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The Classical Theory of Trade

1. Introduction

Trade can take place if there is a difference in autarkic relative prices between countries, which may be due to different demand and supply conditions. For example, two countries with identical supply conditions may have unique autarkic relative prices because of differences in consumers' tastes. On the supply side, technological differences and disparities in factor endowments can also cause a difference in relative autarkic prices.

The classical model of trade focuses on the supply side, and singles out the difference in technology as the chief determinant of trade. To illuminate the role of technology, the classical model relies on a very simple production structure by assuming competitive product and factor markets with a single or composite factor of production called labor. The difference in relative costs is thus solely due to the difference in labor productivities. In 1817, David Ricardo[2] laid out the theory of comparative advantage, which showed that all nations could benefit from free trade even if a nation was less efficient than its trading partners at producing all kinds of goods.

In a two-country, two-good setting, the Ricardian model has the following four basic assumptions:

1. Labor is the only factor of production.

2. Labor productivities are constant. (This is the same as the assumption of constant returns to scale (CRS).)

[2]David Ricardo (1772-1823) was the son of a Jewish financier. When he converted from Judaism to marry a Quaker, his father abandoned him and never spoke to him again. Ricardo made a fortune on the London stock market. He purchased an estate in Gatcombe Park and also held a seat in Parliament, and advocated free trade and the repeal of the Corn Laws. His theory of comparative advantage was first published in Ricardo (1817).

3. Labor productivities are different between two countries in an industry. Labor is freely mobile between industries within a country but not mobile between countries.

4. There is perfect competition in the product and factor markets.

The difference in labor productivities can be due to labor skills or natural endowments, such as weather and the fertility of land. Constant labor productivity is equivalent to constant returns to scale, which means that as labor input is doubled, the output is also doubled. This ensures that the average and marginal products of labor are constant and equal to each other for any level of output.

Let L be the fixed labor endowment (supply) in the home (H) country and L_j $(j = 1, 2)$ the employment of labor in industry j. Also let S_j be the production (supply) of good j in H. Denote $a_{Lj} \equiv L_j/S_j$ which is the number of labor-hours needed per unit of good j in H; e.g., $a_{Lj} = 2$ means that two labor hours are needed to produce one unit of good j. a_{Lj} is often called an **input/output coefficient**. The foreign counterparts are denoted with an asterisk.

Under the assumption of constant returns to scale, if L_j is doubled, then S_j is also doubled. Therefore, the ratio $L_j/S_j = a_{Lj}$ is constant. Hence, the production function in industry j is a linear function showing that output is a constant multiple of labor input: $S_j = a_{Lj}^{-1} L_j$. The coefficient a_{Lj}^{-1} is the average product of labor (S_j/L_j) and is also the marginal product of labor (dS_j/dL_j). The production side of the Ricardian model can be summarized by the following input/output coefficient (or technology) matrix: $\begin{bmatrix} a_{L1} & a_{L1}^* \\ a_{L2} & a_{L2}^* \end{bmatrix}$. As shown later, the remarkable feature of the Ricardian model is that the trade pattern is completely determined just by this technology matrix.

2. Autarkic Equilibrium

Let w be the money wage rate in H and w^* the money wage rate in F. A competitive firm in an industry is a price taker. It chooses output to maximize profit facing constant product and factor prices. The profit function in industry j is

$$\Pi_j = p_j S_j - w L_j = p_j a_{Lj}^{-1} L_j - w L_j.$$

Maximization of Π_j with respect to L_j yields the first-order condition:[3]

$$wa_{Lj} = p_j,\ j = 1, 2. \tag{1}$$

A competitive firm sells at a given market price p_j. Every unit of sale has the same price so that p_j is the average revenue and also the marginal revenue. To produce one unit of good j requires a_{Lj} hours of labor. Each hour of labor costs w dollars. Hence, wa_{Lj} is the average cost of good j. Since wa_{Lj} is constant for a firm, the average cost is also equal to the marginal cost. The first-order condition thus shows that the marginal cost is equal to the marginal revenue, which is the condition for any profit-maximizing firm. It also shows that the average cost is equal to the average revenue. Therefore, the profit is zero for the competitive firm. With free entry and exit, a competitive industry can only earn zero profit in the long run. The profit maximization conditions in (1) turn out to be the long-run equilibrium conditions as well. These conditions are referred as **the zero-profit conditions**. The foreign country's counterparts are

$$w^* a^*_{Lj} = p^*_j,\ j = 1, 2. \tag{2}$$

As we have discussed, trade is determined by the difference in autarkic relative prices. In the Ricardian system, the autarkic relative prices are readily obtained from the zero-profit conditions:

$$\frac{p_1}{p_2} = \frac{wa_{L1}}{wa_{L2}} = \frac{a_{L1}}{a_{L2}},\ \ \frac{p^*_1}{p^*_2} = \frac{w^* a^*_{L1}}{w^* a^*_{L2}} = \frac{a^*_{L1}}{a^*_{L2}}. \tag{3}$$

Clearly, the autarkic relative prices are determined only by the input-output coefficient ratios, and are independent of the wage rates. As a result, in the Ricardian model, the trade pattern is determined by the technology matrix only.

[3] Strictly speaking, if $p_j a_{Lj}^{-1} < w$, then the optimal $L_j = 0$; but if $p_j a_{Lj}^{-1} > w$, then $L_j = \infty$. We rule out both cases as we require both sectors to produce positive output in autarkic equilibrium.

3. The Law of Comparative Advantage

3.1 The Case of Absolute Advantage

Consider the technology matrix:

$$\begin{bmatrix} a_{L1} & a^*_{L1} \\ a_{L2} & a^*_{L2} \end{bmatrix} = \begin{bmatrix} 1 & 4 \\ 2 & 1 \end{bmatrix}.$$

In this case, each country is absolutely superior in the production of one and only one good. H is more efficient in good 1 (G1) and F in good 2 (G2). By (3), the autarkic relative prices are $p_1/p_2 = 1/2 < 4/1 = p^*_1/p^*_2$. Thus, H exports G1, and F exports G2. This is a case of **absolute advantage**, which is attributed to Adam Smith.[4]

3.2 The Case of Comparative Advantage

Consider the following technology matrix:

$$\begin{bmatrix} a_{L1} & a^*_{L1} \\ a_{L2} & a^*_{L2} \end{bmatrix} = \begin{bmatrix} 1 & 40 \\ 2 & 10 \end{bmatrix}.$$

In this case, H is more efficient in the production of both goods, and F is less efficient in both. Can trade still take place?

It is commonly thought that F is dominated in both goods and therefore cannot compete. What makes the Ricardian theory famous is that it accounts for the fact that trade will still take place. H cannot undersell both goods to F. To prove the Ricardian theory, recall that trade is determined by autarkic relative prices. Although H is more efficient in both goods, it is only **relatively** more

[4]Adam Smith (1723-1790) was a Scottish political economist and philosopher, who became famous for his influential book, *An Inquiry into the Nature and Causes of the Wealth of Nations*, written in 1776. The book examined in detail the virtues of economic freedom. It discussed numerous themes such as the role of self-interest, the function of markets, the division of labor, and the international implications of a laissez-faire economy. Smith is credited with the doctrine of "the invisible hand," which he used to demonstrate how self-interest guides the most efficient use of resources in a nation's economy.

efficient in G1 ($p_1/p_2 = 1/2 < 40/10 = p_1^*/p_2^*$). Consequently, it can only export G1 since it only has a **comparative advantage** in that good. F can still export G2 to H because it has a comparative advantage in G2 ($p_2^*/p_1^* = 10/40 < 2/1 = p_2/p_1$); stated differently, F is comparatively less disadvantaged in G2. The Ricardian theory, therefore, verifies that no country can undersell a foreign country in all industries. A country can only export a good in which it has a comparative advantage, and a country, no matter how absolutely disadvantaged, can still export a good in which it is comparatively less disadvantaged.[5]

Proposition 1 ***(The Ricardian Law of Comparative Advantage)*** *Trade is not determined by comparing a_{Lj} with a_{Lj}^* but is determined by comparing (a_{L1}/a_{L2}) with (a_{L1}^*/a_{L2}^*). If $a_{L1}/a_{L2} < a_{L1}^*/a_{L2}^*$, the home country has a comparative advantage in good 1 and will export good 1 and import good 2; the foreign country has a comparative advantage in good 2 and will export good 2 and import good 1. If $a_{L1}/a_{L2} > a_{L1}^*/a_{L2}^*$, the trade pattern is reversed.*

Although the autarkic relative prices are the crucial determinants of trade, once trade is opened up, these autarkic prices will disappear and the new world prices will dominate the market. Without transport costs and other impediments to trade, the relative prices under free trade will be equalized between countries. We will now denote the prices observed under free trade by a superscript t so that p_j^t is the money price of good j under free trade in H and p_j^{*t} is the money price of good j under free trade in F. Once trade is opened up, H exports G1 and imports G2, given $p_1/p_2 < p_1^*/p_2^*$. This will force the relative prices of G1 in H and F to converge to $p^t\,(= p^{*t})$.

3.3 Opportunity Costs and the Production Possibility Frontier

In the classical model, the wage rate adjusts freely to labor market conditions. Whenever there is excess demand in the labor market, w will go up; whenever there is excess supply, w will go down.

[5] Nobel laureate Paul Samuelson was once challenged by the mathematician Stanislaw Ulam to name one proposition in all of the social sciences which is both true and non-trivial. Several years later, Samuelson (1969) responded with the Law of Comparative Advantage—"That it is logically true need not be argued before a mathematician; that it is not trivial is attested by the thousands of important and intelligent men who have never been able to grasp the doctrine for themselves or to believe it after it was explained to them."

w adjusts to clear the labor market so that those seeking employment at the equilibrium w will all be employed. Full employment is the outcome of the classical flexible wage assumption.

The full-employment condition in H is $L_1 + L_2 = L$, which is equivalent to

$$a_{L1}S_1 + a_{L2}S_2 = L. \tag{4}$$

As discussed before, under constant returns to scale (CRS) and the condition that there is one factor of production, each a_{Lj} is constant. The above equation is thus a linear equation with two variables S_1 and S_2 (in a no growth economy, the labor endowment L is assumed constant). This defines the production possibility curve (or the production possibility frontier (PPF)), which is a **straight line** in the classical model, unlike the usual bowed-out shape in neoclassical models.

Similarly, the full-employment condition in F defines its production possibility line (frontier):

$$a^*_{L1}S^*_1 + a^*_{L2}S^*_2 = L^*. \tag{5}$$

Example 1 *Consider the following technology matrix:* $\begin{bmatrix} a_{L1} & a^*_{L1} \\ a_{L2} & a^*_{L2} \end{bmatrix} = \begin{bmatrix} 1 & 4 \\ 2 & 1 \end{bmatrix}$ *and* $\begin{pmatrix} L & L^* \end{pmatrix} = \begin{pmatrix} 40 & 80 \end{pmatrix}$. *This implies that the two full employment conditions are* $1 \cdot S_1 + 2S_2 = 40$ *and* $4S^*_1 + 1 \cdot S^*_2 = 80$. *The production possibility lines are plotted in Figs. 1 and 2.*

The slope of a country's PPF measures the trade-off between producing the two goods by reallocating labor from one industry to the other. Let the absolute value of the slope be defined as the marginal rate of transformation (MRT):

$$MRT \equiv -dS_2/dS_1 \text{ and } MRT^* \equiv -dS^*_2/dS^*_1.$$

In the example above, $MRT = 0.5$, which implies that in order to produce one more unit of good 1 in H, production of good 2 must be reduced by 0.5 units. This is **the opportunity cost** of good 1 (in terms of good 2) in the home country.

From the two full employment conditions in (4) and (5), we obtain $-dS_2/dS_1 = a_{L1}/a_{L2}$ and

Figure 1:
The Home Country's PPF

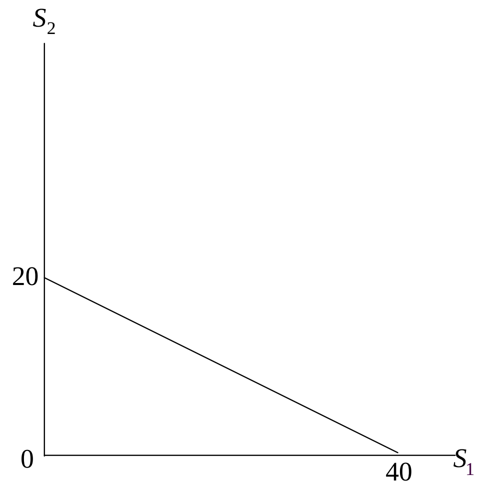
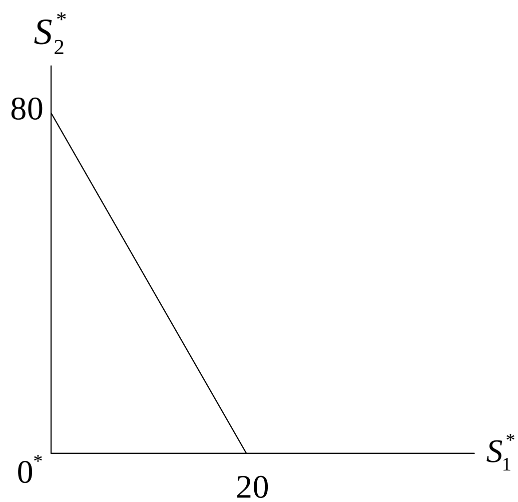


Figure 2:
The Foreign Country's PPF



$-dS_2^*/dS_1^* = a_{L1}^*/a_{L2}^*$. But we have shown that $a_{L1}/a_{L2} = p_1/p_2$ and $a_{L1}^*/a_{L2}^* = p_1^*/p_2^*$. It follows that

$$MRT = p_1/p_2 = MC_1/MC_2$$
$$MRT^* = p_1^*/p_2^* = MC_1^*/MC_2^*$$

where MC_j denotes the marginal cost in industry j in H. Thus, the slope of the production possibility frontier is the opportunity cost of one good in terms of the other and is completely determined by the technology matrix. With the numerical example in the technology matrix given above, we have $MRT = p_1/p_2 < p_1^*/p_2^* = MRT^*$; hence, H exports G1, and F exports G2.

4. Autarkic Equilibrium

Having examined the supply side, we turn to the demand side in order to determine the autarkic equilibrium. Let preferences be represented by the social utility functions in the two countries: $U = U(D_1, D_2)$ and $U^* = U^*(D_1^*, D_2^*)$. In autarky, the consumers in H maximize $U(D_1, D_2)$ subject to the budget constraint

$$p_1 D_1 + p_2 D_2 = p_1 S_1 + p_2 S_2, \tag{6a}$$

where $p_1 S_1 + p_2 S_2$ is the nominal national income. Since in autarky, $D_1 \leq S_1$ and $D_2 \leq S_2$, maximization of $U(D_1, D_2)$ is equivalent to choosing the highest attainable consumption point subject to the PPF. The optimal point is shown in Fig. 3 as point A. The tangent line at A to the indifference curve U^a shows the budget constraint equation (6a). This line coincides with the equation showing the PPF, which is also the full-employment condition in (4). The marginal rate of substitution (MRS) at point A is the absolute value of the slope of the indifference curve at that point:

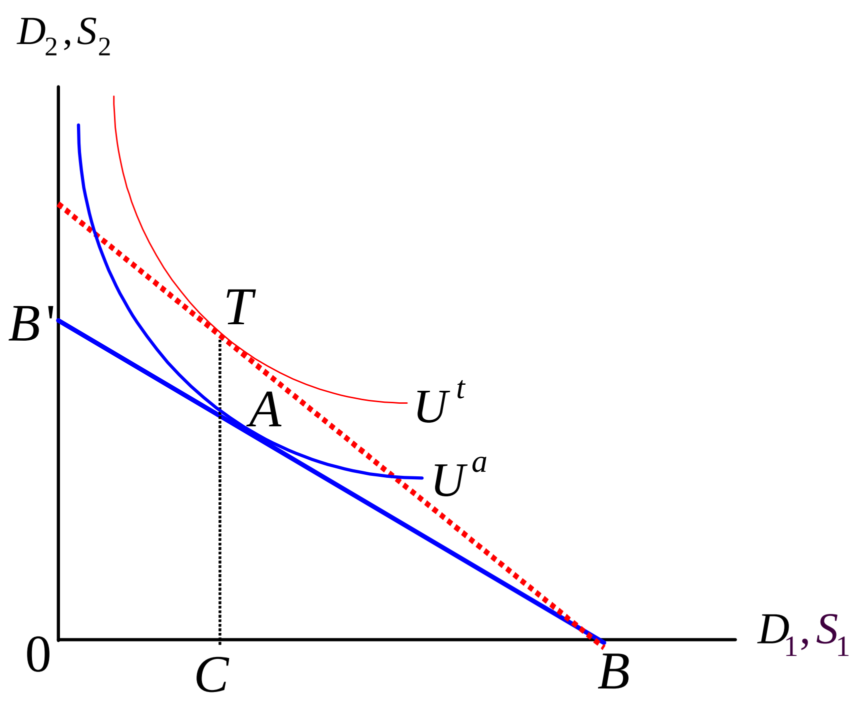
$$MRS|_{U=\bar{U} \text{ at } A} \equiv -dD_2/dD_1 = U_1/U_2,$$

where U_j is the marginal utility of good j. The absolute value of the slope of the PPF at point A is MRT, which is MC_1/MC_2, as already shown. The absolute value of the slope of the budget line (the BA line in Fig. 3) is p. It follows that the autarkic equilibrium is characterized by

$$MRS = U_1/U_2 = p = MC_1/MC_2 = MRT. \tag{7}$$

Under the equilibrium autarkic price ratio p, consumers attain their maximum utility under their budget constraint and the producers attain their maximum profit, which is zero. It is the relative price that brings consumers and producers together and the competitive markets that allow them to achieve their objectives efficiently.

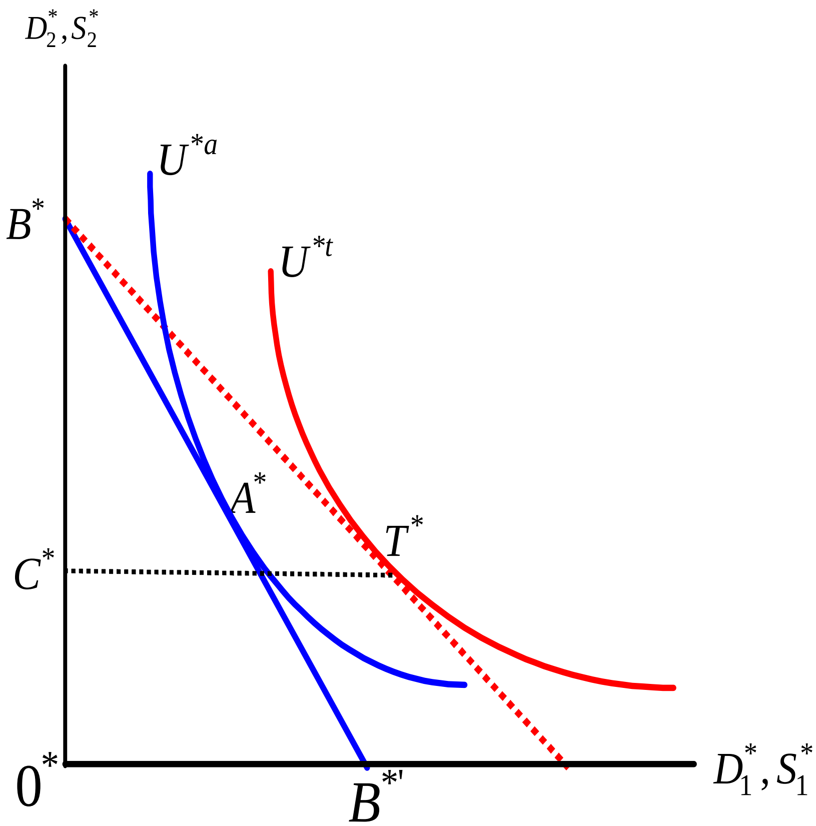
Figure 3:
Autarkic and Free Trade Equilibrium in H



Similarly, in the foreign country, the autarkic equilibrium is represented by point A^* in Fig. 4 and

$$MRS^* = U_1^*/U_2^* = p^* = MC_1^*/MC_2^* = MRT^*. \tag{8}$$

Figure 4:
Autarkic and Free Trade Equilibrium in F



5. Free Trade Equilibrium

In autarky, $p < p^*$. Once trade is opened up, the two autarkic relative prices will converge to a common world relative price $p^t \ (= p^{*t})$. Industry 1 will expand and industry 2 will contract in H. The production point in H will move from point A downward on its PPF. If H is still diversified after trade, both sectors must still satisfy the zero-profit conditions, and the marginal costs ratio is still the same as in the autarkic case. Thus, $p^t = p$. In this case, the home country is sufficiently large so that it does not become completely specialized. The consumers will continue to face the same budget constraint as in the autarkic case, and the chosen consumption point will remain at A.

If the home country is small enough such that $p < p^t$, it will become completely specialized in good 1 after trade, and good 2 will not be produced in H. If it were possible to produce both goods, both industries would have to earn zero profits in a long-run equilibrium, and we would have $w^t a_{L1} = p_1^t$ and $w^t a_{L2} = p_2^t$. This would imply $p^t = a_{L1}/a_{L2} = p$, a contradiction. Thus, industry 2 would be unprofitable ($w^t a_{L2} > p_2^t$) and could not remain in operation. The free trade production point is at point B in Fig. 3.

Facing (p_1^t, p_2^t) under free trade, the home consumers' budget constraint becomes

$$p_1^t D_1 + p_2^t D_2 = p_1^t S_1^t + p_2^t S_2^t. \tag{9}$$

Line BT in Fig. 3 is such an equation with $S_2^t = 0$. The nominal GDP becomes $p_1^t S_1^t$. The consumption point moves from A to T, which is also a trading point relative to the production point B. H exports BC of G1 in exchange for CT of G2 at the terms of trade $p^t = M/X$. Clearly, the home country's utility level increases from U^a to U^t.

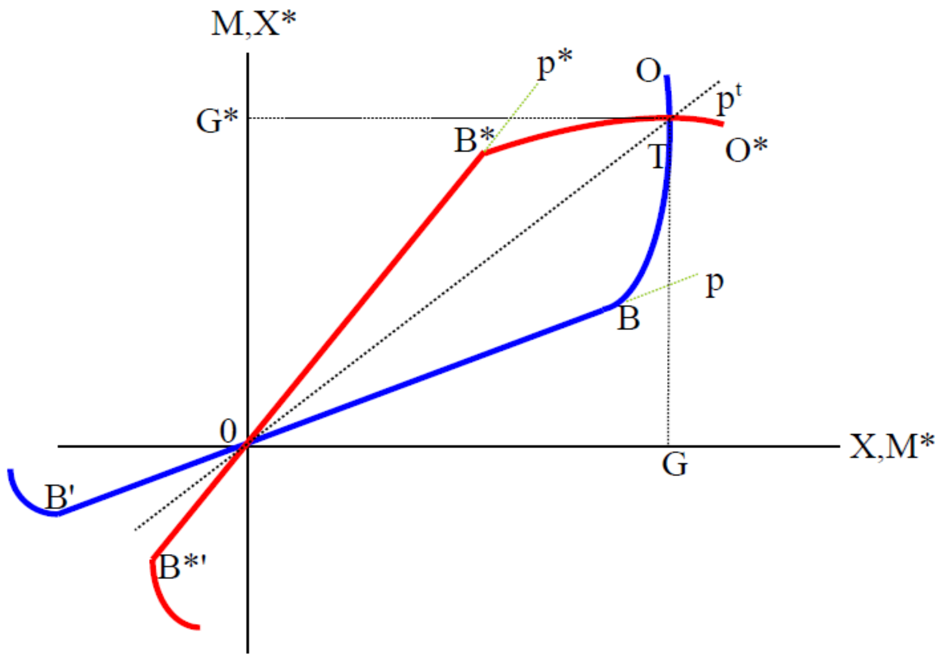
The foreign country's production point moves in the opposite direction to point B^*, as shown in Fig. 4. It exports B^*C^* of G2 and imports C^*T^* of G1. Since p^t clears both markets, the two triangles TCB and $B^*C^*T^*$ must be identical. The trading volumes are $BC = X = C^*T^* = M^*$ and $CT = M = B^*C^* = X^*$.

How is the equilibrium p^t determined? It is convenient to use the offer curve analysis to answer this question. At the autarkic p in Fig. 3, the production and consumption points are both at A. This corresponds to Fig. 5 at the origin 0 in the (X, M) space. As already discussed, if $p = p^t$, then the production point can be at any point on the PPF, but the consumption point is at A in Fig. 3. Thus, the possible trading locus in Fig. 5 is the linear segment BB' which corresponds to the PPF in Fig. 3. At point T in Fig. 5, the economy is completely specialized in G1. If $p < p^t$ so that p^t is like the BT line in Fig. 3, H's desired trading triangle is BCT, which corresponds to the triangle $0GT$ in Fig. 5. The locus $B'0BO$ is the home country's **offer curve**. It extends to the third quadrant since the desired trade pattern is reversed if $p^t < p$. In the curved segment BT, H is completely specialized in good 1; but if in the interior of the straight line segment BB', it is diversified in production.

The foreign country's offer curve is depicted as the locus $B^{*\prime}0B^*O^*$. Free trade equilibrium occurs at T, and the equilibrium terms of trade are the slope of the $0p^t$ ray. The home trade triangle $0GT$ is the exact match of the foreign trade triangle $0G^*T$, and both markets are cleared. Note that at T, both countries are specialized in production, and p^t lies between p^* and p.

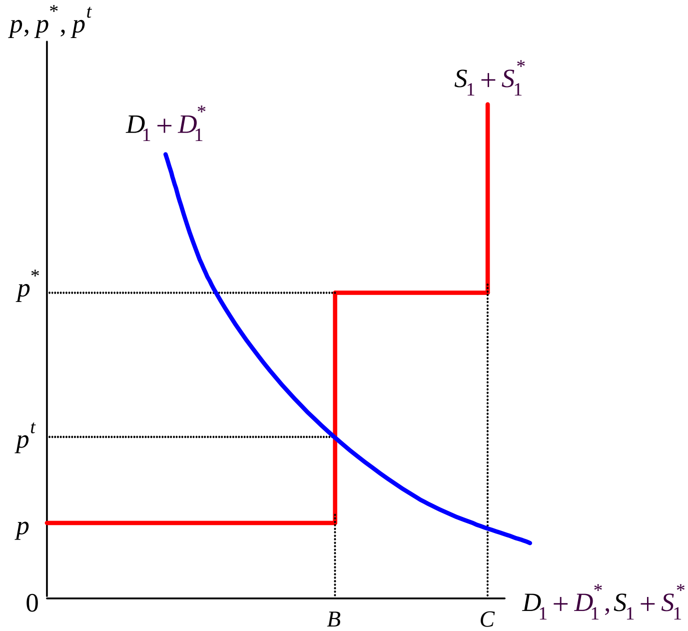
If two countries are different in size, then the larger one is likely to produce both goods after trade. One can imagine that in Fig. 5, if F is small so that its PPF is very close to the origin, the $B^{*\prime}B^*$ segment will be short and the trading point will likely be on the linear segment $0B$ of the home offer curve. In this case, $p^t = p < p^*$. The small foreign country moves to a higher indifference curve, but the large home country has no gains from trade. This points to an important result: *Countries that experience greater deviations between their autarkic and free-trade price ratios enjoy larger gains from trade*.

Figure 5:
Free Trade Equilibrium



One can alternatively use the world supply and demand functions to determine the equilibrium terms of trade. According to Walras' Law, equilibrium in one market ensures equilibrium in both. Consider, for example, the market for good 1. Recall that p and p^* are the two autarkic price ratios in H and F, respectively, and that p^t is the world relative price of good 1, which is common to both countries. Fig. 6 shows that world demand, $D_1 + D_1^*$, is a decreasing function of p^t and that world supply is a step function of p^t. If $p^t < p$, both countries will produce G2 and $S_1 + S_1^* = 0$. If $p^t = p < p^*$, H's production can be at any point on its PPF, but F is specialized in G2 so that $S_1 + S_1^*$ ranges from 0 to B, with the length $0B$ being the length of the projection of H's PPF onto its S_1 axis. If $p < p^t < p^*$, H specializes in G1 and F in G2 so that any p^t in this range leads to the same $S_1 + S_1^*$. If $p < p^t = p^*$, then F can produce at any point on its PPF, and its potential supply of G1 can range from B to C. The length BC is the length of the projection of F's PPF onto its S_1^* axis. Finally, if $p^* < p^t$, then both countries specialize in G1, and world production is at C.

Figure 6:
The Determination of Equilibrium Terms of Trade



If H is large and F is small, the segment $0B$ will be long and BC will be short, and the equilibrium p^t will likely be the same as p. Similarly, if F is large and H is small, it is likely that $p^t = p^*$. The positions of the demand curve and the supply structure determine the equilibrium terms of trade p^t.

5.1 The Gains from Trade

We have already demonstrated that if a country is specialized after trade, then its consumption point is on a higher indifference curve than in the autarkic case. The gains from trade are reflected in higher consumers' utilities. In this section, we demonstrate the gains from trade from a different perspective, showing that if specialization in production occurs, then the real wage rate in terms of the imported good will go up and workers are better off.

Trade forces industries in both countries to adjust. Industry 1 in H expands to meet new foreign demand, and industry 2 contracts as a result of imports. If H is not relatively too large in size, it is conceivable that it may become completely specialized in G1. Due to the assumptions of perfect competition and CRS, the equilibrium in industry 1 after trade must meet the new zero-profit condition:

$$w^t a_{L1} = p_1^t. \tag{10}$$

If $p < p^t$, then the production of G2 in H must become unprofitable under the new world price:

$$w^t a_{L2} > p_2^t. \tag{11}$$

To measure the welfare of workers, what matters is the real wage rate and not the money wage rate w. The real wage rate is the money wage rate divided by a price index. Here we define w^t/p_j^t as the real wage rate in terms of good j; namely, one hour of work is paid w^t dollars which can buy w^t/p_j^t units of good j. Thus, w^t/p_j^t is the hourly pay in terms of good j. Since $w^t/p_1^t = a_{L1}^{-1}$ and $w^t/p_2^t > a_{L2}^{-1}$ from (11) and (10) and $w/p_1 = a_{L1}^{-1}$ from the zero-profit condition in (1), we obtain

$$w^t/p_1^t = w/p_1 \text{ and } w^t/p_2^t > w/p_2. \tag{12}$$

As G2 is imported, workers must be consuming it. They are better off after trade since their real wage rate, though unchanged in terms of G1, rises in terms of G2. The gains from trade are evident by increases in the real purchasing power of their earnings.

6. References

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7. Exercises

1. If $\begin{bmatrix} a_{L1} & a^*_{L1} \\ a_{L2} & a^*_{L2} \end{bmatrix} = \begin{bmatrix} 1 & 4 \\ 2 & 1 \end{bmatrix}$, what are the average and marginal labor productivities in each industry in both countries?

2. Consider a Ricardian model.

   (a) Draw the average and marginal cost curves as functions of output in the Ricardian model.

   (b) Draw the average and marginal revenue curves of a Ricardian firm.

   (c) What are the implications for the equilibrium profit?

   (d) What are the implications for the equilibrium output level of a firm?

3. In a two-good Ricardian model, assume that $\begin{bmatrix} a_{L1} & a^*_{L1} \\ a_{L2} & a^*_{L2} \end{bmatrix} = \begin{bmatrix} 100 & 40 \\ 200 & 10 \end{bmatrix}$. Determine the pattern of trade.

4. Assume that both the home and foreign countries become completely specialized after trade in a two-good Ricardian model. Prove that there are gains from trade for both countries in terms of the changes in real wage rates in the two countries.

5. In a two-good Ricardian model, assume that $\begin{bmatrix} a_{L1} & a_{L1}^* \\ a_{L2} & a_{L2}^* \end{bmatrix} = \begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix}$, $\begin{pmatrix} L & L^* \end{pmatrix} = \begin{pmatrix} 200 & 300 \end{pmatrix}$.

   (a) Suppose that in autarky, the home country employs 100 workers in each of the two industries. Workers in both industries are paid \$6 per hour. What are the autarkic product prices of industry 1 and 2 in the home country?

   (b) When the country opens to free trade, what will be the pattern of trade? what is the possible range of the world relative price p^t? If the world prices are \$10 per unit of good 1 and \$20 per unit of good 2 under free trade, what will be the national income per hour for each country?

   (c) Contrary to the normal Ricardian model assumptions, suppose that workers are unable to change occupations when trade is opened. In other words, we continue to have 100 workers in each industry in the home country. What is the national income per hour of the home country? How does it compare with the national income of part (b) which assumes that workers are mobile among sectors?

6. In this two-good Ricardian economy, assume that the autarkic real wage rate in terms of good 1 (w/p_1) is 5 and the autarkic relative price of good 1 (p_1/p_2) is 0.4. After trade is opened up, the nation becomes completely specialized in good 1 and one unit of its exports is exchanged for 4 units of imports.

   (a) What is the input/output coefficient vector for this country?

   (b) Does the real wage rate in terms of good 1 go up after trade? If yes, by how much?

   (c) Does the real wage rate in terms of good 2 go up after trade? If yes, by how much?

7. If a large country remains diversified in production after trade, it has no gains from trade. Why will trade still take place?

8. Consider the market for good 2. Draw a diagram similar to Fig. 6 for the determination of **the relative price of good 2 in terms of good 1** ($p_2/p_1 = 1/p$).

9. In a two-good Ricardian model, assume that $\begin{bmatrix} a_{L1} & a_{L1}^* \\ a_{L2} & a_{L2}^* \end{bmatrix} = \begin{bmatrix} 40 & 10 \\ 10 & 10 \end{bmatrix}$. Determine the pattern of trade.

10. In a two-good Ricardian model, assume that $\begin{bmatrix} a_{L1} & a_{L1}^* \\ a_{L2} & a_{L2}^* \end{bmatrix} = \begin{bmatrix} 10 & 20 \\ 5 & 2 \end{bmatrix}$ and $\begin{pmatrix} L & L^* \end{pmatrix} = \begin{pmatrix} 500 & 200 \end{pmatrix}$. Assume that after trade, both countries are completely specialized.

    (a) What is the range of possible equilibrium world relative price p^t?

    (b) What is the equilibrium world supply of good 1, $S_1 + S_1^*$ after trade?

11. Suppose 50 years later, F became extremely small compared to H. Other settings are the same as Question 10.

    (a) What is the possible relative price p^t?

    (b) What is the possible world supply of good 1, $S_1 + S_1^*$?