Relative U.K./U.S. Output Reconsidered: A Reply to Professor Broadberry

MARIANNE WARD AND JOHN DEVEREUX

In the September 2003 issue of this JOURNAL, we provided benchmark comparisons of U.K./U.S. income from 1870 to 1990.[1] In contrast to long-span projections from Angus Maddison and others, our estimates show the United States leading from 1870 in terms of income per capita and output per worker.[2] In a 12-page comment that accompanies our article, Professor Stephen Broadberry criticizes our work on three grounds.[3] First, he charges our estimates are inconsistent with his U.K./U.S. sectoral productivity comparisons. Second, he chastises us on the grounds that our price benchmarks conflict with standard U.S. and U.K. price indices. Finally, he queries our nominal GDP estimates.

In reply, we provide new GDP comparisons based on sectoral productivity data for 1870, 1890, and 1910. As it turns out, Broadberry understates U.S. productivity for the key sectors of agriculture, construction, and trade by up to 100 percent.[4] After adjusting his estimates, we find that U.K./U.S. GDP implied by sectoral productivity data accord with our direct estimates. Next, we show Broadberry's criticisms of our price data stem from his misinterpretation of the methodology of international comparisons. Our price benchmarks compare price levels across space at a point in time. Broadberry, however, uses our price data to compare price levels over time.[5] This leads him to misread disparities between domestic price indices and our U.K./U.S. price levels. We also address his concerns regarding our nominal GDP estimates.

SECTORAL PRODUCTIVITIES

Broadberry begins his comment with a discussion of sectoral productivity drawing on his earlier work.[6] He claims his U.K./U.S. sectoral labor productivity estimates support the long-span U.K./U.S. projections over our direct estimates. We agree with Broadberry that it is important to reconcile our direct estimates with his sectoral comparisons. This section provides our reconciliation.

The appendix provides U.K./U.S. sectoral comparisons for overall GDP as well as for the nine sectors considered in Broadberry's 1997 article: agriculture, mining,

The *Journal of Economic History*, Vol. 64, No. 3 (September 2004). © The Economic History Association. All rights reserved. ISSN 0022-0507.

Marianne Ward is Assistant Professor, Department of Economics, Loyola College in Maryland, 4501 North Charles Street, Baltimore, Maryland, 21210-2699. E-mail: mward3@loyola.edu. John Devereux is Professor, Department of Economics, Queens College and the Graduate Center, CUNY, Flushing, New York, New York, 11367-1597. E-mail: Jdevereu@qc.edu.

We would like to thank Michael Edelstein, Knick Harley, Alan Heston and Leandro Prados de la Escosura for valuable comments and suggestions. The usual disclaimer applies.

[1] Ward and Devereux, "Measuring British Decline."

[2] Maddison, *Monitoring the World Economy* and *World Economy*.

[3] Broadberry, "Relative Per Capita Income Levels."

[4] Broadberry, "Forging Ahead" and "How did the United States."

[5] Broadberry, "Relative Per Capita Income Levels."

[6] Broadberry, "Relative Per Capita Income Levels," "Forging Ahead," and "How did the United States."

https://doi.org/10.1017/S0022050704003018 Published online by Cambridge University Press

TABLE 1
COMPARING AGRICULTURAL OUTPUT
(United States = 100)

Year	Current Price U.K. Output per Worker ($)	Current Price U.S. Output per Worker ($)	Relative Current Price Output per Worker Y_{uk}/Y_{us}	Our Benchmark		Broadberry's	
				Relative Farm Gate Prices p_{uk}/p_{us}	Calculated Real Output per Worker U.K./U.S. y_{uk}/y_{us}	Implied Relative Farm Gate Prices p_{uk}/p_{us}	Real Output per Worker U.K./U.S. y_{uk}/y_{us}
1870	281	369	76	148	52	66	115
1890	248	262	95	156	61	97	98
1910	276	496	56	107	52	58	97
1950	1,396	3,115	45	94	48	57	79

Notes and Sources:

Nominal Value added per agricultural worker: United States: We take the U.S. estimates for nominal value added in 1870 and 1890 from Gallman, "Commodity Output," p. 43. His estimates refer to 1869 and 1889. We project them to 1870 and 1890 using growth in nominal GDP from Gallman as reported in Rhode, "Gallman's Annual Output Series," p. 33. See also the notes to Table 3. We take nominal value added in 1910 from U.S. Bureau of the Census, *Historical Statistics,* pp. 483–84 using K265 through K278. The agricultural labor force is from Lebergott, *Manpower*, p. 510. Nominal value added per agricultural worker in 1950 is from Paige and Bombach, *Comparison,* p. 19.

United Kingdom: Nominal value added in agriculture and the agricultural labor force in 1870, 1890 and 1910 are from Feinstein, *National Income*. Nominal value added is from T60 and the agricultural labor force is from T131. Nominal value added per agricultural worker in 1950 is from Paige and Bombach, *Comparison,* p. 19.

U.K./U.S. Farm gate prices. We use prices for wheat, barley, oats, hay, flax, hops, potatoes, milk, beef, mutton, and pigmeat. The benchmarks use U.K. gross output weights. U.K. prices for 1870, 1890, and 1910 are from Ojala, *Agriculture*, pp. 193–208, where prices are projected to benchmark years using Sauerbeck wholesale prices. U.S. prices are from Towne and Rasmussan, "Farm Gross Product," pp. 281–312; and Barger and Landsberg, *American Agriculture*, pp. 332–51. The U.K./U.S. Farm-gate price level in 1950 is from Paige and Bombach, *Comparison,* p. 21. The Broadberry estimates for 1870–1950 are from Broadberry, "Forging Ahead," table 3, p. 7.

manufacturing, construction, trade, transportation, public utilities, finance/services, and government.[7] As it turns out, Broadberry overstates U.K./U.S. output levels for agriculture, trade, construction, and transportation. After adjusting his estimates, the sectoral data provide powerful support for our direct estimates.

The problems with Broadberry's estimates are best seen for agriculture, which is central to U.K./U.S. productivity comparisons. Table 1 presents estimates of U.K./U.S. agricultural labor productivity in nominal and real terms for 1870, 1890, 1910, and 1950. Columns 2 and 3 give nominal U.K. (Y_{uk}) and U.S. (Y_{us}) value added per agricultural worker in U.S. dollars obtained from standard sources. Column 4 shows the ratio of U.K./U.S. value added per worker at market exchange rates, (Y_{uk}/Y_{us}). The United Kingdom has lower nominal value added for all years.

We provide U.K./U.S. farm-gate price level benchmarks (p_{uk}/p_{us}) in column 5. These are direct comparisons of U.K./U.S. farm-gate prices. As we would expect, the

[7] Broadberry, "Forging Ahead."

https://doi.org/10.1017/S0022050704003018 Published online by Cambridge University Press

United Kingdom has substantially higher farm prices before 1910. They are 50 percent higher in 1870 falling to 7 percent above U.S. prices in 1910. The levels and trends in our U.K./U.S. farm prices in Table 1 are consistent with other evidence on food price gaps for the 1870–1910 period.[8]

We use the price benchmarks to calculate relative real output per worker in column 6, (y_{uk} / y_{us}). The results show U.S. output per worker at double U.K. levels for most years.

Column 8 gives Broadberry's estimates of U.K./U.S. real output per worker.[9] He derives his estimates by extrapolating Lazlo Rostas's 1937 agricultural benchmark with domestic output indices.[10] In contrast to our results, he finds the United Kingdom with a 15-percent lead in 1870. Labor productivity is roughly equal in 1890 and 1910 and the United States has a 20-percent lead in 1950. Column 7 gives the relative farm-gate price levels implied by his estimates. Remarkably, they imply U.K. farm-gate prices are 70 percent of U.S. levels in 1870 and 60 percent in 1910. This is impossible given the United States is an agricultural exporter.

Thus, Broadberry's estimates for agriculture appear to be off by a factor of up to 100 percent.[11] Two conclusions follow. First, his projections yield flawed measures of relative output per worker for agriculture.[12] Second, he must overstate overall output per worker for the United Kingdom (relative to the United States) for 1870 and 1890 by a considerable margin.[13]

There are also problems with Broadberry's U.K./U.S. output levels for trade, construction, and transportation.[14] In each case, he overstates U.K./U.S. output levels. The appendix provides our direct benchmark estimates of U.K./U.S. GDP per worker.

Table 2 pulls together estimates of U.K./U.S. output per worker from the various methodologies. The first column compares output per worker using market exchange rates. In nominal terms, U.S. output per worker is higher for all years. The second column gives output per worker derived from Maddison's long span GDP estimates.[15] These show the United States with a slight lead in 1870 and 1890.[16] The United States is well ahead in 1910 and 1950.

[8] See O'Rourke and Williamson, *Globalization.*

[9] Broadberry, "Forging Ahead."

[10] Rostas, *Productivity*.

[11] Broadberry, "Forging Ahead."

[12] What explains these differences? First, Broadberry ("Forging Ahead," p. 7) relies on Rostas (*Productivity*), who appears to underestimate U.K./U.S. output per worker for 1937, see Clark, *Conditions*, p. 244. Broadberry (ibid., pp. 27–31) also checks his agricultural projections against agricultural benchmarks for 1870, 1890, and 1910. His nominal value-added estimates are close to ours for 1870 and 1890. For 1910, he uses output per worker for Great Britain ($378) rather than the United Kingdom ($276). In addition, his U.S. value-added estimates ($347) are lower than ours ($496). Finally, Broadberry provides agricultural PPPs for 1870 and 1890 based on wheat prices. His estimates imply a U.K./U.S. price level of 1.25 for 1869–1871 and 1.16 for 1889–1891. Leaving aside the merits of a PPP based on one commodity, we find larger gaps for wheat prices. More generally, Patrick O'Brien and Leandro Prados de la Escosura ("Agricultural Productivity") outline the difficulties in projecting sectoral productivities for agriculture over long spans.

[13] Correcting agriculture and leaving all Broadberry's other sectoral estimates unchanged leads to a U.K./U.S. output per worker of 81 for 1870 as compared to his estimate of 108.

[14] Broadberry, "Forging Ahead."

[15] Maddison, *Monitoring the World Economy* and *World Economy*.

[16] Our long-span estimates of U.K./U.S. output per worker are higher for 1870 than Maddison's, (*World Economy*) as we adjust his U.S. labor force estimates; see Ward and Devereux, "Measuring British Decline," p. 841. Maddison, *World Economy*, p. 349, shows the United Kingdom as ahead for 1870.

https://doi.org/10.1017/S0022050704003018 Published online by Cambridge University Press

TABLE 2
COMPARATIVE U.K./U.S. OUTPUT PER WORKER
(United States = 100)

	Exchange Rate	Long-Span Comparison	Direct Comparison	Sectoral Comparison
1870	65	94	70	72
1890	68	99	70	75
1910	53	83	71	67
1950	32	62	46	52

Notes and Sources: 1870, 1890, and 1910: U.S. Nominal GDP is from Rhode, "Gallman's Annual Output Series," table 3. See Table 3 in this note for more details. U.K. nominal GDP is from Feinstein, *National Income*, table 12, compromise estimate. Exchange rates are from eh.net at http://eh.net/hmit/ exchangerates/pound.php. Employment estimates for the United States are from Lebergott, *Manpower*, table A-1. U.K. employment estimates are from Feinstein, *National Income*, table 55, column 5.

The long-span comparison is from Maddison, http://www.eco.rug.nl/~Maddison/, along with the employment estimates detailed above. The direct comparison is derived from the GDP benchmarks in Ward and Devereux, "Measuring British Decline," and the employment estimates detailed above. Note our direct GDP benchmarks in "Measuring British Decline," are for 1872, 1891, and 1905. We project them to 1870, 1890, and 1910 with U.K. and U.S. GDP volume indexes. The U.S. estimates for 1870–1890 are from Rhode, "Gallman's Annual Output Series," table 2; and the estimates for 1910 are from Kendrick, *Productivity Trends*, table A-IIa. The U.K. estimates are from Feinstein, *National Income*, table 18, column 4. The sectoral comparisons are from the Appendix.

1950: The exchange rate, direct comparison, and sectoral comparisons are from Paige and Bombach *Comparison*, pp. 15–21. There are slight differences between their estimates and those in Ward and Devereux, "Measuring British Decline," table 6, which use revised nominal GDP and employment. To allow comparison with Paige and Bombach, we use their nominal GDP and employment.

The next column provides the direct estimates derived from our article and criticized by Broadberry.[17] In contrast to Maddison's estimates, they show the United States with a commanding lead in terms of output per worker from 1870.[18] The final column gives U.K./U.S. GDP per worker derived from the sectoral productivity estimates presented in the Appendix. After adjusting Broadberry's estimates, the sectoral estimates show U.K./U.S. output per worker that is similar to our direct estimates.[19] Broadberry claims that sectoral comparisons conflict with our direct comparisons of U.K./U.S. GDP.[20] In fact, they provide powerful independent confirmation of our work.

[17] Ward and Devereux, "Measuring British Decline," and criticized by Broadberry, "Relative Per Capita Income Levels."

[18] Maddison, *Monitoring the World Economy* and *World Economy*.

[19] Broadberry, "Forging Ahead." Paige and Bombach (*Comparison*, p. 112) discuss why sectoral productivity estimates tend to be favorable to the United Kingdom. The U.S. lead in output per capita is smaller due to lower labor force participation ratios; see Table 3.

[20] Broadberry, "Relative Per Capita Income Levels."

https://doi.org/10.1017/S0022050704003018 Published online by Cambridge University Press

RELATIVE U.K./U.S. PRICE LEVELS

Next, Broadberry questions the validity of our price data.[21] We will use this section to reply to his criticisms. We will then move to a general discussion of differences between direct and long-span estimates. At this point, it worth reminding our readers that we provide comparisons of U.K./U.S. real GDP at isolated points in time where U.K./U.S. nominal GDP is deflated using price comparisons based on goods and services that are directly comparable *between* the United States and the United Kingdom in each benchmark year. This is the standard procedure in the international comparison literature from Milton Gilbert and Irving Kravis to the present.[22] Such price comparisons across space are distinct from price comparisons *over time* in either the United States or the United Kingdom such as the CPI or the GDP deflator.[23]

Our U.K./U.S. price level benchmarks are for 1872, 1874, 1878, 1884, 1891, 1905, and 1930. For 1872 to 1891, we rely on a series of surveys associated with Carroll D. Wright.[24] For 1905 and 1930, we use the Board of Trade and International Labor Organization studies.[25] As far as possible, we tried to ensure our benchmarks covered broadly similar areas of consumption, that is food, rent, and so on at each point in time. Yet the price data differ across each benchmark in terms of compilation methods, coverage, and the specification of goods sampled.[26] This means that any comparison of price levels over time for the United States or the United Kingdom using our data is invalid.[27] Likewise, our benchmark comparisons of U.K./U.S. GDP do not allow us to determine U.S. or U.K. growth rates in isolation.

Broadberry's criticisms of our price data show his failure to grasp these fundamental points.[28] He devotes most of his comment to using our price data to compare price levels across time forming CPIs, GDP deflators, and domestic output indexes for the United States and the United Kingdom. He argues our price data are flawed as he finds differences between his new indexes on one hand, and U.S. and U.K. domestic CPIs, GDP deflators, and output indexes from standard sources.[29]

[21] Ibid.

[22] Gilbert and Kravis, *International Comparison*.

[23] Dalgaard and Serensen ("Consistency," pp. 6–7) provide a recent discussion of the conceptual differences between international comparisons over time and those across space.

[24] Wright pioneered field data collection techniques used in international comparisons when he served as the Chief of the Massachusetts Bureau of Statistics of Labor and later as the U.S. Commissioner of Labor. His work on international comparisons pre-dates the Board of Trade by 30 years. Furthermore the Board of Trade's mandate to collect retail price and wage statistics appears to have been the result of similar work completed in the United States under Wright's direction. See Phelps Brown and Browne, "Carroll D. Wright," pp. 279–81.

[25] These studies do not cover all of consumption nor do they cover investment. We fill these categories from other sources, see Ward and Devereux, "Measuring British Decline," pp. 830–31.

[26] There are similarities between our surveys for 1872, 1874, 1878, and 1884. Indeed our U.S. data for 1872, 1874, and 1878 are from the Weeks report used in the U.S. CPI. There are, however, large differences between these price data and those for 1884, 1891, 1905, and 1930.

[27] For example, we form the 1891 price benchmark using 89 items as opposed to 33 items for the 1905 price benchmark. Furthermore the quality of the items compared is not constant across the benchmarks. Finally, we do not provide U.K. or U.S. clothing prices for each year rather we provide U.K./U.S. relative price indices.

[28] Broadberry, "Relative Per Capita Income Levels," does not reference the huge literature on international comparisons.

[29] Broadberry (ibid.) never discusses our price data. This is surprising given the lengths we go in our article to emphasize that we relied on price data collected specifically for purposes of international comparison. Furthermore, Broadberry refers to the "Ward and Devereux price in-

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There are two points to consider. First, our data are completely ill-suited for use in the manner that Broadberry uses them.[30] To repeat, our price data are to provide comparisons across space at a point in time. They cannot be used to compare prices over time. Second, contrary to Broadberry's claims, the differences between the growth-rate differentials implied by our benchmarks and national accounts data for the United States and the United Kingdom are not unusual. They are to be expected in all international comparisons. Robert Summers and Alan Heston, for example, discuss this point in reference to the Penn World Tables[31]:

> One should expect a problem to arise from working with intertemporal (national accounts) and interspatial (ICP) data sets that appear to view country-time interrelations in the same way but in fact do not. The problem at hand in part is one of merging different data sets not based on identical prices and goods. . . In fact the two data sets are far from being perfectly in accord. In many cases, a country's standings in consecutive benchmark studies—at the level of GDP or its components—imply a growth rate between the benchmarks years that differs significantly from the growth rate embedded in the constant price series of the country's national accounts.

Recently, such differences are documented in detail in reference to the various benchmarks studies of the OECD and Eurostat.[32] These differences have spurred research to identify procedures for reconciling the benchmarks with national accounts data, a process that is seen as essential to improving the comparability of national accounts.[33]

There is an important general point to be made here about the inevitability of some conflict between long-span and direct U.K./U.S. comparisons. It is well known in the literature that using national accounts data to project any benchmark international comparison of relative GDP to other years yields differences between other benchmark levels and the projected levels. The point to note is that these differences are not symptoms of problems with price data. Rather, they are an empirical reality that must be addressed by economic historians in any effort to develop consistent space-time international comparisons.

It is clear that work towards reconciliation of our pre-1950 benchmarks and national accounts data will be a fruitful area for future research. It is one that we plan to pursue. A comparison of our consumption benchmarks with the U.S. and U.K. CPIs provides some initial explanations for such differences. First, there are differences in weighting and coverage. Our benchmark weights are for overall consumption whereas the U.K. and U.S. CPIs use working-class weights. There are also large differences in coverage. For instance, the U.S. CPI does not cover travel or services and it covers alcohol only

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dex." It should be clear that we compare prices across space. We do not provide domestic price indices and we never intended our data for use in this fashion.

[30] We are not aware of any work prior to Broadberry, ibid., that uses the Board of Trade or ILO data to estimate inflation rates for either the United States or the United Kingdom. Nor are we aware of cases where researchers use data from the benchmarks of the International Comparison Project to compute inflation within an economy. One reason for Professor Broadberry's inappropriate use of our data is that we did not have the opportunity see his work prior to publication. Although he widely circulated his comment, we learned about it when it appeared next to our paper.

[31] Summers and Heston, "Penn World Table," p. 340.

[32] Varjonen, "Consistency," pp. 3–5 and 12–13, documents these differences for GDP and its components in 1993, 1996, and 1998. The differences are often large.

[33] See for example, Heston and Summers, "What can we Learn"; Aten and Heston, "Benchmark Reconciliations"; and Varjonen, "Improving the Quality."

https://doi.org/10.1017/S0022050704003018 Published online by Cambridge University Press

after 1890. As a result, price benchmarks will equal extrapolations from other price benchmarks only by chance. It seems fair to point out that Broadberry seems oblivious to such matters.[34]

NOMINAL GDP

Finally, Broadberry is unhappy about our nominal GDP.[35] We compared U.K./U.S. GDP using conventional measures of nominal GDP. Again this is the standard procedure in the literature. Broadberry, however, believes our nominal GDP estimates are flawed. As we understand it, his argument is that because we provide new price indices for each country we are also obliged to change nominal GDP. Broadberry and Douglas Irwin provide a clear statement of this principle in a recent working paper where they state[36]:

> To a large extent the value of nominal GDP in historical income accounts is obtained by reflating volume indicators using limited price information. If the price information set is expanded, it is appropriate to calculate new estimates of nominal GDP. It is incorrect to leave nominal GDP unchanged and to use the new price information to derive different estimates of real GDP.

Broadberry's comments reveal his misunderstanding of our methodology and, more generally, of the methodology of international comparisons.[37] To belabor the point made previously, we do not present new price indices for either economy. Rather we present U.K./U.S. comparative price benchmarks. As discussed earlier, our price data cannot be used to compare domestic price changes over time.

We are, however, grateful to Broadberry for drawing our attention to the general issue of nominal GDP and in particular to the U.S. data. The U.S. estimates before 1929 stem from the work of Simon Kuznets as extended by John Kendrick and Robert Gallman.[38] Gallman provides the most complete series.[39] He builds his GNP series using nominal flows for commodity-producing sectors from William Shaw's estimates in producer prices.[40] Next he applies distributive and transportation mark ups along with estimates for services to obtain GNP in final prices. Only then does he form his real GNP series using deflators prepared by Dorothy Brady.[41] The Gallman nominal

[34] Broadberry, "Relative Per Capita Income Levels."

[35] Ibid.

[36] Broadberry and Irwin, "Labor Productivity," p. 16.

[37] Broadberry, "Relative Per Capita Income Levels." Furthermore, his comments would seem to apply equally to the Penn Tables and the various benchmarks of the International Comparison Project. To accept his points would cast doubt on all international expenditure comparisons.

[38] Kuznets, *National Product* and *Capital*, as extended by Kendrick, *Productivity Trends*; and Gallman, "Gross National Product."

[39] Broadberry ("Relative Per Capita Income Levels") restricts his comments to Kuznets, *NationalProduct* and *Capital.* Gallman, "Gross National Product," is, however, the basis for subsequent work, see Rhode, "Gallman's Annual Output Series," pp. 15–16. As Rhode emphasizes, Gallman did not construct his series for analysis of business cycle issues. We do not see this as a problem in our work.

[40] Shaw, *Value*.

[41] Brady, "Price Deflators." We agree with Broadberry ("Relative Per Capita Income Levels") about the frailties of the data on nominal GDP for early periods particularly with regard to estimates for nonbenchmark years. On the other hand, it is not clear to us why interpolation

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TABLE 3
U.K./U.S. BENCHMARKS WITH REVISED U.S. NOMINAL GDP

	U.K./U.S. Real GDP Per Capita		U.K./U.S. Real GDP Per Worker	
Year	Ward and Devereux†	New Estimates	Ward and Devereux†	New Estimates
1872	85	86	63	64
1874	85	92	65	71
1878	79	82	66	69
1884	77	78	69	69
1891	82	79	70	68
1905	82	82	75	74

† Ward and Devereux, "Measuring British Decline."

Notes and Sources: U.S. Nominal GNP: Rhode, "Gallman's Annual Output Series," table 3. GNP including inventory changes. Please refer to Rhode, ibid., for cautions as to the use of these series. In particular Rhode asks users to realize that "*these data were not constructed for analysis as annual series."* We follow Balke and Gordon, "Estimation," note 1C to adjust Gallman's government spending. We also adjust Gallman from GNP to GDP. U.K. Nominal GDP, U.K. and U.S. population, U.K. and U.S. labor force, and U.K./U.S. price levels are from Ward and Devereux, "Measuring British Decline," tables 5 and 6.

series is thus conceptually a nominal series. It is therefore appropriate for our purposes.

On the other hand, more recent U.S. GDP estimates of Christina Romer and of Nathan Balke and Robert Gordon follow different procedures.[42] To keep our sources consistent with Maddison's, we took U.S. nominal GDP for the late nineteenth century from Balke and Gordon's work.[43] Prompted by Broadberry's concerns, we now believe it is better to use Gallman's nominal series, which are available for 1870 to 1909 from Paul Rhode.[44] Table 3 shows that this modification in no way changes the central findings of our article.

SUMMING UP

In our article we used U.K./U.S. price-level benchmarks to derive new estimates of U.K./U.S. output per worker and income per capita from 1870 to 1990. Broadberry challenges our estimates on the grounds they are inconsistent with his U.K./U.S. sectoral productivity comparisons, that they conflict with U.S. and U.K. price indices, and that we mismeasure nominal GDP. In regard to his first point, our findings accord with estimates based on sectoral data when we adjust the estimates in Broadberry's earlier pieces.[45] We have also shown that his second and third criticisms arise from his mis-

methods should systematically bias the estimates of nominal GDP in a particular direction for purposes of international comparison.

[42] Both Romer, "Pre-War Business Cycle"; and Balke and Gordon, "Estimation," accept the long-run trends in the Gallman series but they adopt different procedures to estimate noncommodity production. Furthermore, Balke and Gordon use new interpolators and a different GDP deflator. As a result, their series for nominal GDP do not correspond conceptually to the Gallman series.

[43] Maddison, *Monitoring the World Economy* and *World Economy*; Balke and Gordon, "Estimation."

[44] Rhode, "Gallman's Annual Output Series."

[45] Broadberry, "Forging Ahead" and "How did the United States."

https://doi.org/10.1017/S0022050704003018 Published online by Cambridge University Press

understanding of our methodology. In sum, we find nothing in Broadberry's note to suggest our original conclusions were mistaken.

Appendix: Sectoral Comparisons

This appendix provides U.K./U.S. sectoral comparisons from 1870 to 1950 for overall GDP as well as for the nine sectors considered by Broadberry: agriculture, mining, manufacturing, construction, trade, transportation, public utilities, finance/services, and government.[46] The first panel in Appendix Table 1 gives Broadberry's estimates of real output per worker.[47] These are projections from his 1937 benchmark.

We provide new estimates of sectoral productivity in the second panel. In contrast to Broadberry's estimates, our estimates are built around direct comparisons of output rather than projections.[48] We have already discussed our agricultural benchmarks. To compare output per worker in construction, we use relative nominal value added and a price benchmark of building wages and input prices. For transportation, we compare costs per passenger mile and per ton-mile. For trade, we form estimates of the quantity of goods flowing through wholesale and retail channels. For manufacturing, mining and public utilities, we accept Broadberry's estimates.[49] Finally, we assume that labor productivity is equal for finance/services and government.[50]

Our U.S. labor productivities are higher for each of agriculture, construction, distribution, and transport. The new estimates have striking implications for overall U.K./U.S. output per worker. It is now below the United States for all benchmark years. It is 72 percent of U.S. levels in 1870. Although it increases to 75 in 1890, it falls back to 67 in 1910. By 1950, it is down to 50 percent of U.S. levels.

[46] Broadberry, "Forging Ahead."
[47] Ibid.
[48] Ibid. See Ward and Devereux, "New Benchmark Estimates," for the complete details.
[49] Broadberry, "Forging Ahead.
[50] Although this assumption is not ideal, it is widely used in the literature. Replacing our estimates for these sectors with those of Broadberry, "Forging Ahead," has a small impact on overall GDP per worker.

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APPENDIX TABLE 1
COMPARATIVE OUTPUT PER WORKER
(United States = 100)

	1870	1890	1910	1950
		A: Broadberry†		
Agriculture	115	98	97	79
Mining	97	92	62	27
Manufacturing	55	52	49	38
Construction	105	61	50	56
Trade	149	103	83	74
Transportation	91	60	46	29
Public Utilities	179	88	67	17
Finance/Services	156	188	128	90
Government	88	97	104	86
Total GDP	108	93	76	60
		B: Our Benchmarks		
Agriculture	52	61	52	48
Mining	97	92	62	n/a
Manufacturing	55	52	49	37
Construction	78	63	40	67
Trade	71	64	63	56
Transportation	75	58	53	30
Public Utilities	179	88	67	n/a
Finance/Services	100	100	100	78
Government	100	100	100	100
Total GDP	72	75	67	52

† Broadberry, "Forging Ahead."

Notes and Sources: *Benchmark Sectoral Labor Productivity*: We take the sectoral estimates in the first panel from Broadberry, "Forging Ahead," table 3, p. 7. Total GDP in the first panel is calculated using the sectoral implicit price levels from Broadberry, "Forging Ahead," table 3 along with housing prices from Ward and Devereux, "Measuring British Decline," table 2. They thus differ slightly from the estimates in Broadberry, "Forging Ahead," table 3.

In the second panel our benchmark estimates for mining, manufacturing and public utilities are also from Broadberry, "Forging Ahead," table 3. We calculate the sectoral productivities for agriculture, construction and transportation using U.K./U.S. nominal value added per worker and U.K./U.S. sectoral price levels. *Agriculture* is explained in Table 1. *Construction* relative prices are obtained using the price index for construction described in Ward and Devereux, "Data Appendix," pp. 11–12. *Transportation* relative prices are measured using a Fisher ideal price index for price per passenger and per ton-mile. U.S. data are from Fishlow, "Productivity," table 1, p. 585. Mitchell and Deane, ***Abstract*,** provides U.K. data, table 5, p. 225. We assume that the average freight journey for the United Kingdom is 52 miles and that the average U.K. passenger journey is 10 miles. U.K./U.S. sectoral productivities in *Trade*:We use the U.K. margins from Jefferys and Walters, "National Income," as reported in Feinstein, *National Income*, p. 15. For the United States, we adopted a comparable procedure using Barger, *Distribution's Place*, table 26, p. 92. We assume U.S. and U.K. labor productivities are equal for *Finance/Services* and *Government*.

1950: All sectoral productivities are from Paige and Bombach, *Comparison*, pp. 15–21. Their estimates for mining and public utilities are not comparable to benchmarks for other years so we omit them.

https://doi.org/10.1017/S0022050704003018 Published online by Cambridge University Press

APPENDIX TABLE 1 — continued

Nominal Value Added per Worker: United States: 1870 and 1890, Gallman, "Commodity," table A-1, p. 43; and Gallman and Weiss, "Service," table A-1, p. 307, and table A-4, p. 312. Their estimates refer to 1869 and 1889. We project them forward using nominal GDP growth rates from Gallman in Rhode, "Gallman's Annual Output Series"; see also notes to Table 3. 1910: Agriculture is from Table 1. U.S. Historical Statistics for value added in mining and manufacturing using P4 and M4. The other shares are projections from the 1890 benchmark. We take employment estimates from Gallman, "Commodity," table 6; Gallman and Weiss, "Service," table A-12; Lebergott, *Manpower*, table A-1, and *Americans*, table 7.3; and U.S. Bureau of the Census, *Historical Statistics*, D159–165. 1950. Paige and Bombach, *Comparison*.

United Kingdom: 1870 to 1910: Rough estimates are derived from Feinstein, *National Income*, table T208; and Mathews et al., *British Economic Growth*, table 8-1, pp. 221–32. We checked these estimates against Deane and Cole, *British Economic Growth*, table 37, p. 166. 1950: Paige and Bombach, *Comparison*, pp. 15–21. We take employment estimates from Feinstein, *National Income*, table 60.

Overall Nominal GDP per worker: United States: Gallman from Rhode, "Gallman's Annual Output Series," see table 3. United Kingdom: compromise estimate from Feinstein, *National Income*, T12-13.

Overall Labor Productivity 1870–1910: We combine sectoral productivities using the information on nominal sectoral value added plus housing with rents from Ward and Devereux, "Measuring British Decline." Finally, we calculate overall GDP per worker as the geometric average of output per worker at U.S. and U.K. prices.

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