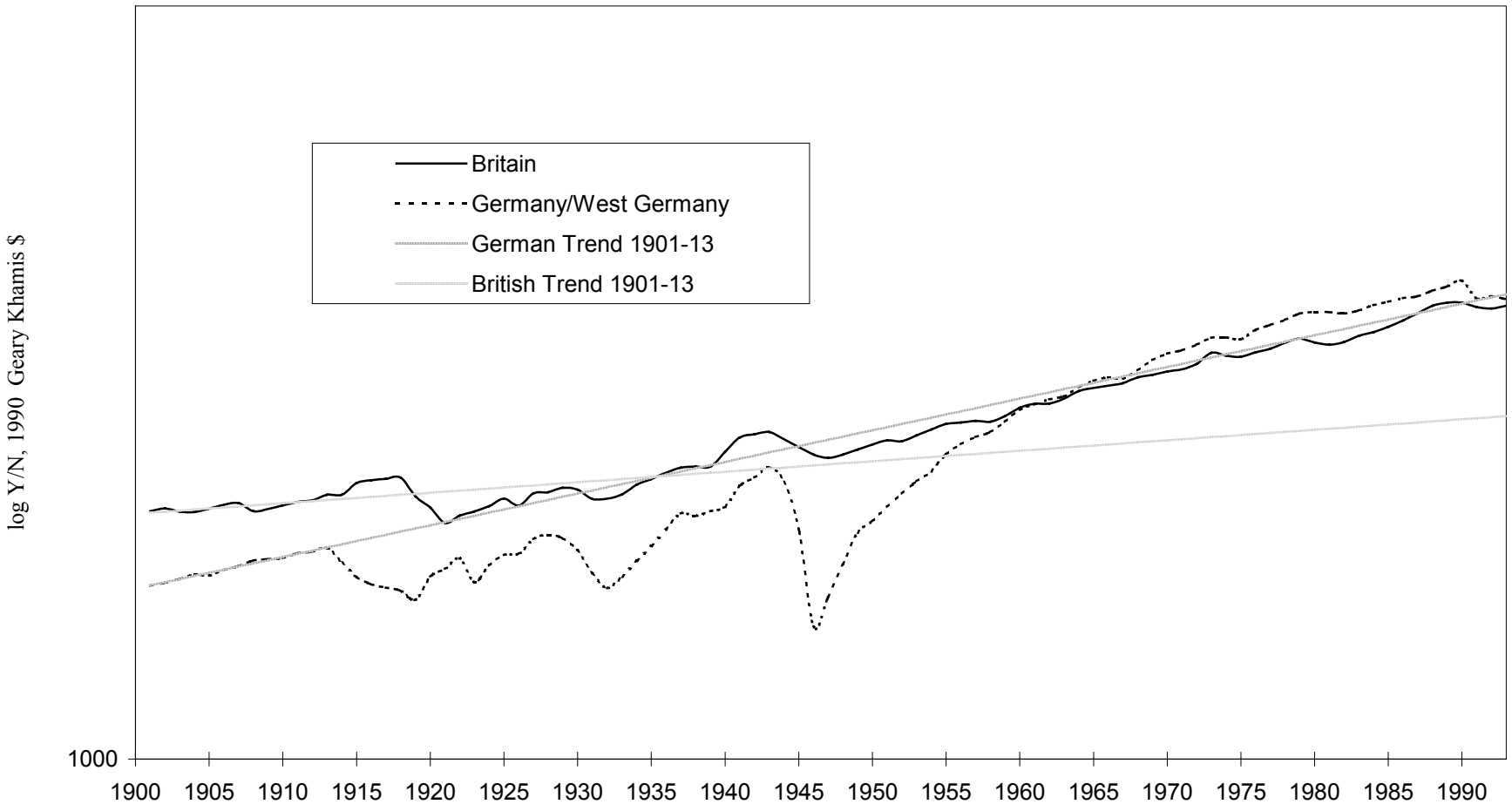

Figure 3: Productivity in German Coal Mining by District

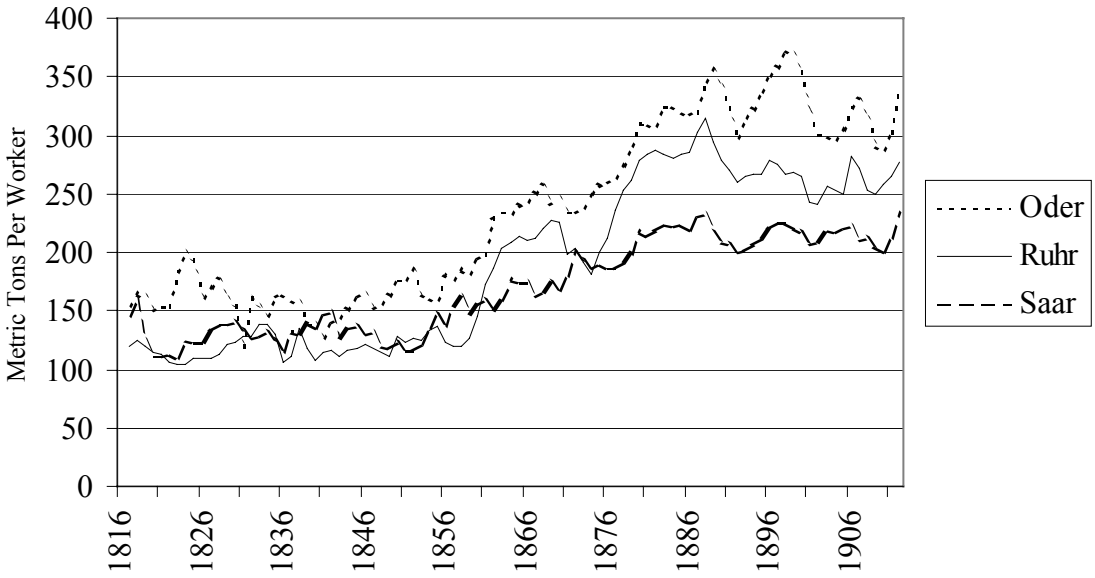

Table 1: GDP per person employed in Germany (D) relative to UK and US

(per cent)

	Original			Revised	
	D/UK		D/US	D/UK	D/US
	I	II		Revised	Revised
1871	59.6	59.5			
1881		57.3			
1891		60.5			
1901		68.4		**66.8**	
1911		75.5		**76.9**	
1913	78.3		67.8	**76.1**	**64.3**
1925		69.0		**74.7**	
1929	78.8	74.1	56.7	**77.3**	**50.5**
1935		75.7		**69.9**	
1938	82.6		63.3	**77.8**	**54.6**
1950	65.8	74.4	42.8	**65.8**	**42.8**
1973	111.7	114.0	74.1	111.7	74.1

Source: Calculated from Maddison [1995], Broadberry [1997a], Spoerer and Ritschl [1997]

Table 2: Agricultural Productivity in Germany (D) relative to the UK and the US

	D/UK	D/UK revised	D/US	D/US revised
1901	67.2	53.7	63.2	50.5
1911	67.3	57.3	65.2	55.5
1925	53.8	54.7		
1929	56.9	57.6	51.9	52.5
1935	70.6	70.6	68.3	68.3
1950	41.2	41.2	32.7	32.7
1960	47.8	47.8	31.2	31.2

Source: Calculated from Broadberry [1998],
von der Decken and Wagenfuehr [1935]

Table 3: Productivity in Mining in Germany (D) relative to the UK and the US

	D/UK	D/UK revised	D/US	D/US revised
1881	72.1	112.3	72.6	113.1
1891	80.9	101.0	74.2	92.6
1901	86.4	115.4	58.7	78.4
1911	101.2	107.1	62.5	66.1
1925	106.8	103.4		
1929	116.4	113.0	46.8	45.4
1935	123.6	123.6		
1950	92.4		24.5	24.5
1960	132.1		21.4	21.4

Source: Calculated from Broadberry [1998], Wagenfuehr [1933]

Table 4: Productivity in Construction in Germany (D) relative to the UK and the US

	D/UK	D/UK revised	D/US	D/US revised
1901	98.8 *108.7*	115.4 *127.0*	70.7 *77.8*	82.6 *90.9*
1911	117.7 *129.5*	124.6 *137.1*	59.3 *65.2*	62.8 *69.1*
1925	65.7 *72.3*	63.6 *70.0*		
1929	50.2 *55.2*	48.7 *53.6*	37.5 *41.3*	36.5 *40.1*
1935	70.6	70.6		
1950	84.2	84.2	47.4	47.4
1960	102	102	43.3	43.3

Source: Calculated from Broadberry [1998], Wagenfuehr [1933]

Slanted figures are relative to adjusted 1935 benchmark

Table 5: Employment in armament industries included in residual category of 1936 census

1936 "other industries"	# of establishments	Employment	RM Wage bill	Gross sales
		- 1000 -	- mill. RM -	
Firearms	93	22.3	39.2	73.9
Aircraft engines	16	38.2	79.1	275.2
Aircraft cells	58	107.3	231.8	610.3
Aircraft industry total	74	145.5	311.0	883.0 **
All "other industry" total	167	167.9	350.1	959.4
For comparison: motor vehicles	91	110.1	264.0	636.5

**: Gross output far exceeds 1 bn RM

Source: German Federal Archives, R3102/3028.

Table 6: Output in German manufacturing, 1901-1935

	1913=100					rebased to 1935=100		
	Wagenführ/Official			Hoffmann		Wagenführ/ Official		Hoffmann
	I	II				I	II	
1901	58.1			58.3		56.6	*54.6*	47.5
1907	75.4							
1911	90.2			90.4		88.0	*84.8*	73.7
1920	51.0 *		*56.1* +					
1923	48.9 *		*53.8* +					
1925	90.3		*99.3* +	104.6	*115.1* +	88.0	*84.9*	85.3
1929	106.4		*117.0* +	122.8	*135.1* +	103.8	*100.0*	100.1
1935	102.5	*106.3*	*112.8* +	122.7	*135.0* +	100.0	*100.0*	100

Source: Calculated from Broadberry [1998],
Wagenfuehr [1933], *IfK Wochenberichte* , various issues.
Data exclude construction, mining, and public utilities.
*including construction
+constant territory

Table 7: Output in Britain and Germany, 1913-35, selected sectors

	Steel			Shipbuilding		Mechanical Engineering		Clothing		Food Drink (F & D)			Paper and Printing		Railway freight volumes
	GB	D	D*	GB	D	GB	D	GB	D	GB	GB	D	GB	D	D
1913	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1925	96.4	72.0	104.9 *	44.8	61.3	110.0	66.9	85.5	65.6	125.3	72.6	76.8	134.8	105.1	79
1929	125.7	96.4	140.5 *	70.2	55.2	116.7	97.5	94.5	61.0	142.7	72.0	92.7	153.9	130.3	83
1935	128.6	95.7	118.5 *	37.8	48.0	106.6	80.2	103	66.5	182.9	69.7	92.1	174.8	129.4	

Calculated from Feinstein [1972], Mitchell (1988), Wagenfuehr [1933], *IfK Wochenberichte* , various issues.

* constant territory

Table 8: Productivity in Manufacturing in Germany (D) relative to the UK and the US

	UK rel. to	Germany relative to			
	UK 1935	Germany 1935	UK 1935	**UK same year**	
	(i)	(ii)	(iii)	(iv)	(v)
1891	45.4				
1895	*49.1*	55.7	56.8	**115.6**	***95.6***
1901	55.2	65.5	67.7	**122.6**	***101.3***
1907	*62.5*	78.8	80.3	**128.5**	***106.2***
1911	64.5	89.6	91.4	**141.7**	***117.1***
1925		77.1	78.6		
1929	87.3	89.7	91.5		
1935	100	100	**102**	**102**	***84.3***

Sources and Methods:

(i) Manufacturing output calculated into employment, from Feinstein [1972].
1895 and 1907 values interpolated

(ii) Output as in Table 6, employment from Hoffmann [1965].

(iii) 1935 benchmark from Broadberry and Fremdling [1990].
Entries for other dates from (ii), spliced to 1935 benchmark.

(iv) = 100 * (iii)/(i), comparative productivity extrapolated from 1935 benchmark.

(v) = 100 * (iii)/(i), comparative productivity extrapolated from 1911 estimate in Broadberry [1997].

Table 9: German output of coal and steel compared to indices of industrial production

1913=100

	Coal		Steel		Metal-working	Machine Building		
	Hoffmann	Wagenfuehr	Hoffmann	Wagenfuehr	Hoffmann	Wagenfuehr	Hoffmann	Wagenfuehr
1901	57,10	57,10	32,00	33,80	45,30	39,50	58,70	64,90
1911	84,60	83,40	83,00	79,30	85,20	82,60	90,70	96,00
1925	69,80	69,52	69,80	71,98	131,40	66,89	103,40	84,33
1929	86,00	85,95	92,50	96,40	170,30	94,92	121,40	102,64
1935	75,20	75,08	93,20	95,72	163,90	80,15	121,20	97,46

Sources: Hoffmann (1965), Wagenfuehr (1933), Wagemann (1935)

Table 10: Steel Productivity and the Index of Industrial Production

OLS, 1890-1938 annual. All data in logs

	Hoffmann			Wagenfuehr			Hoffmann vs. Wagenfuehr
	Index	Index w/o Construction	Index w/o Construction and Steelmaking	Index	Index w/o Construction	Index w/o Construction and Steelmaking	Index Aggregate (Hoffmann)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	2.3015 (0.0841)*	2.4111 (0.0886)*	2.5044 (0.0889)*	2.7310 (0.0712)*	2.5931 (0.0880)*	2.6764 (0.0880)*	-0.0001 (0.2058)
Steelmaking (Hoffmann)	0.4828 (0.0292)*	0.4549 (0.0311)*	0.4380 (0.0311)*				
Steelmaking (Wagenfuehr)				0.4225 (0.0295)*	0.4185 (0.0305)*	0.3976 (0.0305)*	
Aggr. Index (Wagenfuehr)							1.001 (0.05488)*
Dummy	0.1262 (0.0564)+	0.2396 (0.0620)*	0.2713 (0.0621)*	0.0237 (0.0749)	0.0006 (0.0696)	-0.0322 (0.0695)	0.3034 (0.0558)*
Trend	0.0046 (0.0023)a	0.0041 (0.0025)	0.0035 (0.0025)	-0.0021 (0.0031)	0.0025 (0.0029)	0.0029 (0.0029)	0.0001 (0.0023)
N	38	38	38	38	32	32	31
adj. R^2	0.9862	0.9869	0.9864	0.9702	0.9604	0.9554	0.9886
DW	1.0472	1.0552	0.9867	0.8589	0.9526	1.0118	0.7213