Chapter 13

TRADE COSTS, TRADE VOLUMES AND FIRM BEHAVIOR

13.1 Geography and trade costs

Much of what we have done so far presents rather stark comparisons between a country that does not trade at all, and one that engages in completely free and costless trade. No one claims that this is a realistic comparison; rather, it is done for analytical simplicity which in turn permits a clear and simple presentation. The purpose of this chapter is to introduce costs of trade, which we can think of as shipping costs (it should also include time costs but this requires an explicitly dynamic treatment). Costs imposed by governments such are tariffs and quotas are really rather different and will be treated in a later chapter.

Trade costs have traditionally been underplayed in international trade textbooks. We think that the reason was the supposition that trade costs were not terribly interesting: trade costs just put a country somewhere between free (costless) trade and autarky. Thus there is not very much interesting to say. There is considerable truth in this and indeed we will illustrate this point in the next section. But even in a traditional comparative-advantage model such as the Heckscher-Ohlin model, we will note that trade costs must leave factor prices different between countries and hence there will be incentives for factors to migrate. But in non-comparative-advantage models with oligopoly and monopolistic competition, trade costs can do some quite interesting things indeed. In particular, outcomes with positive but moderate trade costs are not "in between" free trade and autarky. Quite a large part of this chapter will be focused on these interesting cases.

Trade costs (unlike tariffs) require the use of real resources such as labor, fuel and capital equipment such as ships and planes. In a sophisticated framework, we would want to model these as production sectors which produce transportation services. But in order to keep things manageable, we will avoid introducing an explicit transport sector in one of two ways. First, we will in section 3 use essentially a partial-equilibrium assumption and just say that there is some cost t to moving a good between countries. So if mc is marginal cost, the cost of supplying the foreign market is $(mc + t)$. In a one-factor model such Ricardian models, this would be in units of labor for example.

A second approach that is often taken is to assume what has become known as "iceberg" trade costs. This means that part of a good shipped abroad "melts" during transit: less arrives than is shipped. This is essentially the assumption that the transport technology uses the good itself and nothing else. We understand that the earliest example of this was due to an economist named von Tünen, who told the parable of a farmer taking hay to a market in a horse-drawn wagon. The horse has to be fed some of the hay, and so less hay arrives in the market than leaves the farm: the transport cost is in terms of the good itself and there is no need to model a transportation service sector.

Suppose that the transportation cost rate or "melt rate" is τ, and so if X is shipped, $X/(1+\tau)$ arrives "unmelted". It is cumbersome to keep carrying this notation around, so generally trade economists simplify the transport cost by writing it on a gross basis, $t = (1+\tau)$. Then $t = 1$ is free trade, not $t = 0$, and $t = 1.5$ would be, for example, a rate of 50 percent. We will follow this convention.

If a firm ships a quantity X, then the amount that arrives in the foreign country is X/t. Suppose that the home price of the good is p and further assume that the firm cannot price discriminate between markets. Then export sales earn the firm the same price as domestic sales (we will explain about price discrimination below). The earnings on export sales by the domestic firm must equal what the foreign imported pays. So what is the price in the foreign country? Let p^* be the foreign (importer's) price. Then the revenue balance condition must be:

$$pX = p^*(X/t) \quad \Rightarrow \quad p^* = pt \tag{13.1}$$

The left-hand side of the first equation is the revenues received by the exporter and the right-hand side is the amount paid by the importer. It follow that the price in the importing country is $pt \geq p$ with equality in free trade and a strict inequality when trade costs are strictly positive. In summary, if X units are shipped at an exporter's price of p, then (X/t) units arrive and sell for a price of **(**pt).

13.2 Trade costs and trade volumes in competitive, comparative-advantage models

In competitive, perfect-competition models where trade is based on comparative advantage, it is not inaccurate to say that trade costs between two countries leave each of them somewhere between autarky and free trade. This is shown a little more formally in Figure 13.1. Assume that a country has an excess demand curve for X_1 in free trade given by the dashed line in that figure. p^a is the world price at which the country does not want to either import or export X_1, also equal to its autarky price ratio. Suppose that trade costs are incurred in both inward and outward directions. An example would be the port costs of loading and unloading ships. Then an importer of X_1 would have to pay p^*t where p^* denotes the world price, and an exporter would only receive p^*/t.

Figure 13.1

The country would be indifferent to importing X_1 if the world price is given by $p^* = (p^a/t)$ in which case the domestic price p is given by $p = p^*t = p^a$. The country would be indifferent to exporting X_1 if the world price is given by $p^* = p^a t$ in which case the domestic price p is given by $p = p^*/t = p^a$. This is shown in Figure 13.1, and we see that there is now a range of world prices in which the country will not trade. At any world price p^*, the country will export less X_1 (or none at all) or import less X_1 (or none at all).

If we repeat this exercise for the other country, an outcome for two symmetric countries is shown in Figure 13.2. If p^* is the world price ratio p_1/p_2, then country h exporting X_1 faces (effectively) at price ratio p^*/t and country f importing X_1 faces a price ratio p^*t. Their production points are given by X_h and X_f in Figure 13.2 respectively and their consumption points by D_h and D_f respectively. There are positive trade and positive gains from trade, and if you refer back to Figure 8.2 in Chapter 8 you will see that the outcome is indeed in between autarky and free (costless) trade.

Figure 13.2

Nevertheless, there are a couple of things to note. First, note from Figure 13.2 that each country is relative "specialized" in consuming the same good as it is specialized in producing. This is true if preferences are identical and homogeneous across countries. Country h, for example, is relatively specialized in good X_1 and also relatively specialized in consuming it. This is just a reflection of the price differences inside the two countries: in each country the export good is relatively cheap and the import good is relatively expensive. So countries that produce relatively more food will consume relatively more food even if preferences are identical.

This is sometimes referred to as a "home-market effect" as we will discuss below. However, there is a subtlety if you are interested. The result about consumption specialization refers here to quantities, but home-market effect is often used to refer to value or expenditure shares in consumption (price times quantity divided by income). But in each country the low quantity good is also the high-priced good so it does not follow that it's expenditure share of consumption is lower. In fact, with Cobb-Douglas preferences the share spent on each good does not depend on prices and so the two countries in Figure 13.2 would be observed to spend the same share of income on each good (see equation (3.4)). We won't comment more on this issue here.

The second interesting thing about Figure 13.2 relates back to the Stolper-Samuelson theorem of Chapter 8. In that chapter, we demonstrated that in autarky, each country had a relatively high price for its scarce factor. Under special circumstances, completely costless trade brings the price of each factor into equality across countries (the factor-price-equalization theorem). Consistent with the notion that costly trade is something in between autarky and costless trade in competitive, constant-returns models, the price of each factor will be brought closer together across countries but not equalized in Figure 13.2. Thus each country will still have a high price for its scarce factor. This will have important implications for the incentives for factors to migrate when that is possible as we will see in a later chapter.

13.3 Trade costs, price discrimination, and trade volumes in oligopoly models

As we hinted above, trade costs often create outcomes in models with imperfect competition and increasing returns to scale that are not in between autarky and costless trade. We turn to some of these effects in this and in the next couple of sections. In the current section, we use the simple oligopoly model of Chapter 11 in which there is linear demand, constant marginal costs, and firms produce identical products. We will assume that the two countries are absolutely identical (to exploit symmetry in solving the model), that each country has a single firm in the X sector, and that there is no exit or entry of firms.

This model is often used to analyze price discrimination: defined here as the ability of firms to set different prices in different markets. So a firm in one country can set one price for domestic sales and another price for export sales. When a firm sets a lower price for export sales than for domestic sales, this is one of many definitions of "dumping" which in turn is the subject of many trade disputes. (This is quite a weak definition of dumping: a stronger version is selling below costs, which firms will not do in this simple model.)

The demand for good X in market i is linear and depends on the supply of the domestic firm X_{ii} and the supply of the foreign firm X_{ji}.

$$p_i = \alpha - \beta(X_{ii} + X_{ji}) \tag{13.2}$$

Let π_{ij} denote the profits of firm i on it sales in market j. Profits for firm i on its domestic sales are given by

$$\pi_{ii} = p_i X_{ii} - c_i X_{ii} = [\alpha - \beta(X_{ii} + X_{ji})]X_{ii} - cX_{ii} \tag{13.3}$$

Let t denote a specific trade costs as discussed above (not iceberg costs: here $t = 0$ is costless trade). Profits of firm i on its export sales to j are given by.

$$\pi_{ij} = p_j X_{ij} - (c + t)X_{ij} = [\alpha - \beta(X_{ij} + X_{jj})]X_{ij} - (c + t)X_{ij} \tag{13.4}$$

The firm optimizes with respect to domestic and foreign sales independently given its ability to price discriminate. Firms behave in a Cournot fashion, choosing their optimal sales given the sales of the rival firm. The first-order conditions for profit maximization are given by:

$$\frac{d\pi_{ii}}{dX_{ii}} = \alpha - 2\beta X_{ii} - \beta X_{ji} - c = 0 \tag{13.5}$$

$$\frac{d\pi_{ij}}{dX_{ij}} = \alpha - 2\beta X_{ij} - \beta X_{jj} - c - t = 0 \tag{13.6}$$

Exploiting cost symmetry because the firms and countries are identical, we can solve (13.5) and (13.6) for the Cournot domestic and foreign sales of the firm i by setting $X_{ii} = X_{jj}$ and $X_{ij} = X_{ji}$.

$$X_{ii} = \frac{\alpha - c + t}{3\beta} \qquad X_{ij} = X_{ji} = \frac{\alpha - c - 2t}{3\beta} \tag{13.7}$$

The homogeneous good sells for the same price in both identical countries. Thus the transport cost is fully absorbed by the exporter, and the export price (received by the exporter) is lower by t than the domestic producer price. Hence the term "dumping"(Brander and Krugman 1983). Note from (13.7) that as long at $\alpha - c - 2t > 0$, each firm will serve both markets. Thus we would observe the curious outcome of identical goods traveling in both directions across the ocean. This is often referred to as intra-industry trade, though the term is also widely used for closely related but differentiated goods as in the monopolistic-competition model.

If the results in (13.7) are substituted back into the demand function in (13.2), the domestic price (earned on local sales) and the export price (earned on foreign sales after covering trade costs are given by:

$$p = 2(\alpha - c)/3 + t/3 \qquad (p - t) = 2(\alpha - c)/3 - 2t/3 \tag{13.8}$$

Notice for future reference that trade costs essentially protect a firm in its home market in that the firm can raise its home price, but hurts the firm on its export sales by lowering the export price.

The two equations in (13.8) can be used to determine the net price that the firm in each country receives on its domestic and export sales. These are

$$(p - c) = (\alpha - c + t)/3 \qquad (p - c - t) = (\alpha - c - 2t)/3 \tag{13.9}$$

Using (13.7) plus (13.9), we can then solve for profits of the firm on its domestic and foreign sales.

$$\pi_{ii} = (p - c)X_{ii} = \beta X_{ii}^2 \qquad \pi_{ii} = (p - c - t)X_{ii} = \beta X_{ij}^2 \tag{13.10}$$

Now consider the same utility function that we discussed in Chapter 10 which gives rise to the linear demand function in the first place. Utility is given by

$$U(X) = \alpha(X_{ii} + X_{ji}) - (\beta/2)(X_{ii} + X_{ji})^2 + Y \qquad (13.11)$$

Assume a single factor of production L, and assume that one unit of Y production requires one unit of labor, and that L or Y is numeraire with price one. The budget constraint for the economy requires that labor income plus profits equal expenditure on X and Y.

$$L + \pi_{ii} + \pi_{ij} = Y + p_{ii}X_{ii} + p_{ji}X_{ji} \qquad (13.12)$$

Consumer surplus is generally defined as the utility derived from X consumption minus the amount that consumers pay for X. This is given by

$$CS = \alpha(X_{ii} + X_{ji}) - (\beta/2)(X_{ii} + X_{ji})^2 - pX_{ii} - pX_{ji} = (\beta/2)(X_{ii} + X_{ji})^2 \qquad (13.13)$$

Substitute the budget constraint in (13.12) into (13.11). Utility is the sum of consumer surplus and profits, which is equal to

$$U_i = CS_i + \pi_{ii} + \pi_{ij} = (\beta/2)(X_{ii} + X_{ji})^2 + \beta X_{ii}^2 + \beta X_{ij}^2 \qquad (13.14)$$

While (13.14) may look simple, it turns out to be complicated and not only non-linear in the trade cost but non-monotonic (e.g., rising over some range and falling over another range of trade costs. Figure 13.3 presents a simulation over trade costs on the horizontal axis (the results can be proved analytically and do not depend on the parameter values chosen). Total welfare (plotted on the right-hand vertical axis) is the sum of consumer surplus and profits (both plotted on the left-hand vertical axis. The left-hand end of the horizontal axis is free trade and the right-hand end is autarky: trade costs are prohibitive to trade at $t = 2$.

Figure 13.3

As trade costs fall from a prohibitive level (moving to the *left* along the horizontal axis), welfare actually falls over a range between approximately $t = 2.0$ and $t = 1.5$ and then begins climbing. Welfare in free trade is 18 percent higher than in autarky, normalized to a value of one in the Figure. The region of declining welfare is due to the fact that profits fall faster in this region than consumer surplus rises. Interestingly, profits recover with further falls in trade costs when trade costs are low near the right-hand boundary.

This result can seem puzzling at first, even to trained economists who would guess that welfare should rise with any fall in trade costs. The intuition is to remember that trade costs consumer real resources in transport. When trade costs are very high, a fall in these costs generates more trade and consumes more resources than when trade is prohibitively costly. Each firm has an incentive to invade the other firm's market, but when they both do this resources are wasted in inefficiently cross-hauling the same good across the ocean. While consumer surplus rises, this is more than outweighed by the fall in profit income. But when trade costs become sufficient small, further falls in costs generate a fall in total resources devoted to trade, and welfare unambiguously rises.

Finally, note that there is a distributional issue in Figure 13.3 as there so often is in our trade models. Over an intermediate range of trade costs, there is a conflict between profit income and consumer surplus from lower prices. The equity owners of the firm will not like falls in trade costs which expose them to more competition, while the consumers will benefit from the lower prices that this competition engenders.

13.4 Trade costs, inter and intra-industry trade in monopolistic-competition models

Trade costs in monopolistic-competition models also have interesting and complex effects, so much so that a whole literature, sometimes referred to as the "new economic geography" has grown up around the intersection of Dixit-Stiglitz models and trade costs. Let us return now to the iceberg costs discussed in the first section above. For a domestic firm, X_{ij}^{d} is the amount produced in country i and shipped to country j. Similarly, p_{ij} is the export price per unit in country i. Let t ($t \geq 1$) be the ratio of the amount of X exported to the amount that arrives "unmelted". Alternatively $1/t$ is the proportion of a good that "survives" transit (the proportion "unmelted"). If X_{ij} is shipped, the amount received in country j is X_{ij}/t.

Second, we again make the assumption that there is no price discrimination and so the home price of a good for local sales equals its export price. Thus we can use the notation p_i and p_j for the price of all goods *produced* in country i and country j respectively. The revenues received by the exporter are equal to the costs paid by the importer: p_iX_{ij} is the revenue received by the exporter and X_{ij}/t are the number of units arriving in the importing country, so the price per unit in the importing country must be p_it ($p_iX_{ij} = (p_it)X_{ij}/t$). Rather than introduce additional notation, we will therefore use X_{ij}/t and p_it as the quantity and price in country j of a country i variety exported to country j.

As in Chapter 12, we assume a two-level (nested) utility function in which there is Cobb-Douglas substitution between X varieties and Y, and a CES or Dixit-Stiglitz substitution between X varieties. For now, let labor be the only factor of production and one unit of labor produces one unit of Y. The utility function and the budget constraint are then given by

$$U = \left[\sum_i X_i^{\alpha}\right]^{\frac{\beta}{\alpha}} Y^{1-\beta} \qquad \sigma = \frac{1}{1-\alpha} > 1 \qquad L = np_xX + Y \tag{13.15}$$

If you solve the optimization problem, the consumer's demand for an individual home-produced X variety and the price index (cost of purchasing one unit of the composite X good) are given by

$$X_i = p_i^{-\sigma}\left[\sum_i p_i^{1-\sigma}\right]^{-1}\beta L = p_i^{-\sigma}e^{\sigma-1}\beta L \qquad e = \left[\sum_i p_i^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{13.16}$$

The price index for country i is given by:

$$e_i = \left[N_ip_i^{1-\sigma} + N_j(p_jt)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{13.17}$$

Now separate varieties in country i into home produced and imported varieties, remembering that X_{ji} is the amount shipped from j to i and so the amount received and consumed in *Xji/t*. *Assuming* that X goods are produced in both countries, the demand functions for the various *X* varieties sold in country i are given by:

$$X_{ii} = p_i^{-\sigma} e_i^{\sigma-1} \beta L_i \qquad X_{ji}/t = X_{ij}/t = (p_j t)^{-\sigma} e_i^{\sigma-1} \beta L_i \tag{13.18}$$

where the second equation can also be written as:

$$X_{ji} = X_{ij} = p_j^{-\sigma} t^{1-\sigma} e_i^{\sigma-1} \beta L_i = p_j^{-\sigma} \phi e_i^{\sigma-1} \beta L_i \qquad \phi \equiv t^{1-\sigma} \tag{13.19}$$

The parameter ϕ ("phi") has been dubbed the phi-ness (mnemonic for "freeness") of trade: it takes a value of one when trade costs are zero (t = 1) and approaches a value of infinity as trade costs go off to infinity (remember $\sigma > 1$ so that the exponent of t in ϕ is negative: $(1 - \sigma) < 0$).

p_i will denote the home price of a representative good produced in country i (all goods produced will have equal home prices). Again assuming that both countries produce *X* goods (not trivial as we shall see), there are two equations, one marginal revenue equals marginal cost and one for zero profits: markup revenues cover fixed costs as in Chapter 12. These are given by:

$$p_i(1 - 1/\sigma) = mc \qquad (p_i/\sigma)(X_{ii} + X_{ij}) = fc \tag{13.20}$$

There are two identical equations for a firm located in country j. Thus any good that is produced in either country must sell for the same price and be produced in the same quantity as a good in the other country, even if the countries are of different sizes. Solve these two equations, eliminating p, to get the price and total output of any representative variety produced.

$$p = \frac{\sigma}{\sigma - 1} mc \qquad X = (X_{ii} + X_{ij}) = (\sigma - 1)\frac{fc}{mc} \tag{13.21}$$

Because the output quantity of a good is identical across countries, we can do the following.

$$X_{ii} + X_{ij} = X_{jj} + X_{ji} \qquad X_{ii} - X_{ji} = X_{jj} - X_{ij} \qquad \frac{X_{ii} - X_{ji}}{X_{jj} - X_{ij}} = 1 \tag{13.22}$$

Exploiting again the result that any good from country i has a home price equal to the home price of a good in country j, (13.18) and (3.19) allows us to write the numerator of the right-hand equation in (13.22) as

$$X_{ii} - X_{ji} = p^{-\sigma}(1 - \phi) e_i^{\sigma-1} \beta L_i \tag{13.23}$$

There is a similar expression for country j, and dividing (13.23) by the similar equation for country j allows us to write the right-hand equation of (13.22) as

$$\frac{X_{ii} - X_{ji}}{X_{jj} - X_{ij}} = 1 = \left(\frac{e_i}{e_j}\right)^{\sigma - 1}\frac{L_i}{L_j} \qquad e_i^{\sigma - 1} = \left[N_i p^{1-\sigma} + N_j (pt)^{1-\sigma}\right]^{-1} \tag{13.24}$$

Suppose that country i is bigger than country j. Then it must be true that country i is going to produce more varieties in equilibrium than country j: $N_i > N_j$. Each country spends the same fraction of its income on *X* varieties and since each variety is produced in the same quantity regardless of home country, then country i must produce more varieties (there is an exception to this in free trade, discussed shortly). The representative price of a good can be factored out of the price index expression in the right-hand equation of (13.24). This allows us to write the left-hand equation as:

$$\left(\frac{e_i}{e_j}\right)^{\sigma - 1}\frac{L_i}{L_j} = \frac{N_j(1 + \phi N_i/N_j)}{N_i(1 + \phi N_j/N_i)}\frac{L_i}{L_j} = 1 > \frac{N_j/L_j}{N_i/L_i} \quad \textit{if} \quad \phi < 1 \tag{13.25}$$

The inequality on the right follows from $N_i/N_j > 1$ and positive trade costs (the phi-ness of trade is less than one where one is costless trade). In words, the result is that the large country not only produces more varieties in absolute terms, it produces more varieties relative to its size. The large country is relatively specialized in *X* goods.

13.6 The core-periphery model

In fact, it is not quite so simple. For small trade costs (t and ϕ near one but t > 1 and ϕ < 1), the left-hand equations in (13.25) does not have a solution with positive values for both N_i and N_j. The true solution for small trade costs is that the large country i produces all *X* varieties and country j specializes in *Y* and exports *Y* in exchange for *X*.

The result is shown in a numerical simulation in Figure 13.4. The trade cost t is shown on the horizontal axis and the share of all varieties of *X* produced in each country is shown on the vertical axis. Country i is three times the size of country j in the simulation. In free trade (t = 1), any distribution of the *X* industries is an equilibrium, though the small country will not be able to satisfy all world demand for *X* if the share of income spend on *X* is greater than 1/4. But 1/4 of the varieties produced in j and 3/4 produced in i is one possible outcome. But for small to moderate trade costs, country j producers cannot compete and all varieties are produced in the large country i.

Figure 13.4

The intuition for this result is that, at moderate trade costs, the demand for any variety produced in country j must be less than the demand for a variety produced in i: for a country i firm, most of the demand is in the large home market and only a small portion comes from export sales and vice versa for a country j firm. Thus under free entry, the second equation of (13.20), the small-country firms make losses and do not enter. But as trade costs continue to increase, the price index in country j, ej, rises but the price index does not change in country i when it does not import any *X* goods. At some level of trade costs (about 1.35 in Figure 13.4), the demand for a local variety rises sufficiently that firms can begin to enter in country j (follows from 13.18 and 13.19). As trade costs continue to rise toward a prohibitive level (autarky), the share of firms in country i approaches 3/4, the same as its share of total income.

This result is rather extreme and depends in particular on the assumption of only one factor of production. A more general result with a two-factor Heckscher-Ohlin model is found in Krugman and

Venables (1991). The *X* sector is capital intensive and the *Y* sector is labor intensive, but assume that the two countries have the same relative endowments and differ only in size. The equivalent of Figure 13.4 for the two-factor model is shown in Figure 13.5. In free trade (t = 1), the share of firms in each country is no longer indeterminate. Each country will have a share of firms strictly in proportion to its size: if a country had a larger share of firms than relative size, this would drive up the price of capital and its firms would be uncompetitive.

Figure 13.5

As trade costs rise, the share of firms in the large country however increases above its relative size as shown in Figure 13.5 due to the larger demand for each large-country varieties as discussed above. But a rising price for capital means that the small country's firms are not driven out of business. As trade costs continue to rise, the price index e rises faster in the small country and this increases demand for the small country's goods. As in the case of Figure 13.4, the shares of firms in the two countries approaches their relative size as trade costs become very large.

To summarize the result in Figure 13.5, the share of firms in each country is proportional to its share of world income both in free trade and in autarky. In free trade, this is caused by factor market (cost) effects, while with prohibitive trade costs this is caused by product market (demand) effects. For intermediate trade costs, there is a divergence in shares and the outcome is clearly not "in between" the free trade and autarky outcomes. When countries do differ in size, trade costs lead to the simultaneous existence of intra and inter-industry trade: the large country is a net exporter of differentiated goods but also imports then while the small country is a next exporter of the homogeneous competitive good. Also note that each country is relatively specialized in the consumption of its own differentiated goods (in addition to obviously being specialized in producing them), another instance of the "home-market effect".

Figures 13.4 and 13.5 will also have implications for per capita income and factor prices and, if factors can migrate, intermediate levels of trade costs can lead to further divergency between countries. This topic is postponed until Part III of the book.

13.7 Heterogeneous firms and firm-level export behavior

In all of the models with free entry and exit of firms that we have looked at up to this point in the book, there are many potential entrants, all of whom are identical. A zero-profit condition cuts off the number of firms that can be active in equilibrium, but who is active and who does not enter is entirely arbitrary: firms have no individual identity just as the products in Dixit-Stiglitz love of variety have no particular identity. In recent years, there has been great theoretical and empirical interest in so-called heterogeneous firm models, stimulated in the international trade field by a paper by Meltiz (2002). In this approach, there are many potential firms, not all of whom can successfully enter the market. But the firms different in their productivity or conversely their marginal cost of production.

In the standard Melitz approach, the parable is a lottery in which firms pay an entry fee and then there is a draw in which each entrant into the lottery draws a marginal cost. These costs (or productivities) are then ordered from the firm with the lowest cost to the highest cost. In Figure 13.6, the curve labeled cummulative distribution function gives the total number of firms with a marginal cost below a given number. At the left of the axis are the lowest-cost (most productive) firms and at the right is the highest cost firm, with a marginal cost denoted mc_0.

Again following the standard story, if a firm wants to enter domestic production after it gets its draw, it must pay an additional fixed cost which we will denote fc_d. If it also wants to export, there is an added fixed cost of setting up its foreign contacts and distribution network, denoted fc_x (so the total fixed costs for an exporting firm are $(fc_d + fc_x)$).

Assuming that there are a sufficient number of potential firms relative to the market size and that the distribution of costs is large enough, general equilibrium will establish some critical "cutoff" levels. These cutoff levels are marginal costs under which the firm with the cutoff cost just breaks even. There are two critical cutoff costs in this model. First, the lowest-cost (most productive) firms will find it profitable to enter both the domestic and export markets. We have denoted the cutoff level for exporting firms as mc_x in Figure 13.6: the firm with this cost level just breaks even on its export sales but earns positive profits on its domestic sales. Then there is a second cutoff cost at which a firm just break even serving only the domestic market. This is denoted as mc_d in Figure 13.6. Firms with draws in the interval (mc_x, mc_d) serve only the domestic market and firms with costs in the interval (mc_d, mc_0) do not enter after getting their disappointing number.

Figure 13.6

This model has a number of very empirically appealing features. Specifically, only a subset of firms engage in exports and those firms are both larger and more productive than the strictly domestic firms. Both predictions are strongly confirmed in the data. Figure 13.6 plots what the distribution of exports looks like across firms, with the strictly domestic firms exporting nothing.

Let firm d denote the marginal domestic firm with cutoff cost mc_d. Then this firm is characterized by a pricing equation and a zero-profit condition as follows.

$$p_d(1 - 1/\sigma) = mc_d \qquad (p_d/\sigma)X_d = fc_d \tag{13.26}$$

The marginal exporting firm earns zero profits on its export sales, which we denote X_x.

$$p_x(1 - 1/\sigma) = mc_x \qquad (p_x/\sigma)X_x = fc_x \tag{13.27}$$

In the right-hand equations of (13.26) and (13.27), substitute in the demand equations given in (13.18) and (13.19), letting $\beta = 1/2$. Assume again that there are two identical countries, so in equilibrium the price index will be the same in each country and so we can drop the subscript on the price index. The right-hand equations of (13.26) and (13.27) become

$$p_d^{1-\sigma} e^{\sigma-1}(L/2) = \sigma fc_d \qquad p_x^{1-\sigma} \phi e^{\sigma-1}(L/2) = \sigma fc_x \tag{13.28}$$

Now we can use the first equations of (13.26) and (13.27) to eliminate prices and replace them with the cutoff marginal costs. The two equations in (13.28) become

$$\left[\frac{\sigma}{\sigma-1} mc_d\right]^{1-\sigma} e^{\sigma-1}(L/2) = \sigma fc_d \qquad \left[\frac{\sigma}{\sigma-1} mc_x\right]^{1-\sigma} \phi e^{\sigma-1}(L/2) = \sigma fc_x \tag{13.29}$$

Assume that both equations hold; that is, there are both exporting and domestic firms in equilibrium. Then dividing the first equation by the second and rearranging then, we get:

$$\left[\frac{mc_x}{mc_d}\right]^{\sigma - 1} = \phi \frac{fc_d}{fc_x} < 1 \qquad iff \quad \phi < \frac{fc_x}{fc_d} \tag{13.30}$$

The right-hand inequality is a boundary condition for the simultaneous existence of exporting an domestic firms: the added fixed cost of exporting must be sufficient high and/or the phi-ness (freeness) of trade must be sufficiently low in order for $mc_x < mc_d$ and thus for strictly domestic firms to exist as shown in Figure 13.6.

Examining (13.30), it is clear that a fall in trade costs, an increase in ϕ, must increase mc_x relative to mc_d.

$$\frac{\partial(mc_x/mc_d)}{\partial\phi} > 0 \tag{13.31}$$

This last result in (13.31) is actually quite weak. While the gap between the cutoff for exporting firms and the cutoff for domestic firms shrinks, this could be consistent with both going up and down and does not by itself prove that $dmc_x > 0$ and $dmc_d < 0$. But this is indeed the case. It can be demonstrated with a lot more algebra, so we must limit ourselves here to trying to show just the intuition behind the result.[1]

Arbitrarily consider country i, but remember both countries are identical. The logic of a falling t (rising ϕ) goes something like this. (1) country j firms that were initially exporting continue to export but their price in country i falls due to lower ϕ. (2) some firms in j that were initially domestic now find it profitable to enter exporting. For both reasons, the impact effect in country i is that the price index e must fall. (3) from the first equation of (13.29), we see that the fall in e means that the highest marginal cost domestic firms in country i must exit.

Baldwin (2005) shows that in the special case where $fc_x = fc_d$ (however implausible), it turns out that the number of varieties *consumed* in each country stays unchanged once all general-equilibrium adjustments have taken place. From the previous paragraph, this must mean that the number of domestic firms that exit in each country must be exactly balanced by the number of foreign domestic firm which switch to exporting status. So let's just concentrate on this special case, though we want to emphasize that none of the key results about changes in cutoff productivities etc. rely on this assumption.

(4) given that the number of varieties consumed in a country i does not change with the fall in ϕ, this must mean that the price index e in equation (13.17) must fall. This is because the prices of initially imported varieties fall and the prices of the newly imported varieties are lower than the prices of the exiting domestic firms. (5) from the first equation of (13.29), this in turn means that the cutoff marginal cost for domestic firms mc_d must fall. We might also point out that if this result is not true, it means that the price index for X goods rises with lower trade costs which in turn is a sufficient condition (given a single factor of production) to imply welfare losses from lower trade costs.

The fact that e falls does not imply that the productivity cutoff mc_x for exporting firms rises in the second equation of (13.29). While e falls, ϕ rises. But indeed further analysis shows that mc_x must rise. This must be true if some domestic firms are becoming exporters: these switching firms have higher marginal costs that the highest marginal cost (cutoff) initially exporting firm. Thus ϕ rises in the second equation of (13.29) faster than e falls. Note the if this result is not true, it must mean that some initially-exporting firms stop exporting and switch to being purely firms after trade costs fall, a result that clearly seems to contradict our intuition.

These results are shown graphically in Figure 13.7. The effect of rise in ϕ (fall in t) shifts the cutoff mc_x to the right and the cutoff mc_d to the left. We also graph the initial sales per firm labeled "initial sales" in Figure 13.7 and "final sales" in the diagram. Firms up to the new exporting cutoff mc_x'produce more (the cutoff firm adds foreign sales to its existing domestic sales). Firms that remain purely domestic produce less and firms with costs above the new cutoff cost mc_d' exit.

Figure 13.7

The point about the results in Figure 13.7 is that trade liberalization is predicted to make firms in a sense more unequal. The more productive firms get larger, some middle firms shrink, and the initially least productive are forced to exit the market. We then have an addition source of gains from trade liberalization: the average productivity of firms in the market rises.

13.7 The gravity equation

An important empirical tool in international trade analysis is called the gravity equation. The term comes from physics and Newton's law of gravitational attraction. Let G be the gravitational attraction between two bodies, one of mass M_1 and the other of mass M_2. Let d denote the distance between them. α is some constant of proportionality. G is given by the formula

$$G = \alpha \frac{M_1 M_2}{d^2} \qquad (13.32)$$

In the economics version of this equation, G is replaced by the volume of trade between countries 1 and 2 which we can denote by T_{ij}. M_1 and M_2 become the incomes of the two countries. d continues to denote distance or some other measure of trade costs but there is no presumption that trade falls exactly with the square of distance. Then economists usually take the logs of both sides of the equation so that it is linear in logs (useful for estimating regression equations). The economics gravity equation for trade between countries i and j is then

$$\ln T_{ij} = \alpha + \beta_1 \ln M_1 + \beta_2 \ln M_2 + \beta_3 \ln d \qquad (13.33)$$

Empirical analysis consists of estimating the α and β coefficients via regression analysis. The first three coefficients should be positive and β_3 should be negative. This negative effect of distance (trade costs) should be apparent from Figures 13.1 and 13.2.

There are several theoretical drawbacks of the gravity equation, perhaps the most important of which is that it has no role for comparative advantage trade. Trade between two countries of given total income is independent of their factor endowment and technology differences for example. But it works (fits) surprisingly well in practice, so well in fact that this long troubled trade economists. There have been many papers adding additional features to the gravity equation to reflect factors such as comparative advantage, institutions, common language and so forth and we cannot present an analysis of all these extensions here.

We do however want to comment on one feature of the gravity equation (also true in Newton's equation) which is that trade is predicted to depend not only on the total incomes of the two countries combined but also on the size difference. For a given total income ($M_1 + M_2$), gravity (13.32) and trade (13.33) are maximized when the countries are identical in size ($M_1 = M_2$) and minimized as one country goes to zero size. This is in fact a feature of the Dixit-Stiglitz love-of-variety monopolistic-competition model. The latter is therefore often advocated as a theoretical foundation for the gravity equation.

Suppose that we have two countries which are identical except for size and assume that trade is costless (let that be represented by $d = 1$). We don't need to assume a second sector Y, suppose all goods are X goods in the sense derived several times above. Let the total number of goods be normalized to one, the output of each equal to one, and let their prices equal one. If the countries are identical, each country will produce a number of goods equal to 1/2. Further, each country will consume half of each of its own goods and half of the output of each of the other countries good. A country's exports are then 1/2 of each of its goods, with the number of goods it produces equal to 1/2 (the world total is normalized at 1). The total two-way volume of trade will then be given by the sum of the two countries' exports:

Trade volume = (1/2)*(1/2) + (1/2)*(1/2) = 1/2

Now suppose that we hold the world size constant, but that one country has only 1/4 of the total endowment and the other country has 3/4. The small country will produce 1/4 of the total number of goods, with 1/4 of each being consumed at home and 3/4 being exported. The large country produces 3/4 of the goods, retaining 3/4 of each at home and exporting 1/4 to the small country. Total trade volume is now

Trade volume = (1/4)*(3/4) + (3/4)*(1/4) = 6/16 = 3/8 < 1/2

The total trade volume falls as the countries become more unequal in size holding total world size constant, exactly the prediction of the economics gravity equation in (13.33).

As noted above, there have been many extensions to the gravity equation via adding addition variables in the estimating equation (see Evenett and Keller (2002) for a review). In addition, it has been noted that different underlying economic models imply different predicted values and relative values for β_1 and β_2 in (13.33). These different prediction are the taken to data in order to help discriminate among alternative theories of trade (Feenstra, Markusen, and Rose (1999)). Unfortunately, we cannot go into more detail here but simply note that the basic gravity equation is often a starting point in empirical investigations.

13.8 Summary: what you should know

Trade costs have long been somewhat neglected in both trade theory and empirical analysis. We conjecture that this made be due to an implicit assumption that trade costs are not inherently interesting:

they simply put countries somewhere between autarky and free trade. We think this “between” statement is probably fair in models in which trade is motivated by comparative advantage. But even in this case there are important points to be made, such as unequal factor prices that give incentives for factors to migrate. More on this later in the book

In models with increasing returns and imperfect competition however, there are quite a number of situations in which trade costs do not leave country in between autarky and free trade. We first consider a simple oligopoly model of the type analyzed in Chapter 11 and allowed firms to price discriminate between markets. We showed that trade costs in this environment can lead to two-way trade even in identical goods, a form of intra-industry trade, and to the pricing of exports below that of domestic sales (dubbed “reciprocal dumping” by Brander and Krugman (1983)).

Monopolistic-competition models generally assume that price discrimination is not possible (why, we don’t know), yet several interesting features have been identified. One is that countries that differ only in size will have different patterns of specialization in the presence of trade costs. The larger country will be relatively specialized in the differentiated goods sector, being a net exporter of differentiated goods to the small country and a net importer of the homogeneous competitive good. Thus intra and inter-industry trade will co-exist even though the countries are identical except for size. Each country will be relatively specialized in consuming the differentiated goods produced at home, sometimes referred to as the “home-market effect”. This has further implications if some factors are mobile between countries and this will be discussed in a later chapter.

Next we looked at a new class of models in which firms have heterogeneous productivities or costs. A full analysis of this is beyond the scope of this book . But firm heterogeneity is quite interesting in the presence of trade costs. In particular, a fall in trade costs leads to the exit of the least productive domestic firms, and the switching of the most productive domestic firms into exporting as well. Falling trade costs now offer an additional source of gains from trade due to the rise in the average productivity of firms surviving in the market place. The heterogeneous firm models are popular in part because many of their predictions seem closely consistent with data, in particular observations that only a minority of firms export and firms that do export are larger and more productive that strictly domestic firms that do not export.

Finally, we present a brief analysis of the gravity equation, a widely-used empirical starting point for estimating the determinants of trade flows. Almost any theoretical approach provides a rationale for why trade flows decrease with the distance between trading partners, and the monopolistic competition model provides a nice rationale (theoretical foundation) for why trade flows should decrease with increased size *differences* between two countries, holding their total combined size constant.

ENDNOTES

1. Presenting the full general-equilibrium model is beyond the scope of this paper. There are a number of analytical complications and the solution involves taking integrals across firms over some probability distribution. The cost of entering the lottery is important in establishing an aggregate zero-profit condition and this in itself is complicated (recall the difficulty of having positive profits in general equilibrium that we discussed in Chapter 11). Firms enter the lottery up to the point where each has an expected payoff of zero. Firms with really bad draws don't subsequently enter production and so there ex post profits are negative and equal to the lottery entry cost, whereas the lucky firms make positive profits; but total profits ex post are zero. Incidentally, this assumes the existence of some sort of perfect underlying equities market, something rarely mentioned in this literature.

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Figure 13.1

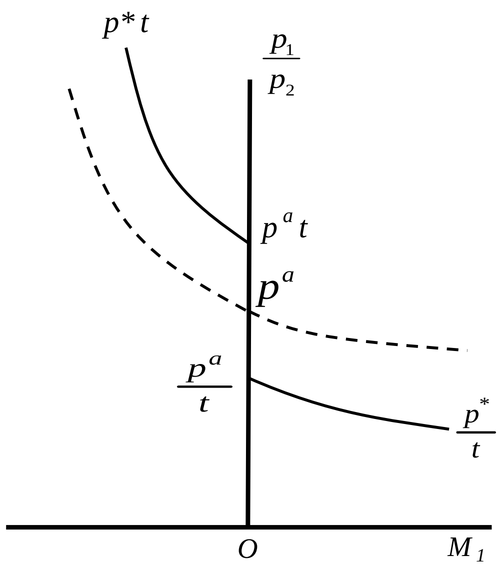
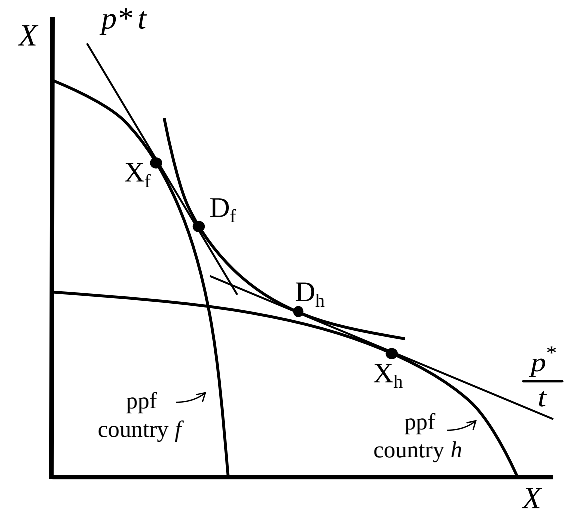


Figure 13.2



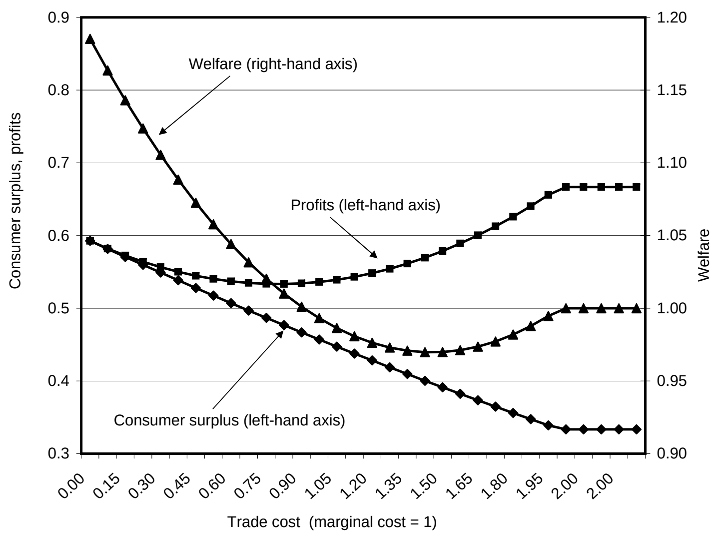


Figure 13.3 Effect of trade costs in the "reciprocal dumping" model

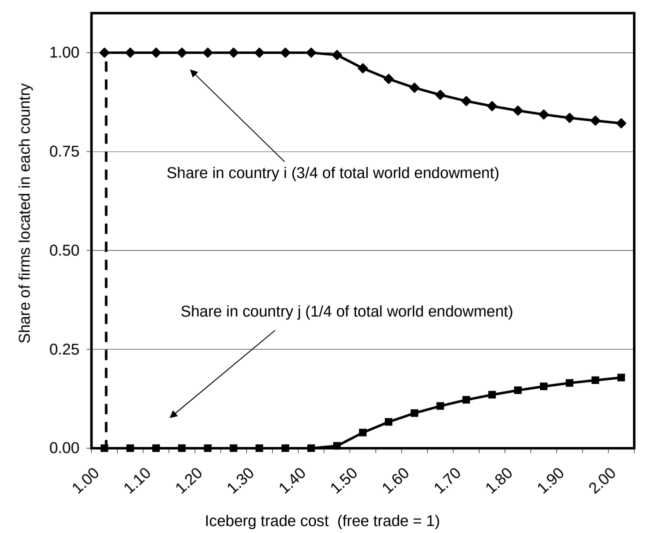


Figure 13.4 Trade costs and the home-market effect: one-factor model

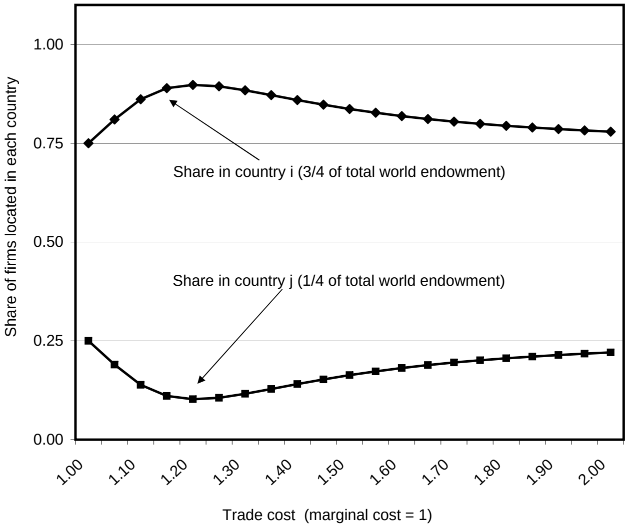


Figure 13.5 Trade costs and the home-market effect: two-factor model

Figure 13.6

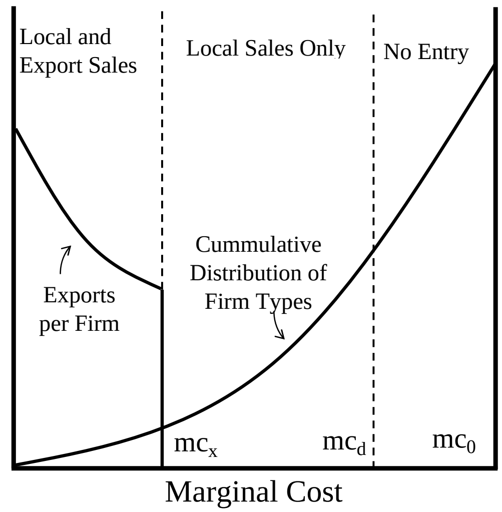


Figure 13.7

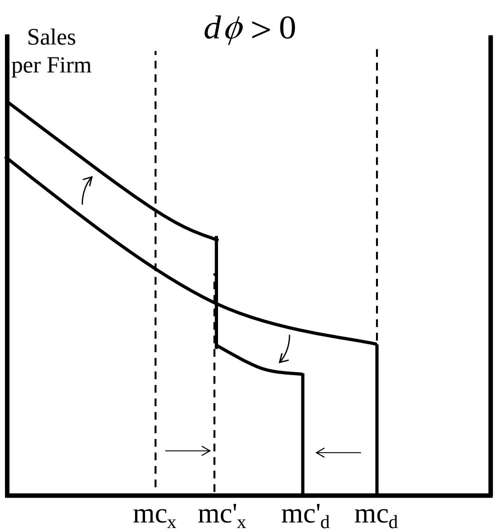


Figure 13.1

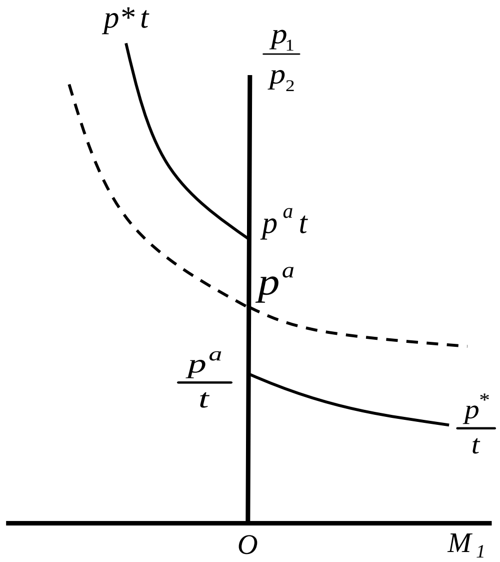
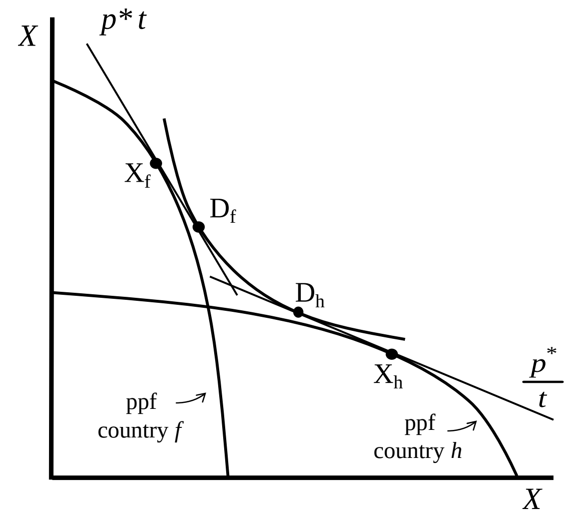


Figure 13.2



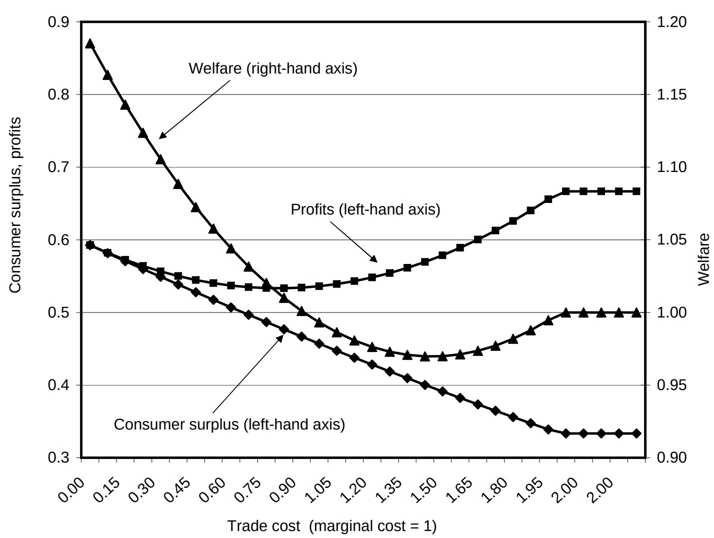


Figure 13.3 Effect of trade costs in the "reciprocal dumping" model

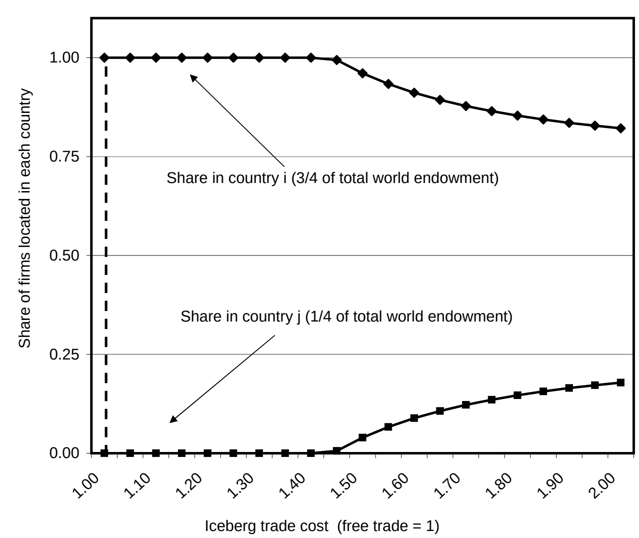


Figure 13.4 Trade costs and the home-market effect: one-factor model

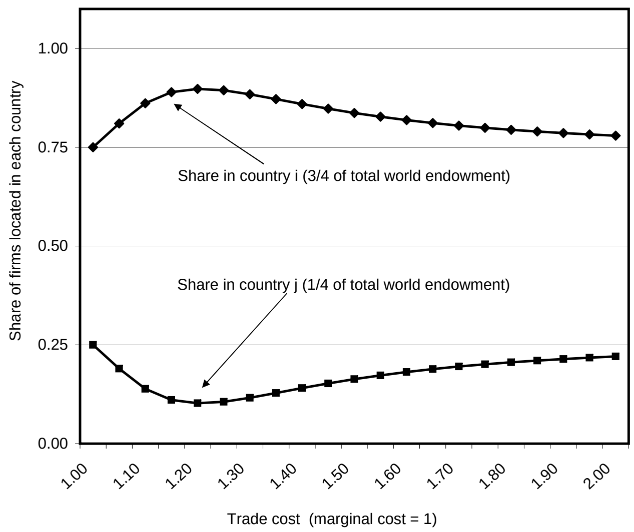


Figure 13.5 Trade costs and the home-market effect: two-factor model

Figure 13.6

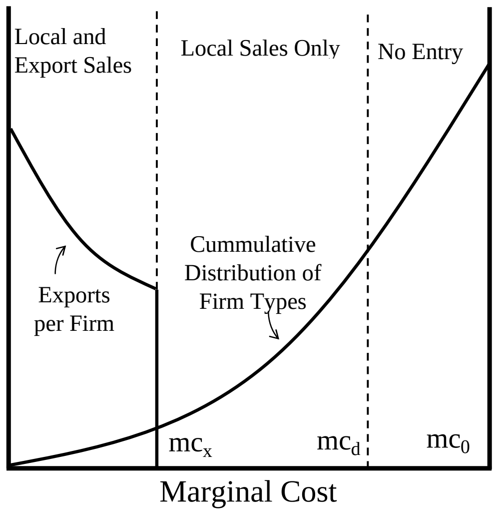


Figure 13.7