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NEW COMPARATIVE ECONOMIC HISTORY †

Made in America? The New World, the Old, and the Industrial Revolution

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The Industrial Revolution in Britain coincided with victory over the French in a struggle for world domination. After more than a century of combat, in 1815 Britannia finally ruled the waves. The British used that mastery to gain access across the globe to raw materials and export markets. British trade with both the New World and the Old escalated.

Earlier histories of the Industrial Revolution linked military success, the expansion of trade, and the onset of modern growth (e.g., H. John Habakkuk and Phyllis Deane 1963). More recent accounts, however, starting with Joel Mokyr (1977), have emphasized, in contrast, its "home grown" nature. Technological advances in cotton textiles, iron and steel, and transport generated within Britain lie at its core (e.g., Nicholas F. R. Crafts 1985; Mokyr 2005). The struggle for world domination, for colonies and markets, was of secondary importance. As Robert P. Thomas and Deirdre N. McCloskey (1981, 102) memorably noted, "Trade was the child of industry." This consensus has been in turn challenged by Kenneth Pomeranz (2000). In his "coal and colonies" interpretation of the Industrial Revolution, Britain, and not China, had an Industrial Revolution in part because Britain had access to the raw materials of the New World, while China did not.

This paper sets out to test, with a formal computational general equilibrium (CGE) model, the role of trade with the New World, and trade itself, in explaining the growth of productivity and income in Industrial Revolution Britain. We find, to our surprise, that the New World mattered little, even by the 1850s. Had the Americas not existed, the Industrial Revolution would still have looked much as it did in practice. There were ready substitutes for the cotton, sugar, corn, and timber of the New World in Eastern Europe, the Near East, and South Asia.

However, had all trade barriers been substantial—if, say, a victorious France had cut off Britain's access to overseas trade—then British history would have been very different. British incomes per person, instead of rising by 45 percent between the 1760s and 1850s, would have risen by a mere 5 percent. The total factor productivity (TFP) growth rate, already a modest 0.4 percent per year, would have fallen to 0.22 percent per year.

The magnitude, scale, and transforming power of the Industrial Revolution lay in its unification of technological advance with the military power that generated easy British access to the markets of Europe, the Americas, the Near East, and the Far East. As Ronald Findlay and O'Rourke (2007) emphasize, trade in a mercantilist world was not just the product of comparative advantage, but of comparative advantage married to the musket and the cannon. Britain's trading partners gained, however, along with Britain from the forced opening up of trade. A substantial share of the British TFP gain over these years was exported as cheaper manufactures to the rest of the world (Clark 2007).

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I. The Model

We ask what Industrial Revolution Britain would have looked like had trading opportunities with North America (and the Caribbean), or the rest of the world, been removed. We could use a simple Britain-only model and impose counterfactual trade levels, but as Nancy L. Stokey (2001) notes, this approach is limited; absent detailed disaggregation it says nothing about cotton textiles, and absent other regions and the terms of trade, it says nothing about income and welfare. Our preferred tool is a three-region world economy model, for two benchmark periods, 1760–1769 and 1850–1859, the start and end of the Industrial Revolution. The model thus extends the two-region Industrial Revolution models developed by Crafts and C. Knick Harley (Harley and Crafts 2000).

The CGE model is fully described by two sets of information. The first is an accounting matrix for each region listing, for each sector, the value of goods produced, imported, and exported—and hence the domestic demand for those goods—and also the cost structure (inputs of primary factors and intermediate goods). The sectors are cotton textiles; other textiles; iron and steel; coal; agriculture; tropical raw materials; tropical food; and the rest of the economy. The factors are land, labor, and capital. All factors are region-specific but mobile across sectors (although land is used only in agriculture, tropical raw materials, and tropical food). The intermediate inputs accounted for by this model are: coal into iron and steel; agricultural products into other textiles and coal; and tropical raw materials into cotton textiles and other textiles (and, for the 1850s, into agriculture and the rest of the economy as well).

The three regions are England (1760s) and later Britain (1850s); North America (including the Caribbean); and the "Rest of the World" (including Ireland). Trade is assumed costless. Goods produced in each region are assumed to be imperfect substitutes for each other, which allows two-way trade in the model. Imports and exports for each commodity are thus broken down by source and destination. Tropical raw materials and foods are produced in North America and the rest of the world, but not in Britain. The regional production and trade matrices fully describe the static benchmark equilibrium.

The second thing we need is a set of elasticities that describe the response of the economy to perturbations. Sectoral production is modelled as a Leontief combination of intermediate inputs and a value-added aggregate. Value added is in turn a constant elasticity of substitution (CES) aggregate of the primary inputs. The elasticities of substitution in each sector are similar to those used by Harley and Crafts (2000): elasticities are 1 (Cobb-Douglas) in cotton textiles, other textiles, iron and steel, coal, and the rest of the economy; elasticities are 0.5 in agriculture, tropical raw materials, and tropical food. Consumption is modelled by assuming a representative agent in each region, endowed with all primary factors of production in that region, and spending all her income on a composite utility good (the production of which thus serves as a welfare indicator). The utility good is produced by a CES utility function, with all eight commodities as inputs, and an elasticity of substitution of 0.5.

What consumers consume, and what sectors use as intermediate inputs, are actually aggregates of the different varieties of each commodity produced in each of the three regions. These 24 Armington aggregate consumption goods, one for each sector and region, are again CES combinations of the three varieties of the relevant commodity. Values of the Armington elasticities of substitution used for each commodity are close to those used by Harley and Crafts: we used values of 5 for cotton textiles, iron and steel, and coal; 2 for "other textiles" and the rest of the economy; and 100 for agriculture. The Armington elasticities for tropical raw materials and food are particularly important for the counterfactuals experiments we conducted, and we consider these separately below.

II. Calibration and Counterfactuals

The sources of the data for the model are described in detail in Clark, O'Rourke, and Taylor (2008).

Using estimates of expenditure, imports, and exports for each of the eight goods in England/Britain, the value of the production of each good could then be inferred. Next, based on our estimates of factor shares and intermediate costs shares, we were able to compute the input-output structure and the value of payments to factors in each sector, and thus in the aggregate. These

factor payments equal total expenditure. For simplicity, we impose balanced trade, although our results do not depend on this.

North American final expenditure in each period on each good was assumed to be the same per capita, and so is a simple multiple of British expenditure, scaling by population relative to England/Britain. For the rest of the world, we assumed that incomes per person relative to England were the same in the 1760s, and were 40 percent of the British level by the 1850s. In the rest of the world, we imposed a pattern of final consumption with the following weights: cotton textiles, 0.02, other textiles, 0.04, iron and steel, 0.01, coal, 0.001, temperate agriculture, 0.375, tropical agriculture, 0.375, rest of the economy, 0.18. Thomas Ellison's discussion of cotton consumption in India in the 1850s suggests this probably leads to an underestimate of cotton and cotton goods production in the rest of the world, even though it implies that the rest of the world cotton industry was 5 times as large as in England (Ellison 1858, 73). Clark, O'Rourke, and Taylor (2008) describe how import and export data between each region, and production within the regions, were then constructed. Once again, factor incomes are assumed equal to expenditure, and trade was forced to be balanced.

Our interest is in evaluating the hypothesis that the British Industrial Revolution depended crucially on international trade—with North America, the rest of the world, or both. To test that, we impose three different counterfactual shocks on the model:

- "No NA": Reduce North American endowments by a factor of 20;
- "No ROW": Reduce rest of the world endowments by a factor of 20;
- "No NA/ROW": Reduce both sets of endowments by a factor of 20.

Note that we cannot entirely eliminate each region's endowments, since each region makes a differentiated product whose price would be infinite were its supply to be reduced to zero, but these endowment shocks provide a reasonable estimate of the gains from trade to the British economy that would have been sacrificed had trade been made almost impossibly costly.

The "No NA" shock permits us to grapple with the thesis of Pomeranz (2000) and see how critical were New World supplies of raw cotton to the rise of Lancashire. The "No ROW" shock allows us to see the importance of other major export markets for Lancashire's cotton products, as well as the role played by alternative suppliers of raw cotton like Egypt and India. In the remainder of the paper, we describe the results of these counterfactuals and how they challenge current interpretations of the Industrial Revolution.

III. Results

The results depend largely on trade patterns in the 1760s and 1850s (see Clark, O'Rourke, and Taylor forthcoming). Several differences between the two periods stand out. First, and most obviously, in the 1760s England was still a large net importer of cotton textiles from the rest of the world, which also exported textiles to North America. By the 1850s, Britain was a large net exporter of cotton textiles to both the other regions, thanks to the new technologies of the Industrial Revolution. Second, in the 1760s England was paying for her imports of food and tropical products primarily with net exports of "other" goods, and of woollens and other textiles. By the 1850s, exports of noncotton textiles had declined in relative importance: cotton textiles and exports of "other" goods were now relatively speaking far more dominant. A third point to note is that, in the 1760s, imports of tropical raw materials came predominantly from the rest of the world, while imports of tropical food came predominantly from North America. By the 1850s, imports of tropical raw materials from North America had considerably grown in relative importance, thanks to the boom in raw cotton exports, while the rest of the world was now more important than North America as a source of tropical food imports.

Both "tropical raw materials" and "tropical food" cover a wide variety of goods from many regions of the world. From the British point of view, a crucial question, had trade with North America been impossible, is how easily could the raw cotton crucial for the growing cotton textile industry have been provided by the rest of the world. The experience of the early 1860s, when Brazil, Egypt, and above all India sharply increased their exports to Britain in response

to the "cotton famine," suggests there would indeed have been a compensatory supply from the rest of the world, although not a perfectly elastic one, since British industry did suffer during the cotton famine.

In our model, the issue boils down to the size of the Armington elasticity of substitution between the tropical raw materials Britain was importing from North America and the rest of the world. We experimented with several values for this elasticity, as well as with the corresponding elasticity for tropical food. While the elasticity of substitution between New World sugar and Asian pepper, say, might not have mattered for the fortunes of British industry, it should have had an impact on British consumer welfare, in a counterfactual world in which Britain was prevented from trading with either of the two regions. In our benchmark specification, these elasticities are both set to 5, since these are the "upper end" Armington elasticities used by Harley and Crafts, but we also tried lowering the elasticities to 2, and increasing them to 100 (equivalent to making the different varieties of these goods almost perfect substitutes).

Consider first the effects of isolating England from its trading partners in the 1760s. For each of our three counterfactual scenarios, the model generated outputs in each sector; prices in each sector; nominal factor prices; the price of the utility good, which is equivalent to a consumer price index; nominal household income; real factor prices and household income; and utility (i.e., the output of the utility good). The most important point is that "eliminating" trade between England and North America would have had barely any effect on England. In the benchmark case, utility declines by less than 2 percent, with a modest real wage decline of 4.3 percent, a decline in real profits of 5.7 percent, and a rise in real land rents of 9.4 percent. Cotton textiles output would have gone down only barely: by just 1.1 percent, as compared with a decline in the output of other textiles of almost a tenth, the latter due to the disappearance of North American markets.

Removing the rest of the world would have had a bigger effect, since it was a much bigger region. Strikingly, "eliminating" trade between England and the rest of the world in the 1760s would have *increased* English cotton textile output by a third, since England was still a net importer of Indian cotton textiles. Similarly, English agricultural output would have expanded (by 8.8 percent) to replace food imported from the rest of Europe. As a result, all other sectors would have contracted, as resources were sucked away from them. Utility would have declined less than previously (1.7 percent), but with greater distributional shifts, since in the 1760s English imports of temperate climate agricultural products still came predominantly from Europe rather than from North America (or other continents). Thus, English landlords would have seen real incomes rise by over a quarter, while workers and capitalists would have seen real income declines of 7.9 percent and 10.6 percent, respectively.

Not surprisingly, "eliminating" both North America and the rest of the world has an even bigger impact on the other textiles sector, cutting it by over a quarter. Cotton textiles production would have increased by a quarter, and agriculture by 14.5 percent. Real rents increase by 44.9 percent, at the expense of real wages (down 13.9 percent) and real profits (down a fifth), but the aggregate utility effect would still have been surprisingly small (a decline of less than 4 percent). Finally, note that varying the Armington elasticities for tropical food and tropical raw materials would have barely changed the results.

The results are very different for the 1850s. "Eliminating" trade with North America in the benchmark case would have lowered cotton textiles output by 8 percent and other textiles output by a tenth. Cotton textiles output would have declined both because of the disruption to raw cotton supplies, and because of the loss of markets. On balance, the former effect seems to be more important, since the real price of British cotton textiles increases in this simulation. Furthermore, when the elasticity of substitution between tropical raw materials from North America and the rest of the world is lowered from its benchmark value of 5 to 2, implying that the rest of the world was less able to substitute for lost American raw cotton supplies, British cotton textiles output contracts by more (15 to 18 percent). On the other hand, if that elasticity is raised to 100, then the output falls by only 2 percent. Utility falls by between 1.6 percent and 3.6 percent, depending on the sizes of Armington elasticities chosen, with larger elasticities corresponding to lower welfare losses. While these are larger welfare effects than those calculated for the 1760s, they are still

modest. The rest of the world could have filled in for a missing North America, providing markets, raw materials, and tropical food products, thus minimizing the overall loss to the British economy. Once again, landlords would have gained by roughly 10 percent, at the expense of workers and capitalists.

On the other hand, the welfare loss is much greater—over 10 percent—when trade with the rest of the world, rather than North America, is "eliminated." Cotton textiles output contracts by over a third, as the foreign markets upon which Lancashire was increasingly dependent vanish. (Note the difference with the results for the 1760s: by the 1850s Britain was a net exporter of cotton textiles to India and the rest of the world, rather than a net importer.) Since the rest of the world mattered for the British cotton textiles industry more by providing markets than by providing raw cotton, it is not surprising that the two Armington elasticities highlighted earlier turned out to be essentially irrelevant for this counterfactual experiment. Consistent with Stokey (2001), the distributional effects of this shock are enormous, with real rents more than doubling, and real wages and profits declining by over a fifth. In terms of TFP performance, a decline of a third in the cotton textile sector would have lowered the economy-wide TFP growth rate by 0.06 percent per annum, or by 6 percent over the entire 1760s–1850s period (assuming unchanged sector-specific TFP growth rates).

Finally, "eliminating" all of Britain's trading partners would have had an even bigger effect on the economy, with utility falling by over 27 percent in the benchmark case (again, this result was invariant to changes in the two aforementioned Armington elasticities). This is an enormous effect in the context of a model with no increasing returns or other nonconcavities, and is much larger than previous estimates in the literature (for example, according to Harley (2004, 194), "Self-sufficiency in 1860 … would have cost Britain only … about 6 per cent of national income"). Cotton textiles output would have declined by almost three-fifths, implying a reduction in the economy-wide TFP growth rate of 0.11 percent, more than a quarter of the Industrial Revolution productivity growth rate, while real wages and profits would have declined by over a third. If we had been able to go further, and completely eliminate Britain's trading partners, the effects on economy-wide welfare and textiles output would obviously have been even greater (and the crucial cotton textiles sector would of course have vanished altogether). And ours may yet be a conservative estimate of hypothetical TFP losses, for if the dynamic cotton textiles sector had grown more slowly, then the incentives to innovate (or even passive "learning by doing" opportunities) might have been scaled down as well.

IV. Conclusion

While colonies were not required for an Industrial Revolution, supply-side TFP growth was not alone sufficient. In Smithian terms, in the nineteenth-century global "division of labor," it was the "power of exchanging" that "gave occasion" to the Industrial Revolution. The highly specialized British economy was extremely dependent on foreign trade by the 1850s.

It is worth emphasizing why the 1850s results are so different from those of the 1760s. This has nothing to do with model specification. The model is identical in both cases, as are all the embedded elasticities. The different results arise from the data fed into the model, which in turn reflect the profound shifts in the structure of the British economy during the Industrial Revolution. First, unbalanced productivity growth meant that British autarkic relative prices diverged from those in the rest of the world, implying much larger gains from trade. The cotton textiles sector became dependent on foreign markets for about 60 percent of its total sales. Second, British population growth meant that the island depended on foreign agriculture for both food and raw materials, implying that it needed to export a growing amount of manufactures to pay for these imports (Harley and Crafts 2000; Clark 2007).

As a famous Welsh economic historian put it, "How could this unprecedented swarming of people on a small, offshore island be made consistent with a rising standard of living? It was impossible on the fixed area of English cultivable land, whatever miracles English technological progress in agriculture might accomplish. The way out was for England (through a transportation revolution and international trade) to endow itself with the equivalent of a vast extension of its own land base" (Brinley Thomas 1985, 731).

In that context, by the mid-nineteenth century, the maintenance of an open international trading system was of vital strategic importance to Britain.

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