THE "TRIANGULAR TRADE" AND THE ATLANTIC ECONOMY OF THE EIGHTEENTH CENTURY: A SIMPLE GENERAL EQUILIBRIUM MODEL

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The "Triangular Trade" and the Atlantic Economy of the Eighteenth Century:
A Simple General Equilibrium Model*

by

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I would like to thank Peter Kenen for the invitation to deliver the Graham Lecture, on which this paper is based, and for his careful editorial attention to my original manuscript. I benefited enormously from the advice of Herbert Klein, of the History Department at Columbia. His unpublished paper, Klein (1987), was an invaluable guide to the recent historical literature on the Atlantic slave trade and its ramifications. Sandy Darity's original work provided the inspiration for my own model of the triangular trade. I have also had the benefit of detailed written comments from Michael Edelstein, Charles Kindleberger and Stefano Fenoaltea. A seminar at Rochester gave me the opportunity to pick the brains of Stan Engerman and Ron Jones, as well as the pleasure of meeting Joseph Inikori for the first time. Seminar participants at Princeton, North Carolina, Cornell, Harvard and Rochester made many helpful comments. In particular I would like to thank Henry Wan, Richard Cooper and Jeffrey Williamson. Finally I would like to acknowledge the support and encouragement of my friends at Columbia -- Mike Gavin, Doug Irwin and Stan Wellisz. Needless to say none of the above are to be held responsible for surviving errors of fact and logic.
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An earlier version of this paper was delivered as the Graham Lecture at Princeton in April, 1988. I am deeply grateful to the sponsors of this series of annual lectures in memory of Frank D. Graham, one of the most fertile minds ever to specialize in the field of international economics, for the privilege of being included in the distinguished company of previous speakers. Graham's own contributions to the field covered so wide a range that none of the previous Lectures given in his name, so far as I am aware, was on a topic that altogether escaped his interests. I had feared that the rather exotic subject matter of my own lecture, the "triangular trade" in slaves, raw materials and manufactures that connected the continents of Africa, America and Europe for centuries, would be an exception. Gene Grossman very kindly pointed out to me, however, the following passage, Graham (1934, p. 73), in his monograph on Protective Tariffs:

"Had a laissez-faire commercial policy been pursued in the United States during the whole of the nineteenth century it would, no doubt, have enlarged the relative importance of cotton growing in our economic life. The possible consequent higher ratio of Negro to White population would, from the point of view of most Whites at any rate, have been undesirable, and would seemingly have lowered the national per capita productive capacity."

While one regrets his casual assumption of white superiority, so prevalent a generation ago, this passage is nevertheless salutary in reminding us of the fact that the ethnic composition of the present population of the United States, and indeed of much of Europe, is heavily influenced.
The modern world economy, with its complex networks of interdependence, was essentially created as a consequence of the European voyages of discovery in the fifteenth and sixteenth centuries. This is not to say that international and even inter-continental trade did not have any significance prior to that time. Africa had been connected to Europe by the "golden trade of the Moors", vividly described in the book with that title by Bovill (1970). China was trading with Europe along the famous Silk Road through the oases of Central Asia since Roman times. It was Columbus, Vasco da Gama and Magellan, however, who laid the foundations of the present truly global economic system.

The pattern of trade across the Atlantic that prevailed since shortly after the time of the discoveries down to as late as the outbreak of the American Civil War came to be known as the "triangular trade" since it involved the export of slaves from Africa to the New World where they produced sugar, cotton and other commodities exported to Western Europe to be consumed or embodied in manufactures, which were in turn partly exported to Africa to pay for the slaves. The earlier impression that a single ship would complete the entire circuit from Liverpool or Nantes, carrying textiles, guns and spirits, to Whydah or Old Calabar on the West Coast of Africa, then make the Middle Passage with a cargo of slaves to Kingston or Port au Prince, returning with sugar, tobacco and cotton to the original port, is now known to be largely false since the volume of trade was sufficiently great to make it worthwhile for specialized craft to be constructed for each leg of the journey. The convenient term "triangular trade" will nevertheless be used here to represent the three-cornered exchange of slaves, raw materials and manufactures as
Figure 1
The inter-continental links were actually even more extensive than in Figure 1. For most of the eighteenth century the textiles that were exchanged for slaves on the west coast of Africa were manufactured in India and exported by the British and French East Indian Companies. Thus the "European" manufactures of our schema can be thought of as initially exchanged for these Indian cloths, better suited to African tastes and climates. Richardson (1987, p. 127) estimates that 25% of English exports to Africa in the third quarter of the eighteenth century were re-exports from India. This additional link in the complex pattern of inter-continental trade in the eighteenth century will be ignored in the rest of this paper.

The triangular trade fitted into the "colonial system" of the emerging absolutist monarchies of early modern Europe, and was a key element in the pursuit of the twin objectives of "power" and "plenty" to which, according to Jacob Viner (1948), the Mercantilist writers considered all trade and economic activity should be devoted. One of the most systematic and clear-sighted of these writers was Malachy Postlethwayte (1707-67) who summed up the significance of the triangular trade for Britain in 1745 as follows:

"...is it not notorious to the whole world, that the Business of Planting in our British Colonies, as well as in the French, is carried on by the Labour of Negroes, Imported thither from Africa? Are we not indebted to those valuable People, the Africans for our Sugars, Tobaccos, Raisins, and all other Plantation Produce? And the greater the Number of Negroes imported into our colonies, from Africa, will not the Exportation of British Manufactures among the Africans be in Proportion, they being paid for in such Commodities only? The more likewise our Plantations abound in Negroes, will not more Land become cultivated, and both better and greater Variety of Plantation Commodities be produced? As those Trades are subservient to the Well Being and Prosperity of each other; so the more either
flourishes or declines, the other must be necessarily affected; and the general Trade and Navigation of their Mother Country, will be proportionably benefited or injured. May we not therefore say, with equal Truth, as the French do in their before cited Memorial, that the general NAVAGATION of Great Britain owes all its Increase and Splendor to the Commerce of its American and African Colonies; and that it cannot be maintained and enlarge otherwise than from the constant Prosperity of both those branches, whose Interests are mutual and inseparable?"

[Quoted by W.A. Darity, Jr. (1988)]

This statement cannot be surpassed for its insight into the structure of a complex pattern of economic interdependence between three continents. The competing ambitions of the major European states, however, made them all intervene in the natural operation of this system by a host of measures in trade and navigation designed to promote the national advantage at the expense both of their own colonies and of their rivals. Adam Smith's revulsion at the restrictiveness of Mercantilism even led him into logical error, when he maintained that British restrictions on the colonial trade harmed not only the colonies and her European competitors but Britain herself.¹ It took a chapter by Ricardo, in which he clearly anticipates the modern "monopoly power" argument for trade restrictions, to set the matter straight.² Despite this, Adam Smith's influence, operating in perhaps a subterranean way on later writers, has been such as to create a long-sustained belief that Britain derived no very large benefit, and perhaps even loss, from her early and intimate association with the slave trade and slavery. The well-known work of J.E. Cairnes (1862) is a good case in point, since he also regarded slavery in the American south as an inefficient and unproductive system, aside from its moral depravity. It is only recently, with the work of Conrad and Meyer (1958) and Fogel and Engerman (1974) that we are beginning to come to terms with the fact that slavery can be consistent with rationality and efficiency in the
pursuit of profits, generating a higher real output and investible surplus than in the absence of the institution.

Adam Smith did recognize, however, the enormous benefits that the voyages of discovery had brought to Europe. He said that "the discovery of America, and that of a passage to the East Indies by the Cape of Good Hope, are the two greatest and most important events recorded in the history of mankind", and that "one of the principal effects of these discoveries has been to raise the mercantile system to a degree of splendor and glory which it could never otherwise have attained to." Speaking of "the commercial towns of Europe" he says that "instead of being the manufacturers and carriers for but a very small part of the world (that part of Europe which is washed by the Atlantic ocean, and the countries which lie round the Baltic and Mediterranean Seas), have now become the manufacturers for the numerous and thriving cultivators of America, and the carriers, and in some respects the manufacturers too, for almost all the distant nations of Asia, Africa and America. Two new worlds have been opened to their industry, each of them much greater and more extensive than the old one, and the market of one of them growing still greater and greater every day."

The discoveries and the associated African slave trade were also emphasized by Karl Marx in his concept of "primitive accumulation", the early phase of conquest and plunder in the rise of capitalism. In connection with the expansion of the Lancashire cotton textile industry and its voracious appetite for the raw material from the slave plantations he made his cynical observation that "In fact, the veiled slavery of the wage-workers in Europe needed, for its pedestal, slavery pure and simple in The New World." His vision has inspired authors of the "dependency" school, such as Frank (1978) and Wallerstein (1974) to interpret the expansion of Europe as being largely at the expense of the peoples of the Third World.
The most remarkable modern work on the triangular trade and its wider ramifications is undoubtedly that by the late Trinidad scholar and statesman Eric Williams (1964). This book conveys a sweeping vision of the association between the slave trade and early British industrialization with meticulous historical scholarship and a scintillating prose style. While the so-called Williams Thesis has usually been framed in terms of the role of profits from the slave trade in providing the source of capital accumulation for the Industrial Revolution the book as a whole also stresses the role of the New World plantation economies as sources of raw materials and markets for manufactured products.

Since Williams' book appeared there has been a vast amount of research on all aspects of the triangular economic relationship. Our knowledge of the supply of slaves from Africa, and the volume of the traffic across the Atlantic, has been greatly enhanced. The economic conditions of the Caribbean plantations and the American colonies on the mainland are also much better known now than they were at the time when Williams was writing. While the broad outlines of the Industrial Revolution and its impact on the British and world economies have not been altered essentially in the last few decades, recent years have seen a great expansion in quantitative and analytical work, outstanding examples of which are the book by Crafts (1984) and the volume edited by Joel Mokyr (1985). All of this has led to an ongoing reassessment and controversy regarding Williams' seminal contribution.

The only analytical general equilibrium model of the triangular trade as a whole at present available, however, is by Darity (1982). He provides an ambitious specification that attempts to integrate all three components into a comprehensive model of growth and trade of the Atlantic economy. The price of the attempt to be comprehensive, as might be expected, is some unwieldiness in the resulting formulas and solutions and difficulty in grasping the reasons for some of the results of numerical simulations. The alternative model that I present in the next three sections of this paper is simpler and more
"streamlined" in structure, but it is clearly indebted to Darity's pioneering effort. I have also benefited greatly from reading his recent general essay on the subject, Darity (1988).

The genre to which the present essay belongs is that of the application of small-scale general equilibrium models to economic history, of which there are now a great many examples. The methodological issues involved are discussed with characteristic subtlety and insight by Peter Temin (1971). As to why I should inflict a model of the triangular trade in the Atlantic economy of the eighteenth century on an audience that might well expect more standard fare from a Graham Lecture, I can only quote my wise master, Robert Solow, who observed in a symposium on "Economic History and the Modern Economist" that: "Few things should be more interesting to a civilized economic theorist than the opportunity to observe the interplay between social institutions and economic behavior over time and place."
II

In the initial version of the model, that will be presented in this section, each region is completely specialized on the production of a single commodity -- "Europe" on manufactures, "America" on raw materials which are intermediate inputs for Europe's manufactures, and "Africa" on slaves, the export of which contributes to the labor force with which the raw materials are produced in America.

The production function for manufactures in Europe is given by

\[ M = \min \left[ F(K,L), R/\alpha \right] \]  

(1)

where \( M \) denotes the gross output of manufactures, \( R \) is the amount of imported raw material used up in production and \( \alpha \) is a constant denoting the amount of the raw material per unit of manufactured output. Capital and labor are denoted by \( K \) and \( L \) and the function \( F \) is homogeneous of degree one, with positive first and negative second derivatives with respect to each argument. Thus the manufacturing sector has a familiar neoclassical production function with substitutable inputs of capital and labor governing its output, but requires in addition a fixed quantity \( \alpha \) of raw material per unit of output.

The labor force is fixed and the supply of labor is perfectly inelastic with respect to the real wage. Capital, however, is endogenous in the model. It is assumed that there is a constant rate of time preference, and thus a real rate of interest, denoted \( \rho \), at which the supply of capital is perfectly elastic, in the long run. As in the one-sector neoclassical growth model capital and output are of the same "stuff" and so the marginal product of capital, under perfectly competitive markets, will be equal to the rate of interest. Given the relative price \( p \) of the raw material in terms of manufactures, profit maximization will lead to

\[(1-\alpha p) f'(k) = \rho\]  

(2)
where \( k \) is capital per worker, \( f(k) \) is gross output per worker and \( f'(k) \) is the marginal productivity of capital in terms of gross output while \( (1-\alpha p) f'(k) \) is the marginal productivity of capital in terms of "value added."

Differentiating (2) we obtain:

\[
\frac{dk}{dp} = \frac{\alpha f'(k)}{(1-\alpha p)f''(k)} < 0
\]  

(3)

Since

\[ M = Lf(k) \]  

(4)

it follows that

\[
\frac{dM}{dp} = Lf'(k) \frac{dk}{dp} < 0
\]  

(5)

Since the raw material input \( R \) is proportional to output it follows that \( R \) also varies negatively with the price of the raw material \( p \). Note that even though the input requirement per unit of output \( \alpha \) is a constant we still obtain a downward sloping demand curve for \( R \) as a function of \( p \). The reason is that the rise in \( p \) reduces the value added per unit of output, which requires a reduction in the capital-labor ratio to make the marginal product of capital (in terms of value added) continue to be equal to \( p \) as required by (2). With the given labor force \( L \) and less capital \( K \) gross output \( M \) must fall and thus the demand for \( R \) will decline in proportion to \( M \), giving us the negatively sloped relation between \( R \) and \( p \).

"America" is completely specialized on the production of the raw material \( R \) which
where the diminishing returns to slave labor $S$ is due to a fixed supply of land. The level of the slave labor force $S$ is an endogenous variable that has to be determined by the model.

Slaves are assets, with a real price in terms of manufactures denoted as $\pi$. We assume, with good historical justification for the most part, that conditions are such that the slave population does not reproduce itself. Reasons for this are varied, including the unbalanced sex ratio in favor of males in the traffic, the generally unhealthy climate and the harsh working conditions. We will denote by $\delta$ the death rate minus the birth rate, which is thus the rate at which the slave population "depreciates" in the absence of fresh imports. We assume also that the same rate of interest $\rho$ prevails in America as in Europe.

Under stationary or "steady state" conditions the following condition must hold for the slave price $\pi$ to be in equilibrium:

$$ (\rho + \delta) \pi = p R'(S) $$

(7)

The subsistence cost of slaves is taken as a constant and provided by the slaves themselves and therefore does not figure in equation (7).

Given $\pi$ and $p$ the asset demand for slaves can be determined from (7), since the marginal physical product of the slave labor force is a decreasing function of its size. Holding $p$ constant an increase in $\pi$ will reduce the asset demand for slaves, since the yield or "rental" must rise to maintain the same ratio $(\rho + \delta)$ to the price $\pi$. Holding $\pi$ constant and increasing $p$ must lead to an increase in the asset demand for slaves, to drive the marginal product down in proportion to the rise in $p$ so as to maintain (7).

The source of slaves in the model is "Africa." The flow supply of slaves, denoted $E_S$, is an increasing function of the price obtainable from the world market, which in the absence of trade impediments and transport costs will be equal to $\pi$. We thus have
\[ E_S = E_S(\pi) \quad \text{with} \quad E_S'(\pi) > 0 \quad (8) \]

The supply of slaves is obtained through capture or tribute by a predatory coastal state that conducts raids into the interior of the continent for the purpose of gaining access to this lucrative source of revenue. The historical evidence in support of this hypothesis is provided in section V.

In a "steady state" characterized by constancy in the stocks of capital and slaves, the import of slaves into the New World would have to meet the attrition or "depreciation" of the existing stock of slaves. The required condition is thus that

\[ E_S(\pi) = \delta S \quad (9) \]

which implies that the larger the slave population the higher must be the equilibrium price of slaves so as to induce the necessary supply of replacements.

The specification of the model is now complete and we can turn to the solution of the system, which is conveniently described in terms of Figure 2.

The upward sloping curve BB in the upper right-hand quadrant of Figure 2 is obtained as follows. From (9) we have seen that \( \pi \) is an increasing function of \( S \) in the steady state. Using this fact and differentiating (7) totally we obtain

\[ \frac{dS}{dp} = \frac{R'(S)}{[(\rho + \delta)p'\pi(S) - pR''(S)]} > 0 \quad (10) \]

which gives us the positive relation between \( S \) and \( p \) that is depicted by the curve BB. This curve illustrates the fact that the higher the price of raw materials in terms of manufactures the more profitable will it be to hold slaves as an asset in the New World, which requires an increase in the stock of slaves to drive down the rental \( pR'(S) \) and raise the supply price.
of replacements \( \pi \) sufficiently to leave the gross rate of return \((\rho + \delta)\) unchanged, as
required by (7).

The downward sloping curve MM in the upper left-hand quadrant depicts the
negative relationship between \( M \) and \( p \) established by (5). The proportional relationship
between \( M \) and \( R \) is indicated by the ray through the origin in the lower left-hand quadrant.
The lower right-hand quadrant depicts \( R \) as a concave function of \( S \), as given by (6). Thus
to each \( p \) there corresponds a given \( M, R \) and ultimately \( S \). Connecting all these points
gives us the downward sloping curve AA in the upper right-hand quadrant of Figure 2.

The curve AA illustrates the fact that the higher the price of the raw material, the
less will be the demand for it in the manufacturing center and therefore the less will be the
derived demand for a slave labor force in the New World. Equilibrium is thus obtained
only at the intersection of the two curves AA and BB, which gives us the magnitudes \( p^* \),
\( S^* \), \( K^* \), \( M^* \), \( R^* \) and \( \pi^* \) of all the endogenous variables of the system. The real wage \( w^* \) in
Europe and the rental of land in America will also be determined since the first depends
only on \( p^* \) and \( K^* \) and the second only on \( p^* \) and \( S^* \).

The GNP of each region can also be conveniently expressed below:

\[
Y_E^* = (1 - \alpha p^*) M^* = w^* L + \rho K^* \tag{11}
\]

\[
Y_{Am}^* = p^* R^* = p^* [R'(S^*)S^* + (R^* - R'(S^*)S^*)] \\
= (\rho + \delta) \pi^* S^* + p^* (R^* - R'(S^*)S^*) \tag{12}
\]
\((1 - \alpha p^*)M^*\) which is divided between wages \(w^*L\) and profits \(pK^*\). In America the GNP is equal to the total value of raw material output \(p^*R^*\). This can be divided between the earnings of the slave labor force \(p^*R'(S^*)S^*\), which of course accrues to the owners, and the residual which is the rent of land. The returns that the slave-owners receive is in turn equal to the sum of the depreciation of the value of their assets, which is \(\delta \pi^*S^*\), and the return on it at the rate \(\rho\), which is \(\rho \pi^*S^*\). African GNP is just equal to the value of slave exports, which in the steady state is equal to the replacement requirement of the slave population in America.

The difference between American exports of raw materials to Europe \(p^*R^*\) and American imports of slaves from Africa \(\pi^*\delta S^*\), assuming balanced trade i.e. no international borrowing and lending, would be American imports of manufactures from Europe, representing consumption of their income by slave-owners and land-owners. African import of manufactures \(\pi^*\delta S^*\) from Europe is exactly equal to their export of slaves to America. Europe's export of manufactures to both Africa and America exactly covers its raw material requirements \(p^*R^*\), leaving the "value added" at home to be consumed by workers and capitalists.
III

This section investigates the effect of various exogenous shocks to the system.

(a) An Increase in the Labor Force of Europe

We begin by considering the effects of a rise in $L$, the labor force in Europe. Observe first that the MM curve in the upper left-hand quadrant of Figure 2, that depicts the negative relationship between the price of the raw material and the output of manufactures, is proportional to the labor input in manufacturing. This is because equation (2) indicates a unique value of $k$, the capital-labor ratio, that makes the net marginal product of capital equal to the given rate of interest $p$. The capital stock $K$ must therefore increase in the same proportion as $L$ and $M$ also since the function $F(K,L)$ in equation (1) is homogeneous of the first degree. The demand for the raw material $R$ must increase in the same proportion as well because of the fixed coefficient $\alpha$.

The derived demand for slaves in the New World, however, would increase more than proportionately, because of diminishing returns with a fixed supply of land. If we relax this assumption of diminishing returns the demand for slaves would also increase in the same proportion, at the original equilibrium price $p^*$ of the raw material, i.e. the AA curve in Figure 2 shifts to the right in proportion to $L$. The BB curve, however, would still be upward sloping even in the absence of diminishing returns. This follows from equation (10), putting $R'(S)$ equal to zero, since $\pi'(S)$ is positive. Thus the effect of an increase in the labor force of Europe would be to raise the equilibrium price of the raw material $p^*$ so long as the supply of slaves from Africa is not perfectly elastic. The rise in the price of the raw material, by equation (2), will require a fall in the capital-labor ratio $k$. Hence the total capital stock and therefore the output of manufactures will rise less than proportionately to the increase in the labor force. Thus per capita output and real wages decline in Europe as a result of the adverse shift in the terms of trade with America. The equilibrium price of
slaves π* rises and so Africa as well as America are both made better off at Europe's expense if there is an increase in the labor force of Europe. The terms of trade deterioration for Europe would be even greater if there were diminishing returns in the production of the raw material since in that case the shift in the derived demand for slaves would be even greater.

The rising supply price of slaves from Africa thus acts as a check on purely extensive growth in Europe. Technological progress, i.e. an "Industrial Revolution", is one possible way out of the dilemma for Europe, which suggests the next exercise in comparative statics.

(b) An Industrial Revolution

The simplest way to depict the Industrial Revolution is as a Hicks-neutral shift in the production function F(K,L) or f(k) for the manufacturing sector. A coefficient λ, initially equal to unity, can be placed outside the production function, and the consequences of an increase in its value investigated.

Equation (2) will now be modified to (2)' below which is

\[(1 - \alpha \rho) \lambda f'(k) = \rho \]  \hspace{1cm} (2)'

Differentiating (2)' with respect to λ, holding p constant we obtain

\[\frac{\partial k}{\partial \lambda} = -\frac{f'(k)}{\lambda f''(k)} > 0 \]  \hspace{1cm} (14)

Thus the MM curve is shifted to the left in Figure 2 since the same labor force is now equipped with more capital per head in addition to the increase in productivity arising from the technical progress itself. The demand for the raw material, and the derived demand for slaves both increase as well, so that the AA curve is shifted to the right more
Figure 3
than in proportion to the increase in $\lambda$ because of the induced capital accumulation and the diminishing returns to slave labor. The BB curve will remain unchanged and so the effect of the Industrial Revolution is to raise the equilibrium prices $p^*$ and $\pi^*$ of both raw materials and slaves as well as the slave population $S^*$ in the New World.

Since $S^*$ increases it is clear that $R^*$ and so the gross output $M^*$ of manufactures must increase also. The deterioration of the terms of trade with America, however, raises the possibility of a reduction in value added if it is sufficiently great. In other words, we could have an instance of the Edgeworth-Bhagwati phenomenon of "damnifying" or "immiserizing" growth?.

To examine this possibility further we plot long-run supply and demand curves for the raw material in Figure 3. The demand curve DD' follows immediately from the M(p) curve MM' in the upper left-hand quadrant of Figure 2 since R(p) is simply $\alpha M(p)$. To each $p$ we find the value of $M$ from MM' and read off the corresponding R in the lower left-hand quadrant of Figure 2. Thus $K$ is varying all along DD' in such a way as to preserve equation (2). The long-run supply curve SS' is obtained by finding the $S$ corresponding to each $p$ from the BB' curve in the upper right-hand quadrant and then finding the R corresponding to that $S$ from the concave production function depicted in the lower right-hand quadrant. Thus equations (6), (7), (8) and (9) are all satisfied along SS'. The intersection of DD' and SS' depicts the original equilibrium values of $p^*$ and $R^*$.

The Industrial Revolution shifts DD' to the right while leaving SS' unchanged, so that the new equilibrium values of both $p^*$ and $R^*$ are higher than before. The extent of the rise in $p^*$, given the shift in DD', depends solely on the elasticity of the SS' curve. We define

$$e = \frac{p}{R} \ \frac{dR}{dp}$$  \hspace{1cm} (15)
as the long-run elasticity of supply of the raw material.

National income or "value added" in Europe is defined by the first equality in (11) of the previous section. Differentiating that equation we obtain

\[
\frac{dM}{M} > \frac{\alpha p}{(1-\alpha p)} \frac{dp}{p}
\]

as the condition for the change in national income, \(Y_F^*\), to be positive. Since \(M\) and \(R\) are proportional to each other this condition can be expressed as

\[
e > \frac{\alpha p}{(1-\alpha p)}
\]

i.e. "damnifying" or "immiserizing" growth requires the long-run elasticity of supply of the raw material to be less than the proportion of raw material cost to value added in the production of manufactures.

Thus once again, we see the critical importance of the elasticity of supply of the raw material from America, and hence ultimately of the elasticity of the supply of slaves from Africa, for the well-being of Europe.

(c) Technical Progress in Raw Material Supply

We now examine the effects of a shift in the production function for raw materials in America. This could arise either from an extension of the land frontier in the New World or an innovation such as the famous cotton gin of Eli Whitney, which actually also made it profitable to extend the land frontier as well. In any case the effect is to increase the output obtainable from a given slave labor force. Once again we can put a coefficient \(\theta\), initially equal to unity, in front of the production function \(R(S)\), and then examine the consequences of an increase in \(\theta\).
Equation (7) is now replaced by (7)' below

\[(\rho + \delta) \pi (S) = p \theta R'(S)\]  \hspace{1cm} (7)'

Differentiating (7)' with respect to \(\theta\) and holding \(p\) constant results in

\[
\frac{\partial S}{\partial \theta} = \frac{pR'(S)}{\{(\rho + \delta) \pi'(S) - p\theta R''(S)\}}
\]  \hspace{1cm} (18)

The increase in \(\theta\) therefore shifts the BB curve in Figure 2 to the right, i.e. there is a greater slave population that owners will desire to hold at any given price of the raw material since there has been an increase in their productivity. The AA curve is however shifted to the left as a result of the increase in \(\theta\). This is because each value of \(p\) corresponds to the same values of \(M\) and \(R\) as before but the derived demand for slaves is reduced since the same amount of the raw material can now be produced with a smaller slave labor force. The result is that the equilibrium price of the raw material \(p^*\) must fall as the result of the increase in \(\theta\) but the effect on the level of the slave population \(S^*\) and hence on the price of slaves \(\pi^*\) is ambiguous.

The lower \(p^*\) must result in a higher \(K^*\), \(M^*\) and \(Y_E^*\), so Europe is definitely benefitted as a result of the technical improvement in America. The effect on Africa depends upon whether the demand for slaves in America goes up or down. The effect on America itself depends on the extent of the deterioration of her terms of trade as a result of the shift in her long-run supply curve of exports. In terms of Figure 3 the SS' curve is shifted to the right while Europe's demand curve for raw materials DD' remains unchanged. The imports of manufactures that America can consume is simply the area \(p^*R^*\) of the rectangle defined by the equilibrium price and quantity of raw material supplied. This area rises or falls depending upon whether the elasticity of the long-run demand curve DD' of Europe is greater or less than one. This is exactly the Edgeworth criterion for "damnifying" growth in his original model with complete specialization.
(d) Restriction on Slave Exports

Finally we consider the effects of a restriction in the export of slaves from Africa. After the British and the United States declared the slave trade illegal in 1807, and the British interdicted slave ships under any flag on the high seas, the traffic across the Atlantic declined but by no means disappeared, since the enforcement was not sufficiently comprehensive. Thus the effects of the British action were analogous to an export tax that shifts the supply curve for slaves from Africa, represented by equation (8), to the left i.e. each value of \( \pi \) corresponds to a lower export of slaves \( E_S \) than before.

The effect of this in Figure 2 would be to shift the BB curve to the left while leaving the AA curve unchanged. The relative price of the raw material \( p^* \) will be raised and the slave population \( S^* \) will be reduced. Europe will experience a decline in \( K^* \), \( M^* \) and \( Y^*_E \) as a result. The price of slaves \( \pi^* \) will rise in America but the price received by the African exporters will fall, the difference being due to the implicit export tax imposed by the British interdiction.

Thus both Europe and Africa are adversely affected by the policy of interdiction since they experience deteriorations in their terms of trade. America's volume of exports \( R^* \) declines in response to the decline in the slave population but its terms of trade \( p^* \) with Europe improve. If the elasticity of European demand for the raw material is less than unity America's consumption of imported manufactures would rise and her welfare improve. In other words the interdiction could move America closer to the "optimum" tariff level of zero.
The only sure welfare gain arising from the interdiction is thus the not unimportant one of fewer inhabitants of the African continent being sold into slavery across the Atlantic every year.
A limitation of the model that we have been using up to now is that it exaggerates the role of manufacturing, and hence of slavery in the New World, on the economy of Europe. In the eighteenth century, in even the most advanced regions such as England the production of wheat and other staples in domestic agriculture was the major occupation of the labor force. Would recognition of this undoubted fact affect the qualitative results of the model in any significant way?

To examine this question we now assume that Europe has a domestic agricultural sector that produces wheat which is a non-traded good. At this stage in history trade in wheat or beef did not take place to any significant extent across the Atlantic, but was confined to intra-European trade. It is therefore justifiable to treat the output of the agricultural sector as a non-traded good for Europe as a whole, and even for deficit regions such as England the proportion of imports was still quite small.

The given labor force of Europe now has to be allocated between manufacturing and agriculture. As in Jones (1971) we assume a fixed supply of land that is specific to the agricultural sector and that labor is perfectly mobile between agriculture and manufacturing, which has the same technology as before.

We have

\[ L_a + L_m = L \]
Equation (2) above will continue to hold in the augmented model, except that the capital-labor ratio \( k \) will now refer not to the ratio of \( K \) to the total labor force \( L \), but only to \( L_m \). The real wage will be

\[
(1 - \alpha p) \left( f[k(p)] - f'[k(p)] k(p) \right) = w(p)
\]

(21)

where \( k(p) \), as before, denotes the value of \( k \) that satisfies equation (2), i.e. that makes the net marginal product of capital equal to \( p \). Thus given \( p \) the value of \( w \) is uniquely determined. In view of (3) it follows by differentiation of (21) that

\[
\frac{p}{w} \frac{dw}{dp} = -\frac{\alpha p}{1-\alpha p} \left( \frac{f(k)}{f'[k(p)] k(p)} \right) < 0
\]

(22)

Equilibrium in the labor market requires, with \( q \) as the relative price of \( A \) in terms of manufactures, that

\[
qA'(L_a) = w(p)
\]

(23)

Thus for any given value of \( p \), it follows that \( L_a \) and hence \( A \) is an increasing function of \( q \) because \( A''(L_a) \) is negative. In fact, we can specify that

\[
A(L_a) = A[L_a (q, w(p))]
\]

(24)

so that the positive relationship between \( q \) and \( A \) derived above, holding \( p \) constant, can be thought of as a partial equilibrium supply curve for \( A \).

We can also define

\[
C_a = C_a (q, Y)
\]

(25)

as the demand function for the output of the agricultural sector, with

\[
\frac{\partial C_a}{\partial q} < 0 , \frac{\partial C_a}{\partial Y} > 0
\]

(26)
where $Y$ denotes national income and the partial derivatives are the price and income effects on consumption of wheat. It can be seen that

$$Y = (1-\alpha)p f(k)k_m + qA$$  \hspace{1cm} (27)

Thus, for any given value of $p$ we can determine $Y$ and hence trace out a partial equilibrium demand curve $C_a(q)$ that is negatively sloped for $C_a$. The equilibrium value of $q$, for any given value of $p$, is obtained by setting

$$C_a(q) = A[L_a(q)]$$  \hspace{1cm} (28)

and finding the unique value of $q$ that satisfies this equation, which corresponds to the intersection of the demand curve defined by $C_a(q)$ with the supply curve $A[L_a(q)]$.

We now need to investigate the effects of variation in $p$ on the equilibrium value of $q$ obtained by (28). Any change in $p$ will affect $w(p)$, and thus shift the supply curve for $A$, as well as $Y(p)$, and thus shift the demand curve for $C_a$.

Differentiating (28) totally, taking account of (24) and (25), we obtain

$$\hat{q} = \frac{\partial C_a}{\partial Y} \frac{dY}{dp} \cdot \frac{A'(L_a)}{A''(L_a)} \frac{dw}{dp} \div \frac{1}{A(\sigma + \eta)} < 0$$  \hspace{1cm} (29)

where $\hat{q}$ is the proportionate change in $q$, $\sigma$ is the supply elasticity of $A$ with respect to $q$ and $\eta$ is the price-elasticity of demand for $C_a$ with respect to $q$.

The negativity of $\hat{q}$ is easy to establish. $Y$ is maximized for any given value of $p$, since there are no distortions in this perfectly competitive economy. Thus arise in $p$ must imply a reduction in $Y$ so that the derivative of $Y$ with respect to $p$ in the first term of the numerator is positive. In view of (23), (24) and (26) it follows that $\hat{q}$ must be negative.
The rise in \( p \) shifts the supply curve \( A[L_a(q)] \) to the right and the demand curve \( C_a(q) \) to the left. Thus the relative price \( q \) of the agricultural good must fall as a result of the rise in \( p \). We have thus defined \( q \) as a function of \( p \)

\[
q = q(p) \quad \text{with} \quad q'(p) < 0
\]  
\hspace{1.28in}(30)

The effect of the rise in \( p \) on the equilibrium output of \( A \), and hence on employment in the agricultural sector \( L_a \), depends on the relative magnitudes of the shifts in the demand and supply curves. Holding the demand curve constant it follows from (29) that

\[
\sigma A_\hat{q} + \frac{A'(L_a)}{A''(L_a)} \frac{dw}{dp} = -\eta A_\hat{q} > 0
\]  
\hspace{1.28in}(31)

in which the first term on the left-hand side is the induced decline in the supply of \( A \) resulting from the fall in \( q \), and the second term is the positive shift in the supply of \( A \) induced by the fall in \( w \) associated with the rise in \( p \). Since \( \eta \) is positive it follows that the right-hand side is positive and so the induced decline in the supply of \( A \) must be less than the positive shift that led to the fall in \( q \). So long as the shift in the demand curve is sufficiently small this result in (31) would continue to hold. The demand shift is the product of two terms, the marginal propensity to consume wheat out of real income, and the effect on national income of a rise in the price of the raw material for the manufacturing sector. The latter in particular is likely to be quite low in view of the relatively low share of manufacturing at the time of the Industrial Revolution. We therefore have established that

\[
A = A(p) \quad A'(p) > 0
\]  
\hspace{1.28in}(32)
A rise in the relative price of the raw material therefore leads to a reduction in manufacturing employment. Since we have already shown in (3) that the capital-labor ratio also varies negatively with \( p \) it follows that \( K \) and hence \( M \) must also vary negatively with \( p \).

In terms of the MM curve in the upper left-hand quadrant of Figure 2 the augmented model thus only serves to increase its elasticity with respect to \( p \) since employment as well as capital per worker are now being reduced in response to a rise in \( p \). Since all other curves in Figure 2 remain unchanged it follows that we have established that introducing an agricultural sector into Europe does not alter the qualitative properties of the original model in any way. This in turn implies that all the comparative static exercises carried out in the previous section continue to have the same results in terms of the direction in which the different endogenous variables are affected. In view of its importance, however, it would be useful to discuss the impact of the Industrial Revolution in the context of the wider model a little more fully.

Holding \( p \), and therefore also \( q \) constant, the initial effect of the technical progress in the manufacturing sector is to raise the capital-labor ratio and therefore also the real wage in that sector. With conditions in the agricultural sector unchanged the rise in the real wage offered by manufacturing will divert labor into that sector. Thus not only capital per worker, but employment as well will increase initially in manufacturing as a result of the Industrial Revolution. At the initial relative prices \( p \) and \( q \) there will be an increase in the demands for both raw materials and wheat, while there will be a leftward shift in the supply of wheat as well. The relative price of both raw materials and wheat must therefore rise. These relative price increases will dampen some of the initial increase in the capital stock and employment of the manufacturing sector, though they cannot reverse it.

The model of the present section also enables us to investigate the effects of an Agricultural Revolution in Europe, generally regarded as having accompanied the Industrial
Revolution in the eighteenth century. At initially given $p$ and $q$, and therefore at a given $w(p)$ in manufacturing, an Agricultural Revolution would shift the marginal productivity of labor schedule in agriculture, and thus the supply curve of wheat as well, to the right. Demand for wheat would also shift to the right, but by less, so that $q$ would fall for given $p$. At each $p$ employment, and capital in the same proportion, would be reduced in manufacturing. The MM' curve and hence the AA' curve in Figure 2 would thus both be shifted to the left so that $p$ will fall. This reduction in $p$ will induce some increase in capital per head and employment in manufacturing and thus reverse some of the initial decline in $q$.

The significance of the Agricultural Revolution is that it prevented large relative price increases for wheat and raw materials from choking off the manufacturing expansion induced by the technological progress of the Industrial Revolution itself. There was no "scissor's crisis" as in the case of the Soviet industrialization drive of the 1920's that led to Stalin's collectivization of the peasantry. The increased output from domestic agriculture, plus intra-European imports, enabled England to overcome this problem much more successfully. The "primitive accumulation" took place in Africa and America, rather than in the local countryside.
This section will relate the implications of the model to the broad patterns of the historical record of the Atlantic economy during the period under discussion.

(a) Volumes and Prices of Slave Exports

In the most authoritative study to date on the numbers involved in the Atlantic slave trade Philip Curtin (1969) estimates that total slave imports into the New World from the inception of the trade in the fifteenth century to its end around 1870 amounted to 9,566,100 persons. The annual level rose from about 13,000 during the seventeenth century to a peak of 55,000 during the period 1701-1810, falling to 31,600 during the period 1810-1870, i.e. after the British abolition in 1807. The eighteenth century accounted for about two-thirds of the total number of slave imports into the New World over the entire history of the trade. Many indicators show that the trade peaked during the last two decades of the eighteenth century, i.e. the period 1780-1800 that is usually associated with the onset of the Industrial Revolution in England. Curtin (Table 63, p. 211) reports that slave exports by England, France and Portugal, the major nations involved, rose from about 470,000 during the decade 1771-1780 to 790,000 from 1781-1790; 623,000 in 1791-1800 and then falling to 493,000 from 1801-1810, no doubt reflecting the effects of the British abolition. In another important study David Eltis (1987) estimates slaves imports into the United States as 55,800 for 1781-1790; 79,000 for 1791-1800 and 156,300 during 1801-1810, while the corresponding imports into the British Americas was 100, 200 in the first, 194,300 in the second and 105,400 in the last of these same decades.

There is also strong evidence that slave prices were rising faster than the prices of manufactures during the latter part of the eighteenth century, i.e. that the terms of trade were turning in favor of Africa. Eltis and Jennings (1988, Table 1) report that Britain's gross barter terms of trade with Africa rose from 100 in 1700 to 112 in 1750 and then fell to 40
by 1800 i.e. slave prices (the major African exports) rose two and a half times relative to the prices of manufactures (Africa's main import). Eltis and Jennings also observe that a slave was worth two muskets at the beginning of the century and no less than fifteen at the end, not to speak of the possible quality improvement in firearms that had taken place over this period.

Evidence on the terms of trade also comes from a detailed study of the Senegambia region in West Africa by Curtin (1975), that is cited extensively in an interesting discussion of the triangular trade by Fernand Braudel (1984) in the third volume of his massive work. The terms of trade of this region are calculated by Curtin to have risen from 100 in 1680 to 475 in 1780, during which period the proportion of slaves in total exports rose from 55% at the beginning to 86% at the end. Referring to this experience Braudel (p. 439) says "Finally -- and here comes the surprise -- faced with Europe's still voracious demands (for slaves), Africa in the end reacted according to the classic rules of economics: by putting up her prices." Why the great French savant should find this surprising I do not know.

The impact of the slave trade on West Africa is discussed in an imaginative and convincing manner by A.G. Hopkins (1973, chapter 3). He states (p. 105):

"The remarkable expansion of the slave trade in the eighteenth century provides a horrific illustration of the rapid response of producers in an underdeveloped economy to price incentives".

Our assumption on the nature of slave supply is also supported by another quote from the same page of Hopkins' study where he says that:

"...it is possible that part of the increase in the price paid for slaves in the eighteenth century resulted from a growing
scarcity of labor resources and from better defensive
arrangements on the part of those who had become frequent
targets of slave-gathering expeditions. In other words, slave
suppliers may have experienced increasing *marginal costs*
(italics mine) as a result of the growth of external
diseconomies which, given the extent of slaving, were
inevitable."

Eltis and Jennings (1988) report that textiles constituted 56% of African imports in
the 1780's, alcohol about 10%, miscellaneous manufactures another 10% and guns and
gunpowder 8%, rising to nearly 15% by the 1820's. Firearms could possibly be regarded
as a component in the production function for slave acquisition, as mentioned in the
following quotation from a stimulating study by the anthropologist Jack Goody (1971, p.
55):

"...the states of Ashanti and Dahomey refused to allow guns
and powder to pass through their territories to the inland
kingdoms; for it was precisely their control of these weapons
that enabled them to dominate the interior and to extract from
its peoples the slaves they needed to purchase more guns and
to maintain their standards of living."

We shall have to leave to a future occasion, however, the pursuit of this fascinating
link between foreign trade and the formation of predatory states through the import of
firearms. The question of the "opportunity cost" of the slave exports in the domestic
African economy and other aspects of the supply conditions for slaves from Africa is
pursued in an extremely stimulating paper by Stefano Fenoaltea (1988) that came to my
attention after the first draft of this paper was written. His approach is largely complementary to mine.

Included in the imports of alcohol was rum from New England. Indeed, the native American version of the triangular trade was the export of molasses from the West Indies and the southern colonies to New England, from which rum would be made and exported to Africa in exchange for slaves who were then imported into the sugar producing regions. Thus, in terms of our model, New England has to be viewed as a trans-Atlantic extension of Old England. Eric Williams (p. 80) says "The rum trade on the slave coast become a virtual monopoly of New England."

(b) Overseas Trade and European Expansion

We now turn our attention from the African corner of the triangle to the European one. Since data on a continent-wide basis are not available in any convenient form we have to look at the situation in terms of individual countries, beginning of course with the most dynamic of all, England. It used to be commonplace among the more traditional economic historians that there was a Commercial Revolution that preceded the Industrial Revolution, after which the changes in technology, production and trade all merged together.

This view is expressed in a most illuminating and convincing way by Phyllis Deane (1965, chapter 4). Not only did domestic exports and retained imports rise about fivefold in the course of the century, picking up speed in the second half, but this substantial overall growth was accompanied by a pronounced shift in the geographical pattern and commodity composition of trade. In 1700 the rest of Europe took 85% of her exports and provided 66% of her retained imports. In 1798 Europe's shares had fallen to 30% and 43% of exports and retained imports respectively. North America, the West Indies and Africa, the "triangular" component, took only about 12% of exports and provided about 20% of imports in 1700. By the end of the century these shares had risen to 60% of domestic
exports and 32% of retained imports. In other words the inter-continental triangular trade
had expanded much more rapidly than the intra-European component of British foreign
trade. 9

While colonial trade grew faster than total trade for England in the eighteenth
century, total trade grew more than twice as fast as national income. Deane and Cole (1969,
Table 19, p. 78) indicate that while the index number of total real output rose from 100 in
1700 to 251 in 1800 the output of export industries rose from 100 to 544 over the same
period. Export industries also grew faster than total industry and commerce, which rose
from 100 to 387. There is therefore little doubt that British growth in the eighteenth
century was "export-led" and that among exports it was manufactured exports to and re-
export of colonial produce from the New World that led the way.

For most of the eighteenth century the key import into England was sugar. We are
used to thinking of sugar as a final consumer good, but it was unrefined brown or
"muscovado" sugar, syrup and molasses that were exported by the West Indian plantations.
In good Mercantilist fashion the final processing into refined white sugar and distillation of
molasses into rum were reserved for the industry of the mother country. New England
was able to get into the rum trade in a significant way only because of the inconvenience of
transporting molasses across the Atlantic. Differentiated tariffs provided the necessary
"effective protection" for hundreds of sugar refining establishments in Bristol, Glasgow
and London, which was the main center. Per capita consumption of sugar in England,
stimulated by association with tea and coffee, rose sharply and re-export of refined sugar to
the continent was also a lucrative business. Raw sugar was a fifth of total imports in 1774,
far exceeding any other items, according to Davis (1973, p. 251). A fascinating account of
the role of sugar in European economy and society is provided in a recent study by the
Production of sugar in the New World, which was about 50,000 tons in 1700, rose to 200,000 tons by the end of the American Revolution. The growth of sugar production was closely correlated with slave imports and the size of the slave population. Craton (1974, p. 54) has a graph that reveals the first point very clearly. He also reports (p. 139) that the slave population in the British West Indies rose from 100 to 600 thousand over the eighteenth century, while production of sugar rose fivefold from 25,000 to 125,000 tons. There is thus a close conformity between the growth of sugar production in the West Indies, the foreign trade of England and the traffic in slaves across the Atlantic, that is also brought out very clearly in the fine piece by Richardson (1987).

France, the other heavyweight of the European economy, was subject to much the same trends as England with respect to growth and foreign trade in the course of the eighteenth century, as reported by Crouzet (1967). Not only was the over-all growth rapid, but the same structural shift in favor of the Caribbean is pronounced. Saint Domingue (the present-day Haiti) was the main French sugar colony, experiencing an explosive growth in its slave population which doubled from about 240,000 to 480,000 in 1791, just before the outbreak of the famous slave revolt led by Toussaint l'Ouverture. Re-exports of colonial produce, especially sugar and coffee were an important component of total trade and trade with her colonies constituted almost 40% of total French trade. France was even able to displace England in the supply of sugar to the rest of Europe, since the English sources were Barbados and Jamaica, where soil exhaustion had led to higher costs in those islands making Britain less competitive and in fact even requiring protection within the British market.

Both England and France were also important sources of manufactured imports into Brazil and Spanish America. Portugal required her colonial possessions to direct their trade through the mother country in the usual Mercantilist fashion but she was herself unable to supply the rising Brazilian demand for manufactured goods, stimulated first by sugar
cultivation and later by the boom in gold production in Minas Gerais, which was also dependent on slave labor. English exports to Portugal, the famous exchange of Cloth for Wine as in Ricardo’s example, was to a considerable extent undertaken to ultimately satisfy Brazilian and not Portuguese demand. This example clearly shows how the statistics cited earlier, about the shift in emphasis of English trade to the "triangular" as compared with the intra-European component, actually understates the true shift since export to Portugal was really to a large extent export to Brazil. Gold from that country, which England obtained by the surplus of her exports of woolen and other manufactured goods to Portugal over her import of wines and other primary products, was used to maintain the operation of the gold standard and thus contributed to the monetary basis of English prosperity. The Anglo-Portuguese trade, interestingly described by Fisher (1963) and Sideri (1970), had its counterpart in the Franco-Spanish relation that found an outlet for French manufactures in the American possessions of Spain.

Sugar continued to be the main commodity involved in the triangular trade up to the decade of the 1780’s. Fogel and Engerman (1974) state that up to 60 or 70% of all slave imports were into one or the other of the European sugar colonies. Slave mortality was particularly high in the sugar colonies for both climatic and economic reasons, with the rate of natural decrease, the δ of our model, varying between 5% and 2% in these regions for most of the century. The British and French possessions in the Caribbean took 58% of all slave imports, Brazil 38% with the rest evenly divided between colonies of the smaller European states and the North American mainland. This share of only 6% for the region that was to become the United States, with its large slave population at the time of the Civil War is surprising. The explanation is that the better climate and the absence of the ravages of sugar production on the mainland resulted in a surplus of births over deaths for the slave population from the outset of colonization in this region.
Cotton was a comparative latecomer to the triangular trade, starting only from the decade of the 1780's in a significant way. The technical innovations occurring in the Lancashire cotton textile industry that we normally associate with the Industrial Revolution, led to an explosive growth in the demand for raw cotton imports from the New World that created a boom in all aspects of the Atlantic trade. Lancashire trebled its imports of raw cotton in the 1780's compared with the previous decade, doubling in each subsequent decade up to an annual average of about 60 million lbs. in the first decade of the nineteenth century. Initially the supplies came from the West Indies and Brazil but ultimately it was the United States that was the major source of raw material for Lancashire, right up to the outbreak of the Civil War.

Cotton exports from the United States were only 189,000 lbs. in 1791 but grew by leaps and bounds to an average of about 70 million lbs. for the three years prior to the outbreak of the War of 1812, continuing to grow rapidly after a brief interruption due to this event. The terms of trade of the United States also improved sharply during this period. The invention of the cotton gin by Eli Whitney in the 1790's was a major stimulus to the extension westwards of the area under cotton cultivation. The role of cotton in the ante-bellum U.S. economy is a large and fascinating subject that lies beyond the scope of the present paper. It is worth asking, however, what might have happened if the abolition of the slave trade and the natural increase of the slave population had not cut off the link to Africa and thus prevented the Atlantic economy from behaving as predicted by our model during the nineteenth century. The further importation of slaves did in fact continue, particularly into Brazil and Cuba, but on a much smaller scale than predicted by the model. In the United States, moreover, the growth of cotton cultivation would surely have furnished a new and far more dynamic basis for the slave trade. This is certainly a clear case in which one would not wish life to imitate art. Eltis and Jennings (p. 959) state unequivocally that:
"If the slave trade had not been abolished the impact of overseas trade (on Africa) would have been larger in the nineteenth century ..." and that "rising European needs for raw materials from plantations would have prompted an expansion of the traffic that might well have dwarfed the nineteenth-century migration from Europe." They add that "slave prices would have increased substantially but this would not have prevented massive expansion of the traffic."
While a detailed examination of the Williams Hypothesis is beyond both the scope of this paper and the scholarly capabilities of its author, I cannot resist the temptation to make some remarks on the continuing debate surrounding this fascinating subject on the basis of the model and the summary of historical experience presented here. Williams' thesis was that Britain's participation in the slave trade, and in the plantation system of the New World, had a significant, if not even indispensable, role to play in the emergence and financing of the Industrial Revolution. The link that is stressed in much of the subsequent debate is the reinvestment of profits from the slave trade itself, or more broadly from the plantation system as a whole, in the cotton mills of Lancashire and other industrial projects associated intimately with the Industrial Revolution. Williams' evidence on this is largely anecdotal, the citing of particular instances where such financing took place. There was certainly no attempt to make even an informed guess about the proportion of industrial investment in Britain that was financed in this way.

Engerman (1972) made an ingenious calculation designed to provide an upper bound for this critical proportion. Taking profits from the slave trade only, the proportions come to 0.54% of national income, 7-8% of total investment and 38.9% of commercial and industrial investment in 1770. If profits from sugar plantations are added in the total rises to possibly as much as 5% of British national income, compared with a share of about 7% of total investment in national income. Engerman felt that these numbers were sufficiently low to reject the Williams thesis but I agree with Barbara Solow (1985) in finding them remarkable.
Williams also, however, stresses the channels that we have emphasized in our model, the role of the New World plantations as both sources of raw material and markets for finished manufactures. As Williams says (p. 71):

"Manchester received a double stimulus from the colonial trade. If it supplied the goods needed on the slave coast and on the plantations, its manufacturers depended in turn on the supply of the raw material. Manchester's interest in the islands was twofold."

This broader hypothesis of the role of Africa and America in relation to European expansion is vigorously disputed by Patrick O'Brien (1982). Conducting an Engerman-style exercise in this extended context he claims (p. 18) that "...for the economic growth of the core, the periphery was peripheral" [his terms "core" and "periphery" correspond to our "Europe" on one hand and "Africa" and "America" on the other] and that the attempts to argue a role for the periphery in the expansion of the core "founder on the numbers" (p. 16).

Once again, it seems that smallness lies in the eyes of the beholder. Table 1 of O'Brien's paper presents some numbers that appear to me to be as high as the most enthusiastic Williams supporter could hope for. His "Estimated Flows of Profits to British Capitalists Engaged in Trade and Commerce with the Periphery" for 1784-1786 give a figure of 5.66 million pounds sterling as compared with gross investment for the same period of 10.30 million pounds sterling, i.e. over 50%. If investment in industry and commerce is taken as the usual 20% of the total this means that these "colonial" profits were two and a half times as high as industrial investment. In other words a propensity to save out of such profits of 40% could have financed all industrial investment. Once again this does not establish the Williams thesis but it is hard to see how O'Brien can claim that
the "periphery was peripheral" and that the thesis "founders on the numbers" in the light of his own estimates. His corresponding calculations in the same table for 1824-1826 put colonial profits and gross investment at 15.95 million pounds and 34.30 million pounds respectively, a slight decline to just below 50% as compared with the earlier period.

O'Brien's impression of the quantitative insignificance of the triangular trade and colonial trade generally to Europe seems to be based essentially on the smallness of the ratios of foreign trade and trade-dependent industries such as Lancashire cotton textiles to national income. In common with all less developed countries Europe in 1800 had the bulk of its activity in agriculture, most of the output of which went into domestic consumption. He cites estimates of foreign trade being about 4% of national income for Europe as a whole at this time, implying that trade with Asia, Africa and America could not have amounted to much more than 1% of national income. The cotton textile industry in England at the height of the Industrial Revolution was also only about 7% of national income.

Dividing by national income can stop almost any conversation or debate in economics, including free trade versus protection, direct versus indirect taxation or almost anything else. If the bottom line is always going to be what difference does anything make relative to national income as a whole the simple answer is usually going to be -- not much. But is it relevant or appropriate in every case to divide by the national income?

Clearly in this case what is crucial is not "Europe" as a whole but the more dynamic and progressive part of Europe at that time, which was Britain followed by France. Furthermore, crucial as improvement in agriculture was to the acceleration of "modern" economic growth it was not the "leading sector" in this advance. As we have seen in the previous section foreign trade grew substantially faster than national income in both England and France during the course of the eighteenth century and the colonial trade of
both grew substantially faster than total foreign trade. Lancashire exported over two-thirds of its output of cotton textiles to overseas markets and of course obtained all of its raw materials from them. Even the more traditional woollens industry was highly dependent on exports, much of it to colonial markets. While cotton textiles may have been just 7% of national income, which in any case is "large" by any standards and particularly for an industry totally dependent on imported inputs it was, as everyone knows, the pioneer in terms of technology and factory organization for the rest of British industry and then for Europe and ultimately the world. On the other side of the Atlantic the cotton growing sector in the American South provided the "engine of growth" for the U.S. economy as a whole from 1790 to 1860, as even a modified version of Douglass North's (1966) thesis suggests.\(^1\)

In view of the fact that the colonial trade and the cotton supply were hardly conceivable without slavery, it is very surprising indeed to have O'Brien say (p. 9) that "...a hypothetical British edict abolishing the slave trade in 1607, rather than two centuries later, could not have made that much difference to the levels of wealth and income achieved in Western Europe in 1807." In the absence of any likely alternative overseas markets O'Brien presumably feels that the West European economy would have done it on its own, on the basis of industries other than cotton to provide the initial stimulus. Conceivably cotton could have been supplied from the Middle East, but it is clear that the volume of supplies would have been much less and relative prices much higher. O'Brien relies extensively on technical progress, which he seems to see as an exogenous force that operates independently of the exigencies of markets and sectors and the advantage to later comers of emulating successful pioneers.\(^2\)

As Joseph Inikori (1987) has argued in an imaginative and stimulating contribution, even the surge of population growth in England in the second half of the the eighteenth century can be related to the better wages and employment prospects opened up
by the expansion of international trade which induced a rise in fertility through lowering the age of marriage. The technical improvements that took place in agriculture could be a response, in the fashion of Boserup (1981), to the pressures generated by this increase in the rate of population growth. In denying the role of the periphery, and hence of slavery, O'Brien is driven to deny the entire stimulus that the maritime orientation of the European economy of the eighteenth century gave not only to commercial and industrial, but to financial and institutional changes as well.

The fallacy of attempting to "deduce significance from size," as Barbara Solow (p. 103) elegantly puts it, was dealt with long ago by no other than Paul Mantoux (1962) himself, the great pioneer in the study of the Industrial Revolution. He says (p. 103):

"...if we may borrow an analogy from natural science, only a negligible quantity of ferment is needed to effect a radical change in a considerable volume of matter. The action of foreign trade upon the mechanism of production may be difficult to show, but it is not impossible to trace."

To avoid misunderstanding I should make it clear that I emphatically reject any view that it was solely through the plunder and pillage of Africa and other areas of the "periphery" that Europe was able to create the foundations of the modern industrial world in the eighteenth century. Plunder and pillage of one society by another goes back into the mists of antiquity without any traces of leaving even an incipient industrial revolution. Thus slavery and associated violence is certainly not "sufficient" to explain the emergence of the Industrial Revolution in Britain. Nor do I think that it was even "necessary", in the sense that without it the Industrial Revolution could never have happened, albeit somewhat later. What I do believe, is that it was an integral part of a complex inter-continental system
of trade in goods and factors within which the Industrial Revolution as we know it emerged. Within this system of interdependence, as I have tried to illustrate in the structure of the simple general equilibrium model, it would make as much or as little sense to trace a causal arrow from slavery to British industrialization as the other way around. Those who would dismiss slavery as essentially irrelevant, however, ought at least to specify the necessary counter-factual experiments for the sources of tropical products and markets for manufactured goods that the triangular trade provided.
1See Smith (1976), Volume Two, Book IV, chapter VII, Part III "Of the Advantages which Europe has Derived from the Discovery of America, and from that of a Passage to the East Indies by the Cape of Good Hope."

2See Ricardo (1951), chapter XXV "On Colonial Trade."


6This is the approach I adopted in Findlay (1982) in an earlier attempt to analyze the relation between foreign trade and the Industrial Revolution. That model had a domestic agricultural sector in addition to manufacturing in England but did not allow explicitly for imported raw materials as a manufacturing input. The extended model of the next section of the present paper, which introduces domestic agriculture, therefore generalizes my 1982 analysis of trade and growth in the Industrial Revolution.

7See Edgeworth (1894) and Bhagwati (1958).

8This raises interesting issues of why the British interdiction was introduced, if it did not benefit any readily identifiable group in the country. Prima facie it seems to be consistent with a purely humanitarian or "ideological" motivation, as opposed to one based on "interests" of particular groups. The simple model used here, however, does not have enough structure to have any real bearing on this question.

9The original source of much of this information is Davis (1962).

10See Mathias (1969), Table 34.

11See Lee and Passell (1979), chapter 7 for a balanced discussion regarding North's hypothesis and its critics.

12Berrill (1960), for example, points to the role of large foreign markets in encouraging investments that embody new technology while Landes (1969) emphasizes the role of "emulation" or "diffusion" in the spread of the Industrial Revolution from Britain to the continent.
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