Chapter 3: Taste, Technology, and Markets

A decentralized economy motivated by self-interest and guided by price signals would be compatible with a coherent disposition of economic resources ... It is important to understand how surprising this claim must be to anyone not exposed to this tradition. The immediate 'common sense' answer to the question "What will an economy motivated by a very large number of different agents look like?" is probably: there will be chaos ... A quite different answer has long been claimed true and has indeed permeated the economic thinking of a large number of people who are in no way economists.

Kenneth Arrow and Frank Hahn

The last chapter ended unhappily. Unrestricted freedom of each person to act in his own interest as he thinks best led to a society where everyone, fishermen and pirates alike, was worse off than if people were constrained to act in the common interest. The required constraint could only be supplied by an organized police force, and there appeared to be no way to prevent an organization intended to suppress piracy from suppressing the rest of society as well. "Who guards the guardians?" points to a dilemma from which very few societies have escaped.

Much depends on the range of the authority of the guardians. As will be argued in detail later on, the capacity of the society to guard the guardians will depend on what exactly the guardians are called upon to do. A hierarchically organized corps of guardians called upon to direct the economy in detail would have to exert such extensive and such specific authority over the lives of ordinary citizens that, as the experience of communism in our time has abundantly shown, the guardians would evolve into a predatory ruling class and the status of the ordinary citizen would be reduced to little better than slavery. On the other hand, the great lesson of economics is that, subject to a host of qualifications which constitute a large part of the subject matter of economics, it is sufficient for the government to protect property rights. Once property rights are protected, the ordinary play of self-interest by an uncoordinated multitude of producers and consumers can be relied upon to run the economy efficiently. This highly counter-intuitive proposition, rendered commonplace by repetition in the classroom and in public discussion, is the subject of the present chapter.

We approach the proposition in three stages. Forces governing the mix of goods produced, their prices and their allocation among people can be usefully classified under the headings of technology and taste, or, equivalently, of supply and demand. To introduce these concepts as simply and as cleanly as we can, we begin in the first part of the chapter with an isolated person who produces and consumes but does not buy or sell. His technology is represented by a *production possibility curve*. His taste is represented by *indifference curves*. These in turn are summarized for any good by a *supply curve* and a *demand curve*. The crossing of the supply curve and the demand curve indicates that the person is as well off as he can be with the technology at his disposal. Applications of demand and supply curves to the study of taxes, tariffs, patents, monopoly, and other matters will be the subject of the next chapter. The second part of the chapter is a brief introductory discussion of the indeterminacy of bargaining. This discussion may well leave the reader with the impression that the anticipation of chaos from an unregulated market, referred to in the quotation from Arrow and Hahn at the outset of this chapter, is well justified, setting the stage for the examination of market-determined order to follow. The third part is on markets and market prices. It is shown how and in precisely what sense the price mechanism conscripts self-interest in the service of the common good. The chapter ends with a list of the virtues and vices of the competitive economy.

Part A: Technology and Taste in a One-Person Economy

Technology and the Supply Price

Think of Robinson Crusoe alone on his island. He consumes only two goods, bread and cheese. Both goods are produced with land exclusively. Outputs of the two goods depend on the allocation of land between them. Robinson Crusoe's input of labour is fixed; he cannot increase output by working harder. Specifically, the island contains five distinct plots of land - called A, B, C, D, and E - with different fertilities depending on which crop is produced. Plots may be devoted entirely to bread, entirely to cheese or partly to both in whatever proportion Robinson Crusoe thinks best. Output is measured per unit of time. Think of the unit of time as a week. Production is assumed to remain the same week after week. Robinson Crusoe's only choice is how to allocate the available land between bread-making and cheese-making. If all the land were devoted to bread-making, he would have plenty of bread but no cheese. If the land were devoted to cheese-making, he would have plenty of cheese but no bread. As every sandwich-eater knows, a person wants some of both goods and must allocate the available land between them.

There are two aspects to production. Robinson Crusoe must decide how much of each good to produce, whether, in effect, to produce lots of cheese and a little bread, or lots of bread and a little cheese. He must also decide which plots of land to devote to each good, a simple representation of the wider problem in real economies of deciding how to deploy resources efficiently among competing uses.

The technology of this example is described in Table 1. The first column of the table identifies plots. The second column shows the output of each plot if used entirely for the production of bread. The third column shows output of each plot if used entirely for the production of cheese. The last column entitled "rate of trade-off in production, (loaves per pound)" is the ratio of the two preceding columns. The meaning of the first row, for example, is that plot A can be used to produced either 16 loaves of bread per week, or 4 pounds of cheese per week, or an any combination of the two (such as 8 loaves and 2 pounds, or 4 loaves and 3 pounds), and that 4 loaves must be forgone for every pound of cheese acquired by diverting production on that plot from bread to cheese.

Table 1: Outputs of Bread and Cheese per Week on Each of Five plots of Land

Plots	Loaves of bread when the plot is used exclusively for bread	Pounds of cheese when the plot is used exclusively for cheese	Rate of trade-off in production: (loaves per pound)
A	16	4	4
B	8	4	2
C	5	10	1/2
D	6	6	1
E	12	4	3

From the information in this table, we cannot say what Robinson Crusoe will do because that depends in part on this tastes, or preferences, about which we have so far said nothing. What we can say is that, whatever his tastes, Robinson Crusoe wants to produce *efficiently*. He organizes production to get as much bread and cheese as possible in the sense that no reorganization of production would enable him to obtain more of both goods. For instance, if Robinson Crusoe chooses to produce only 4 loaves of bread, he insists on producing those 4 loaves on plot A rather than plot B because, by producing bread on plot A rather than plot B, he acquires 2 extra pounds of cheese.

The key to the allocation of land to goods is the right hand column showing the trade-off in production between bread and cheese on each plot. The lower the number in the right hand column, the better the plot for cheese production, not absolutely, but relative to bread production. Thus, if Robinson Crusoe is a bread-lover who consumes almost no cheese, the little bit of cheese he does consume will be produced on plot C for which the loss of bread per pound of cheese is as small as possible. To produce cheese on plot C "costs" only one-half (the number in the right hand column) of a loaf of bread, for the 10 pounds of cheese acquired when plot C is devoted to cheese is at the expense of only 5 loaves of bread which plot C could have produced instead.. As long as Robinson Crusoe is content with up to 10 pounds of cheese, all cheese is produced on plot C. If Robinson Crusoe wants more cheese than can be produced on plot C, he must draw upon the next best plot, D, where a full loaf of bread must be sacrificed per pound of cheese acquired. If he wants more than 16 pounds (the output of cheese from plots C and D combined), he must convert some of plot B from the production of bread to the production of cheese, and so on.

The information in table 1 is reorganized in table 2 to show the range of efficient combinations of bread and cheese that might be produced. The first column lists the five plots of land according to their relative efficiency in the production of cheese. The efficient ordering of plots - from most to least productive for cheese relative to bread - is C, D, B, E, and A. Plot C is first in this ordering because it yields the most cheese, 2 pounds, per loaf of bread forgone as indicated in the right hand column of the table. No other plot supplies cheese so cheaply. The ordering of plots in the first column is a reflection of the relative productivity of the different plots of land, as shown in the final column of table 1 and relabeled as the *supply price* of cheese. "Supply price" means "rate of trade-off in production between bread and cheese." The latter term is the more descriptive; the former is more in accordance with common usage in economics and is better connected to ordinary market prices to be discussed later on. The supply price of cheese rises from 0.5 loaves per pound on plot C to 4 loaves per pound on plot A.

Table 2: Efficient Combinations of Bread and Cheese

efficient ordering of plots devoted to cheese production	pounds of cheese on the "last" plot	loaves of bread on the "last" plot	total pounds of cheese produced	total loaves of bread produced	supply price of cheese (loaves forgone per extra pound acquired on "last" plot)
none	-	-	0	47	-
first plot: C	10	5	10	42	1/2
second plot: D	6	6	16	36	1
Third plot: B	4	8	20	28	2
Fourth plot: E	4	12	24	16	3
Last plot: A	4	16	28	0	4

For each row, the "total pounds of cheese produced," as shown in the fourth column of the table, is the sum of the productive capacity of the plot shown in that row and all preceding plots. For example, the total output of cheese corresponding to plot B (20 pounds) is the combined output of plots C, D, and B because plots C and D would have been devoted to cheese production already before production of cheese on plot B could be efficient. Similarly, for any plot listed in the first column, the fifth column shows the total output of bread when that plot, together with all higher plots, is devoted to the production of cheese.

Three observations on the interpretation of the table: First, though the table shows combinations of bread and cheese that might be produced when each plot is used for bread or for cheese exclusively, Robinson Crusoe can produce any amount of bread up to 47 loaves, as long as the output of cheese is adjusted accordingly. To obtain 8 loaves of bread, he devotes half of plot A to bread-making, and devotes the rest of plot A and all of the other plots to cheese-making, producing 26 pounds of cheese as well. To obtain 19 loaves, he devotes all of plot A and a quarter of plot E to bread-making and the rest to cheese, producing 23 pounds of cheese as well.

Second, the table shows all *efficient* combinations of bread and cheese, where efficiency is interpreted to mean that production cannot be rearranged to yield more of both goods and where the source of efficiency in this example is the ordering of the plots devoted to bread. Any other arrangement would yield less of one good for any given amount of the other. For example, if Robinson Crusoe wanted to produce 10 pounds of cheese, he could produce them on plots D and B, but that would be inefficient because the remaining plots - A, C, and E - would yield only 33 loaves of bread rather than the 42 loaves of bread pounds that could be produced on plots A, B, D, and E. Ordering of plots according to the supply price of cheese is efficient; every other ordering is inefficient in that there would be less of bread, cheese or both.

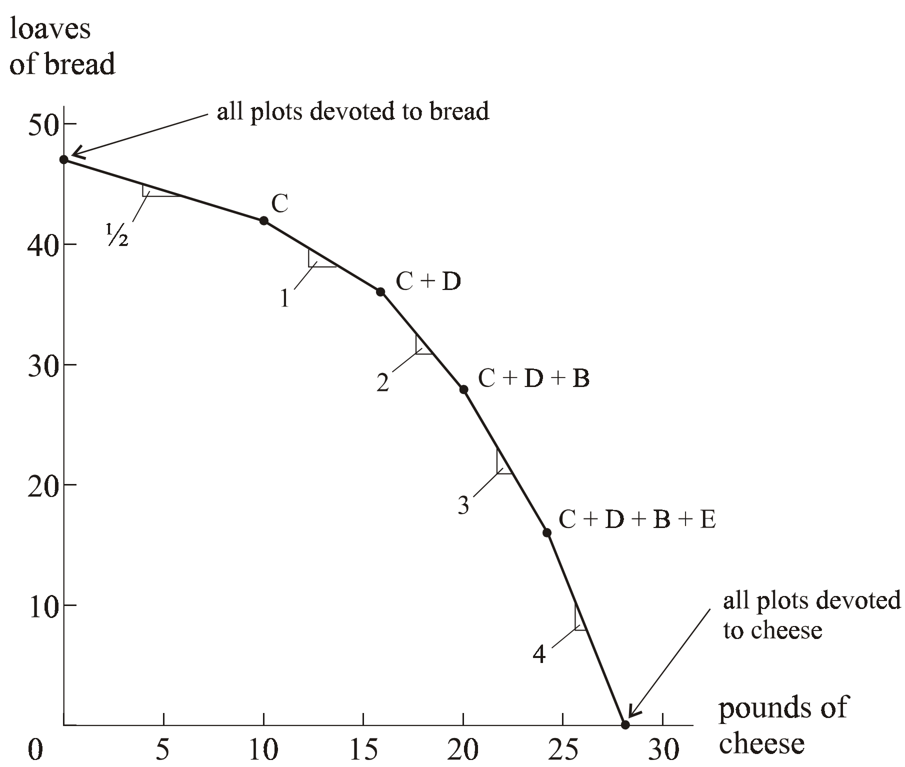
Third, the name "supply price of cheese" in the final column requires some explanation. When you buy cheese at the grocery store, you are quoted a price of, say, $3 dollars per pound. This means that you must give up $3 in return for a pound of cheese, $6 in return for two pounds, and so on. Price cannot be expressed that way in the Robinson Crusoe example because money is meaningless in an environment with only one person. Robinson Crusoe is, nevertheless, confronted with a sort of price, a price in terms of bread rather than dollars. Think of Robinson Crusoe as, initially, producing bread and nothing else. If he wants some cheese as well, he has to give up some bread in return. The exchange is effected through production rather than purchase, but it is an exchange nonetheless. Initially, as indicated in the first row of the table, Robinson Crusoe is producing 47 loaves of bread and no cheese. Then he can acquire up to 10 pounds of cheeses at a price of half a loaf per pound. If he wants more cheese, he must convert all or part of plot D from bread to cheese, raising the supply price from 0.5 to 1 loaf per pound. As more cheese is produced, the supply price rises not steadily, but in jumps, as one plot after another is diverted from bread to cheese, until, in the end when only plot A is left, Robinson Crusoe faces a supply price of 4 loaves for each additional pound of cheese.

The supply price of cheese in table 2 is similar but not altogether identical to the ordinary price of cheese in the grocery store. The price of cheese at the grocery store is a *money price,* measured as dollars per unit of quantity, for instance, $3 per pound. The price of cheese in table 2 is a *relative price*, measured as quantity per unit of quantity, the first quantity being a standard of comparison (in our example, bread) and the second quantity being of the good (in our example, cheese) that is priced. Of course, it is arbitrary, within the context of our example, which quantity is chosen as the standard of comparison. If we had chosen cheese rather than bread to be the standard of comparison, then the headings of the final columns of tables 1 and 2 would have been reversed. "Loaves per pound" would have to be changed to "pounds per loaf" and all the numbers in those columns would have to be inverted; the numbers 0.5, 1, 2, 3, and 4 would have to be changed to 2, 1, 0.5, 0.33, and 0.25.

The difference between money price and relative price is not really as sharp as may at first appear because a money price can be looked upon as a relative price where the standard of comparison (the technical term for that standard is *numeraire*) is all other goods rather than just one good as in our example. To say that the price of cheese has increased from $3 to $6 is to say that one must forgo consumption of twice as much of other goods to acquire an extra pound of cheese. (The astute reader may well ask at this point whether that is still true under inflation when all prices double. Obviously, it is not. To interpret a money price as a relative price with respect to "all other goods" as the numeraire is to suppose that the price of cheese rises while the price level, the average price of all other goods, remains the same.)

There is another difference between ordinary money prices and the supply price of cheese in table 2. The supply price of cheese is presented in table 2 as a list, or schedule, of the cost of cheese in terms of bread depending on how much cheese Robinson Crusoe chooses to acquire, while the money price of cheese in the grocery store is seen by the buyer of cheese as a fixed number determined by the market and independent of the amount he wants to buy. The supply price of cheese in table 2 could also be pinned down to a particular number if we knew how much cheese Robinson Crusoe chooses to produce, but that depends in part on Robinson Crusoe's taste for bread and cheese, which has not, as yet, been introduced in the example, but will be presently.

Figure 1: The Production Possibility Curve
[Points indicate plots devoted to cheese. Slopes indicate supply prices of cheese.]



The economic significance of the information in table 2 is clarified by translation into a *production possibility curve* as shown in figure 1, with total loaves of bread on the vertical axis and total pounds of cheese on the horizontal axis. All pairs of numbers in the fourth and fifth columns of table 2 are plotted as points on the figure, and adjacent points are joined by line segments. The resulting production possibility curve is the locus of all efficient combinations of bread and cheese that Robinson Crusoe might produce. He could produce at points below the curve (for instance by producing bread on plot D and cheese on all other plots), but he would never choose to do so. As an *economic man*, he would never voluntarily accept less of both goods than he might otherwise obtain. By assumption, he cannot produce outside of the production possibility curve. That would be beyond the confines of the available technology. Robinson Crusoe must choose a combination of bread and cheese from among the combinations represented by the production possibility curve.

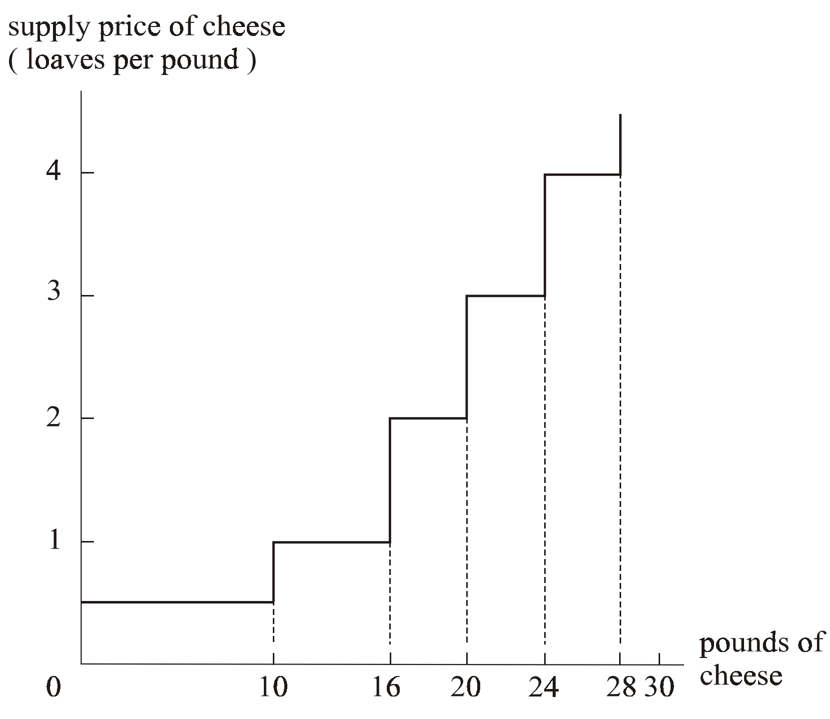
Notice the shape of the production possibility curve. It must, of course, be downward sloping because any increase in the output of one good must be at the expense of the other as long as the allocation of land between bread and cheese is efficient. That it is also bowed outward is a geometrical consequence of the differences among plots of land in the ratio of the potential output of cheese to the potential output of bread. The assumed productivities of the five plots of land, as shown in the second and third columns of table 1, could be random numbers drawn out of a hat, and still the production possibility curve would be bowed out. Different numbers would yield a different curve, but all such curves would be bowed out as shown in figure 1. The numbers in table 1 were chosen to facilitate calculation, but the main story is independent of that choice. On the other hand, the production possibility curve becomes a downward-sloping straight line when all land is equally productive for both goods. It could only be bowed inward if production of one good interfered with the production of the other as, for example, if smoke from a foundry interfered with a laundry nearby.

If Robinson Crusoe chooses a combination of bread and cheese represented by one of the six nodes on the production possibility curve, then he is using all of some plots for bread and all of other plots for cheese. If he chooses a combination of bread and cheese represented by a point on a line between nodes, then some plot (never more than one, for that would be inefficient) is being used partly for bread and partly for cheese. At each node on the diagram is an indication of which plots of land are devoted to cheese-making, on the understanding that the remaining plots are devoted to bread.

By construction, the slope of any segment of the production possibility curve is the corresponding supply price of cheese. Consider, for example, the first segment on the left. This represents Robinson Crusoe's options for the disposition of plot C, the plot with the lowest supply price of cheese, when all other plots are devoted to bread exclusively. If all of plot C were used for bread as well, the output of bread would be 47 loaves. If instead plot C were used entirely for cheese, the output of bread would fall to 42 loaves but Robinson Crusoe would acquire 10 pounds of cheese. Along that segment, one loaf would be sacrificed for every two pounds of cheese acquired, so that the relative price of cheese would be 0.5 loaves per pound as indicated on the diagram. Relative prices from the last column of table 2 are indicated for every segment of the figure. Supply prices at nodes are not defined.

There is yet another way of presenting this information. The production possibility curve shows the quantity of cheese together with the corresponding quantity of bread. We might instead show the quantity of cheese together with the supply price of cheese, i.e. with the rate of trade-off in production of bread for cheese. The new curve - called a *supply curve* - is shown in figure 2 with pounds of cheese on the horizontal axis and the supply price of cheese on the vertical axis. The supply curve may be constructed from the production possibility curve or, equivalently, from the data in the fourth column and the last column of table 2. The supply curve of cheese is stepped rather than smooth because the supply price of cheese remains steady as more and more cheese is produced on any given plot of land, and then jumps sharply once that plot of land is completely devoted to cheese and any extra cheese must be produced on the next, less productive, plot. The supply curve becomes vertical at 28 pounds of cheese because no extra cheese can be produced at any price.

Figure 2: The Supply Curve of Cheese

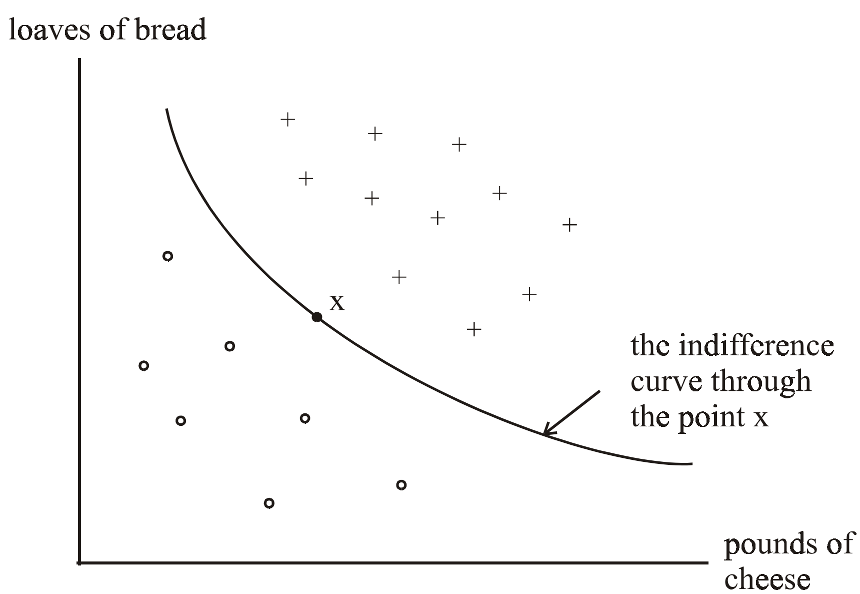


In choosing how much of each good to consume, Robinson Crusoe can be looked upon as picking the best point on the production possibility frontier or, equivalently as picking the best point on the supply curve of cheese. The relation between these curves is that, for any given quantity of cheese produced, the slope of the one curve is the height of the other. That is how the curves are constructed[1]. Note, finally, that the supply curve is not just a reflection of the technology of the economy. It is a reflection of the technology of the economy when resources are used efficiently, with plots of land allocated to bread or to cheese so as to maximize the amount of cheese produced for any given output of bread or, equivalently, to maximize the amount of bread produced for any given output of cheese.

Taste and the Demand Price

Though it is sufficient within the terms of this example to say that Robinson Crusoe picks the best point on the production possibility curve, the generalization of the example to a more realistic economy requires that taste, or equivalently preferences, be modelled in some detail. What this means in practice is that we need a device, or picture, showing at a glance which of any two combinations of bread and cheese - or, generalizing to an economy with many different kinds of goods and services, which of any two bundles of goods consumed - is preferred. The device is a set of *indifference curves* such that (1) any two combinations of bread and cheese represented by points on the same curve are equally desired, and (2) any combination of bread and cheese represented by a point on a higher indifference curve is preferred by Robinson Crusoe to any combination of bread and cheese represented by a point on a lower indifference curve. Since indifference curves are a reflection of Robinson Crusoe's preferences, they can only be discovered by asking him to tell us what they are. In principle, we could ask Robinson Crusoe to draw his indifference curves. Alternatively, we could elicit that information from his answers to a long series of questions of the form, "Do you prefer this to that?"

Figure 3: An Indifference Curve



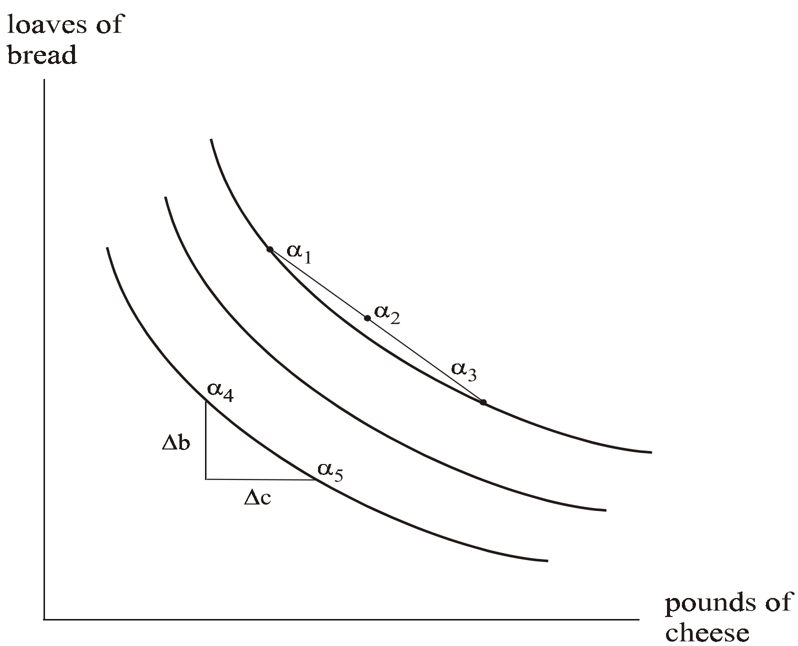
[1] Readers with some knowledge of the calculus will recognize that the production possibility frontier and the supply curve are related as integral and derivative.

Indifference curves representing Robinson Crusoe's taste for bread and cheese can be superimposed on the production possibility curve. Start with an empty graph with loaves of bread consumed on the vertical axis and pounds of cheese consumed on the horizontal axis. Choose any point on the graph and call it "x". Then pick any other point, and ask Robinson Crusoe whether he would rather consume the combination of bread and cheese represented by the other point than to consume the combination of bread and cheese represented by the point x. If his answer is that he prefers the combination of bread and cheese represented by the other point, mark that point with a "+". If his answer is that he prefers the combination of bread and cheese represented by the point x, mark the other point with a "0". Repeat the process over and over again until the entire graph is filled up with + or 0, as illustrated in figure 3.

There must, however, be a boundary between the space covered by + and the space covered by 0, as illustrated by the smooth line on the figure. As long as Robinson Crusoe is consistent in his responses, the point x must lie on that boundary; he must be indifferent between the point x and any other any point on the boundary. Asked whether he would prefer the amounts of bread and cheese represented by the point x or amounts of bread and cheese represented by another point of the indifference curve, Robinson Crusoe would have to say he is indifferent between the two.

By choosing different values of x as the starting point for this conceptual experiment, the entire graph can be filled up with indifference curves which never cross because no combination of bread and cheese can be simultaneously indifferent to and preferred to some other combination. Three indifference curves like that in figure 3 are reproduced in figure 4. The points "$_1$, "$_2$, "$_3$,"$_4$ and "$_5$ will be explained presently.

Figure 4: Several Indifference Curves



The logic of rational choice is sufficient to account for the existence of indifference curves and for the fact that they do not cross, but something more is required to account for their shapes. As drawn in figure 4, the indifference curves are bowed in, as south-easterly portions of loops. This postulated shape of indifference curves is a consequence of the common assumption in economics that people avoid extremes; if I am indifferent between two slices of bread and two slices of cheese, then I would prefer one slice of bread and one slice of cheese for a proper sandwich. More generally, if Robinson Crusoe is indifferent between the combinations of bread and cheese represented by the points "$_1$ and "$_3$ in figure 4 (as he must be because they lie on the same indifference curve), then both of these combinations must be inferior in Robinson Crusoe's assessment to a third combination, represented by the point "$_2$, consisting of a fraction of the bread and cheese at "$_1$ <u>plus</u> one-minus-that-fraction of the bread and cheese at "$_3$. For instance, the combination "$_3$ might consist of one-quarter of the bread and cheese at "$_1$ plus three-quarters of the bread and cheese at "$_3$. By simple geometry, it may be shown that all such points must lie on a straight line from "$_1$ to "$_3$, close to "$_1$ if the fraction is high and close to "$_3$ if the fraction is low. To say that indifference curves are bowed-in is to say that any point such as "$_2$ lies on a higher indifference curve the points "$_1$ and "$_3$.

The slope of an indifference curve is the rate of trade-off in use between bread and cheese. Consider the two points "$_4$ and "$_5$ on the same indifference curve, and define)b and)c as the changes in the amounts of bread and cheese between these two points. Consumption at the point "$_5$ contains)c more cheese than consumption at the point "$_4$, and)b less bread. The ratio)b/)c is the trade-off in use between bread and cheese, the decrease in the number of loaves of bread per pound of cheese acquired leaving Robinson Crusoe neither better off not worse off with the combination of bread and cheese at the point "$_5$ than he would be with the combination of bread and cheese at the point "$_{4.}$ A rate of trade-off in use between bread and cheese may be identified not just between two points, but at a single point on an indifference curve. The rate of trade-off at a point - for example, at the point "$_4$ - is just the slope of the indifference curve at "$_4$, or, equivalently, ratio)b/)c between "$_4$ and "$_5$ when "$_5$ is very close to "$_4$.

Analogously with the supply side of this simple economy, we refer to the rate of trade-off in use between bread and cheese (at any given combination of bread and cheese) as the *demand price* of cheese. Another way to describe the characteristic shape of indifference curves is to say that the demand price becomes steadily lower from left to right along an indifference curve. The more cheese one has, the less one is willing to pay for an extra pound.

Nothing in the construction of the indifference curves supplies a numbering of the curves themselves. It seems natural to speak of indifference curve as higher and lower according to whether the person to whom the curves refer becomes better off or worse off in exchanging a combination of bread and cheese on one indifference curve for a combination of bread and cheese on the other. Of the three curves shown in figure 4, the lowest curve is the one closest to the origin, the middle curve is next and the highest curve is the farthest away, but there, as yet, is no basis for numbering these curves. The numberings 1, 2, and 3, or 1, 10, and 150, or -50, -25, and 0 would all seem to do equally well. Any three numbers would do, as long as the higher number is attached to the higher curve. Any such numbering would be consistent with the test by which indifference curves are discovered.

Representation of taste by indifference curves allows us to speak of *choosing* as *maximizing*. Once indifference curves have been identified, Robinson Crusoe's choices become logically equivalent to maximizing *utility*, where utility is any numbering of indifference curves whatsoever as long as higher numbers are assigned to higher curves. To say that Robinson Crusoe maximizes utility is just a convenient and expedient way of saying that he chooses consistently.

In general, the utility function may be written as u(c, b) attaching a value of u to every combination of c and b. For purposes of exposition, it is convenient to postulate a specific functional form. A simple and useful assumption specification of the utility function is

$$u = cb \tag{1}$$

where u is mnemonic for utility. An indifference curve becomes the trace of all combinations of c and b for which u is constant. Consider two combinations of bread and cheese, $\{c_1, b_1\}$ and $\{c_2, b_2\}$. If Robinson Crusoe's tastes just happen to conform to equation (1), if $c_1b_1 = u_1$ and if $c_2b_2 = u_2$, then the first combination of bread and cheese is indifferent to, preferred to or dispreferred to the second according as u_1 is equal to, larger than or smaller than u_2. Bear in mind that, in postulating that tastes conform to equation (1), there is no presumption that a person's tastes should conform; it is simply supposed for purposes of exposition that they do. They might easily have conformed to some other function instead.

Though it is not possible to specify a function such as that in equation (1) without at the same time specifying a distinct value of u for any pair of values of b and c, no meaning is being attached to the magnitude of u and nothing in the derivation of the demand price depends upon it. For example, b = 7 and c = 9, then, according to equation (1), u = 63, but that is of no economic significance. Robinson Crusoe's behaviour is exactly the same when the utility function is
$u = 50cb$, or $u = (cb)^2$ or any function of cb whatsoever, as long as the greater cb generates the greater u. Also, as will be shown presently, the utility function u = cb has the property that the corresponding indifference curves are bowed in as shown in figures 3 and 4. The reader should be warned, however, that the utility function in equation (1) has some very special properties that make it very convenient for introducing to supply and demand curves, but at the cost of suppressing some aspects of economic behaviour.

The demand price of cheese corresponding to any combination of bread and cheese is defined as $p^D(c, b) =)b/)c$ where $)b$ and $)c$ are absolute values of small changes in b and c along the indifference curve at the point $\{c, b\}$. For the utility function u = cb, the demand price of cheese can be derived analytically. It is easy to show that[2].

$$p^D(c, b) = b/c \tag{2}$$

A *demand curve* for cheese, comparable to the supply curve in figure 2 but downward-sloping rather than upward-sloping, will be constructed presently.

Equilibrium

Now the demand and supply sides of the economy can be pulled together, first in table 3 and then in figure 5. Table 3 is a list of quantities, supply prices, demand prices and utilities. With the exception of the row entitled “C, D and part of B”, each row in the table shows quantities and prices when plots of land are used entirely for one good or entirely for the other. Outcomes when other plots are divided between bread and cheese are not shown in the table but are easily computed. “Pounds of cheese produced”. “loaves of bread produced,” and “supply price,” are reproduced from table 2. The new columns in table 3 show Robinson Crusoe’s utility on the special assumption that Robinson Crusoe’s tastes are accurately represented by the utility function in equation (1), so that the demand price of cheese becomes $p^D = b/c$. This equation is used in deriving the numbers in the final column of table 3.

The main story in the table is that there is a best combination of bread and cheese characterized at once by the maximization of utility and the equality between the demand price and the supply price of cheese. Start at the top row of table 3 where all plots of land are devoted to bread-making so that output consists of 47 loaves of bread and no cheese. Then, passing down the rows as one extra plot after another is devoted to cheese, Robinson Crusoe trades off more and more bread for cheese at an ever higher supply price (rate of trade-off in production of bread for cheese) and an ever lower demand price (rate of trade-off in use of bread for cheese). At the same time, Robinson Crusoe’s utility grows steadily from a low of 0 when no cheese is produced, to 420 when plot C is converted from bread to cheese, to 576 when plot D is converted

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[2] For the student with some knowledge of calculus, the derivation of the demand functions in equation (2) from the utility function in equation (1) is obvious. Otherwise, the the demand functions have to be derived from first principles. To derive equation (2), consider the points "$_4$ and "$_5$ in figure 4 above. Let the point "$_4$ represent the combination of bread and cheese {b, c}, in which case the point "$_5$ must represent the combination {b -) b, c +) c}. The main step in establishing the validity of equation (2) is to suppose that the points "$_4$ and "$_5$ are very close together so that) b and) c are both very small, approaching zero, by comparison with b or c. By construction, the points the points "$_4$ and "$_5$ lie on the same indifference curve and must have the same value of utility. It follows immediately from equation (1) that

bc = (b -) b)(c +) c) = bc - c) b + b) c -) b) c

from which it follows that

) b/) c = b/c +) b/c = b/c

which is equation (2) in the text because the term) b/) c is the demand price and as long as the term) b/c is small enough to be ignored. For example, if b = 10, c = 20,) b = 0.1 and) c = 0.2, then b/c = .5 but) b/c = .005. If b = 10 and c = 20, but) b = 0.01 and) c = 0.02, then b/c remains at .5 but) b/c falls to .0005. As) b and) c approach zero, the ratio) b/c approaches zero as well, and the ratio) b/) c becomes at once the slope of the indifference curve and the demand price of cheese at the point {b, c}.

as well, to a maximum of 578 when the appropriate portion of plot B is converted to cheese and the rest of plot B remains in the production of bread. Thereafter, utility falls steadily to 560 when the rest of plot B is converted to cheese-making, to 384 when plot E is converted, and finally back to nothing when all land is devoted to cheese and no bread is produced at all.

Robinson Crusoe's best available combination of bread and cheese could be observed directly by checking the value of utility at every point on the production possibility curve, but it can also be deduced from a comparison of demand and supply prices. If the demand price of cheese exceeds the supply price, then the amount of bread Robinson Crusoe would be willing to give up to acquire an extra pound of cheese must be greater than the amount of bread he is obliged to give up in order to produce the extra cheese, and the quantity of cheese produced must be too small. Similarly, if the supply price of cheese exceeds the demand price, then the amount of bread Robinson Crusoe would be obliged to give up in order to produce the extra pound of cheese must be greater than the amount of bread he is willing to give up, and the quantity of cheese produced must be too large. In either case, a change in the mix of bread and cheese produced is warranted whenever the supply price differs from the demand price. Robinson Crusoe can only be content with the mix of goods produced when the two prices are the same. The best combination of bread and cheese can be identified by equating demand and supply prices.

Table 3: Supply and Demand Curves for Cheese

plots devoted to cheese production	pounds of cheese produced (c)	loaves of bread produced (b)	Robinson Crusoe's welfare u = cb	supply price of cheese (loaves forgone per extra pound acquired)	demand price of cheese $p^D = b/c$
none	0	47	0	0.5	infinity
C	10	42	420	1	4.2
C and D	16	36	576	2	2.25
C, D and part of B	17	34	578	2	2
C, D and B	20	28	560	3	1.4
C, D, B and E	24	16	384	4	0.67
C, D, B, E and A	28	0	0	infinity	0

The demand price of cheese is higher than the supply price - 2.25 as compared with 2 - when all of plots C and D are devoted to cheese and all of plots B, E and A are devoted to bread. The demand price of cheese is lower than the supply price - 1.4 as compared with 3 - when the whole of plot B is shifted from bread production to cheese production. Thus, starting from a position where plots C and D are devoted to cheese, Robinson Crusoe makes himself as well off as possible by switching some but not all of plot B from bread to cheese. The appropriate share of plot B is identified by the equality between the demand price and the supply price of cheese. It turns out that demand and supply prices are equal when a quarter of plot B is devoted to cheese and the remaining three-quarters to bread[3].

It is important to distinguish what is contingent in the table (contingent on the arbitrarily chosen productivities of land in table 1) from what is characteristic of all technology and taste. The exact outputs of bread and cheese and the common value of the supply price and the demand price are contingent on our choice of numbers in table 3 and are without general significance. What is not contingent is the equality between the demand price and the supply price, signifying that Robinson Crusoe is as well off as possible with the technology at hand.

The very same story is told twice in figure 5. It is told on the top half of the figure combining the production possibility curve with indifference curves. It is told again on the bottom half of the figure with the supply and demand curves. The top half of figure 5 contains a set of indifference curves, assumed for convenience to be in accordance with equation (1) above, superimposed on the production possibility curve from figure 3, representing Robinson Crusoe's options for the production of bread and cheese. In choosing among these, Robinson Crusoe seeks to make himself as well off as possible. His best option is where an indifference curve just touches the production possibility curve, for, whenever an indifference curve cuts the production possibility curve, some higher indifference curve must necessarily be attainable by moving one way or the other along the production possibility curve. For example, an indifference curve cuts the production possibility curve at the node representing 42 loaves of bread and 10 pounds of cheese, but a higher indifference cuts the next node to the right.

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[3]Let x be the share of plot B devoted to cheese. Equating the demand price of cheese from equation (2) with the supply price of cheese along plot B, it follows that $b/c = 2$ where b and c are Robinson Crusoe's chosen outputs of bread and cheese. Recall that the output of plot B is either 8 loaves of bread or 4 pounds of cheese or some weighted average of the two. When none of plot B is devoted to cheese, the outputs of bread and cheese are 16 pounds and 36 loaves. When a share x of plot B is devoted to cheese, the outputs of bread and cheese are

$$b = 36 - 8x \text{ and } c = 16 + 4x$$

When $b = 2c$, as it must be when demand and supply prices are equal, it follows that

$$36 - 8x = 2(16 + 4x)$$

so that $x = 1/4$, $b = 34$ and $c = 17$ as shown in table 3.

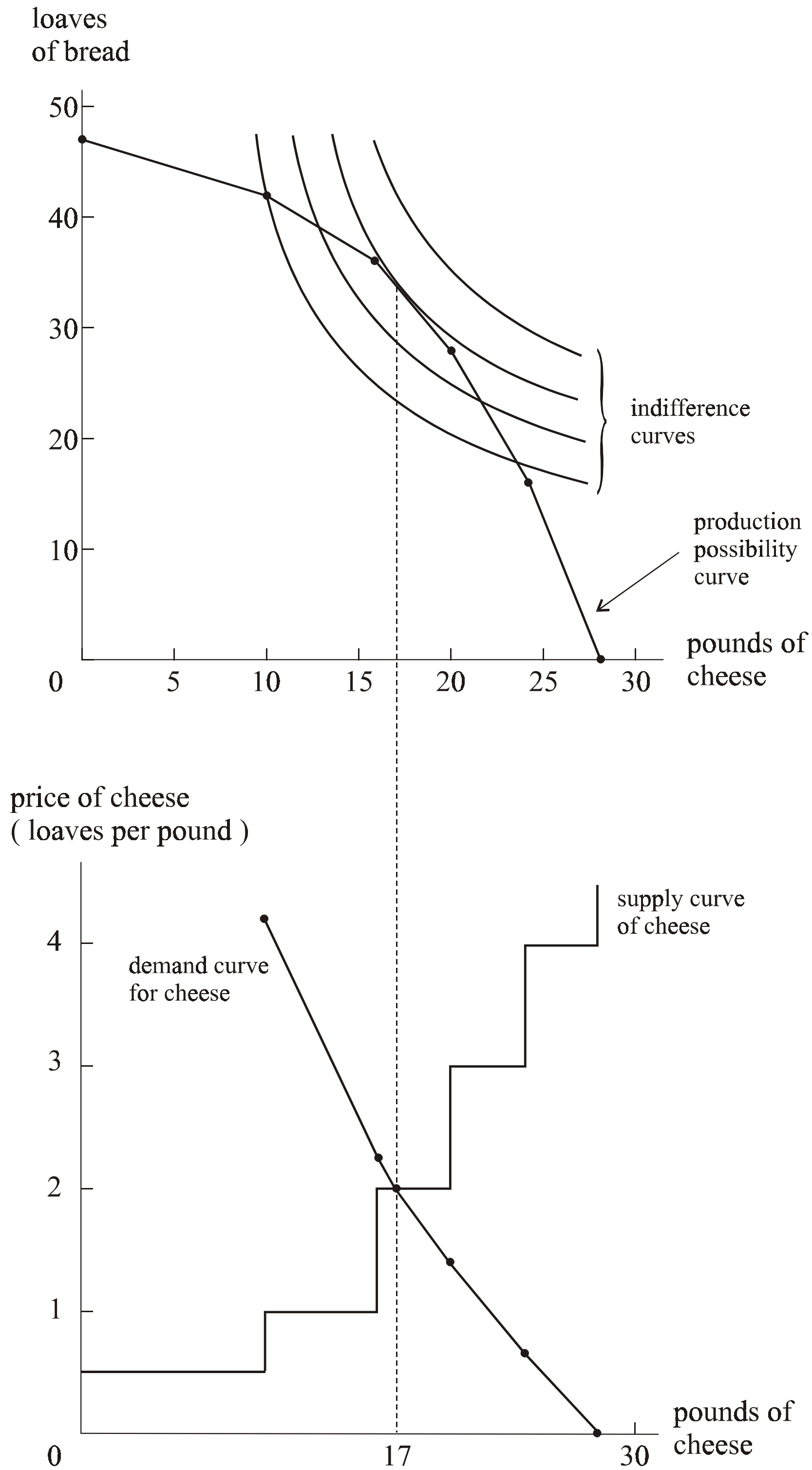
Robinson Crusoe's best option - corresponding to the highest attainable indifference curve - is characterized by the tangency of an indifference curve to the production possibility frontier. But the supply price is the slope of the production possibility curve, the demand price is the slope of the indifference curve, and the common tangency of the production possibility curve and the highest attainable indifference curve guarantees an equality between the supply price and the demand price at the best attainable combination of bread and cheese. This information is reproduced in the bottom half of the figure. The supply curve in the bottom half of the figure shows the quantity of cheese produced for each and every supply price of cheese as represented by the slope of the production possibility curve. Carried over unchanged from figure 2 , the supply curve in figure 5 is upward-sloping, a reflection the curvature of the production possibility curve.

The corresponding *demand curve* for cheese connects the demand price of cheese with the quantity of cheese consumed. At each point on the demand curve on the bottom part of figure 5, the demand price is consistent with equation (2). For each and every quantity of cheese, the demand curve shows the demand price of cheese representing the slope of the indifference curve cutting the production possibility curve at that quantity of cheese, together with the corresponding quantity of bread.

The crossing of the demand and supply curves on the bottom half of figure 5 has a double significance. First, it identifies the *equilibrium* price and quantity of cheese, the price and quantity that emerge as the outcome of the interaction between supply and demand, or, equivalently, between technology and taste. Later on, when we pass from a one-person economy to a many-person economy, the equilibrium price will evolve into the market-clearing price at which everything for sale is bought and all demands are satisfied. Second, the crossing of the supply and demand curves identifies the *optimal* quantity of cheese. It identifies the best possible pair of outputs of bread and cheese, where "best" means that Robinson Crusoe's consumption is on the highest indifference curve attainable with the technology at his disposal.

Admittedly there is not much difference between equilibrium and optimum in Robinson Crusoe's world. Equilibrium is what he chooses. Optimum is what is best for him. Why would he not choose what is best? The difference between equilibrium and optimum becomes important in more complex economies with many people where - as in the story of the fishermen and the pirates - the outcome is not necessarily for the best. There is even some question as to whether a best outcome can ever be identified. A best outcome can be identified easily enough in the Robinson Crusoe example where there is only one person and in the fishermen and pirates example where everybody's consumption is the same. In the fishermen and pirates example, the outcome is unambiguously best when there are no pirates. What is best is less evident when people's tastes differ or when full equality of income in no longer feasible. We will return to that question later on.

Figure 5: Technology and Taste: Supply and Demand



A Smooth Production Possibility Curve

The supply curve in figure 5 is a step function because it was convenient for exposition to postulate a technology with five distinct plots of land. The supply curve can easily be made continuous. One might simply postulate a production possibility curve that is bowed-out as in figure 1 but that is at the same time continuous so that the derived supply curve is smoothly upward-sloping. Alternatively, one can make up a technology from which the production possibility curve is implied. Assume that Robinson Crusoe lives on a rectangular island, one kilometre from north to south and D metres from east to west. Productivity of land is assumed to be uniform on any strip from north to south, so that we need only keep track of differences in productivities from east to west, and we can speak unambiguously about production per metre, rather than per square metre, of land. Let x be the number of metres devoted to cheese and z be the number of metres devoted to bread, where

$$x + z = D \tag{3}$$

For some purposes, it is sufficient to suppose that all land is equally productive for both goods. Suppose the output of cheese is " pounds per metre and that the output of bread is \$ loaves per metre, regardless of how the available land is allocated between the two goods. Outputs of bread and cheese are "x pounds and \$z loaves. The production possibility curve becomes

$$D = x + z = (c/'') + (b/\$)$$

or, equivalently,

$$b^{max} = b + (\$/'')c \tag{4}$$

where b^{max}, defined equal to \$D, is the most bread that could be produced if no cheese were produced at all. Robinson Crusoe's production possibility curve in equation (4) shows all combinations of bread and cheese he might produce. It is downward-sloping but not bowed outward. The supply of cheese, p^S, must be equal to \$/" no matter how much or how little cheese is produced, and the supply curve of cheese is flat at a height p^S above the horizontal axis.

A more interesting assumption about technology is that the west side of the island is best for the production of bread, the east side is best for cheese, but there is no clear boundary between bread land and cheese land. Instead, the productivity of land for cheese increases steadily from east to west while the productivity of land for bread increases steadily from west to east. That pattern may be represented by the functions

$$c = /(x/*) \quad \text{and} \quad b = /(z/() \tag{5}$$

where the x metres on the west side are devoted to cheese, the z metres on the east side are devoted to bread, * are (parameters reflecting the productivity of land for cheese and for bread and, once again, x + z = D. Additional land devoted to cheese yields more cheese in total but less cheese per metre (for the output of cheese per metre is c/x = (/ *x)/x = /(*/x) which diminishes with x). The larger *, the more land is required to produce any given amount of cheese. The larger (, the more land is required to produce any given amount of bread. Robertson Crusoe's only choice is the dividing line between bread and cheese production. From these assumptions, it follows immediately that the production possibility curve becomes a quarter circle if * and (are the same. Otherwise, the production possibility curve is squished, horizontally or vertically depending on the ratio of * and (.

$$D = x + y = *c^2 + (b^2 \tag{6}$$

By an argument analogous to the derivation of the demand function in equation (2), it may be shown that the supply price - the rate of trade off between bread and cheese along the supply curve - is

$$p^s(c, b) = \ ) b/) c \text{ (along the production possibility frontier)} = (*/()(c/b) \tag{7}$$

where b is connected to c in accordance with equation (6)[4].

The essential common feature of the supply curves in figure 5 and in equation (7) is that both curves slope upward as a reflection of the economic principle that goods are produced as cheaply as possible. The first pound of cheese is produced at the lowest possible cost in loaves of bread forgone. The next pound may be slightly more expensive because the least expensive combination of resources devoted to cheese-making has already been used up in producing the first pound. The alternative cost of cheese goes higher and higher as the total production of cheese increases. This is the fundamental principle in both examples. By contrast, the supply curve associated with equation (4) and the portions of the supply curve in figure 5 representing additional allocations of land to cheese within the same plot are both flat.

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[4] Let {c, b} and {c +) c, b -) b} be two points on the production possibility frontier. Necessarily,

$$*c^2 + (b^2 = D \text{ and } *(c +)c)^2 + ((b -)b)^2 = D$$

from which it follows at once that

$$*[2c)c + ()c)^2] + ([-2b)b + ()b)^2] = 0 \text{ or } ()b/)c) = (*/()(c/b)\{[1 -)c/2c]/[1 -)b/2b]\}$$

As the two points {c, b} and {c +) c, b +) b} get closer and closer together, the terms) c and) b get smaller and smaller as ratios of c and b respectively. In the limit, the ratios vanish altogether and the expression in squiggly brackets approaches 1. Hence ( ) b/) c) = (*/()(c/b) which is equation (7).

Income

Robinson Crusoe's problem is to maximize his utility given his options as summarized in a production possibility curve. For reasons that are not especially compelling as long as we concentrate on Robinson Crusoe alone but that become compelling later on when we turn to economies with more than one person, Robinson Crusoe's maximization can be split into two distinct components: his maximization of income given his opportunities for production, and his maximization of utility given his income.

To illustrate the bifurcation of the maximization problem, replace the segmented production possibility curve of figure 3 with a smooth production possibility curve in equation (8) which is a special case of equation (6) where * = 4, (= 1 and D = 2,500.

$$4c^2 + b^2 = 2{,}500 \tag{8}$$

Robinson Crusoe can produce 50 loaves of bread or 25 pounds of cheese but more than half of each if he chooses to produce some of both goods. (The parameter 4 is chosen to generate an equilibrium price of cheese of 2 loaves per pound in an example to follow.) From equations (7) and (8), it follows immediately that the supply price of cheese is

$$p^S = 4c/b = 4c/\surd(2500 - 4c^2) \tag{9}$$

Robinson Crusoe's choice of bread and cheese is illustrated in figure 6 which is just like the top half of figure 5 except that the segmented production possibility curve based on information in table 1 is replaced by the smooth production possibility curve in equation (8). As in figure 5, Robinson Crusoe's best combination of bread and cheese is identified equally well by the tangency of an indifference curve to the production possibility curve, by the equality of the demand price and the supply price and by the crossing of the demand and supply curves for cheese (not shown in figure 6). Equation (2) indicates that the demand price, p^D, is b/c.

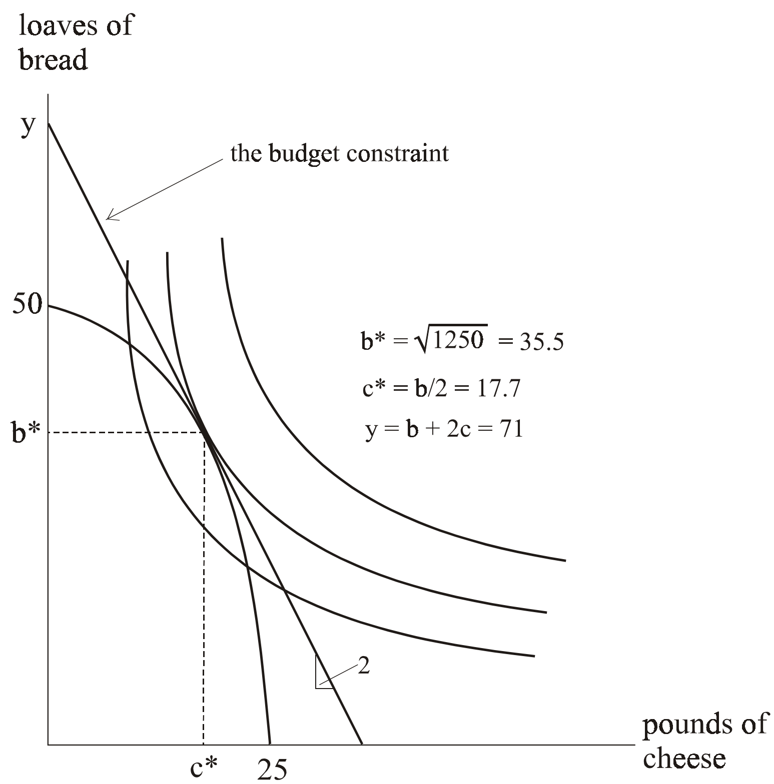
Equation (9) indicates that the supply price, p^S, is 4c/b. For these prices to be equal, their common value must be 2 loaves of bread per pound of cheese, from which it follows that b = 2c when b and c are the chosen quantities of bread and cheese. Substituting this into the production possibility curve in equation (8), it follows that $2b^2 = 2{,}500$, or $b^* = \surd 1{,}250 = 35.5$ and $c^* = b/2 = 17.7$ where b* and c* are Robinson Crusoe's chosen quantities of bread and cheese as shown in figure 6.

The new ingredients in figure 6 are *income* and the *budget constraint*. Since indifference curves are bowed in while the production possibility curve is bowed out, the common tangent of the highest attainable indifference curve and the production possibility curve touches neither curve except at the point of tangency. For reasons that will soon be obvious, the common tangent itself is called the *budget constraint.* The projection of the budget constraint onto the vertical axis is called *income* and is denoted by y. All combinations of b and c along the budget constraint are indicated by the equation

$$b + p^M c = y \tag{10}$$

where p^M is the common value of the demand price and the supply price where the demand and supply curves cross. The letter M is mnemonic for "market" price because that is what p^M is destined to become in the multi-person society to be discussed later on in this chapter. For the present, p^M is just the common slope of the production possibility curve and the indifference curve on the point on the production possibility curve where Robinson Crusoe's utility is as large as possible. In this example, p^M is 2 loaves per person.

Figure 6: Income, the Budget Constraint and the Market Price of Cheese



By construction, Robinson Crusoe's chosen quantities, b* and c*, of bread and cheese conform to equation (10). Here, income is graduated in loaves of bread, but its connection with ordinary money income is straightforward. Suppose you have a money income of \$20 to spend on bread and cheese when the price of cheese is \$4 per pound and the price of bread is \$2 per loaf. That is exactly equivalent to having a stock of 10 loaves of bread, any amount of which may be exchanged for cheese at a rate of 2 loaves per pound. Your income, y, in equation (10) is your stock of bread, your money income divided by the money price per loaf of bread. The relative price of cheese, p^M , is the ratio of the money price of cheese to the money price of bread. In short, income and price in equation (10) are converted from money income and the money price of cheese by dividing both dollar values by the price of bread.

Defined originally as Robinson Crusoe's utility-maximizing quantities of bread and cheese along the production possibility curve, b* and c* can be looked upon as both his best choice of bread and cheese along his budget constraint and his choice of bread and cheese to maximize his income at the going market price. In the latter choice, Robinson Crusoe's income must be thought of as a variable. Imagine a set of lines all parallel to the budget constraint in figure 6. Corresponding to each line is an income, defined as the height of the intersection of the line with the vertical axis. As producer, Robinson Crusoe may be thought of as choosing a point on his production possibility curve to place himself on the highest attainable line or, equivalently, as seeking the largest attainable income.

Part B: The Indeterminacy of Bargaining

Increase the population from one person to two. Robinson Crusoe splits into two people called Mary and Norman. Mary can produce cheese but no bread, while Norman can produce bread but no cheese. Mary owns a plot of land where she produces 50 pounds of cheese. Norman owns a plot of land where he produces 100 loaves of bread. Their tastes, which may but need not be the same, can be represented by indifference curves like those in figure 4. In short, Mary and Norman would like to consume both goods but can produce only one. For both goods, total production equals total consumption.

$$b_N + b_M = 100 \text{ and } c_N + c_M = 50 \tag{11}$$

where b_M and c_M are Mary's consumption of bread and cheese and where b_N and c_N are Norman's consumption of bread and cheese. Any trade involves Mary giving c_N pounds of cheese to Norman in return for b_M loaves of bread, where $b_M = c_N = 0$ if they do not trade at all. The question before us is how the amounts c_N of cheese and b_M of bread might be determined. Somehow a bargain must be struck.

Mary and Norman might agree to share their produce equally, so that

$$c_M = c_N = 25 \quad \text{and} \quad b_M = b_N = 50 \tag{12}$$

If it just so happened that their utility functions corresponded to equation (1) above, an equal split of both goods would supply each party with a utility of 1,250. That seems fair enough, and, in practice, many bargains amount to a splitting of the difference between the participants. This is not the only possibility.

Suppose Norman is nasty or greedy or both. If so, he might demand a split more favourable to himself. For instance, he might insist on a 60-40 split in his favour, so that $c_N = 30$ and $b_N = 60$ while $c_M = 20$ and $b_M = 40$. This may seem unfair to poor Mary, but, if Norman is adamant or if he can somehow lock himself into a situation where he literally cannot accept less than 30 pounds of cheese and 60 loaves of bread - in effect trading 40 loaves of bread for 30 pounds of cheese - then Mary has no choice but to accept the trade, for she is better off with that disadvantageous trade than with no trade at all. If Mary accepts Norman's offer, her utility in accordance with equation (1) would fall from 1,250 to 800. If she refuses, her utility falls to 0 as long as Norman would, really and truly, reject any deal less favourable to himself.

The situation is symmetric. Mary may be the nasty one. She may be the first to bind herself so that she cannot accept any deal that is not weighted in her favour. Then Norman may be left with no option other than to accept Mary's disproportionate offer. Either party gets the better of the deal if he is adamant while the other is not. Traditionally in economics, cool reason prevails. Here, irrationality may be advantageous. If Norman is wild-eyed and secure in his belief that the God Thor entitles him to a disproportional share, while Mary is composed and rational, then Norman may get the better of the deal. Adolph Hitler is reputed to have insisted in negotiation that somebody has to be reasonable, and it is not going to be Hitler! To be sure, the parties may be nice to one another, but self-interest alone is insufficient.

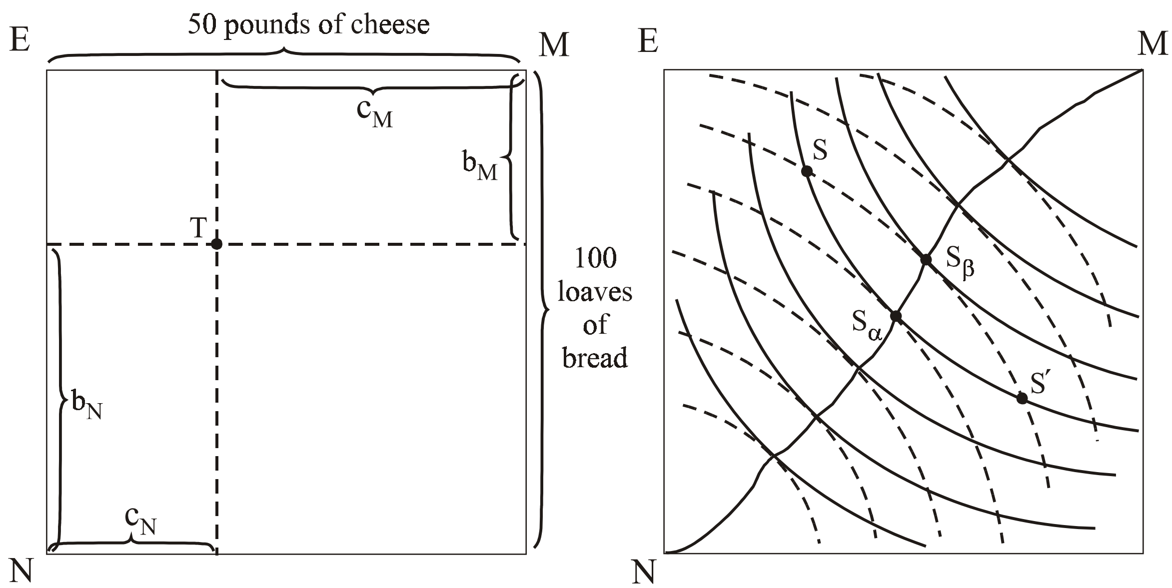
Worse still, this being economics, Mary and Norman are not supposed to be nice to one another. Economics is at bottom the study of greed, of how self-interested people respond to the physical environment and to one another to make themselves as well off as possible. Recall the world of fishermen and pirates where each person chooses his occupation in his own interest exclusively, regardless of the impact of his choice on other people. The moral of the story was that society requires protection from pirates, enabling the fisherman to keep the whole of his catch, and making everybody as well off as the technology of production allows. But Mary and Norman's property is secure. Norman cannot steal from Mary, nor Mary from Norman. The outcome remains not just inefficient, but indeterminate as well. Calculation of self-interest cannot predict what deal Mary and Norman will strike, or even whether they will strike a deal at all.

By analogy with Robinson Crusoe, one might suppose a unique efficient outcome could be identified. One might hope to discover a bargain that does for Mary and Norman together what the crossing of the demand and supply curve does for Robinson Crusoe. That turns out not to be so. Efficient bargains can be identified, but efficiency is no longer unique.

To see why, consider the *box diagram* in figure 7. The box is reproduced twice, side by side, with different information in each reproduction. Look first at the left-hand version of the box. The width of the box is Mary's production of cheese, which we assumed to be 50. The height of the box is Norman's production of bread which we assumed to be 100. The south-west corner of the box, marked N, is Norman's "origin" in the sense that Norman's production of bread, his consumption of bread and his consumption of cheese are to be measured as distances from that origin. The north-east corner of the box is Mary's origin. The north-west corner of the box, marked E, represents endowments, Norman's production of bread as a distance above his origin, and Mary's production of cheese to the left of her origin. Every point within the box, such as T, illustrates a possible sharing of the available bread and cheese between Mary and Norman.

For any such point, Mary's consumption of bread and cheese is measured to the left and down from her origin. Norman's consumption of bread and cheese is measured to the right and up from his origin. It is obvious from inspection of the box that all bread produced and all cheese produced is consumed by one party or the other.

Figure 7: The Indeterminacy of Bargaining



Mary and Norman's tastes are represented within the box by sets of indifference curves like those in figures 3 and 4 above. These are shown in the right-hand version of the box. Measured from his origin at the south-west corner of the box, Norman's indifference curves are shown as solid lines, bowed inward toward the origin. Measured instead from her origin at the north-east corner of the box, Mary's indifference curves are the dashed lines which are appropriately shaped if you turn the page upside down.

The wavy line from Mary's origin, M, to Norman's origin, N, is the *efficiency locus* tracing all points of tangency between pairs of indifference curves, one for Mary and the other for Norman. The meaning of efficiency in this context is that no reallocation of bread and cheese between Mary and Norman can make both of them better off simultaneously. One person can always be made better off at the expense of the other; an unrequited transfer of either bread or cheese will always have that effect. An efficient allocation of bread and cheese is one from which no supplementary trade is mutually advantageous. The efficiency locus would be a straight line from M to N if Mary and Norman's utility functions were in conformity with the utility function in equation (1). Otherwise the efficiency locus would be wavy as in figure 7, opening the possibility that efficient allocations of bread and cheese provide each party with relatively more of one good and relatively less of the other.

To see that points on the efficiency locus really are efficient, consider any point S which is not on the efficiency locus. Since each person's indifference curves cover the entire space in the box and since no two indifference curves are tangent at the point S, there must be a pair of indifference curves, one for Mary and the other for Norman, that cross at S, forming a lens with the point S at one end and another point S′ at the other. It is immediately evident from the figure that S and S′ lie on opposite sides of the efficiency locus, and that any point strictly inside the lens is superior to both S and S′, for both Mary and Norman are better off at that point than they are at either S or S′. Norman is better off because he is on a higher indifference curve. Mary is on a higher indifference curve too, as long as higher is interpreted for Mary as a distance from her origin at the north-east corner of the box. For any point off the efficiency there must be some other point on the efficiency locus at which both Mary and Norman are both better off. Only for points on the efficiency locus is it impossible to find other points that are superior for both parties. A movement north-east along the efficiency locus makes Norman better off at the expense of Mary. A movement south-east makes Mary better off at the expense of Norman.

Among points within the box, any point off the efficiency locus is inferior for both parties to some point on the efficiency locus. Suppose, never mind how, Mary and Norman have traded cheese for bread, bringing them from the point E to the point S which is still off the efficiency locus. If so, Mary and Norman might be expected to continue trading - Norman supplying more bread to Mary and Mary supplying more cheese to Norman - to place themselves at a point on the efficiency locus within the lens formed by S and S′. All such points make both parties better off than they were at S, and any trade to a point within the lense but not on the efficiency locus leaves additional opportunities for new trades that make both parties better off. Recognizing this, Mary and Norman might be expected to trade from S to a point on the efficiency locus between $S_{''}$ and $S_{\$}$, where $S_{''}$ is at once indifferent to S in Norman's assessment and the best point within the lense for Mary, and $S_{\$}$ is at once indifferent to S in Mary's assessment and the best point within the lens for Norman. But which point on the efficiency locus do the parties choose?

Obviously Mary wants $S_{''}$ and Norman wants $S_{\$}$. Somehow, they must agree on an efficient point in between, for failure to agree consigns both parties to their endowments at the point S where they are both worse off than they might become through trade. This is not an artificial problem. It is a paradigm for deals among nations. It is a paradigm for labour relations where management and union sit across the table allocating the earnings of the firm between themselves. It is a paradigm for commercial deals as when people with different assets and skills - such as a cook and a waiter opening a restaurant - establish a new firm and must determine each person's share of the ownership.

We know that people strike deals, and we know from experience that bargaining is frequently time-consuming and costly, but we cannot explain how one particular bargain emerges as the outcome of self-interested behaviour on the part of all parties to the bargaining process. There is no solid explanation of how rational self-interested people choose among the many mutually advantageous bargains that might be struck. To the economist, pie division remains mysterious. By contrast, price will be shown below to clear large markets automatically, confining the realm of bargaining to unique transactions with only a few participants. We return to the bargaining problem later on in the book. For the remainder of this chapter, we concentrate on circumstances where piracy is suppressed, property is secure, and bargaining is circumvented by the price mechanism.

Part C: How Markets Coordinate Production

What can be expected of an economy occupied by many people, each seeking to maximize his own welfare by whatever means he can command? Our analysis so far would seem to suggest that the prospects are bleak. The fishermen and pirates story in chapter 2 was about how self-interested people free to do as they please would allocate themselves between the productive activity and the predatory activity, reducing income per head to well below what could be attained if predatory activity were somehow suppressed. The bargaining story in the preceding section was equally disheartening. Security of property was insufficient to generate an allocation of bread and cheese because there was no mechanism for securing a deal on the trade of bread for cheese. The allocation of people between fishing and piracy was at least determinate. The trade of bread for cheese was not. Even the Robinson Crusoe story was ultimately depressing because the "obvious" lesson was the need for a central authority who, like Robinson Crusoe, would decide how each plot of land is to be employed. Robinson Crusoe is an organizer who decides how each plot of land is to be employed, whether for bread or for cheese. It would stand to reason that organization is no less required in an economy with many people, especially as a decision would also be required on the all-important matter of how the total output is allocated among the occupants of the economy.

Protection of fishermen from pirates, the choice of what to produce and the allocation of the output among consumers would all seem to require a class of guardians and organizers to direct society in detail. But guardians are no less self-interested than anybody else. Once established, a class of guardians might be irresistibly drawn to employ the powers required to contain piracy, produce the right mix of goods and services and allocate the national income for their own ends at the expense of the rest of the population. Either way, the ordinary citizen is impoverished and oppressed.

To direct a modern economy with millions of people and millions of production processes, the organizer would need to assume vast powers over the disposition of resources, communication, the army, the police, and the ordinary citizen. Every person would have to be slotted into the industrial machine, and a wage would have to be assigned to each and every occupation. Each person's employment, remuneration, and livelihood would come to depend on the organizer's goodwill, and his wrath if crossed or criticized could be terrible indeed. The citizen's fear of impoverishment or worse would almost certainly invest the organizer with such complete authority over the rest of society as to place him beyond the control. The organizer might conceivably exercise his authority in the name of equality, but he would certainly be tempted to act in his own interest instead, and there are abundant examples throughout history of organizers who did just that. More will be said about this matter in the discussion of voting and public administration. For the present, take it as a working assumption that an organizer with as extensive control over the economy as Robinson Crusoe exercises over his five plots of land would act despotically. Nobody guards the guardians under those circumstances.

There is, however, another possibility. The central proposition of the science of economics is that, without central direction, something like the result in the Robinson Crusoe example can be attained in a large society as the outcome of self-interested but uncoordinated behaviour. The proposition is that, to some extent and on certain conditions, private property substitutes for central planning, organizing the economy impersonally and without detailed control over the lives of citizens. To be sure, private property requires the support of the state, and a bureaucracy protecting private property has some of the ugly propensities of the central planner. The difference is in the scope of the authority of the bureaucracy. The organizer's reach is vast. The bureaucracy in an economy with private property is very much smaller and less intrusive on the life of the ordinary citizen. There remains some question as to whether this smaller corps of guardians may not be still too large to be restrained by the ordinary citizen, but that is a matter to be considered later on. For the moment, let us go to the other extreme of supposing that property needs no protection. Let it be assumed, as is customary in economic analysis, that property rights are secured costlessly. Our concern here is whether, to what extent, and under what circumstances secure property rights lead to an efficient economy.

Self-sufficiency in a Five-person Economy

Consider first an example where they do not. Imagine a community of five people, each of whom is the owner of one of the five plots of land described in table 1 of this chapter. Plot A is owned by person A, plot B is owned by person B, and so on. Everybody's tastes, as reflected in their indifference curves, are the same. Specifically, as between any two combinations of bread and cheese, the preferred combination is whichever yields the higher utility. Table 4 contrasts Robinson Crusoe's usage of the five plots of land with the usage when each plot is owned by a separate person, when each person's taste is represented by the utility function, $u = bc$, in equation (1), when there is no trade among people, and, consequently, when the mix of bread and cheese on each plot is chosen to maximize the welfare of its owner.

Robinson Crusoe's usage of each plot of land is shown in the top half of the table. As explained in the discussion surrounding tables 2 and 3 above, he becomes as well off as possible with the technology at his disposal when he devotes plots C and D together with a quarter of plot B to the production of cheese, and the remainder of his land to bread. As shown in the top half of figure 4, he acquires 10 pounds of cheese from plot C and 6 pounds of cheese from plot D, but no bread from either plot. He also acquires 16 loaves of bread from plot A and 12 loaves of bread from plot E, but no cheese from either plot. A quarter of plot B is devoted to cheese and the remaining three-quarters is devoted to bread, yielding 6 loaves of bread and 1 pound of cheese. In accordance with equation (2), his demand price of cheese is b/c, equal to 2, where b and c are his total consumption of bread and cheese from the final column of the table.

The bottom half of the table shows the usage of each plot of land for bread and for cheese when each of five people owns one of the five plots and employs his plot to supply himself with the best (utility-maximizing) attainable combination of bread and cheese. It follows from our, admittedly strong, assumptions about technology and taste that, with no trade among people and when every person uses his own plot to produce for himself the most desirable combination of bread and cheese, each of the five people would devote exactly half of his land to bread and half to cheese.

Table 4: The Inefficiency of Self-sufficiency

Robinson Crusoe's Usage of the Five Plots of Land

plots of land	A	B	C	D	E	total
loaves of bread	16	6	0	0	12	34
pounds of cheese	0	1	10	6	0	17

Usage of the Five Plots of Land when Each Plot is Owned by a Different Person, when there is No Trade among the Owners and when each Owner Produces a Mix of Bread and Cheese to Maximize his Individual Utility

plots of land	A	B	C	D	E	total
loaves of bread	8	4	2.5	3	6	23.5
pounds of cheese	2	2	5	3	2	14

Consider person C. His plot of land yields, 10 pounds of cheese, or 5 loaves of bread, or any combination such as 5 pounds of cheese together with 2.5 loaves of bread or 8 pounds of cheese together with 1 loaf of bread. The corresponding production possibility curve is a downward-sloping straight line represented by the equation[5]

$$10 = c + 2b \tag{13}$$

and illustrated by the middle curve in figure 8 below, cutting the vertical axis at 5 and the

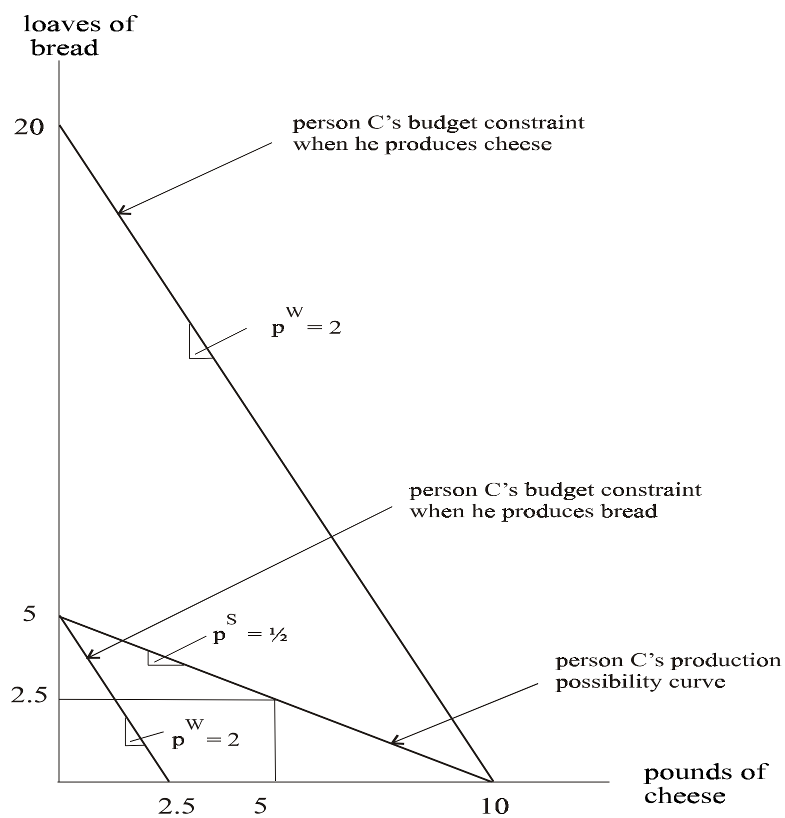
[5]Let s be the share of land devoted to bread, so that (1-s) is the share devoted to cheese. It follows immediately that b = 5s and c = 10(1-s). Substituting for s in the equation for c, we see that

$$c = 10(1-s) = 10(1 - b/5) = 10 - 2b$$

which is equation (13).

horizontal axis at 10.Wishing to consume some of both goods, person C subdivides his land into two parts, one for bread and the other for cheese. Since, by assumption, each square metre of land on plot C is like every other square metre of land in its capacity for cheese production or for bread production, person C's only concern in the division of the plot is with areas devoted to each good. Unlike Robinson Crusoe in his allocation of the five plots, person C does not care which bits of land are devoted to each good as long as the overall division is appropriate. (Ignore for the moment the two budget constraints made possible by trade.)

Figure 8: The Production Possibility Curve and the Budget Constraint of Person C



Like Robinson Crusoe in figure 5, person C chooses a point on his production possibility curve to place himself on the highest possible indifference curve. Think of the space in figure 8 as filled up with person C's indifference curves, exactly as in figure 5 above. An implication of the strong assumption about the form of the utility function in equation (1) is that shares of the land devoted to each good are exactly the same. As illustrated in figure 8 and table 4, person C (and the same is true of the other four people as well) splits his land into two equal parts, one yielding 2.5 loaves of bread and the other yielding 5 pounds of cheese[6]. Other, more realistic assumptions about the form of the utility function will be considered in the next chapter. On these alternative assumptions, the shares devoted to bread and to cheese need no longer be equal, but the story in this chapter about the role of prices in the economy would remain essentially the same.

The lesson in table 4 is that less of both goods are produced when each of the five landowners uses his own land to provide for himself than when Robinson Crusoe organizes production efficiently. Uncoordinated production yields outputs of 23.5 loaves of bread and 14 pounds of cheese as compared with 34 loaves of bread and 17 pounds of cheese when Robinson Crusoe utilizes the five plots of land efficiently to make himself as well off as possible. An organizer could replicate Robinson Crusoe's usage of land to yield more of both goods than when each person produced for his own use on his own land, but he would have to allocate the surplus among the five people in this example. What is true of this simple two-good economy is true a thousand times over of a modern economy with thousands of goods and thousands of industrial processes.

Trade at World Prices

Our examination of the formation of domestic prices begins with a detour into international trade. Think of the five plots of land as situated on five small islands, each close to the mainland where bread and cheese may be traded at fixed prices money of $P^{\$B}$ dollars per loaf and $P^{\$C}$ dollars per pound. These are like ordinary prices in the grocery store. Each of our five people can travel costlessly to the mainland to trade cheese for bread or bread for cheese as he pleases, as long as the value at mainland prices of what he buys is equal to the value of what he sells.

Consider person C once again. He retains the option of dividing his land between bread production and cheese production, but trade provides him with two new options. He can produce only cheese and trade some of his cheese for bread, or he can produce only bread and trade some of his bread for cheese.

Suppose, first, that he produces cheese. His output is 10 pounds of cheese of which he consumes c pounds and sells the rest. He sells (10 - c) pounds of cheese for $(10 - c)P^{\$C}$ dollars, and he uses that money bread to buy $(10 - c)P^{\$C}/P^{\$B}$ loaves of bread. In other words,

$$b = (10 - c)\,(P^{\$C}/\,P^{\$B}) \qquad (14)$$

which may be rewritten as

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[6]As shown in the preceding footnote, b = 5s and c =10(1-s) where s is the share of land devoted to cheese. In accordance with equation (1), u = bc = (5s)(10(1-s)) = 50s(1-s). To show that u is as large as possible when s = ½, set s = ½ +) where) must lie between -1/2 and ½ to ensure that s lies between 0 and 1. The value of s(1-s) becomes (½ +))(½ -)), equal to 1/4 -)^2 which as large as it can ever be when) = 0, implying that s = ½. A person with a uniform plot of land and a utility function represented by equation (1) chooses s = ½, dividing his land equally between the two goods.

$$10\ p^{W} = b + p^{W}c \tag{15}$$

when the ratio ($P^{\$C}/P^{\$B}$) is replaced by p^{W} , the "world" relative price of cheese, the relative price on the mainland, which is what it is independently of the behaviour of person C.

Equation (15) identifies all combinations of b and c attainable by person C if he chooses to produce only cheese and to acquire bread by trading bread for cheese on the mainland. Equation (15) becomes person C's budget constraint attainable by trading cheese for bread. Note particularly that money prices, $P^{\$B}$ and $P^{\$C}$, are in themselves of no interest to person C (or, for that matter, to anybody else). It makes no difference to person C whether he sells cheese at \$2 per pound and buys bread at \$1 per loaf, or if he sells cheese at \$20 per pound and buys bread at \$10 per loaf. All that matters to him is the relative price ($P^{\$C}/ P^{\$B}$), the price of cheese in loaves per pound, which was indicated in equation (15) as p^{W}.

Person C might, instead, produce five loaves of bread, of which he would consume b loaves and sell the remaining (5 - b) loaves for cheese. By the same reasoning that led to the budget constraint in equation (14), it may be shown that person C's new budget constraint would become

$$5 = b + p^{W}c \tag{16}$$

which is represented by the lower budget constraint in figure 8. Both equations, (15) and (16), are special cases of the general budget constraint

$$y = b + p^{W} c \tag{17}$$

where y is income in terms of bread, one's money income divided by the money price of bread. In equation (15), y = 5. In equation (14), y = $10p^{W}$, the output of cheese evaluated at the relative price of bread.

Person C's opportunities - represented by the equation (13) if he chooses not to trade, by equation (15) if he produces only cheese and trades some cheese for bread, and by equation (16) if he produces only bread and trades some bread for cheese - are illustrated by the three downward-sloping budget constraints in figure 8. It is immediately evident from the figure that trade is preferable to no-trade because one of the two trade-created budget constraints must lie entirely above the production possibility curve. Person C may be thought of as selecting the higher of the two trade-created budget constraints. He chooses whichever option yields the larger income at world prices, exporting whichever good is worth more (relative to the other good) abroad than at home. In the absence of trade, person C's supply price of cheese would be 0.5 loaves per pound. At any world price in excess of 0.5 loaves per pound, his better option is to sell cheese and buy bread.

Trade enlarges person C's options, placing him in exactly the same position as if, by magic, the productivity of his land for bread-making increased from 5 loaves to 20 loaves. Person C's trade-created budget constraint is like a new enlarged production possibility curve. Originally, he could produce either 10 pounds of cheese or 5 loaves of bread. Now he can "produce" either 10 pounds of cheese or 20 loaves of bread. In the absence of trade, he would choose to consume 5 pounds of cheese and 2.5 loaves of bread. With the opening of trade, he consumes 5 pounds of cheese and 10 loaves of bread. That his consumption of cheese remains unchanged is an accidental consequence of our assumptions: uniform productivity of land and a symmetry in the utility function in equation (1). That he is made better off by trade is a robust consequence, extending well beyond our special assumptions.

Generalizing somewhat, the story in figure 8 is that trade at world prices makes people unambiguously better off than they would be with no trade at all, as long as world prices differ from domestic prices as they would be in the absence of trade. Established rigourously for person C in his dealings with the mainland, this proposition remains valid in a wide range of circumstances. Person C's sells cheese and buys bread if the world price of cheese is higher than his supply price. Alternatively, he sells bread and buys cheese if the world price of cheese is lower than his supply price. Either way, person C becomes better off than he would be in the absence of trade as long as the world price differs from the domestic price as it would be in the absence of trade and as long as some of both goods is consumed. That trade is better for everybody is a powerful proposition with strong implications for the organization of the world economy.

Located on their islands close to the mainland where bread and cheese are traded at fixed world prices, each of the five people is in essentially the same situation as person C. Each person's options can be represented on a separate diagram with the same general shape as figure 8 but with different numbers corresponding to the productivity of his land for bread and for cheese. Comparing his supply price of cheese with the world price, each person decides whether to sell bread and buy cheese or vice versa. If person C sells cheese and buys bread, he is said to have and *excess supply* of cheese. If he sells bread and buys cheese, he is said to have an excess supply of bread or, equivalently, an *excess demand* for cheese. The same may be said of all five people together. Depending on the world price of cheese in terms of bread, they may have a combined excess supply of cheese or a combined excess demand for cheese. If the world price of cheese is high, they would have a combined excess supply of cheese. If the world price of cheese is low, they would have a combined excess demand for cheese. Since each person's decision to become a net supplier or a net demander of cheese depends on a comparison of the world price of cheese with his supply price in the absence of trade, there must be some world price high enough that the five people together have an excess supply of cheese, there must be some world price low enough that the five people together have an excess demand for cheese, and there must be some world price in between at which there is neither excess demand nor excess supply. This is illustrated first in tables 5 and 6 and then in figure 9. Table 5 shows each person's production, consumption and excess demand at two possible world prices. Table 6 shows the combined excess demand for cheese at each of five prices. The supply and demand curves in figure 9 graphs shows combined response to a range of possible world prices.

Table 5: Production and Consumption in Response to the World Price

price of cheese = 3.5 loaves per pound

person	A	B	C	D	E	total
loaves of bread produced	16	0	0	0	0	16
pounds of cheese produced	0	4	10	6	4	24
loaves of bread consumed	8	7	17.5	10.5	7	50
pounds of cheese consumed	2.3	2	5	3	2	14.3
excess demand or supply (-) of cheese	2.3	-2	-5	-3	-2	-9.7

price of cheese = 2 loaves per pound

person	A	B	C	D	E	total
loaves of bread produced	16	6	0	0	12	34
pounds of cheese produced	0	1	10	6	0	17
loaves of bread consumed	8	4	10	6	6	34
pounds of cheese consumed	4	2	5	3	3	17
excess demand or supply (-) of cheese	4	1	-5	-3	3	0

Table 5 is a comparison of production, consumption and excess demand at two possible world prices, a high price of cheese in terms of bread at which there is an excess supply of cheese from our five people together, and a lower price at which there is neither an excess supply nor an excess demand. The upper half of the table shows how each of the five people responds to a world relative price of cheese of 3.5 loaves per pound. As may be seen in the final column of table 2 above, a world price of 3.5 exceeds the supply prices of cheese of plots C, D, B, and E but not of plot A. Hence, persons B, C, D, and E are induced by that price to produce cheese, and person A is induced to produce bread. As shown in the final column of table 5, combined production of cheese by persons B, C, D, and E is 24 pounds. Computation of the total consumption of cheese is slightly more complicated. Given the world price of cheese in terms of bread, each person's income in terms of bread may be computed in accordance with equation (17). It is a convenient (though not always realistic) characteristic of the postulated utility function in equation (1) that, no matter what the price, expenditures on bread and cheese are the same.[7] Thus, at a world price of 3.5 loaves per pound, person C produces 10 pounds of cheese

[7]Together, equations (2) and (6) - $p^D = b/c$ and $y = b + p^W c$ - imply that $b = p^W c = y/2$ whenever $p^W = p^D$ as is always the case when a person participates in world trade. A table comparable to table 5 could be constructed for any utility function whatsoever, but the computation would usually be less

consuming 5 pounds and selling the rest to acquire 17.5 loaves of bread. Everybody else's consumption of cheese is computed accordingly.

The lower half of table 5 contains the same information when the world price is 2 loaves of bread per pound of cheese rather than 3.5. Three features of this table should be noted. First, though each person has an excess demand or excess supply of cheese, the five people together have neither. At a price of cheese of 2 loaves per pound, the five people combined are neither net suppliers of cheese nor net demanders of cheese from the rest of the world. For all practical purposes, they do not trade with the rest of the world at all. From this it follows that a price of 2 loaves per pound would emerge if the five people constituted a closed market, trading with one another but with nobody else, where each person acted as though the market price were fixed and immutable and as though he could trade as much or as little as he pleased at that price without affecting the price itself. Second, person B alone has the misfortune of acquiring no gain from trade because the world price is the same as his equilibrium price would be if he could not trade at all. With or without trade, he consumes 4 loaves of bread and 2 pounds of cheese. Furthermore, he does not care whether he trades or not. He could acquire his 4 loaves of bread and 2 pounds of cheese by producing them, by producing only bread and trading some of his bread for cheese, or by producing only cheese and trading some of his cheese for bread. However, person B is shown in the lower half of table 2 as producing 6 loaves of bread and 1 pound of cheese because that is required to balance internal trade among the five people in a closed market where external trade is blocked. Third, at the market-clearing price of 2 loaves per pound of cheese, the usage of the five plots of land and the combined production of bread and cheese by the five people together are exactly the same as Robinson Crusoe's utility maximizing usage in table 4. This is partly contingent on the specifics of the postulated utility function in equation (1) which requires that everybody's proportion between bread and cheese be the same for any given relative price of cheese, regardless of how well off or how badly off one happens to be. What is not contingent on the chosen form of the utility function or on the assumption that everybody's utility function is the same is that consumption guided by market prices is efficient in the sense that no planner could reorganize production and consumption to make everybody better off.

For five different prices, production, consumption, and excess demand (or supply) are shown in figure 6. The middle price of 2 loaves per pound is known in advance to be compatible with a balance of trade because it is Robinson Crusoe's equilibrium price when he is the sole owner of the five plots of land. Any higher price must generate an excess supply of cheese, and any lower price must generate an excess demand. The greater the disparity between the actual world price and the market-clearing price for the five people together, the greater the excess demand (or supply) must be. The construction of the table is straightforward. At any world price, the total quantity of cheese produced is the total production of cheese on all plots for which that world price exceeds the supply price in the absence of trade.

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straightforward

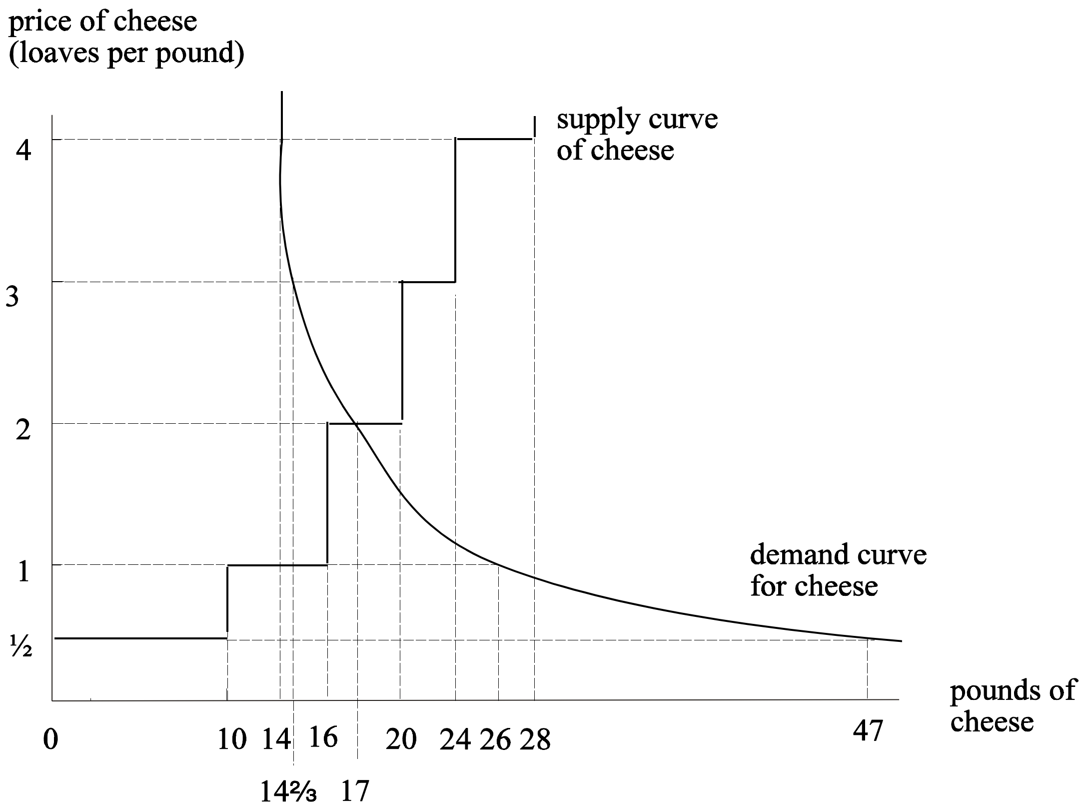
Table 6: Excess Demand and Excess Supply for the Five People Together Depending on the World Price of Cheese

world price of cheese (loaves per pound)	combined production of cheese (pounds)	combined consumption of cheese (pounds)	excess demand (+) or excess supply(-) of cheese (pounds)
3.5	24	14.3	-9.7
2.5	20	15.6	-4.4
2	17	17	0
1.5	16	20	4
0.75	10	33	23

The dependence on the world price of the excess demand or excess supply of cheese for the five people together is illustrated on the demand-and-supply diagram in figure 9. As in figures 2 and 5, the price of cheese is graduated in loaves per pound and shown on the vertical axis, and quantities of cheese are shown on the horizontal axis. However, the price of cheese is now the world price, and the demand and supply curves show the response of quantity to the world price by all five people combined. The supply curve shows how much cheese would be produced at each price. The demand curve shows how much cheese would be consumed at each price. At every price the excess demand or supply is the horizontal distance between the demand and supply curves.

The supply curve in figure 9 is carried over unchanged from figures 2 and 5. It is a reflection of the community's production possibility curve which, by construction, is the same as when Robinson Crusoe occupied all five plots of land. The demand curve is different. Like Robinson Crusoe's demand curve in the bottom half of figure 5, it is downward-sloping and cuts the supply curve at a price of 2 loaves per pound, but it shows the five people consuming considerably more cheese than Robinson Crusoe was able to consume, both when the price of cheese is high and when the price of cheese is low. The reason for these differences is that trade lifts people off their production possibility curves whenever the world price differs from the domestic price as it would be in the absence of trade. At a high price of 4 loaves per pound, the five people consume 14 pounds of cheese where Robinson Crusoe would have consumed only 10 pounds. At a low price of 0.5 loaves per pound, the five people consume 47 pounds of cheese which is considerably more than Robinson Crusoe could provide for himself if he devoted all five plots to cheese.

Figure 9: Demand and Supply Curves Showing the Combined Response of the Five People to the World Price of Cheese



Construction of the demand curve in figure 9 is facilitated by a particularly simple property of the postulated utility function in equation (1). At each world price, think of all five people as accumulating as much cheese as they can, by production or by trade whichever supplies the most cheese, and then trading some of that cheese for bread. The convenient property of the postulated utility function is that, regardless of the world price, half of the accumulated cheese is consumed and the other half is sold for bread. At a price at or above 4 loaves per pound, all five plots of land would be devoted to cheese, total production would be 28 pounds (as shown in table 2), 14 pounds would be sold to finance the purchase of bread, and the remaining 14 pounds would be consumed. At a price of between 3 and 4 loaves per pound, everybody but person A would produce cheese, and person A would acquire cheese by producing bread for sale on the world market. Together, persons B, C, D, and E would produce 24 pounds of cheese, of which they would consume half. Person A would produce 16 loaves of bread, yielding him (depending on the price of cheese) between 4 and 5 1/3 pounds of cheese, of which he would consume half. (Alternatively, person A may be thought of as producing 16 loaves of bread, consuming 8 loaves and selling the rest to finance the purchase of, depending on the world price, between 2 and 2 2/3 pounds of cheese.) As soon as the price of cheese falls below 3 loaves per pound, person E joins person A in producing bread instead of cheese, and so on[8]. A demand curve like that in figure 9 could be constructed when people's utility functions differ and for any form of utility functions whatsoever. The utility function in equation (1) is convenient but not essential.

Figure 9 shows clearly that there is an excess supply of cheese when the world price exceeds 2 loaves per pound, that excess supply increases with the price of cheese over this range, that there is an excess demand for cheese when the world price is less than 2 loaves per pound, and that the excess demand increases as the world price falls. More importantly, from our point of view, figure 9 illustrates that, when excess demand or supply varies continuously with the world price, there must be some equilibrium price - not too high and not too low - for which there is neither an excess demand nor an excess supply of cheese for the five people together and at which the five people need not trade at all except with one another. In this example the equilibrium price is 2 loaves per pound, or, equivalently, any combination of money prices - such as $2 per loaf and $4 per pound, or 25 cents per loaf and 50 cents per pound - for which money price of cheese is twice the money price of bread. The importance of this price is that it would emerge automatically in trade among the five people, as long as each person looks upon the price as market determined and beyond his control, buying or selling cheese at that price to make himself as well off as possible. Person B is something of an exception because his supply price turns out to be the same as the market equilibrium price and because he must apportion his land between bread of cheese. Trading in a world market, he would be indifferent between producing all bread or all cheese or any combination of the two. Trading in the market of five people, he must take cognizance of his effect on the market-clearing price. If he produced all bread, the market price of cheese would rise above his supply price and he would wish he had produced cheese instead. If he produced all cheese, the market price of cheese would fall below his supply price and he would wish he had produced bread instead. Only by dividing his land appropriately between bread and cheese - producing 6 loaves of bread and 1 pound of cheese - can he remain content with his choice.

An important general principle is illustrated in table 7 comparing each person's utility when all trade is blocked and he must consume what he produces on his own land with his utility when he can trade at various world prices. The first row reproduces each person's supply price

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[8]The general formula is

$$c = \tfrac{1}{2}[C + B/p^w]$$

where c is the combined consumption of cheese, C is the combined production of cheese, B is the combined production of bread, p^w is the world price of cheese in terms of bread, and where B and C are amounts produced when each person produces either bread or cheese to maximize the value of his production at world prices.

from table 1. The principle is that each person becomes steadily better as the world price of cheese diverges in either direction from his own supply price reproduced from table 1 in the top row of table 7. For example, person A whose supply price of cheese is higher than any of the possible world prices considered in the table becomes progressively better off the lower the world price happens to be. Among all the prices in the table, he is best off, with a utility of 85.3, when the world price of cheese is 0.75, the lowest world price in the table. By contrast person C whose supply price is lower than any of the world prices considered in the table is best off, with a utility of 87.5, at a world price of 4, the highest world price in the table. Person B, whose supply price is 2, is no better off when the world price is also 2 than he would be in the absence of trade, and he becomes progressively better off when the world price deviates from 2. Note, however, the dependence of the numbers in table 7 on the specification of the utility function. It has been argued above that, for any given set of indifference curves, the specification of the utility function is entirely arbitrary as long as points on the same indifference curve are endowed with the same utility and utility increases on passing from a lower to a higher indifference curve. Thus the numbers in table 7 are no more than indicators of the direction of change in people's well-being. Nor are they comparable from one person to another. A better measure of the gain from trade will be discussed in the next chapter.

Table 7: Utility With and Without Trade

[Utilities measured in accordance with equation (1), u = bc, where b and c are can be computed from numbers in table 2.]

persons	A	B	C	D	E
supply price (loaves per pound)	4	2	0.5	1	3
utility without trade	16	8	12.5	9	12
utility with trade at $p^W = 3.5$	18.3	14	87.5	31.5	14
utility with trade at $p^W = 2.5$	25.6	10	62.5	22.5	14.4
utility with trade at $p^W = 2$	32	8	50	18	18
utility with trade at $p^W = 1.5$	42.7	10.7	37.5	13.5	24
utility with trade at $p^W = .75$	85.3	21.3	18.8	12	48

The Emergence of the Market Price

Up to this point in our story, the relative price of cheese is either implicit in Robinson Crusoe choice of quantities of bread and cheese to make himself as well of as possible with the technology at his disposal, or externally given, allowing our five people in this chapter to trade as little or as much as they please at world prices. How prices get to be what they are in a market with many traders is a question that has not so far been discussed. We take up that question now.

Once again, there are five people, each person own a plots of land, and the five plots differ in productivity. Now, however, the five people constitute an isolated market. They can trade with one another, but there is no trade with outsiders and no world prices at which the five people may buy or sell. Instead a market price emerges from trade among the five people alone. It is immediately evident from the discussion surrounding figure 9 and table 5 that the market would clear - that the quantity of cheese demanded would equal the quantity of cheese supplied and that the quantity of bread demanded would equal the quantity of bread supplied - at a price of 2 loaves per pound as long as each person looks upon the market price as fixed independently of his own behaviour and imagines himself able to buy or sell any amount of bread or cheese at the going market, provided only that the values of his purchases and sales be the same. In a closed society consisting of the five people consuming bread and cheese as described above, the *equilibrium* or *market-clearing* relative price of cheese is whatever world price of cheese would generate no excess demand or supply in the event that trade were permitted. Generalizing from two goods to many goods and from five people to many people, a complete set of equilibrium prices for all goods in the economy is whatever world prices would generate no excess demand or supply for any good. For a five-person two-good economy, the existence of an equilibrium price of cheese is adequately demonstrated in figure 9. The proof of the existence of a set of equilibrium prices for many goods at once is beyond the scope of this book but is treated in advanced courses in microeconomics.

Several questions arise at this point: (1) whether there *exist* market-clearing prices, (2) whether and in what sense trading at market-clearing prices is efficient, (3) whether and in what sense trading at market-clearing prices is socially-desirable, and (4) whether and to what extent actual prices turn out to be the market-clearing. I discuss these questions in turn.

"Existence" as applied to market prices is less ethereal than one unacquainted with economic discourse might suppose. It is a technical term with a very special meaning. Market-clearing prices - which, in our example, boil down to a market-clearing price of cheese in terms of bread - are said to exist when price-taking behaviour by all of the actors in the economy clears all markets at those prices. One may think of market-clearing prices in a country or region closed to world trade as what world prices would have to be if the country or region were open to trade at world prices but did not, in fact, trade with the rest of the world because there was no excess supply and excess demand for any goods at those prices. That is why we examined international trade - trade between the five islands and the mainland where prices are invariant - before considering the formation of prices in a closed economy. Obviously, there exists a market-clearing relative price of cheese in our five person economy, for we have found it. The market-clearing price is identified by the crossing of the excess demand curve with the vertical axis in figure 9. The market-clearing price is 2 loaves per pound because the quantity of cheese demanded by our five people together is just equal to the quantity supplied at that price. If our five people could trade abroad at any other price, they would find it advantageous to do so, but, there is no advantage to trading abroad at a world price of 2 loaves per pound.

That there exist market-clearing prices is a proposition that remains true well beyond our simple example. Our simplifying assumptions about technology and taste are responsible for the transparency of the example and for the easy computation of the market price and of each person's consumption of bread and cheese. But the existence of a market-clearing relative price of cheese does not depend on those simplifying assumptions. It is sufficient for existence of some market-clearing price that the supply curve and the demand curve cross as shown in figure 9. The introduction of more than two goods presents more formidable problems. With just bread and cheese, we know that the clearing of one market implies the clearing of the other. With more than two goods, there would seem to be a possibility that prices which clear the market for cheese might create an excess demand, or supply as the case may be, in the market of beans, that new price clearing the market for beans might create an excess demand for cars, and so on ad infinitum. This is not the place to explain how the infinite regress can be circumvented. Suffice to say that the science of economics struggled with the problem for a hundred years, and that the existence of market-clearing prices in an economy with many people and many goods has been established. Our two-good example can be generalized.

The next question is whether trading at market-clearing prices is efficient in the limited technical sense that more of all goods - or more of some but not less of others - cannot be attained with the available technology of the economy. As demonstrated in table 8, a five-person economy without trade and where each person produces for himself on his own land is not efficient, for total output of both goods was less than Robinson Crusoe would have obtained. Trade at market-clearing prices is efficient in our example because the outcome (34 loaves of bread and 17 pounds of cheese) is at a point on the production possibility curve as described in figure 1. Trade at market-clearing prices remains efficient in more realistic economies, but with one important qualification. In our example, each person produces bread, or cheese as the case may be, to maximize his income. In more realistic economies, income can only be maximized when many diverse resources - workers of all kinds, land, minerals and machines - are organized to produce the goods people want to consume. Prices must be found not just for ordinary goods like bread and cheese but for all resources as well. Market-clearing wages, rents, house prices, and stock prices are all required. Price-taking behaviour must guide the deployment of resources among different industries and in the production and distribution of goods. Prices are signals informing the actors in the economy how best to maximize revenue, ensuring that some point on the production possibility curve is attained.

Whether and in what sense trading at market-clearing prices is socially desirable is a more complex question. In the original Robinson Crusoe example, the crossing of the supply and demand curves signified at once that Robinson was acting as he pleased and that he was making himself as well-off as possible with the technology at his command. Indeed, with only one person in the economy, there was not much point in distinguishing between these conditions. The distinction becomes important in an economy with five people. Acting as one pleases extends naturally to buying and selling at given market prices. Making oneself as well off as possible extends less readily to a community with five distinct people, for a criterion would seem to be required for balancing a gain to one person against a loss to another. There is however a subsidiary criterion that does not require interpersonal comparison of benefits. Extending the notion of efficiency in production, one might define efficiency in use to mean that no rearrangement of production or reallocation of goods to people could make everybody better off, or some people better off without making others worse off.

Turn back to table 5. The outcome with a market-clearing price of 2 is both technically efficient and efficient in use when the five people may trade with one another but not with outsiders, for there is no way to produce more of both goods and no additional trades among the five people could make everybody better off. Consider a trade in which person B supplies cheese to person A in return for bread. The exchange cannot be at a rate of 2 loaves per pound because both parties are already trading as much as it is in their interest to trade at that price. Nor can the exchange be at a different rate between bread and cheese because one party or the other would necessarily be accepting a worse deal than he could get from the market. For example, if the pound of cheese were exchanged for 3 loaves of bread, person A would be giving up more bread than would be required in ordinary trading at market prices. By contrast, disallowing trade with outsiders, the production of 16 loaves of bread and 24 pounds of cheese would be technically efficient but inefficient in use because there is *no* allocation of the 16 loaves of bread and 24 pounds of cheese among the five people for which they are not all worse off than they could be with *some* allocation of another technically feasible combination of bread and cheese, specifically 34 loaves of bread and 17 pounds of cheese. This must the true because the product of 34 and 17 exceeds the product of 16 and 24 and because it is characteristic of the postulated indifference curves in equation (1) that the larger product signifies the higher indifference curve.

Finally, even when market-clearing prices exist, there remains some question as to whether and to what extent such market-clearing prices will emerge from trading in actual markets. Recall the absence of equilibrium in the exchange of bread for cheese between Mary and Norman in section B above. Is five really that different from two? With no equilibrium between two people, why should an equilibrium suddenly emerge from the addition of three more? The real difference between these examples lies not in the number of people, but in how they are assumed to behave. The five people are assumed to be price-takers. The two people are not. In fact, by playing about with figure 7, one can identify a market-clearing price if Mary and Norman are assumed to be price-takers too. And the nice equilibrium in the five-person example disappears if people begin to act strategically. Persons A and E who are the major sellers of bread may form a cartel, refusing to buy cheese at all, except at a price of 1.5 rather than 2 loaves per pound. What differentiated the stories is the absence in one and the presence in the other of universal price-taking behaviour. The size of the market does matter. One person in a two-person economy can exert a considerable influence on the price. One person in a five-person economy is less influential. One person in an economy with millions of people has virtually no influence upon prices, and becomes for all practical purposes a thoroughgoing price-taker. The price of cheese at the grocery store really is determined by forces beyond my control. However, collusion among buyers or sellers remains a possibility. Monopoly will be discussed in the next chapter.

Money and Money Prices

Robinson Crusoe had no use for money. He had no use for little pieces of paper with portraits of George Washington or the Queen of England, and he had no use for gold because he consumed only bread and cheese and not jewelry. Nor, strictly speaking, is there any use for gold or paper money in the community described in this chapter where everyone produces bread or cheese, as the case may be, simultaneously, and then trades some of his produce for some of the other good. Think of the data in the top part of table 5 as describing production and consumption per week, and suppose there is a market every Sunday where the five people in this economy exchange their excess of the good they produce for some of the other good at whatever price - the relative price of cheese - emerges to clear the market. All trading is direct. If I produce only bread, you produce only cheese and we both want to consume both goods, we simply agree to trade some of my bread for some of your cheese. We may haggle over the price, but we have no need for currency to facilitate the transaction.

In practice, there are two principal uses for money, both of which are absent in the simple world we have constructed so far. The first and most important use of money is as a "medium of exchange." With only two goods, they can be exchanged for one another directly, and no medium is required. With many goods, a medium is required to circumvent the "double coincidence of barter" that people who supply what one wants do not necessarily want what one supplies. I supply lectures in economics. I consume, among other things, hamburgers. The person who supplies hamburgers may not want my lectures in economics. The person who wants my lectures does not supply hamburgers. As a medium of exchange, money conjures up a fictitious person who buys what I want to sell and sells what I want to buy, provided only that the values at going market prices of my sales and my purchases are the same. I sell lectures to the university, which resells them to students, who are, let us say, are financed by their parents, who are farmers selling of wheat to brewers, who sell whiskey to accountants, who, with the possible addition of a a great many more steps, provide services to restaurants that provide hamburgers to many people, including me. This complex network of purchases is of no direct concern to me. Money is a vehicle that allows me to collect my pay cheque and to spend my income as I please as long as the value of what I purchase is no greater than the value of what I supply. I must be concerned about the markets for my lectures and for the goods I wish to buy, but not about the intermediate steps that connect the two. I supply lectures in return for gold or for little pieces of paper with pictures of George Washington or the Queen. I am content to do so because I know that other people require money for the same reason I do and will be prepared to accept my money in exchange for what I want to consume.

The other use of money is as a "store of value". A simple extension of the example in the lower portion of table 5 will show how this works. Imagine a community of 260 people, 52 like person A, 52 like person B and so on. Each person's consumption per week is exactly as shown in the table. Each person's *average* weekly production is also as shown in the table, but one's entire annual production is concentrated on a single day, though different people's production is staggered over the weeks of the year. Of the 52 people of type A, one brings his crop to market on the first Sunday of the year, another on the second Sunday, another on the third, and so on, and the same is true of the other four types, B, C, D, and E. Thus, 51 out of every 52 people bring nothing to market on any particular Sunday, but want to consume just the same. We might even suppose that bread and cheese cannot be stored for more than a week. Chaos can only be averted and the outcome described in the lower portion of table 5 can only be reproduced in these circumstances if there is a way for the sellers of bread and cheese on any given Sunday to acquire credits from the rest of the population, credits to be spent on bread and cheese over the rest of the year. With such credits and as long as everybody is a price-taker, the amounts for sale each Sunday are just as described in table 5, the market-clearing relative price of cheese is the same as well.

The community consists of 52 groups, each with five people: one person of type A , one person of type B , one person of type C, and so on. Each group brings its produce to market on a different Sunday, so that the entire year of Sundays is provided for. At a market-clearing relative price of cheese of 2 loaves per pound, each group's weekly expenditure must be 68 loaves-worth (enough to purchase 34 loaves of bread and 17 pounds of cheese as shown in table 5). To finance that level of expenditure throughout the year, the group must provide the rest of the community with 3,536 loaves-worth (68 x 52) on the one day of the year when it comes to market, and, in return the rest of the community must provide that group with credits that are run down gradually over the year until the group's next market day arrives. The group's average credit during the year is 1,768 loaves-worth, which is half the value of the annual production. Since market days are staggered, the credit at any given time of all 52 groups together is 91, 936 loaves-worth (1,768 x 52). Society requires 91,936 loaves-worth of credit if people are to live throughout year on their earnings from their one annual sale of bread or cheese. In short, the economy needs money.

Think of a gold standard. Suppose this society has a stock of 9,193.6 ounces of gold. There is nothing special about this number; any other would serve just as well. The gold circulates. Each person acquires his annual supply of gold on the day he sells his crop, and he gradually spends the gold over the course of the year until he has none left on the day the next year's crop is brought to market. Since society requires a steady supply of 91,936 loaves-worth of accumulated credit and since, by assumption, it has 9,193.6 ounces of gold, the money price of bread must be exactly 1/10 ounces of gold per loaf. Since the market-clearing relative price of cheese is 2, the money price of cheese must be 1/5 ounces of gold per pound. In this example, the money supply must be half the annual income, and the *velocity of money* is 2. On average, a bit of gold changes hands twice a year.

Society requires a stock of money as a store of value and as a medium of exchange. In the store-of-value example above the stock was exactly half the value of the goods and services traded each year. When other considerations are introduced, it may no longer be possible to infer from the technology of the economy the proportion between the stock of money and the value of the national income. Finance is intricate and complicated. However, one may say as a more or less accurate first approximation that there is some fixed proportion between the two. Define the "national income", Y, as the value at money prices of the bread and cheese produced over the course of the year.

$$Y = P^{\$B}B + P^{\$C}C \tag{18}$$

where $P^{\$B}$ is the money price of bread, $P^{\$C}$ is the money price of cheese, B is the *total* output of bread in the economy as a whole, and C is the *total* output of cheese. The assumption we are making, called "the quantity theory of money" is that there is some constant k such that

$$M = kY = k\,(P^{\$B}B + P^{\$C}C) \tag{19}$$

where M is the stock of money in ounces of gold or in dollars and Y is the value of the annual produce. The theory is that, with quantities of goods and relative prices determined by the interaction of technology and taste as described earlier in this chapter, all money prices are then determined once the quantity of money is established. Once we know B and C and the relative price of cheese ($p = P^{\$C}/P^{\$B}$), the money prices, $P^{\$B}$ and $P^{\$C}$, are dependent on the money supply, M. In our example where p = 2, B = 91,936, C = 47,468, M = 9,193.6 ounces of gold and k = ½, the money prices of bread and cheese, $P^{\$B}$ and $P^{\$B}$, must be 1/10 ounces of gold per loaf and 1/5 ounces of gold per pound.

It is not our purpose to investigate money in depth. All we really need from the quantity theory of money to is complete our picture of the economy with an explanation, however crude, of how money prices are determined. Yet, it would be a shame to overlook a few simple and interesting propositions that flow directly from the theory.

(1) When taste and technology remain unchanged, an increase in the available stock of money leads to an equal proportional increase in *all* prices.

The essence of the quantity theory of money is that money prices are directly proportional to the stock of money in the economy. If the stock of money doubles, then all money prices must double too, though the real side of the economy remains unchanged. This follows immediately from equation (19) as long as k is invariant. A doubling of the money supply from 9,193.6 ounces to 18,387.2 ounces of gold has no effect on the required value of the stock of money in units of bread or on the relative price of cheese in terms of bread, but the price of bread must rise from 1/10 ounces to 1/5 ounces per loaf and the price of cheese must rise from 1/5 ounces per pound to 2/5 ounces per pound. Nobody's consumption of bread or cheese is affected as long as the new gold is distributed among people in proportion to their original holdings of gold. Thus,

(2) Though money is useful to society as a store of value and as a medium of exchange, the value of money to society is independent of the quantity of money available.

A gold standard may be autonomous in the sense that it works without the intervention of the government. The establishment of a gold standard may be spontaneous. No collective decision at a given time and place is required for people to accept gold as money. Of course, efficiency in the economy can only be maintained if the government protects people's entitlements to gold, but gold is no different in this respect from any other property. Thus,

(3) A gold standard does not require the intervention of the government in the money market.

A gold standard has some undesirable properties. Suppose one of the 260 people in this economy discovers a gold mine containing with 919.36 ounces, equivalent to 10% of the original supply of gold in the entire market. The extra gold is worth 9,193.6 loaves of bread to the discoverer, but *nothing* to society as a whole because the discovery drives up all prices by about 10% reducing by 10% the value in terms of bread of the original stock of gold before the extra ounce was discovered. The discoverer gains gold worth 9,193.6 loaves of bread. The rest of society loses the equivalent of 9,193.6 loaves of bread from the diminution of the value in terms of bread of the gold it holds. The effect on society as a whole is a wash. It may nevertheless be advantageous for some people to devote their resources to the discovery of new gold. If a person can use his land for prospecting rather than to produce bread or cheese and if the value of the gold he discovers is greater than the value of the bread or cheese he might produce instead, it is advantageous for that person to become a prospector. The prospector becomes better off, but the rest of the population becomes worse off because the total output of bread and cheese must fall by whatever the prospector would have produced had he not become a prospector.

An increase in the money supply leads to an increase in the prices of bread and cheese making all holders of money worse off because their stocks of money are worth less bread and cheese than they were before. Though his activity may be quite legal, the prospector is at bottom a pirate, taking bread and cheese from the rest of the population. The conquistadores who stole the gold of the Incas in the sixteenth century were doubly pirates: once in stealing the gold from its original owners, and then again in exchanging their "worthless" gold for ordinary goods and services produced in Europe. Thus,

(4) The discovery of extra money is beneficial to the discoverer but not to society as a whole, and resources employed to increase the money supply are wasted.

Look once again at equation (19) connecting the stock of money, the velocity of money (k), money prices and outputs of goods, and suppose gold is the only money. Under a gold standard, one would expect prices to bounce up or down randomly as new gold fields are discovered (increasing M), or as outputs of goods (B an C) increase due to increases in population or the productivity of labour. Prices, $P^{\$B}$ and $P^{\$C}$ bounce up or down to equate the demand for and the supply of money. The discovery of new sources of gold or economic growth unaccompanied by new sources of gold give rise to long periods of inflation or deflation. Thus,

(5) An economy with a gold standard risks inflation or deflation as new gold is discovered or as more goods and services are produced.

Both defects of a pure gold standard - the waste of real resources in the production of gold and the variability of prices - can be circumvented by paper money. The government prints pieces of paper saying, "This is legal tender." In themselves the pieces of paper are worthless, but they serve as a medium of exchange and a store of value because people hold them for the same reasons they would hold gold under a gold standard. The government must maintain a monopoly of paper money because these specially marked pieces of paper are worth more as money than as paper. A government that chooses to do so can administer the money supply to hold prices constant, raising or lowering the money supply, M, in the equation (19) above to keep an average of prices, $P^{\$B}$ and $P^{\$C}$, unchanged over time. To say that a government *can* hold prices constant is not to say that actual governments are always prepared to do so. Revenue-hungry governments may print money as a substitute for taxation. The resulting inflation is a tax on the holders of money. Thus,

(6) Paper money has the potential advantages over gold as a medium of exchange that no resources are wasted in producing money and that the government can regulate the money supply to hold average prices constant.

Finally, the discrepancy between the cost of paper and the value of paper as money, creates an incentive to produce money substitutes from ordinary durable assets. Bear in mind that money is not the only store of value. Among the other stores of value are real property, goods in process, stocks and bonds. Money differs from other stores of value that it is quickly and cheaply traded for goods. Thus there emerges an incentive in the market to convert other stores of value into money. That is what banks do. Traditionally, banks create money out of goods in process. Stocks of goods in process are not money to begin with because the person from whom I want to buy a hamburger will not accept, for instance, title to a millionth part of the goods on the shelf at Sears as payment for his hamburger. He does not know what the goods are worth, he is not confident that I am really in possession of a millionth part of the goods on the shelf at Sears and he doubts whether he can use the piece of Sears paper I offer to buy what he wants. Banks facilitate that transaction. They borrow from a million people like me and they lend to a thousand firms like Sears, converting my "ultimate" ownership of a share of Sears goods in process into money that the seller of hamburgers can accept. Thus,

(7) Banks convert non-monetary assets into money.

The Distribution of Property and Income

A key assumption with distinct implications for economies with private property was introduced quietly at the beginning of this chapter and has been maintained throughout. The assumption is that each plot of land is owned by a different person. Person A owns plot A, person B owns plot

B, and so on. There are really two sides to the assumption, one innocuous and the other not. The innocuous side is that people own different kinds of resources. Some people own land that is best for bread, while others own land that is best for cheese, though the best usage of resources is not entirely independent of prices. This aspect of the assumption can be seen as representative of the division of labour in society. People are generalists in consumption but specialists in production. Most people consume some of most goods, but one man is a carpenter, another a doctor, another collects the garbage, another works on the assembly line, another grows wheat, another is prime minister, another gives piano lessons, another writes about economics. The market assimilates all their efforts to produce commodities for everybody to consume. Self-sufficiency would be as productive as the market if everybody owned equal shares of every plot of land, but no conceivable method of economic organization could assign all types of resources and skills to all people or could abandon completely the efficiencies in the specialization of production. The loss of potential output would be too great.

The other side of the assignment of land to people is that it was entirely arbitrary. There was no explanation, within the context of the model, of why, for instance, person A was assigned all of plot A rather than, say, half of it, or of why the assumed endowments of the five people were such that their incomes are not the same. Each person's income is the value at market-clearing prices of the returns to his resources. Suppose the market-clearing prices of bread and cheese are \$3 per loaf and \$6 per pound, which is consistent with the equilibrium in figure 9. With these prices, it is immediately evident from the lower portion of table 5 that the money incomes of the five people are \$48 for person A, \$24 for person B, \$ 60 for person C, \$36 for person D and \$36 for person E. People's incomes differ because their endowments differ. The present distribution of property and income is the outcome of a long history in which violence and fraud as well as talent, effort, enterprise, and saving have all played a part. The arbitrary assignment of property to people in the example is not innocuous because inequality of endowments and incomes is an important consideration in the evaluation of alternative forms of industrial organization and because the lessening of inequality and reduction in the disparity of incomes and the elimination of dire poverty are major goals of social policy. We return to this matter in chapter 9.

Part D: The Virtues of the Competitive Economy

We began this chapter with an analogy between Robinson Crusoe and a central planner. Robinson Crusoe organizes the resources at his command to make himself as well off as possible. A community of people with different resources would seem to require an organizer or principle of organization to direct each person's efforts toward a common good, for self-sufficiency is at best inefficient, as illustrated in table 4, and at worst chaotic, as in the fishermen and pirates example. This chapter is about whether and to what extent private property and the impersonal price mechanism can do the job.

This much must be recognized at the outset: Private property cannot supplant government entirely because private property cannot protect itself. The postulated security of ownership in our five-person example is never automatic as we supposed. Private property requires the support of the law courts, the police the prisons and the army. The point at issue here is how much of the world's work can be undertaken by the market and whether the powers of government, which are inevitably extensive, can be pared down to the point where personal freedom and private enterprise are not squelched altogether.

The example in part C of this chapter is a comparison between two patterns of ownership of the five plots of land. In one pattern, all five plots are owned by Robinson Crusoe. In the other, each plot is owned by a different person with no coordination of production among the five owners except through the intermediary of prices. When everybody's tastes are the same and when indifference curves can be represented by equation (1), the outputs of bread and cheese are exactly the same under both patterns of ownership. When people's tastes differ, the output of goods and the assignment of goods to people depend in part on the distribution among people of the ownership of land. But, regardless of people's tastes, the outcome of the market is efficient in the sense that nothing is wasted; no reallocation of land among goods and no reallocation of goods among people can make everybody better off simultaneously. Whatever the distribution of property, the outcome appears as though it might have been arranged by an ideal economic planner, though that planner would have to be more knowledgeable and more benevolent than any actual planner in this imperfect world is ever likely to be. Specifically, five distinct virtues of the competitive market may be identified.

The first and fundamental virtue of the price mechanism is that it creates "order without orders" or "organization without an organizer", where all participants in the market behave as though they had deliberately coordinated their activities. Some people produce only bread. Others produce only cheese. The price mechanism creates an "equilibrium" where total supplies of bread and cheese are precisely what people wish to consume. No bread remains unconsumed for want of buyers. No cheese remains unconsumed for want of buyers. Markets clear in response to prices alone, and prices adjust accordingly. Not very surprising when there are only two goods, this feature of a competitive economy is quite remarkable in a world with thousands of goods and millions of traders who are unacquainted with one another and whose actions are coordinated by prices as though in conformity with one centrally woven design. There is, ideally, no hesitation or uncertainty about what to produce, and no looking over one's shoulder to see what others are doing before acting oneself. Most readers of this book will remember a children's game called one-finger-two-fingers where the winner is whoever guesses the other's actions correctly. Markets are not like that. Prices inform participants in the market with all they need to know in deciding what to produce and what to buy.

This beautiful property of the competitive model fits the world of work imperfectly. The fit is very close for the stock market and for large commodity markets. It is close enough for groceries, hardware and most consumer goods. It is less close for dealings among businessmen where bargaining is inevitable. It is less close in labour markets, for there could be no unemployment of labour if the model fit the world exactly. Nevertheless, the revelation on first acquaintance with economic ideas is not that markets sometimes fail to work as smoothly as the competitive model would suggest, but that markets work at all and that relations among people free to do as they please are anything other than chaotic. The unemployment of labour and the business cycle are not covered in this book. The student will encounter these topics in courses in macroeconomics.

A second virtue is efficiency. In our example, the price mechanism draws forth the most valuable bundle of goods and services from the resources and the technology at hand and it allocates that bundle of goods and services among people to make everyone as well off as possible in the limited, but nonetheless important, sense that no side-trades, no reallocation of resources to goods or of goods to people could make anybody better off without harming somebody else. This virtue of markets with private property extends, albeit imperfectly, from our five-person example to more realistic economies, though, as will be discussed in chapters to come, there are some quite significant exceptions to this rule. Prices substitute for commands. Prices generate incentives that would, in the absence of markets, have to be supplied by a central planner, whose control of the economy may not, in practice, be up to the task. Suppose that a certain effort is required on the part of the worker to obtain the maximal produce from the land, that each person knows the productivity of the land on which he works, that such information is unavailable to anybody else, and that the planner, in the name of equality, chooses to treat all five people alike. On these assumptions, the planner cannot know whether a particular cheese producer occupies land like plot C yielding 10 pounds of cheese or land like plot D yielding only 6 pounds. Consequently, there is nothing to stop an occupant of land like plot C from slacking off and producing only 6 pounds, for he has nothing personally to gain in return for the extra effort in producing the extra 4 pounds. The divorce of remuneration from effort destroys the incentive to work diligently. The incentive to innovate would also be suppressed, especially, as is often the case in bureaucracy, if failure is punished and success not significantly rewarded. The planner might pay the worker according to his product, but that would be a large step away from equality of income, and would, in any case, be difficult in real economies where production requires the cooperation of many workers with many different skills.

A third virtue is a special case of the second. Markets economize on knowledge. Hold to the assumptions in our example about the apportionment of land among people, but suppose that the owner of each plot of land is the only person who knows its productivity for bread or for cheese. For example, person A knows that plot A yields either 16 loaves of bread or 4 pounds of cheese, but that information is not available to another landowner or to the government that protects property rights. If agriculture were centrally planned, then some of the plots would be misallocated because the planner's best guess as to whether a particular plot should be used for bread or for cheese would sometimes be mistaken. But with agriculture in the private sector, the owner of each plot of land would be driven by prices to use his land to the best advantage, for he, personally, captures the full benefit of the produce. What matters in the example is whether a landowner can identify the most productive use of his land. It does not matter at all whether anybody else has that information. Person A must know a great deal about plot A, person B about plot B, and so on. A planner, on the other hand, has to know everything. Generalizing from the example to real economies with innumerable technologies and special situations requiring detailed information about local conditions, the argument becomes that profit maximization by owners of private property induces each person to make the best use of his own information about particular local situations in the economy and that the price mechanism automatically redirects each person's search for personal gain to the service of the common good, defined in the admittedly limited sense that the outcome for the economy is efficient in production and allocation. By contrast, a planner cannot solve the "thousands of equations" that are solved implicitly when market-clearing prices guide the allocation of resources to the production of goods. These sweeping statements will have to be modified somewhat to take account of aspects of the economy that we have overlooked so far, but there remains in them a good deal of truth.

"Who knows", Milton Friedman is fond of asking, " how to make a pencil?" The answer, oddly enough, is nobody. To be sure a pencil manufacturer knows how to place the graphite inside the wood, how to paint the pencil and how to attach the eraser with a bit of shiny metal. The pencil manufacturer does not know - considering just the wood - how to chop down a tree, how to convert trees into logs or how to dry the wood. The woodsman who knows these things does not know how to convert metal and wood into a saw. The maker of saws does not know how to smelt the ore into metal. The smelter does not know how to mine for ore. The miner does not know how to design and produce machinery. The designer of machinery does not know how to keep the books, or, for that matter, to convert wood and graphite into a pencil. The making of a pencil requires intermediate products, which in turn require other intermediate products, which in turn require still other intermediate products, back and back through technology after technology until the entire technology of the world is somehow engaged. Of that, nobody knows more than a small part.

Prices supply people at each stage of production with exactly the information they require about market conditions and the technology of the economy. The pencil-maker does not need to know how to chop down a tree. All he needs to know about forestry is contained within the price of wood. He knows he can purchase wood of the required quality at such-and-such a price, and no additional knowledge of forestry is needed for the task he is called upon to perform. Prices also signal scarcities that producers may know nothing about. House-builders in Peru may know nothing about the housing market in China, but they may nevertheless cut back on their usage of wood in response to a spate of house building in China because an increase in demand for wood in China raises the price of wood worldwide. The same is true of our bread and cheese model. Producers of bread need know nothing about the technology of cheese-making. It is sufficient for them to respond to price signals in their usage of land.

A fourth virtue of markets with private property is to circumvent bargaining. As discussed above and as will be elaborated in later chapters, bargaining is not always circumvented and almost never completely. No market-clearing price can be identified in many unique person-to-person transactions. There is nevertheless a large domain of activities governed by prices, and the surplus over which people bargain is often small enough that bargains can be struck, not costlessly, but with little enough expenditure of time and money to keep the economy running. By contrast, a centrally planned economy would have to rely entirely on bargaining or command. The organizer is either a despot or a representative of the population at large. There is no need for bargaining if he is a despot because what he says goes. Bargaining may re-emerge among the members of a ruling class. Bargaining becomes unavoidable when the organizer is representative of the population at large and a balance must be struck among competing interests in society. The organizer must decide how practitioners of each and every trade are to be remunerated. He must specify the ranks in the different hierarchies of production, assign people to ranks, and decide how the occupants of every rank are to be rewarded. The organization of the economy becomes one vast multi-person bargaining problem that would have to be solved politically if at all. Little wonder that full-blown socialist economies where the entire means of production are owned collectively through the intermediary of the state are invariably dictatorial in practice.

The fifth virtue of the market is its compatibility with and support for democratic government. There are two aspects of this virtue, one psychological and the other political. The psychological aspect is somewhat problematic. It is often alleged that the experience of participation in the market endows citizens with the independence of mind, respect for others and mistrust of authority that is required for participation in a democratic society. All hierarchy breeds arrogance and subservience. A market economy cannot dispense with hierarchy altogether, but a society without markets must be organized as one vast hierarchy from top to bottom. Firms must be organized hierarchically, but their authority over their workers is tempered by the option of a dissatisfied worker to seek employment elsewhere or to go into business for himself. Competition among firms places bounds on the discretion of management. Stock markets punish arbitrary behaviour. The political aspect focusses not upon the character of the citizen, but upon institutions themselves. As in virtually all economics, people are postulated to be greedy and selfish. The alleged political virtue of markets is that government by majority-rule voting can only maintained in a society of such people when getting and spending is taken out of the political arena, so that voting for leaders need not at the same time be voting about who is to be rich and who is to be poor. The psychological aspect of this virtue seems plausible in the light of the descriptions of predatory government in chapter 2 and of markets in this chapter, but nothing more will be said about it in this book. The political aspect will be discussed in some detail in the chapters on voting, administration, and law.

The competitive economy has vices too. An important, though partially correctable, vice is a tendency to generate a wider distribution of income than many people would prefer, an inequality of income that an ideal organizer could easily correct. An organizer could collect all the bread and cheese produced in the optimal assignment of plots of land to goods and then divide up the total produce equally among the five people. As shown in table 4, each person would be supplied with 6.8 loaves (34/5) of bread and 3.4 pounds (17/5) of cheese. Reliance on an organizer becomes very much more problematic when people differ in skill and tastes, when inequality of remuneration is required as a goad to productivity and in view of the risk that the organizer’s power over the economies will be misused in the interest of a ruling class. A degree of redistribution of income in an economy with private property may be the better bet.

Finally, a problem of method should be recognized before we turn to other matters. In comparing markets with central organization of the economy, it is important to avoid the error of weighing the ideal in one case against the actual of the other. It is important not to weigh, for example, the advantages of markets in our simplified model of the economy against central organization with all its defects in actual economies; and, of course, the opposite error is equally dangerous. We would like to weigh actual markets against actual organization. That may not be feasible because the mind has no direct pipeline to reality and one can only reason about the economy through the intermediary of models that correspond imperfectly to the economy itself. The best we can do is to try to identify as much as possible of the full political and economic consequences of any instance of public intervention in the economy and to judge how the common good might best be served.