

Chapter 7

DIFFERENCES IN TECHNOLOGY: THE RICARDIAN MODEL

7.1. Absolute and Comparative Advantage

The determinants-of-trade question will be analyzed Part II by relaxing, in turn, each of the five assumptions from Chapter 6 and examining the implications for international trade. The first model we consider is one in which production functions (technology) differ across countries. This model is often associated with 19th century British economist David Ricardo. In order to keep the model simple and the focus as clear as possible, we will assume that there is only one factor of production, labor, which we denote by L in this Chapter. By differences in technology, we mean that the amount of output that can be obtained from one unit of labor differs across countries. The one-factor model can be thought of as a special case of condition 2 of the previous chapter: with one factor, the issue of differences in relative endowments does not arise.¹

Constant returns to scale are assumed. In terms of the production functions of Chapter 2, constant returns and one factor together imply that the production possibility frontier will be linear. As we will see later, this assumption significantly simplifies the analysis. We also impose the remaining conditions of Chapter 6: there are no distortions such as imperfect competition or taxes, and tastes are identical and homogeneous (in fact, the last assumption is not needed for any of the principal results).

The Ricardian model, then, assumes that labor is the only constraint on the production process. Assuming that two goods, X_1 and X_2 , are produced with *constant returns*, the production functions and the labor constraint can be written in a very simple form

$$X_{\theta} = F_{\theta}(L_{\theta}) \quad \text{specifically } X_1 = \alpha_1 L_1 \quad (7.1)$$

$$X_2 = F_2(L_2) \quad \text{specifically } X_2 = \alpha_2 L_2 \quad (7.2)$$

$$\bar{L} = L_1 + L_2 \quad (7.3)$$

where α_1 and α_2 are some positive constants. Note that α_1 and α_2 are the *marginal products of labor* in industries X and Y respectively: α_1 and α_2 give the additional outputs obtained from one unit of labor.

Now introduce two countries, h and f as before. The assumption that production functions differ between countries implies that the values of α_1 and α_2 will be different in the two countries, and so we will give the α 's country subscripts as well. Two pieces of terminology and the difference between them are quite important. Absolute advantage refers to the comparison of the α 's for a given industry across countries. Thus we have the following example:

$$\alpha_{h2} > \alpha_{f2} \quad \text{defines country } h \text{ as having an } \textit{absolute advantage} \text{ in good } X_2 \quad (7.4)$$

The term comparative advantage refers to the relative productivity in the two industries across countries. Thus for example:

$$\frac{\alpha_{h2}}{\alpha_{h1}} > \frac{\alpha_{f2}}{\alpha_{f1}} \quad \text{defines country } h \text{ as having a } \textit{comparative advantage} \text{ in good } X_2 \quad (7.5)$$

An important contribution of Ricardo (as we understand it), was to point out that a sufficient

condition for the existence of gains from trade is that there exists comparative advantage; that is, a strict inequality in (7.5) (whether greater than or less than) is sufficient for gains from trade. One country could have an absolute productivity advantage in both goods, but that is not relevant for trade. It is relevant to other questions such as wage comparisons between countries, and that will be discussed later.

The proof of the argument is relatively straightforward. Assume that (7.5) holds. Beginning in a situation in which both countries are producing both goods, let us move some labor in country h out of X_1 and into X_2 and some labor out of X_2 and into X_1 in country f. That is, labor is reallocated in each country toward the comparative-advantage industry.

$$dL_{h2} = -dL_{h1} > 0 \quad dL_{f1} = -dL_{f2} > 0 \quad (7.6)$$

Then the changes in the *total world output* of the two goods will be

$$dX_1 = -\alpha_{h1}dL_{h2} - \alpha_{f1}dL_{f2} \quad dX_2 = \alpha_{h2}dL_{h2} + \alpha_{f2}dL_{f2} \quad (7.7)$$

Set the first equation to zero, reallocating labor within each country to hold world X_1 output constant, and solve for

$$dL_{f2} = -\frac{\alpha_{h1}}{\alpha_{f1}}dL_{h2} \Leftrightarrow dX_1 = dX_{h1} + dX_{f1} = 0 \quad (7.8)$$

Substitute (7.8) into the right-hand equation of (7.7), replacing dL_{f2} with (7.8).

$$dX_2 = \left[\alpha_{h2} - \frac{\alpha_{h1}}{\alpha_{f1}}\alpha_{f2} \right] dL_{h2} = \alpha_{h1} \left[\frac{\alpha_{h2}}{\alpha_{h1}} - \frac{\alpha_{f2}}{\alpha_{f1}} \right] dL_{h2} > 0 \quad (7.9)$$

which follows from (7.5) and (7.6). This shows that, holding the world output of one good constant, it is possible to reallocate labor in each country toward the sector of comparative advantage so that the world output of the other good rises. Note that the sign of (7.9) depends only on comparative advantage and is not invalidated if one country is absolutely more productive in both industries.

Finally, note that a pattern of comparative advantage is both necessary and sufficient condition to be able to increase the world output of one good without decreasing the output of the other. If there is no comparative advantage, that is if (7.5) is a strict equality, then (7.9) is zero (the term in brackets is zero).

7.2 The production frontier

Figure 7.1 shows the production frontier for a single economy. The “economic size” of the country, the distance of the production frontier from the origin, is determined by a combination of its labor endowment and its absolute productivity levels. Total production capacity can be high due either to a large population or high productivity: for total GDP it will not matter which is the case, but it will certainly matter for wages discussed below. The slope of the production frontier is determined only by its comparative-advantage ratio and indeed is equal to the ratios used in (7.5).

Figure 7.1

Figure 7.2 shows production frontiers for two countries on a per-worker basis (or for countries with identical labor forces L) which satisfy the pattern of comparative advantage in (7.5). H_2H_1 is the production frontier for country h and F_2F_1 is the production frontier for country f under the assumption that not only is (7.5) satisfied, but also each country has an absolute advantage in their comparative-

advantage sector. The two production frontier cross one another. Holding country f 's technology constant, $H_2'H_1'$ shows the frontier for country h when it has an absolute advantage in both goods: h 's production frontier per worker will then lie entirely outside f 's frontier.

Figure 7.2

In a symmetric case (countries are mirror images of one another, and half of income is spent on each good), the gains from specialization and trade are as illustrated in Figure 5.2 of the previous chapter. As an exercise, try to draw a situation where one country is absolutely economically bigger as in the case of F_2F_1 and $H_2'H_1'$ in Figure 7.2.

7.3 Excess demand and international equilibrium

The fact that countries *can* potentially gain from trade does not necessarily ensure that they *will* in fact capture these gains. If we assume that the economies are competitive and undistorted, then the gains-from-trade theorem applies and the worst outcome for one country is that it captures zero gains.

Figure 7.3 is essentially a repeat of Figure 5.1 and can be used to construct the excess demand curve M_h for one country, arbitrarily chose to be country h , in Figure 7.4. At the autarky price ratio which is the slope of the production frontier H_2H_1 , the country consumes at point A in Figure 7.3 but is actually indifferent to producing at any point on the production frontier and trading to point A . Thus there is a flat section of the excess demand curve for X_1 in Figure 7.4 at the autarky price ratio. Point H_1 in Figure 7.3 corresponds to being specialized in and exporting X_1 and thus to point H_1 in Figure 7.4 and point H_2 in Figure 7.3 corresponds to being fully specialized in X_2 and hence importing X_1 at point H_2 in Figure 7.4.

Figure 7.3 Figure 7.4

Similarly, price ratios p^{*1} and p^{*2} in Figure 7.3 correspond to p^{*1} and p^{*2} in Figure 7.4, where the country exports at the former and imports X_1 at the latter.

Figure 7.5 presents the excess demand curves for both countries, M_h and M_f , based on their production frontiers in Figure 7.1. Each excess demand curve has a flat section at that country's autarky price. In the situation shown in Figure 7.5, international equilibrium occurs at price ratio p^* at which the import demand of h ($M_{h1} > 0$) matches the export supply ($M_{f1} < 0$) of Country F . As we discussed earlier in the book, the equilibrium world price ratio falls between the autarky price ratios of the two countries. If this was not the case, then both countries would want to either import or export the same good. For example, if $p^* > p_h^a$, then both countries would wish to export X_1 which cannot be an equilibrium.

Figure 7.5

When the free-trade price ratio differs from each country's autarky price ratio as in Figure 7.4, we know from Chapter 5 that both countries must gain from trade. However, the gains from trade are not necessarily distributed "evenly", and the country which trades farthest away from its autarky price ratio is the major gainer. We will return to this point in section 7.5 below.

7.4 The role of absolute advantage in wage determination

To this point we have shown that in the Ricardian model comparative advantage is determined simply by the relative productivity of labor in producing commodities, or, equivalently, by international differences in production technologies. It may seem surprising that wage rates have not entered the discussion at all. After all, there has been much concern expressed in high-income economies about the possible effects of competition from low-wage workers in developing countries. In the Ricardian model,

wages are an endogenous variable reflecting absolute advantage among other things. All workers gains from trade but a more productive country will have higher wages.

Suppose that both countries are specialized as in Figure 7.5, and so the wage rate in each country is determined by the competitive conditions that the value of the marginal product of labor equals the wage rate as discussed in Chapter 2.

$$p_2^* \alpha_{h2} = w_h \quad p_1^* \alpha_{f1} = w_f \quad \text{thus} \quad \frac{w_h}{w_f} = \frac{p_2^* \alpha_{h2}}{p_1^* \alpha_{f1}} \quad (7.10)$$

Second, the world price ratio lies (weakly) between the autarky price ratios of the two countries.

$$\frac{\alpha_{h2}}{\alpha_{h1}} \geq \frac{p_1^*}{p_2^*} \geq \frac{\alpha_{f2}}{\alpha_{f1}} \quad (7.11)$$

Third, assume that country h is has an absolute advantage in both goods in addition to having a comparative advantage in good 2.

$$\alpha_{h1} > \alpha_{f1} \quad \text{and thus} \quad \frac{\alpha_{h2}}{\alpha_{f1}} > \frac{\alpha_{h2}}{\alpha_{h1}} \quad (7.12)$$

We can then add an element to the left-hand side of the change of inequalities in (7.11) using (7.12)

$$\frac{\alpha_{h2}}{\alpha_{f1}} > \frac{\alpha_{h2}}{\alpha_{h1}} \geq \frac{p_1^*}{p_2^*} \geq \frac{\alpha_{f2}}{\alpha_{f1}} \quad \Rightarrow \quad \frac{p_2^* \alpha_{h2}}{p_1^* \alpha_{f1}} > 1 \quad (7.13)$$

where the right-hand inequality comes from multiplying the whole chain in (7.13) through by p_2^*/p_1^* . But the right-hand expression is, from (7.10), the ratio of the wage rates in the two countries.

$$\frac{p_2^* \alpha_{h2}}{p_1^* \alpha_{f1}} = \frac{w_h}{w_f} > 1 \quad (7.14)$$

This demonstrates that if a country has an absolute advantage in both goods, then it must have a higher wage. The higher wage is a result of higher productivity and should not be interpreted therefore as a reason for a high-wage country not to trade. Of course, this depends on a competitive market-set wage and would not be a valid proof under institutional or other forms of distortionary wage setting.

7.5 The distribution of gains from trade between countries

The Ricardian model is often used to shed some light on the question that we posed in Chapter 5 about how total gains from trade are divided between two economies. One principal determinant of this division is the economic size of countries - measured either in terms of their factor endowments or their productivity levels. In other words, a country is "bigger" economically to the extent that its production frontier is further from the origin. Let us therefore conduct a thought experiment with our two countries in which we make Country f bigger by shifting its production frontier in a parallel fashion further out

from the origin. This can be accomplished either by increasing f's endowment of labor or by improving its technology: increasing α_1 and α_2 in the same proportion.

The effect of this is shown in Figure 7.6 where F_2F_1 is the initial production frontier and $F_2'F_1'$ is the expanded frontier. This expansion will leave country f's autarky price ratio unchanged, and increase the length of the horizontal segment of its excess demand curve (equal to the Country f's maximum output of X_1 , F_1'). Suppose that p^{*0} in Figure 7.6 is the initial world equilibrium price ratio, then country f specializes in the production of X_1 and consumes at point D^0 in Figure 7.6. Now expand the production frontier to $F_2'F_1'$. If we hold the world price ratio constant at p^{*0} , country f will now wish to produce at F_1' and consume at D' . Provided that Country f wishes to spend some of its increased income on X_2 (homogeneous demand will do, but it is not necessary), then Country f will wish to export more X_1 and import more X_2 at the existing equilibrium price ratio p^{*0} .

Figure 7.6

The same argument can be repeated for any price ratio. The expansion of the production frontier will lead Country f to wish to trade more at any world price ratio. The effect on Country f's excess demand curve is shown in Figure 7.7. M_fM_f is f's initial excess (import) demand curve. The new excess demand curve is shown by $M'_fM'_f$. The horizontal segment, corresponding to the distance OF_1' in Figure 7.6, expands and similarly the country f now desires to trade more at any price ratio other than its autarky price ratio.

Assuming that nothing has happened in Country h, the old equilibrium world price ratio p^{*0} can no longer be an equilibrium. Country h wants to import the same amount of X_1 that it did previously, but Country f now wants to export more X_1 . There is an excess supply of X_1 and the world price ratio must fall to reestablish equilibrium. This is shown in Figure 7.7 as a fall in the price ratio from p^{*0} to p^{*1} .

Figure 7.7

The change in the world price ratio due to the increase in Country f's size (productivity) has important implications for the gains from trade. First, Figure 7.6 could be used to show that Country f gains less by growth than if the price ratio had stayed constant at p^{*0} (try to redraw Figure 7.6 with the price ratio falling from p^{*0} to p^{*1}). Country f's *terms of trade have deteriorated*; that is, the equilibrating price change involves a fall in the relative price of f's export good. For Country h on the other hand, the price change due to f's growth is beneficial. Country h's *terms of trade have improved*; that is, the price change involves an increase in the relative price of f's export good (fall in the relative price of f's import good).

An extreme case of unequal distribution of the gains from trade between countries is shown in Figure 7.8. In this case, Country f is sufficiently large relative to h that the equilibrium occurs at Country f's autarky price ratio p_f^a . The equilibrium world price ratio is at one extreme end of the feasible spectrum between the two autarky prices. Country h imports the quantity M_h while Country f exports M_f of good X_1 . In this case, Country f captures no gains, although it is not worse off with trade. All gains from trade are captured by the smaller Country h. Country f is indifferent to trade.

Figure 7.8

Two things can be learned from this exercise. First of all, in free trade smaller countries are likely to be major gainers from trade. This result is of considerable importance insofar as some smaller countries worry about their position vis-a-vis large countries.

The second thing to learn from this analysis is that a country may benefit from productivity growth in its trading partner. Trade is not warfare as we have noted, and a productivity growth in a trading partner is very unlike your enemy getting better weapons. Figures 7.6 to 7.8 illustrate that Country h benefits from the productivity growth in Country f in that this productivity growth is passed on

to country h in terms of a lower price for its import good.² Indeed, it is theoretically possible that the deterioration in the term of trade may be so severe for Country f that it is worse off and all of the gains are captured by h (worse off than before growth, not relative to autarky!). This possibility is referred to as "immiserizing growth".

7.6 Summary: what you should know

This chapter is the first of several chapters which offer explanations as to the underlying differences between economies that can lead to differences in autarky price ratios and hence lead to trade. Here we focus on differences in production functions or technology between two countries. Countries can exploit these differences, with each country specializing in the good in which it has a *comparatively* better technology, and exporting that good in exchange for the good in which it has a comparatively poorer technology. The principal results of the chapter are as follows.

The slope of a country's production frontier reflects its *relative* abilities to produce *X* and *Y*. If these relative abilities differ between two countries, a pattern of *comparative advantage* exists. The existence of comparative advantage and potential gains from trade is quite compatible with a situation in which one country has an *absolute advantage* in producing both goods. Such a country can still benefit from trade. Absolute advantage does, however, play a role in determining real wages which can be different in the two countries. Absolute (productivity) advantage is thus important for international real wage comparisons, but not for the direction of trade.

The distribution of gains from trade between the two countries depends on several factors, but one important one is the difference in absolute "economic" size between them, by which we mean the distance of a country's production frontier from the origin. A country is better off to the extent it trades further away from its own autarky price ratio and closer to the other country's autarky price ratio. We showed that when a country becomes bigger or more productive, its terms of trade tend to deteriorate (the equilibrium world price ratio moves closer to that country's autarky price ratio). This transfers some of the benefit of the productivity growth to the other country.

An implication of the previous point is that small countries, in general, are likely major gainers from international trade. A second implication is that countries benefit from productivity growth in trading partners, although in more general models this requires that the productivity growth be either neutral or concentrated in export sectors. The price mechanism causes this transfer of benefits insofar as countries benefit from their partner's growth through lower prices for import goods.

Endnotes

1. In more formal terms, we could show that the assumption of one factor is equivalent to a special case of the two-factor model: countries have identical relative factor endowments, and both goods use factors in the same proportions (the goods have identical relative factor intensities). The latter assumption is somewhat stronger than condition 2 of Chapter 6.

2. This is not a completely general result. When production frontiers are concave ("bowed out") as they will be in the next chapter, countries will in general not specialize completely. Thus if a country achieves a productivity improvement in an import-competing industry, it will wish to import less, and the terms of trade will move against its trading partner. In general, productivity improvements in a country's export industries are partially passed on to trading partners through lower prices.

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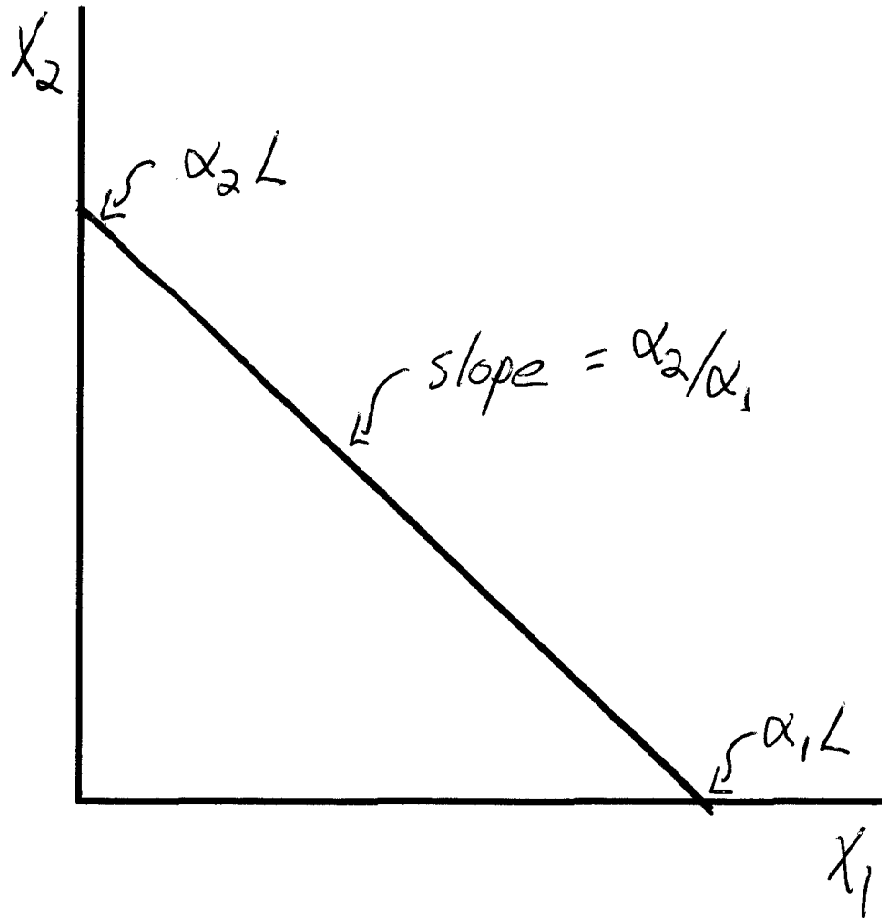


Figure 7.1

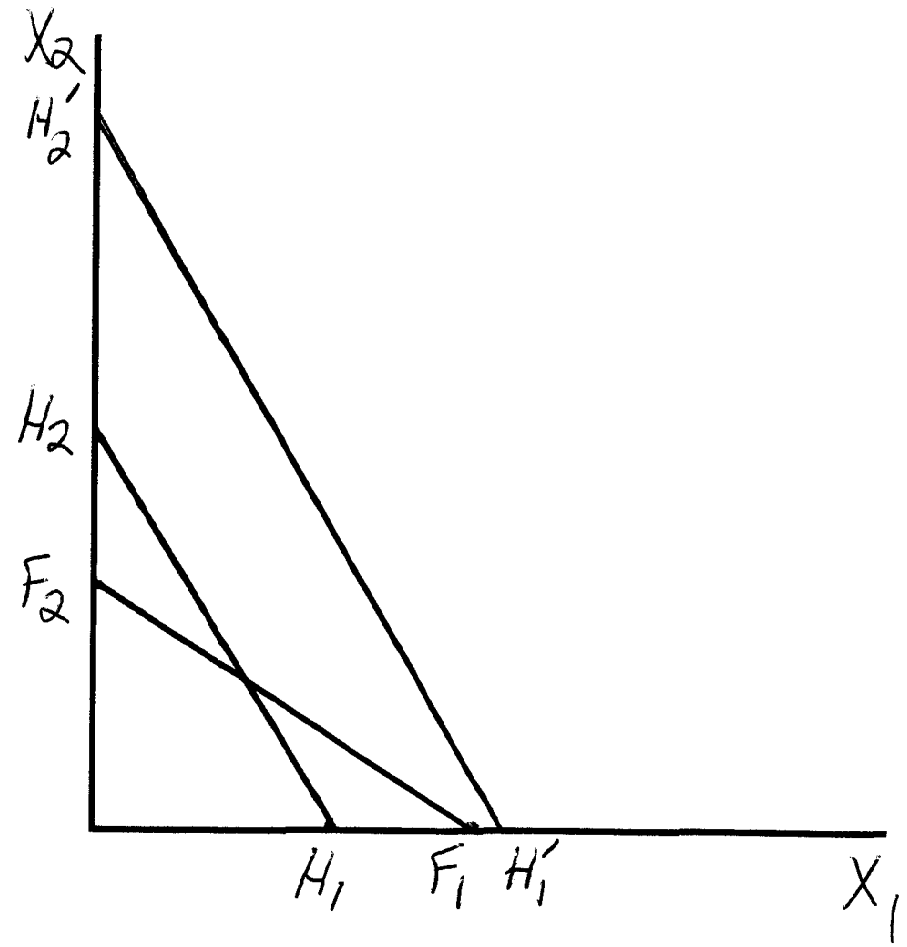


Figure 7.2

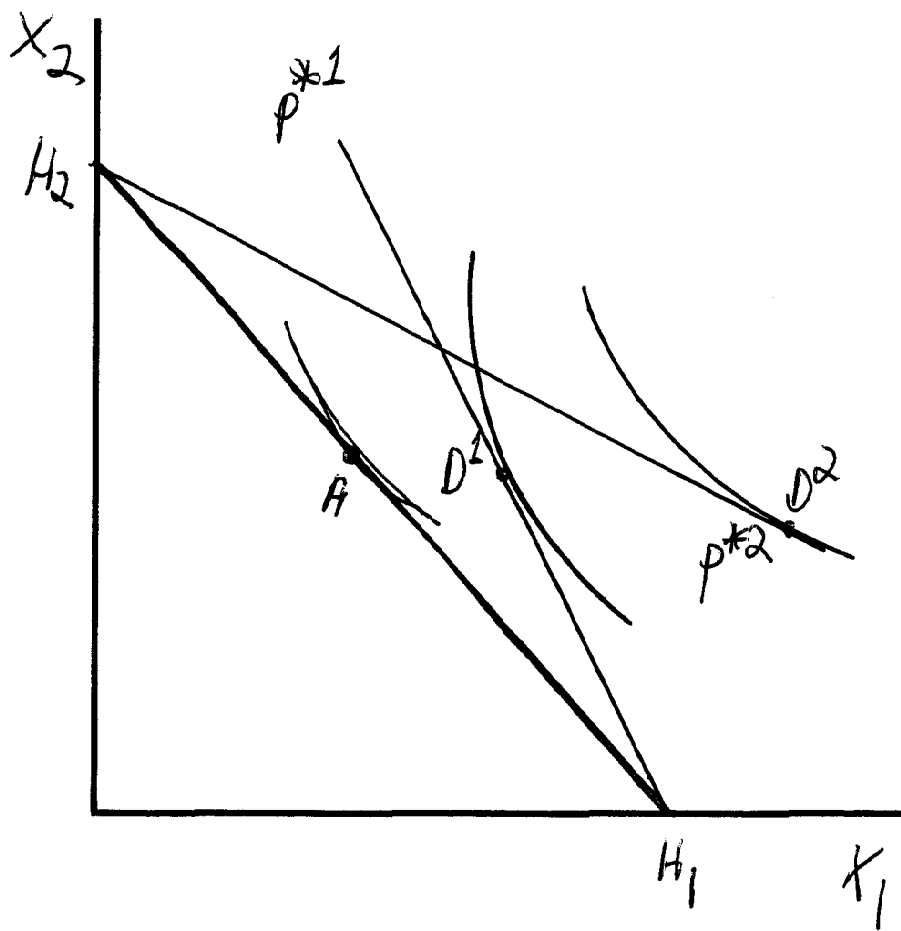


Figure 7.3

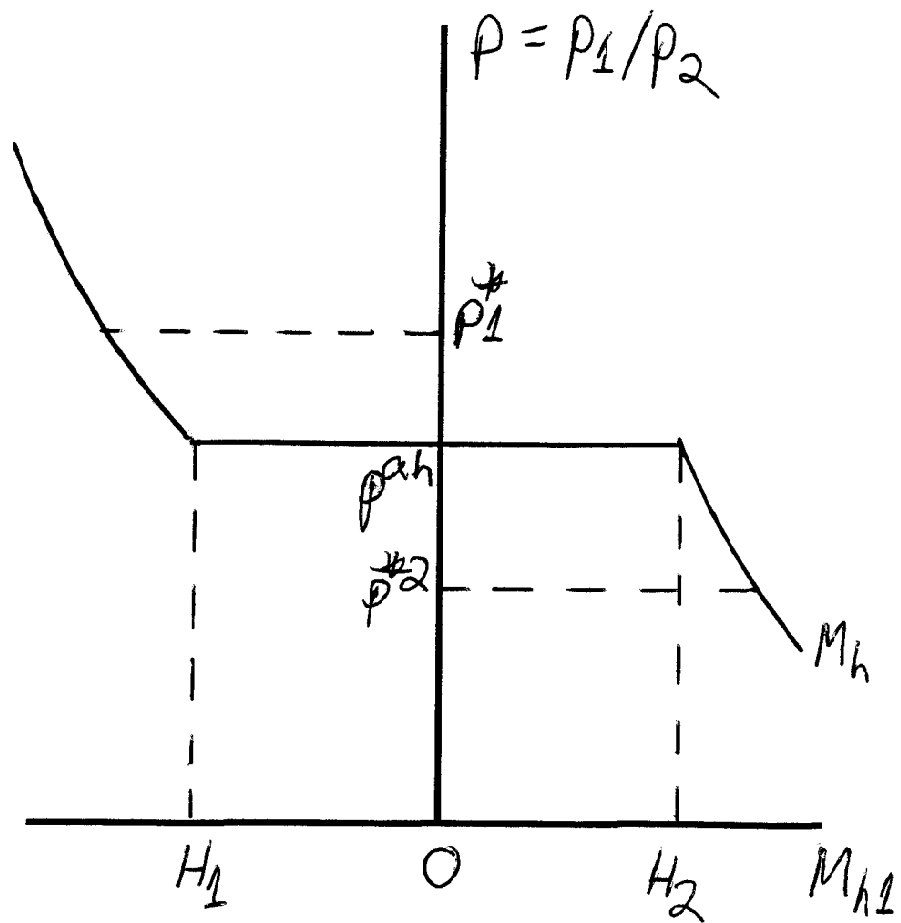


Figure 7.4

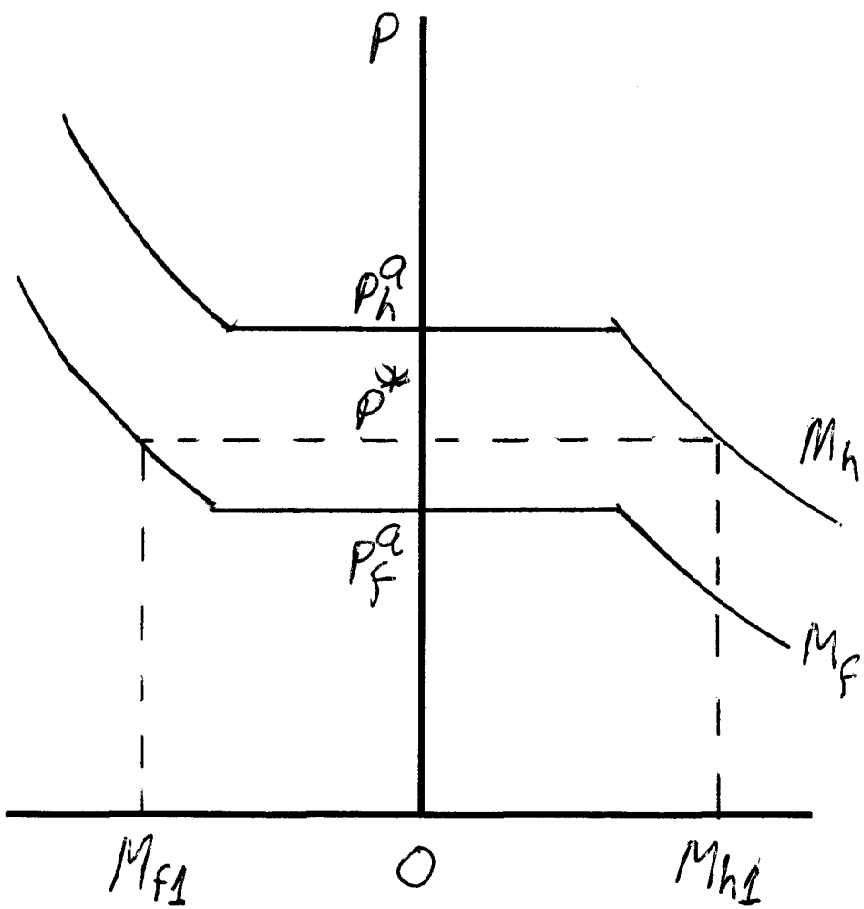


Figure 7.5

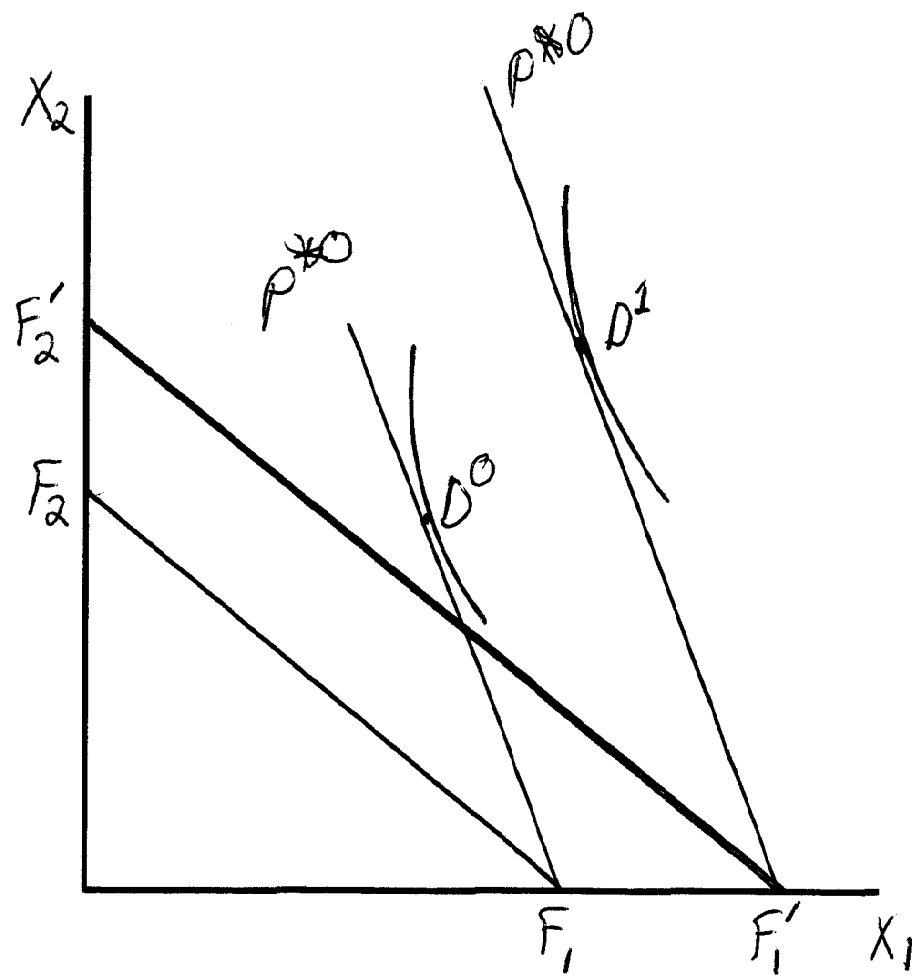


Figure 7.6

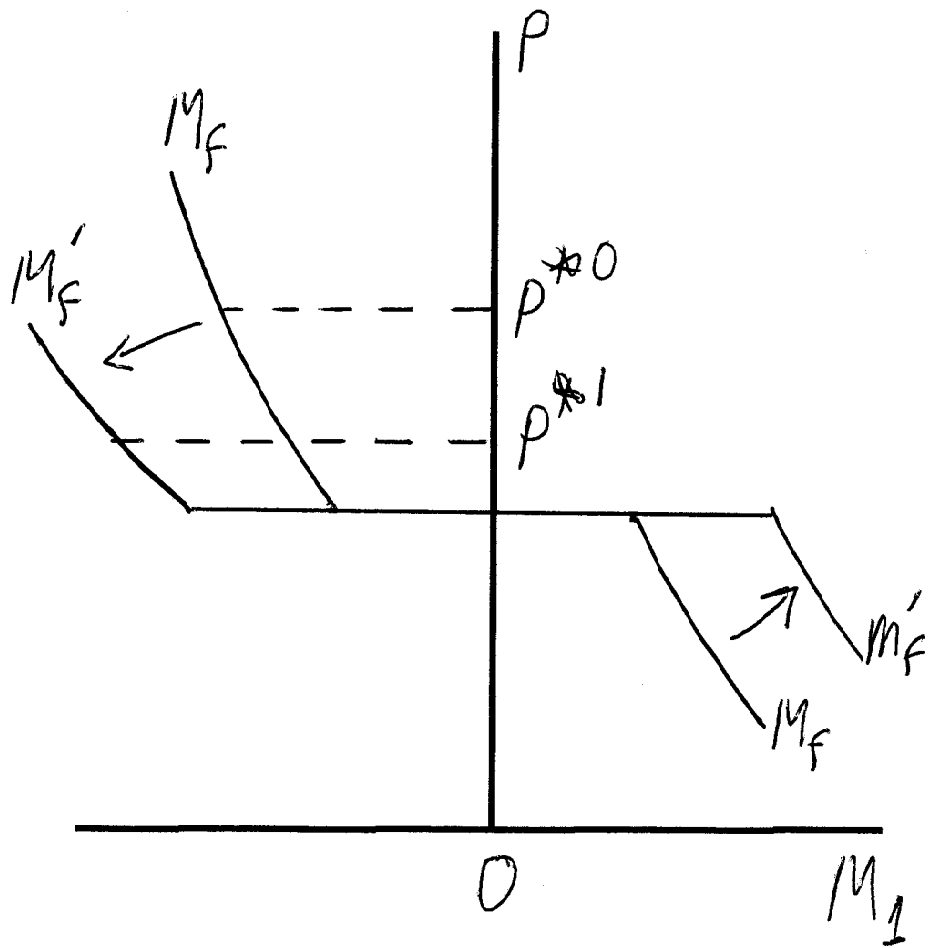


Figure 7.7

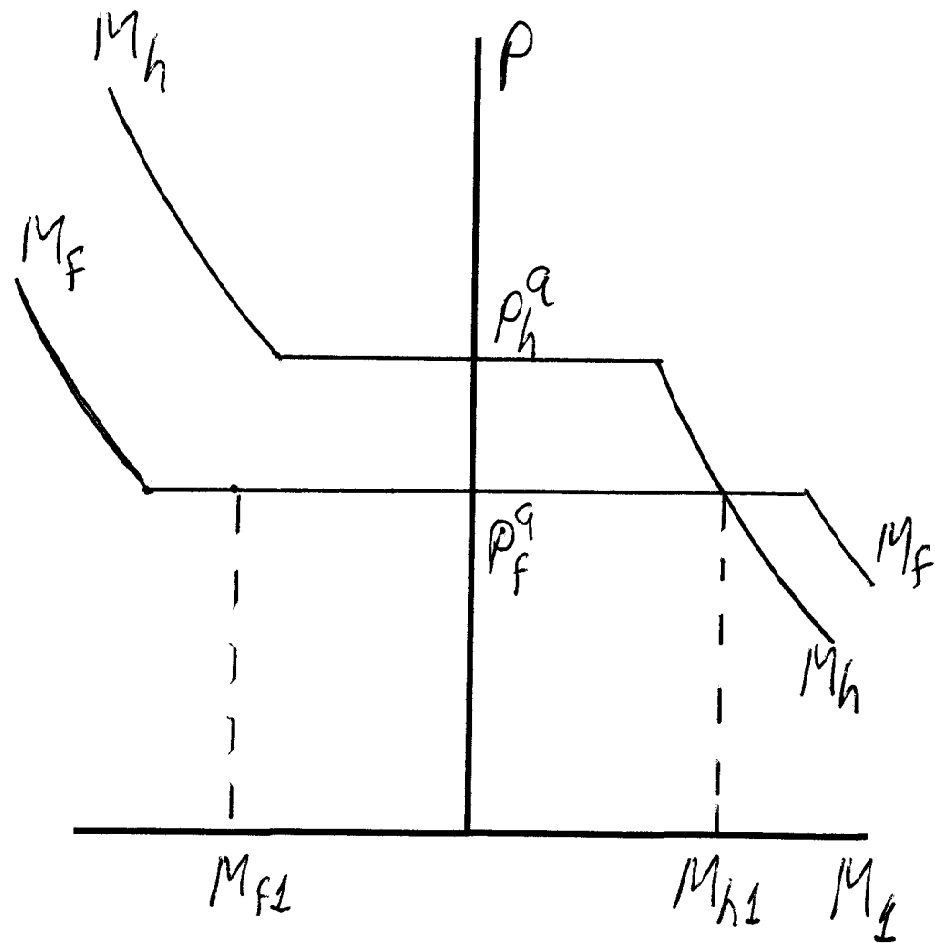


Figure 7.8