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Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economists Supporting Globalization

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Most noneconomists are fearful when an emerging China or India, helped by their still low real wage rates, outsourcing and miracle export-led developments, cause layoffs from good American jobs. This is a hot issue now, and in the coming decade, it will not go away.

Prominent and competent mainstream economists enter into the debate to educate and correct warm-hearted protestors who are against globalization. Here is a fair paraphrase of the argumentation that has been used recently by Alan Greenspan, Jagdish Bhagwati, Gregory Mankiw, Douglas Irwin and economists John or Jane Doe spread widely throughout academia.

> Yes, good jobs may be lost here in the short run. But still total U.S. net national product *must, by the economic laws of comparative advantage, be raised in the long run (and in China, too).* The gains of the winners from free trade, properly measured, work out to exceed the losses of the losers. This is not by mysterious fuzzy magic, but rather comes from a sharing of the trade-induced rise in total global vectors of the goods and services that people in a democracy want. Never forget to tally the real gains of consumers alongside admitted possible losses of some producers in this working out of what Schumpeter called "creative capitalist destruction."
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> Correct economic law recognizes that some American groups can be hurt by dynamic free trade. But correct economic law vindicates the word "creative" destruction by its proof [sic] that the gains of the American winners are big enough to more than compensate the losers.

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The last paragraph can be only an innuendo. For it is dead wrong about *necessary* surplus of winnings over losings—as I proved in my "Little Nobel Lecture of 1972" (1972b) and elsewhere in references here cited (see also Johnson and Stafford, 1993; Gomory and Baumol, 2000). The present paper provides explication of the popular polemical untruth.

Here Ricardian equilibrium analysis will presuppose no permanent loss of jobs either in China or America. Instead, it focuses on the vital question, "Will inventions A or B lower or raise the new market-clearing real wage rates that sustain high-to-full employment in both places?"

Act I(a) of the present paper first rigorously investigates by twenty-first century Ricardo-Mill analysis the following contrived scenario: In the autarky absence of any trade at all, China's precisely measured real income per capita is set at one-tenth of U.S. autarky real income. This for the reason that China's labor productivities are specified here to average out to only *one-tenth* those of the United States. Quasi-realistically, China's total labor population is posited here to be *ten* times that of the United States—so that in autarky any biasing effects of differences in total regional *size* can be kept out of the analysis. In this example, only a good 1 and a good 2 are involved. And, à la the young J. S. Mill, demand tastes are everywhere assumed to be the same: more precisely, consumers even-handedly always spend their disposable incomes 50-50 on good 1 and on good 2.

Despite the initial overall 10-to-1 superiority of the United States in *absolute* productivity, my example stipulates that in good 1, China's inferiority of productivity is much worse than one-tenth; in good 2 China's inferiority vis-a-vis the United States is not as bad as one-tenth. Differences in opinion make for horse-race bets. Differences in *relative* (!) geographical productivities between good 1 and good 2 explain the bounties from specialization and trade. *Vive les différences*!

In Act I(a)'s first part, geographical specialization and fair free trade are shown to happen to double exactly each place's measurable autarky real income. So far, a big brownie point for the economist debaters.

Act I(b) goes on to address how the United States and China will fare when Schumpeterian technical improvement in China has quadrupled her labor's productivity in good 2, which is the good that China has been exporting to the United States. In my stipulated example, China's average productivity still remains far below that of the United States. But, remember that so too are China's real wages far below the United States'.

In a nutshell, the new fair trade equilibrium must definitely create for the United States a better real net national product—better because we can buy our imports cheaper now. China's good 2 elevated productivity does also in my Mill-Ricardo scenario raise *her* real net national product; and it happens to do so equally with the United States—even though China's terms of trade do deteriorate somewhat, albeit not enough to lower China's per capita net national product when demand elasticity is Mill-like. Acts I(a) and I(b)'s valid numerical deductions are pluses for the economist proglobalization debaters.

Act II, however, deals some weighty blows *against* economists' oversimple complacencies about globalization. It shifts focus to a new and different kind of Chinese technical innovation. In Act II, China's progress takes place (by imitation or home ingenuity or . . .) in good 1, in which the United States has previously had a comparative advantage. (High I.Q. secondary school graduates in South Dakota, who had been receiving from my New York Bank wages one-and-a-half times the U.S. minimum wage for handling phone calls about my credit card, have been laid off since 1990; a Bombay outsourcing unit has come to handle my inquiries. Their Bombay wage rate falls far short of South Dakota's, but in India their wage far exceeds what their uncles and aunts used to earn.) What does Ricardo-Mill arithmetic tell us about realistic U.S. long-run effects from such outsourcings? In Act II, the new Ricardian productivities imply that, this invention abroad that gives to China some of the comparative advantage that had belonged to the United States can induce for the United States permanent *lost* per capita real income—an Act II loss even equal to *all* of Act I(a)'s 100 percent gain over autarky. And, mind well, this would not be a short run impact effect. *Ceteris paribus* it can be a *permanent* hurt. ("Permanent" means for as long as the postinvention technologies still apply.)

In Ricardian equilibrium analysis, there is never any longest run unemployment. So it is not that U.S. jobs are ever lost in the long run; it is that the new labor-market clearing real wage has been lowered by this version of dynamic fair free trade. (Does Act II forget about how the United States benefits from cheaper imports? No. There are no such neat *net* benefits, but rather there are now new net harmful U.S. terms of trade.)

Finally, the Epilogue will comment on the robustness and relevance of the spelled out analyses in the two Acts. Qualitatively my Ricardian theorems do for the most part remain relevant.

Act I(a): How Free Trade Benefits Both Nations' Real Per Capita Incomes Compared to Autarky

Analytical proof trumps mere talk about economic law. Here we begin with China possessed of average productivity only a tenth of the U.S. level. To remove complicating differences in the two places' total outputs and labor force, China's workforce is set at *ten* times that of the United States: say that the total U.S. workforce is 100, while China's total workforce is 1,000.

Four Ricardian productivity parameters are exogenously given in my initial two-good scenarios. For the United States, the respective labor productivities are $\Pi_1 = 2$ and $\Pi_2 = \frac{1}{2}$; for China they are $\pi_1 = \frac{1}{20}$ and $\pi_2 = \frac{2}{10}$ (Notationally, capital letters denote U.S. variables; lower case denote Chinese variables.) Readers will observe that U.S. productivities average out to ten times China's. But the U.S. superiority is more than ten in good 1; and China's inferiority in good 2 is not as bad as one-tenth. Before any trade, China's autarky per capita real income is contrived to work out to precisely one-tenth of U.S. autarky per capita real income;

before trade, good 2 is relatively cheap in China while good 1 is cheap in the United States. Here are the details.

Autarky's "Before" Equilibrium

In autarky, if the United States devotes 50 of its 100 workers to good 1, it can produce a quantity of 100; if it devotes the other 50 workers to good 2, it can produce 25. A parallel calculation holds for China's 1,000 workers: 500 produce only 25 of good 2; and the other 500 produce 100 of good 2. Because people all spend their incomes 50-50 on the two goods, competition will assume that, in autarky, each place must allocate its labor supply 50-50 between goods 1 and 2.

In this autarky example, the opportunity cost of producing a unit of good 2 in the United States is 4 units of good 1. However, in China, the opportunity cost of producing a unit of good 2 is $\frac{1}{4}$ unit of good 1. These differences in relative geographic productivities and in autarky price ratios provide the basis for comparative advantage-induced geographical specialization that will amplify world productivity!

My twenty-first-century tactical advance over nineteenth-century Ricardo-Mill is to recognize that Mill's assumption of 50-50 expenditures on the two goods gives us a firm measuring rod for an exact index of real national incomes and for real world income. This index is the *geometric mean* of consumption.[1] Thus, in the United States, autarky real income can be measured as the geometric mean of producing 100 of good 1 and 25 of good 2, which is the square root of 100 multiplied by the square root of 25, or 50. Dividing by the assumed U.S. population of 100, U.S. per capita real income will then be 0.5. In China, autarky real income is the geometric mean of producing 25 of good 1 and 100 of good 2, which is the square root of 25 multiplied by the square root of 100, or also 50. Dividing by China's population of 1,000, we calculate per capita autarky real income in China as 0.05.

There is a second, equivalent way of measuring these various real national outputs. It is especially useful because it involves the geometric mean, not of quantities produced or consumed, but of *the real wage rates* of the two goods in each place. In autarky, the U.S. real wage rates are respectively precisely, for W/P_1 and W/P_2, the $\Pi_1 = 2$ and $\Pi_2 = \frac{1}{2}$ Ricardian productivities. U.S. real per capita autarky income of 0.5 as computed in the previous paragraph is (*for Mill*) also given by the duality formula: $0.5 = \frac{1}{2}\sqrt{(W/P_1)(W/P_2)} = \frac{1}{2}\sqrt{\Pi_1\Pi_2} = \frac{1}{2}\sqrt{2 \cdot \frac{1}{2}}$. Likewise, for China, its real net national product per capita of 0.05 is given also by $\frac{1}{2}\sqrt{\pi_1\pi_2} = \frac{1}{2}\sqrt{\frac{1}{20} \cdot \frac{2}{10}} = \frac{1}{2}(\frac{1}{10})$.

The above exact equality of U.S. and Chinese total outputs results only from

[1] The use of the geometric mean and the harmonic mean as money-metric utilities, and how they can be derived from indifference curves, is explained in Appendix 2, which is appended to the paper at the journal's website ⟨http://www.e-jep.org⟩.

my contrived simplifying example. We now replace autarky by free trade, thereby deducing a substantial gain in real per capita welfare in both places.

Free Trade's "After" Equilibrium

The present model puts capital movements at zero. In free trade equilibrium, the trade balance is here always zero. With no tariffs, quotas or transport costs, in free trade relative price ratios will end up everywhere equalized. Of course, real wage rates will still diverge after free trade has raised them in both places.

The first step in analyzing free trade is to deduce the qualitative pattern of specialization. Because the opportunity cost of producing good 1, expressed in terms of good 2, is lower in the United States, competition will impel the United States to specialize on good 1. Because the opportunity cost of producing good 2, expressed in terms of good 1, is lower in China, China's competitors will specialize on good 2. Indeed, avaricious U.S. Darwinian competition will concentrate on producing good 1 only; so that its 100 workers with a productivity level of 2 will produce 200 of good 2. China's comparative advantage will impel her competitors to produce good 2 only, and the 1,000 Chinese workers with productivity of two-tenths will produce 200 units of good 2. This free trade geographical specialization can thus vastly raise world income as compared to autarky. Each good's autarky global outputs of 125 are raised 60 percent by free trade's specializations.

Each place imports some of the good it does not produce, and does so at the market clearing prices that equate international supply and demand. The combination of geographical specializations, which use the regions' respective labors to produce only what they can produce *relatively* (!) best, and then trade, does iron out the huge autarky price ratio divergences.

Using Mill's assumption about income being evenly divided in both countries between both goods, and the fact that global production with specialization will equal a quantity of 200 for both goods, then the free trade price ratio, $P_2/P_1 = p_2/p_1$, equalized in both places by frictionless auctioneer exchange, becomes 200/200 or 1. At this balanced price configuration (which is a contrived artifact from my example's cunning skew symmetries whose purpose was to simplify readers' quick understanding), it is self-evident that both nations will share *equally* (not per capita equally) half-and-half in world total real outputs. When each country consumes 100 of each good—half of the 200 world outputs—their free trade geometric mean will be twice their autarky geometric mean. (Without my symmetries, each place's relative gain over autarky will still be positive but will not necessarily be equal.)

Many realistic asymmetries could negate the exact equality of percentage benefits in this example. Most important is the counterintuitive truth that a reduction of China's population relative to the United States will *raise* China's per capita real income at the expense of lowering the U.S. gain from free trade! Noneconomists and Marxian economists guess otherwise, but that is their 180° wrong error.

Act I(b): When China's Technical Progress in Its Export Sector Must Raise U.S. Per Capita Real Income, But When It Might Lower China's

Here our thought experiment has China exogenously experiencing a quadrupling of productivity in her export sector: that is, the initial productivity of $\pi_2 = \frac{2}{10}$ in good 2 becomes postinvention $\pi_{2'} = \frac{8}{10}$. All other productivities remain the same.

Both before invention and after, the Ricardian inequalities of comparative advantage continue to compel the United States to specialize only on good 1 and China to specialize only on good 2. When all 100 U.S. workers produce good 1, they still produce a total of 200 only; when all 100 Chinese workers produce good 2, with the higher productivity level, they now produce 800. World output is clearly increased by this improvement in China's productivity.

Always the United States garners some part of the world gain in measured net global product. Why? Because the new superabundance of China's q_2 relative to unchanged U.S. Q_1 necessarily lowers P_2/P_1 to us as consumers.

Under Millian demand, China also gains in measurable well being. Suppose, however, that empirically demands are much more *inelastic* than in Mill's demand structure. Then the quadrupled supply of China's good 2 output could so much lower China's export terms of trade p_2/p_1 as to plunge postinvention per capita income painfully below preinvention per capita income. (Postinvention, China's share of world net national product drops all the way down to only one-fifth, no longer staying at one-half.) Self-immiseration by a nation is a well-known phenomenon in the economic literature, and it does crop up here in the debate over globalization.[2]

Act II: Proof that the United States Suffers Permanent Measurable Loss in Per Capita Real Income When China Enjoys *Exogenous* Productivity Gain in Good 1 Large Enough to Cut Some U.S. Production of It

By contrast with Act I's proof of U.S. benefit from Chinese technical progress in her export sector, Act II's analysis will rebut any mainstream economist's claims that the United States cannot suffer *long*-term harm from innovation abroad in a world of free trade.

I begin with the same initial two-good Ricardian productivities as in Act I.

[2] In concluding Act I's brief in favor of globalization, I remind readers of my Appendix 2's discussion of how replacing Mill demand by realistic inelastic demand will actually cause China to be hurt by her own invention. Appendix 2, which offers detailed proofs, is appended to this article at the journal website ⟨http://www.e-jep.org⟩.

Before the invention, $\Pi_1 = 2$ and $\Pi_2 = \frac{1}{2}$; $\pi_1 = \frac{1}{20}$ and $\pi_2 = \frac{2}{10}$. But now, for dramatic emphasis, I expand China's labor productivity in good 1 mightily, from $\pi_1 = \frac{1}{20}$ to $\pi_{1'} = \frac{8}{10}$. The rest of the productivities remain unchanged. (Note: Despite the great increase in China's labor productivity for good 1 to above the U.S. level of labor productivity for good 1, China still remains poorer in autarky than the United States—and still with a lower average real wage.)

Before the invention, just as in Act I, the United States produces only 200 units of good 1, while China produces only 200 units of good 2. But now, after the invention, world output potential has markedly grown. However, all comparative advantages have been emasculated—for the reason that now, in every place, Π_1/Π_2 and π_1/π_2 both now equal 4. Each place can do as well in its new autarky as it can do under free trade. (Indeed under free trade rules, no one is any longer motivated to specialize geographically; there is no need or advantage in doing either exporting or importing.) So this example's whole story can be easily told. To appraise U.S. postinvention well being, ignore Ricardo and Mill; just simply compare the United States' postinvention autarky geometric mean with its preinvention free trade geometric mean.

We've seen that the preinvention free trade elicited 200 of good 1 from the United States and 200 of good 2 from China. Also, these balanced numbers mandated $(P_2/P_1)' = (p_2/p_1)'$ of unity. Such a nice balance meant that both places shared one-half of world national income, measured with the geometric mean as $\sqrt{200 \cdot 200} = 200$. Focusing on U.S. per capita welfare, that meant preinvention free trade per capita net national product had been $\frac{1}{2}(200)/100 = 1.0$. Query: Can postinvention U.S. autarky per capita geometric mean ever reattain that earlier level? The answer is a surprising "no." Forced into autarky by China's invention, the United States with its unchanging technology in our crucial thought experiment again divides its 100 workers evenly between producing goods 1 and 2. Producing $50 \cdot 2 = 100$ of good 1, and $50 \cdot \frac{1}{2} = 25$ of good 2, then U.S. real per capita income can be measured by the geometric mean as $\sqrt{100 \cdot 25}/100 = 50/100 = 0.5$. Assuredly that does fall short of her initial per capita national income with free trade, which was 1.0. The new winds of free trade have blown well for China. But in my overdramatic example, they have blown away *all* of the United States' previous enjoyments from free trade. (Test question: Could there be any pattern of future inventions abroad that would repeatedly reduce absolutely per capita U.S. benefits from free trade and globalization? Correct answer: Yes—however unlikely *that* dramatic pattern would be.)

One example can sometimes be "too clever by half." In this one it is free trade's own spontaneous killing off of all trade that does harm to the United States.[3]

[3] To avoid breeding misunderstanding, my Appendix 1, which is appended to this article at the journal's website ⟨http://www.e-jep.org⟩, analyzes a more realistic three-good scenario. Add to goods 1 and 2, with their original productivities in the two countries, a good 3, which begins with $\Pi_3 = 1$ and $\pi_3 = \frac{1}{10}$. The example therefore happens to force initial equal sharing by both places of world total output of good 3: that is, shared comparative advantages. Then, exogenously, let China's productivity in good 3 double

Again my reported numerical results are not mere numbers drawn from a mysterious black box. In every case, it is terms of trade changes in (P_2/P_1; W/P_1, W/P_2; w/p_1, w/p_2)—changes in those variables mandated by exogenous changes in relative scarcities—that have had their intuitively expected effects on supply-demand equilibrium price ratios under competitive free trade.

Economic history is replete with Act II examples, first insidiously and later decisively: in the United States, farming moved from east to west two centuries ago; textiles, shoes and manufacturers moved from New England to the low-wage South early in the last century; Victorian manufacturing hegemony became replaced by Yankee inroads after 1850. Even where the leaders continued to progress in absolute growth, their rate of growth tended often to be attenuated by an adverse headwind generated from low-wage competitors and technical imitators.

Epilogue

Acts I and II have demonstrated that sometimes free trade globalization can convert a technical change abroad into a benefit for both regions; but sometimes a productivity gain in one country can benefit that country alone, while permanently hurting the other country by reducing the gains from trade that are possible between the two countries.[4] All of this constitutes long-run Schumpeterian effects, quite aside from and different from transitory short-run harms traceable to short-run adjustment costs or to temporary rents from patents and from eroding monopolies on knowledge.

It does not follow from my corrections and emendations that nations should or should not introduce selective protectionisms. Even where a genuine harm is dealt out by the roulette wheel of evolving comparative advantage in a world of free trade, what a democracy tries to do in self defense may often amount to gratuitously shooting itself in the foot. A pragmatic and scientifically more correct brief for globalization might go as follows.

> If the past and the future bring both Type A inventions that *hurt* your country and Type B inventions that help—and when both *add* to world real net

to $\pi_{3'} = \frac{2}{10}$, which is just enough to kill off *all* U.S. production of good 3. Does that hurt us permanently *ceteris paribus* net? *Yes, indeed it does.* But this time the hurt to us comes from an *increase* in foreign trade—from initial zero trade in good 3, all of U.S. consumption of good 3 comes after China's π_3 invention from imports alone.

[4] Some past scholars have wondered whether cheapening of transport costs and speedier spreading of knowledge across national boundaries might in the future decimate comparative advantages and foreign trade. They have also wondered whether, when all peoples are as productive as Americans, some of their new benefit might come out of reduced U.S. well-being. So far, economic history has reported gain rather than loss in the ratio between Total Foreign Trade ÷ Total World Output. If trade were ever to cease spontaneously under competition, since shipping goods back and forth for no good reason makes no sense, humanity ought to deem such a result to be good rather than bad, even if it exacts some price from the erstwhile most productive geographical place.

> national product welfare—then free trade may turn out pragmatically to be still best for each region in comparison with lobbyist-induced tariffs and quotas which involve both perversion of democracy and nonsubtle dead-weight distortion losses. In 1900 free traders proclaimed, "Tariffs are the Mother of trusts." In this millennium a more pregnant truth may be: "Tariffs are the breeder of economic arteriosclerosis."

A few words are needed to judge how robust my simplified Ricardo-Mill paradigm is to real-world complexities.

1. Adding *non*tradable goods or other realistic impediments to international exchange, analytic reflection deduces will not negate my fundamental findings.

2. My qualitative conclusions also remain valid after adding to Ricardo's labor-only technologies the post-1930 *multifactor* trade models pioneered by Heckscher, Ohlin, Viner, Haberler, Lerner, Stolper-Samuelson, McKenzie, Jones and others, to say nothing of earlier Marshall and Edgeworth *multifactor* trade models. Just as multifactor Dornbusch-Fischer-Samuelson (1980) nicely generalized the Dornbusch-Fischer-Samuelson (1977) Ricardian labor-only paradigm, so will it be found that the qualitative results of Acts I and II do apply as well to multifactor as to labor-only scenarios.

3. In this paper, along classical lines, all my free trade equilibria are analyzed under the assumptions of zero *net capital movements*. In this epoch of chronic long-term cumulative U.S. net foreign indebtedness, such simple Ricardo-Mill smacks of Hamlet without the Gloomy Dane. Noneconomists like Warren Buffett—the world's richest and most successful investor is one—in November (2003) *Fortune* magazine blamed the chronic U.S. international payments deficit on free trade and therefore proposed auction taxes that would enforce zero U.S. borrowing-and-lending net. This paper's techniques could deduce the measurable self-imposed harm America would bring down on itself by following the Buffett philosophy. But one-way U.S. balance-of-payment deficits need another paper to do that topic justice.

4. What holds in a two-country, two- or three-good model can be shown to essentially hold in an *N*-country, *M*-good Ricardo-Mill paradigm.

5. Smith-Allyn Young-Ohlin-Krugman trade paradigms based squarely on the imperfections of competition inseparable from increasing returns to scale technologies are not well analyzed by classical competitive Ricardianisms. However, Gomory-Baumol (2000) have reported findings similar to mine for various increasing returns to scale scenarios. I should add that it has been globalization's enlargement of market size that has done much to elevate the competitive model to greater policy relevance than the competitive model possessed in the 1890–1950 epoch.

6. My most important omission, for realism and for policy, is treating all people in each region as different *homogeneous* Ricardian laborers. That inhibits our grappling with the realistic cases where some Americans (capitalists and skilled computer experts) may be being helped by what is decimating the real free-trade

wage rates of the semi-skilled or of the blue-collar factory workers. My geometric mean approach can fortunately be adapted to handle just such problems.

Instead of attenuating this paper's theses, heterogeneity amplifies its importance. Contemplate a scenario where Schumpeter's fruitful capitalist destruction harms a really sizeable fraction of the future U.S. population and, say, improves welfare of another group and does that so much as to justify a calculation that the winners could be made to transfer some of their gains and thereby leave *no* substantial U.S. group net losers from free trade. Should noneconomists accept *this* as cogent rebuttal if there is no evidence that compensating fiscal transfers have been made or will be made? Marie Antoinette said, "Let them eat cake." But history records no transfer of sugar and flour to her peasant subjects. Even the sage Dr. Greenspan sometimes sounds Antoinette-ish. The economists' literature of the 1930s—Hicks, Lerner, Kaldor, Scitovsky and others, to say nothing of earlier writings by J.S. Mill, Edgeworth, Pareto and Viner—perpetrates something of a shell game in ethical debates about the conflict between efficiency and greater inequality.

Policy aside and ethical judgments aside, mainstream trade economists have insufficiently noticed the drastic change in mean U.S. incomes and in inequalities among different U.S. classes. As in any other society, perhaps a third of Americans are not highly educated and not energetic enough to qualify for skilled professional jobs. If mass immigration into the United States of similar workers to them had been permitted to actually take place, mainstream economists could not avoid predicting a substantial drop in wages of this native group while the new immigrants were earning a substantial rise over what their old-country real wages had been.

Therefore, as a result of my 1948–1949 revival and perfecting of the 1919–1933 Heckscher-Ohlin argumentation of *factor price quasi-equalization by trade in goods alone*, one could have foreseen the following at World War II's end. Historically, U.S. workers used to have kind of a *de facto* monopoly access to the superlative capitals and know-hows (scientific, engineering and managerial) of the United States. All of us Yankees, so to speak, were born with silver spoons in our mouths — and that importantly explained the historically high U.S. market-clearing real wage rates for (among others) janitors, house helpers, small business owners and so forth. However, after World War II, this U.S. know-how and capital began to spread faster away from the United States. That meant that in a real sense foreign educable masses—first in western Europe, then throughout the Pacific Rim—could and did genuinely provide the same kind of competitive pressures on U.S. lower middle class wage earnings that mass migration would have threatened to do.

Post-2000 outsourcing is just what ought to have been predictable as far back as 1950. And in accordance with basic economic law, this will only grow in the future 2004–2050 period. Other authors could add, to my presented Acts I and II, additional Acts explaining why there took place a historical drop in the U.S. share of total global output from almost 50 percent at 1945 war's end (with Europe and Japan in temporary chaos) down to 40 percent, down to 30 percent and, according to the Penn World Tables of purchasing-power-corrected per capita incomes, now down to perhaps only one-fifth to one-quarter. Although these trends did not mean an absolute decline in U.S. affluence, they arguably did reflect a head wind slowing down the U.S. post-Keynes rate of real growth in the last half of the twentieth century.

Not surprisingly, successful developing nations—such as Japan, Hong Kong, Singapore, Taiwan, South Korea, even Thailand, Indonesia and the Philippines—were able at the end of the twentieth century to reduce America's lead over their own per capita real incomes. The same thing happened for western Europe in the 1950–1980 period. One wondered whether one or more of these trailing bicycle riders would fully catch up with the U.S. bicycle and then maybe even forge ahead of it. The Penn World Tables and Angus Maddison's similar estimates seem not to report that happening as yet. Could that be a sign that the United States' original innovations, as they spread abroad, have been the important factors in explaining America's diminishing lead?

One hesitates to say. Actually there is some suggestive evidence that French or German per-hour productivity does surpass the U.S. per-hour productivity. If only the French and Germans would match U.S. weekly and monthly average number of total hours of work, their bicycles would be running ahead of the U.S. frontrunner. Evidently subjective tastes can modify technological Ricardo-like parameters in explaining dynamic patterns of contemporary global and domestic economics.

Even if my hypotheses are exaggerated, they are what both Ricardo-Mill and more general Ricardo models would seem to be suggesting.

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Appendix 1
A Three-Good Free Trade Equilibrium

A three-good free trade equilibrium reinforces more realistically Act II's two-good proof that Chinese Schumpeterian innovation in a sector where the United States used to have a larger fraction of world production must, *ceteris paribus*, hurt U.S. per capita postinvention NNP permanently. Goods 1 and 2 are here specified to be technically just as before in Acts I and II. Mill-like demand is again specified, except that 50 percent-50 percent fractional expenditures on goods 1 and 2 are now replaced by $33\frac{1}{3}$ percent-$33\frac{1}{3}$ percent-$33\frac{1}{3}$ percent fractional expenditures on goods 1, 2 and 3.

By design, good 3 begins as a borderline good which is produced in both before-invention places at equal shares of world quantities produced ($Q_3 + q_3$). As before, China's productivities π's average only one-tenth of U.S. productivities Π's; also, as before, China's labor supply n is compensatingly ten times the U.S. labor supply N—so that overall size differences do not bias or complicate the investigation.

Here then are the 3-good scenarios before and after a Chinese invention that solely *doubles* her productivity in good 3 from $\pi_3 = \frac{1}{10}$ to $\pi_{3'} = \frac{2}{10}$.

(A1-1) Before $(\Pi_1, \Pi_2, \Pi_3; \pi_1, \pi_2, \pi_3) = (2, \frac{1}{2}, 1; \frac{1}{20}, \frac{2}{10}, \frac{1}{10})$

(A1-2) After $(\Pi_1, \Pi_2, \Pi_3; \pi_1, \pi_2, \pi_3)' = (2, \frac{1}{2}, 1; \frac{1}{20}, \frac{2}{10}, \frac{2}{10})'$.

Because

(A1-3)

$$(\Pi_1/\pi_1) = 2/(\tfrac{1}{20}) = 40 > (\Pi_3/\pi_3) = 1/(\tfrac{1}{10}) = 10 > (\Pi_2/\pi_2)$$

$$= \tfrac{1}{2}/(\tfrac{2}{10}) = \tfrac{10}{4} = 2.5,$$

economists' intuition will assure us that never can China export good 1 to the United States in exchange for our export of good 2. Actually, both before and after the new Chinese invention,

(A1-4) $q_1 = q_1' = 0 = Q_2 = Q_2'$.

Before the invention, since all goods will need to be produced somewhere, each place could specialize producing two of the three goods: Q_1 and Q_3 for the United States; q_2 and q_3 for China. Actually, my (A1-1) technologies were picked to contrive that *initially* both places do produce equal halves of world output of good 3 output. The rest of U.S. labor produces Q_1 only; and China's residual labor produces q_2 only.

Without resort to calculus, economists' intuition notes that in both places labor applied to good 3 contributes only half as much toward the world net national product (as measured by the geometric mean) pot as does a unit of labor applied in the United States to its Q_1; and similarly a unit of China's labor applied to its q_2 adds to World GM twice what producing q_3 can. So a shrewd, daring guess would suggest: Why not apply only $\frac{1}{3}$ of local labor to good 3, applying the other $\frac{2}{3}$ to one's clear-cut comparative-advantage good? (Remark: The market mechanism has no brain. It asks no questions. But ruthless Darwinian competitors gravitate to wherever there is still left a higher disequilibrium temporary profit.)

We can test—and affirm—the shrewd guess by the following trial and error: First, compute world net national product, using the geometric mean formula, for dividing up the labor $(\frac{1}{3}, \frac{2}{3})$. Then do it for (0.3,0.7) and also for (0.4,0.6). If both of the latter give measures of welfare *below* what $(\frac{1}{3}, \frac{2}{3})$ gives, you have rigorously proved that the guess did identify correctly free trade's unique final equilibrium: QED.

Here is the detailed before-innovation equilibrium story:

(A1-5) World Outputs $(Q_{1'}, q_{2'}, Q_{3'} + q_{3'})$

$$= (\tfrac{2}{3} \cdot 100 \cdot 2, \tfrac{2}{3} \cdot 1000 \cdot \tfrac{2}{10}, \tfrac{1}{3} \cdot 100 \cdot 1 + \tfrac{1}{3} \cdot 1000 \cdot \tfrac{1}{10}) = (\tfrac{400}{3}, \tfrac{400}{3}, \tfrac{200}{3}).$$

(A1-6) $$\text{World geometric mean} = [\tfrac{400}{3} \cdot \tfrac{400}{3} \cdot \tfrac{200}{3}]^{1/3} = \tfrac{1}{3} 200 \cdot 4^{1/3} = 105.83$$

(A1-7) $$(P_3/P_1) = \frac{400/3}{200/3} = (p_3/p_2) = 2$$

(A1-8) $$\frac{\text{China share of } 105.83}{\text{U.S. share of } 105.83} = \frac{(p_2 q_2 + p_3 q_3)}{(P_1 Q_1 + P_3 Q_3)} = \frac{1 \cdot 400 + 2 \cdot 200}{1 \cdot 400 + 2 \cdot 200} = 1.$$

Thus Equation (A1-8) does imply *equal* country shares, so that the world pot did initially get divided half and half:

(A1-9) $$\text{China net national product} = \tfrac{1}{2}(105.83) = 52.915$$

(A1-10) $$\text{U.S. net national product} = \tfrac{1}{2}(105.83) = 52.915.$$

Now turn to the free-trade postinvention after scenario. The new abundance of q_3 somewhat cheapens good 3's previous dearness. Therefore, ruthless U.S. competitors will shift some labor *away* from good 3 and toward producing more of good 1. At the same time in China some extra labor is attracted to q_3 because of the extra productivity there. This lowers Chinese labor allotted to q_2. Hence the preinvention geographical allocation of labor—for U.S. $(L_1, L_2, L_3) = (\frac{2}{3}, 0, \frac{1}{3})$ and for China $(0, \frac{2}{3}, \frac{1}{3})$ becomes qualitatively post invention $(\frac{2}{3}+, 0, \frac{1}{3}-; 0, \frac{2}{3}-, \frac{1}{3}+)$. Using intuition, *sans* calculus, one sees that in China labor can now contribute to the world pot exactly as much in good 2 as in good 3. Why? Because its labor productivity in good 3 $\pi_3 = \frac{2}{10}$ is now at a par with its labor productivity in good 2, $\pi_2 = \frac{2}{10}$. A plausible guess is that China's original allocation of labor $(0, \frac{2}{3}, \frac{1}{3})$ will change to $(0, \frac{1}{2}, \frac{1}{2})$. What reaction will that force on the U.S. labor allocation? Maybe the United States should then go all the way and use *all* its labor to produce the good 1 that no one else any longer produces?

Trial and error using the suggested labor allocations (1, 0, 0; 0, .5, .5) shows that indeed the guessed new global outputs

$$(100 \cdot 2{,}500 \cdot \tfrac{2}{10}, 500 \cdot \tfrac{2}{10}) = (200, 100, 100) \tag{A1-11}$$

will achieve a higher geometric mean than any other labor allocation.

The trial and error test is again available. We do find that a .99 U.S. labor share for production of good 1 yields a worse geometric global mean than the 1.0 share does; and similarly testing shows the (.5, .5) China labor allocation does achieve a higher world geometric mean than $(.5 + \varepsilon, .5 - \varepsilon)$ and $(.5 - \varepsilon, .5 + \varepsilon)$ would. All this will serve to make your proof rigorous that our guessed world allocations do achieve the maximum world geometric mean that competition's Invisible Hand will serendipitously arrive at.

Here then is the final definitive measure of inflicted harm to the U.S. net national product (per capita and *in toto*) that results from China's Schumpeterian innovative progress in raising her π_3/Π_3 productivity relative to ours. From (A1-11), we calculate

$$\text{World geometric mean} = (200 \cdot 100 \cdot 100)^{1/3} = (100 \cdot 2^{1/3}) = 125.99 \tag{A1-12}$$

$$(P_2/P_1) = \frac{200}{100} = (P_3/P_1) = \frac{200}{100} = 2 \tag{A1-13}$$

$$\frac{\text{U.S. rel share in (125.99)}}{\text{China rel share in (125.99)}} = \left(\frac{P_1 Q_1}{p_2 q_2 + p_3 q_3}\right) \tag{A1-14}$$

$$= \left(\frac{1}{2}\right) \frac{200}{(100 + 100)''} = \frac{1}{2} = \frac{1/3}{2/3}.$$

Equation (A1-14) tells us that the United States ends up, after China's invention, with only *one-third* of the enlarged world net national product!

$$\text{(A1-15)} \quad \therefore \text{ US new net national product} = (\tfrac{1}{3})(125.99) = 41.997 < 52.91$$

$$= \text{original net national product} = \tfrac{1}{2}(105.83). \text{ QED.}$$

What free trade has done after this kind of Chinese invention is to deprive the United States of 20.63 percent of its preinvention free trade (per capita) real income!

Unlike the text of Act II's draconian free-trade grasping by China of *all* of the U.S. gain from free trade, this Appendix story has greater verisimilitude. Insidiously, and later dramatically, a catch-up nation so to speak often throws out an adverse head wind, slowing down the growth rate of the lead U.S. bicycle racer. This is realism and not just captious pessimism.

Appendix 2
Inelastic Demand Can Cause Inventions to Reduce Welfare

Here I enlarge on Act I(b)'s footnote 1's point that a Chinese invention that raises world net national product, and also raises China's autarky net national product and raises U.S. net national product can, when international demands are realistically *inelastic*, still hurt China's own free trade per capita income permanently. In the Mill version of Act I's demands, the text had defined "before" and "after" terms of trade as follows for before and for after:

$$\text{(A2-1)} \qquad (P_2/P_1) = (p_2/p_1) = (Q_{1'} + 0q_1)/(Q_{2'} + q_2) = \tfrac{200}{200} = 1$$

$$\text{(A2-2)} \qquad (P_2/P_1)' = (p_2/p_1)' = \tfrac{200}{800} = \tfrac{1}{4}{}'$$

$$\text{(A2-3)} \quad \text{Before } \frac{\text{Relative China share of world geometric mean}}{\text{Relative U.S. share of world geometric mean}}$$

$$= (p_2 q_2/P_1 Q_1) = (1)\left(\frac{200}{200}\right) = 1 \text{ for Mill}$$

$$\text{(A2-4)} \quad \text{China net national product} = \tfrac{1}{2}(200) = 100 = \text{U.S. net national product.}$$

Also, the Mill "after" story had divided the enlarged postinvention world net national product half and half:

(A2-5) $$(p_2 800)/(P_1 200) = (\tfrac{1}{4}) \cdot 4 = 1' = \tfrac{1}{2} \div \tfrac{1}{2};$$

(A2-6) U.S. after net national product = China after net national product

$$= \tfrac{1}{2}\sqrt{800 \cdot 200} = \tfrac{1}{2}(400) = 200 < 100 = \text{China before net national product}$$

The above Mill story is the same as in the article.

But now suppose reality makes us shift gears away from Mill-like demand elasticity. Suppose that inelasticity dictates that a new "squared" Law of Demand holds, so that after the invention

(A2-7) $$(P_2/P_1)' = (p_2/p_1)' = (Q_1/q_2)^2 = \left(\frac{200}{800}\right)^2 = (\tfrac{1}{4})^2 = \tfrac{1}{16}'.$$

This is a new ball game, one where China's postinvention abundance of q_2 decimates viciously its own terms of trade. Now China will end not with half of postinvention world net national product, but with only *one-fifth* of world net national product:

(A2-8) $$(p_2 q_2/P_1 Q_1)' = (\tfrac{1}{16})(q_2/Q_1) = \frac{1}{16} \cdot \frac{800}{200} = \tfrac{1}{4}' = (1/5)/(4/5).$$

(A2-8) entails that China's share of world net national product is $\frac{1}{5}$ compared to the U.S.'s $\frac{4}{5}$ share.

To what *exact* index numbers are we now to apply these $(\frac{1}{5}, \frac{1}{4})$ 1 fractions?

There is left this Appendix's task to explicate how correct money-metric utility is to be measured when Mill's (A2-1) demand and its implied geometric mean must be replaced by equation (A2-7)'s new "what kind of mean?" The provable answer is that the harmonic mean corresponds to $P_2/P_1 = (Q_1/q_2)^2$ in a parallel way to how the geometric mean had corresponded to the unsquared $P_1/P_1 = (Q_1/q_2)$.

The unweighted harmonic mean of consumptions C_1 and C_2 is defined as "the reciprocal of the mean of the C_1 and C_2 reciprocals," that is,

(A2-9) $$\text{Harmonic mean of } (C_1, C_2) = [\tfrac{1}{2} C_1^{-1} + \tfrac{1}{2} C_2^{-1}]^{-1}$$

(A2-10) $$\equiv 2C_1C_2/[C_1 + C_2].$$

Applying these definitions to Act I(b)'s "before" production of (200, 200) and "after" production of (200, 800), we use the harmonic mean to calculate world output in both cases for before and for after:

(A2-11) world net national product = 2(200)(200)/[200 + 200] = 200

$$\text{(A2-12)} \quad \text{world net national product} = 2(200)(800)/[200 + 800] = 320' > 200.$$

Is China better off with only $\frac{1}{5}$ of 320 than she had been preinvention, earning then $\frac{1}{2}$ of 200? Unequivocally the answer is "No," that is,

$$\text{(A2-13)} \qquad \tfrac{1}{5}(320) = 64' < 100 = \tfrac{1}{2}(200).$$

General Money-Metric-Utility Means

The exact geometric mean and the exact harmonic mean are two different species of the genus of money-metric utilities. Paired with each of the two are their respective Laws of (Homothetic) Demand:

$$\text{GM} = \sqrt{C_1 \cdot C_2} \leftrightarrow P_2/P_1 = C_1/C_2$$

$$\text{(A2-14)} \qquad \text{HM} = [\tfrac{1}{2}C_1^{-1} + \tfrac{1}{2}C_2^{-1}]^{-1} \leftrightarrow (C_1/C_2)^2.$$

Each happens to be a member of the family of constant-elasticity-of-substitution production functions that are workhorses in neoclassical production theory; and at the same time, they are members of finance theory's family of constant-relative-risk aversion Laplacian utility functions. These functions are concave power mean functions of the following type, except for the Cobb-Douglas geometric mean = $\sqrt{V_1 V_2}$,

$$\text{(A2-15)} \qquad M = [\tfrac{1}{2}v_1^{\alpha} + \tfrac{1}{2}v_2^{\alpha}]^{1/\alpha},\ 1 > \alpha \neq 1.0.$$

The most general money-metric-utility exact mean can be generated from an arbitrary *single* convex monotone-declining indifference curve in the (C_1, C_2) space, written as

$$\text{(A2-16)} \qquad C_2 = I(C_1);\ C = I(C) = \text{say } 1;\ I'(C) < 0 < I''(C).$$

From this single curve, all other homothetic indifference curves can be generated as blow-ups in scale along any Engel's ray fanning out from the origin. Analytically, we can solve the following implicit relations

$$\text{(A2-17)} \qquad C_2/M = I(C_1/M)$$

for its unique general mean,

$$\text{(A2-18)} \qquad M = \mu(C_1, C_2),\ \mu(C, C) \equiv C$$

where μ_3 is a concave and first-degree-homogenous function

$$\text{(A2-19)} \qquad \mu(\lambda C_1, \lambda C_2) \underset{\lambda}{\equiv} \lambda\mu(C_1, C_2),\ \mu(C_1, C_2) \equiv \sum_1^2 C_j[\partial\mu/\partial C_j].$$

Were all people everywhere to have the same demand structure, but their income elasticities were *not* all unity, we would have to replace $f(C_1/C_2)$ by Hicks's two-variable marginal rate of substitution function:

$$\text{(A2-20)} \qquad P_2/P_1 = R(C_1, C_2).$$

In (A2-20), R will satisfy the two-good weak axiom of revealed preference (or equivalently using calculus: $(\partial R/\partial C_1) - R(\partial R/\partial C_2) < 0$).

However, readers beware. When R is not $f(C_1/C_1)$, now (as Marshall knew) multiplicities of equilibrium can occur for international offer curves, some equilibria being *locally* stable and unstable and none being *globally* stable. Also only for the homothetic $f(C_1/C_2)$ case will the shortcuts work that have vastly simplified this article's expositions.

Here is a vivid singular example that can reinforce warnings. Around 1890 Marshall understood that some of the defects of his partial equilibrium model could be softened when, say, good 2 enjoyed *constancy* of its marginal cardinal utility. This can give when each and all share the following identical Bentham-Jevons utility function:

$$\text{(A2-21)} \qquad U = \log C_1 + C_2,\ u = \log c_1 + c_2$$

$$\text{(A2-22)} \qquad P_2/P_1 = 1/C_1,\ p_2/p_1 = 1/c_1.$$

Let's apply this to Act I(b)'s initial productivities of $(2, \frac{1}{2}; \frac{1}{2}, 2)$. Then, as in the text, let China's invention raise its productivity π_2 for good 2 from 2 to $8'$. We can test whether analysis still can prove that this *must* elevate the United States's postinvention utility. (For simplicity, I have here made China and the United States have equal populations and average productivities.)

To calculate utilities for each country before and after productivity shift, a zealous reader must forego the shortcuts used throughout this article that were appropriate for uniform homothetic demand structures à la Mill's geometric mean, à la the inelastic harmonic mean, or à la general homothetic money-metric utilities.

Here is my report of the surprising singular result, which patient readers can check for themselves. Now Americans (each and all) are given *zero* benefit from China's enhanced export good! Here is the before and after comparison:

$$\text{U.S. utility before} = \log C_1 + C_2 = \log 1 + 1$$

$$\text{(A2-23)} \qquad \text{China's utility before} = \log c_1 + c_2 = \log 1 + 1$$

(A2-24) U.S. utility after = $\log C_{1''} + C_{2''} = \log 1 + 1 \equiv$ U.S. utility before

This anomalous result happens only because (A2-21) makes consumers singularly have an income elasticity of *zero* for good 1, something that could not happen for a homothetic demand structure like Mill's. As is well-known, admissible $R(C_1, C_2)$ marginal rate of substitution functions can even generate "inferior goods" with negative income elasticities—so that new abundance of harvest might paradoxically raise rather than lower its price to world consumers.

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