Ch 4   The Optimality of Competition
4.1   The Invisible Hand Theorem
Adam Smith's famous "Invisible Hand" Theorem states that if everyone in the economy specializes in what they do best and trades and competes with everyone else, then a maximum amount of output will be produced. It is impossible to rearrange production so as to produce more of everything under these circumstances. This is based on the idea that if people are allowed to pursue their own interest, no one will be able to rearrange matters and increase productivity. This view opposed the 18th century view that Kings and Queens ruled by divine inspiration and would rule wisely. If this theorem is literally true, there would be little need for government intervention in the economy beyond protecting property rights and certainly no need for Kings and Queens.

4.2   A Pure Exchange Economy
We wish to use the knowledge we have developed so far about consumer behavior, about how firms make their decisions, and about how a single market functions, in order to construct a **model of the entire economy.** In a real economy thousands, if not millions, of consumers and firms interact and we wish to model this interaction. Our two main assumptions are that individual consumers and firms behave optimally in their own best interest and no one has any market power, i.e., everyone behaves competitively, for simplicity. The reader should recall that the theory cannot be judged on the basis of its assumptions but only on the basis of its predictions.

The resulting theory we develop can be used in several ways. First, it can be used to make predictions about how the economy will respond to various stimuli. For example, what happens if we open up the economy to trade? Who will gain and who will lose? What will happen when the price of oil goes up? What will happen if another hurricane like Katrina occurs? Second, we can use the model to understand how markets function. We can observe the effects of higher oil prices on the US economy and learn something from it so we can make better predictions in the future. Third, we can match our model of a perfectly functioning competitive economy against a real world economy and see where the two match up and where they do not. If the real economy doesn't match up with our model of a perfect economy, this can provide us with useful information in designing a policy to help support the private market system.

First, we will begin by studying the simplest model of an economy, the **pure exchange model**. Imagine that production has already taken place and that we are interested in how goods will get allocated by trading on markets. Suppose agents are endowed with different amounts of the goods that are available and make trades with one another. There is a market for each good and in equilibrium, supply equals demand in each market.

Consider the following. Suppose there are two goods, x and y, and two people, A and B. The total amount of x available is 22 units and the total amount of y available is 7 units. Suppose A is endowed with 20 units of x and 2 units of y and B is endowed with 2 units of x and 5 units of y. Consider the diagram below depicting the endowments, point E in each picture, and an indifference curve for each person. Assume A and B are both willing to accept tradeoffs between x and y and more is preferred to less by both consumers.

Notice that if each person moves in the direction of the arrow in their respective diagram, they can be made better off because they can reach a higher indifference curve. By moving in the direction of the arrow, person A can give up some of her endowment of x in exchange for more y and be better off. Similarly, person B can be made better off by giving up some of his endowment of y in exchange for more x because he also reaches a higher indifference curve in doing so. This means that these two agents have an incentive to trade with one another. By trading they can both be made better off.

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Person A   Person B
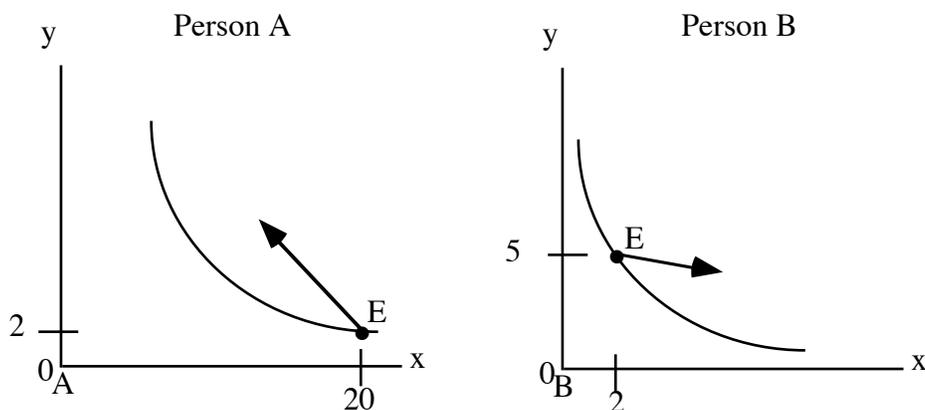
This is the sense in which trading can make people better off. And when people compete with others, the best products are produced at the lowest price. This is the heart of the Invisible Hand Theorem. However, as we will see, sometimes markets can fail to function properly. In some cases, the market might not even exist. In that case, there is a role for government to play.

We will develop a model of competitive markets in which all markets in the economy are in equilibrium simultaneously. This is known as a **general equilibrium**. When we study one market and its equilibrium, that is known as **partial equilibrium analysis**, which has been the focus of our attention until now. To keep things simple, we will assume there are only two output markets in our general equilibrium model. However, everything we will discuss can be worked out using algebra that is perfectly general, e.g., we could assume there are n markets where n is a large number. First, we will develop a pure exchange model of trading. Then we will extend the model to allow for production.

To develop our first model, the **model of pure exchange**, and see the gain to trading more clearly, we need to construct what is known as the **Edgeworth Box**. This is a device that allows us to depict two agents trading with one another.

Imagine a simple economy that contains two goods, x and y, and is composed of a large number of two types of people, type A and type B. A type people are well endowed with good x but not so well endowed with good y. B type people are well endowed with y but not with x. We will assume that both types have utility for both goods. What sort of trading will occur? A types will probably not see much benefit in trading with other A types because they have the same endowments. Similarly for the B types; they won't want to trade with other B types for the same reason. So A types will seek out B types and vice versa in order to make trades that increase the utility of both types when a trade occurs.

Consider one person of type A and one person of type B as in the figure above. Imagine swiveling B's diagram around 180⁰'s as depicted in the diagram below in Step A. B's origin will be diagonally opposite A's origin after B's diagram is swiveled. Next, notice how the two pieces relate to one another as in Step B. A's diagram is the usual one while B's appears "upside down" and reversed. How do we construct the final Edgeworth Box? Bring the two pieces together so that they touch as in Step C. The width of the Box is given by the total amount of x available and the height of the Box is given by the total amount of y available. The two origins, one for A and one for B, are diagonally opposite one another. (Note: the scale of the horizontal and vertical axes may differ. For example, one may be in pounds and another might be in bushels.)

STEP A

STEP B
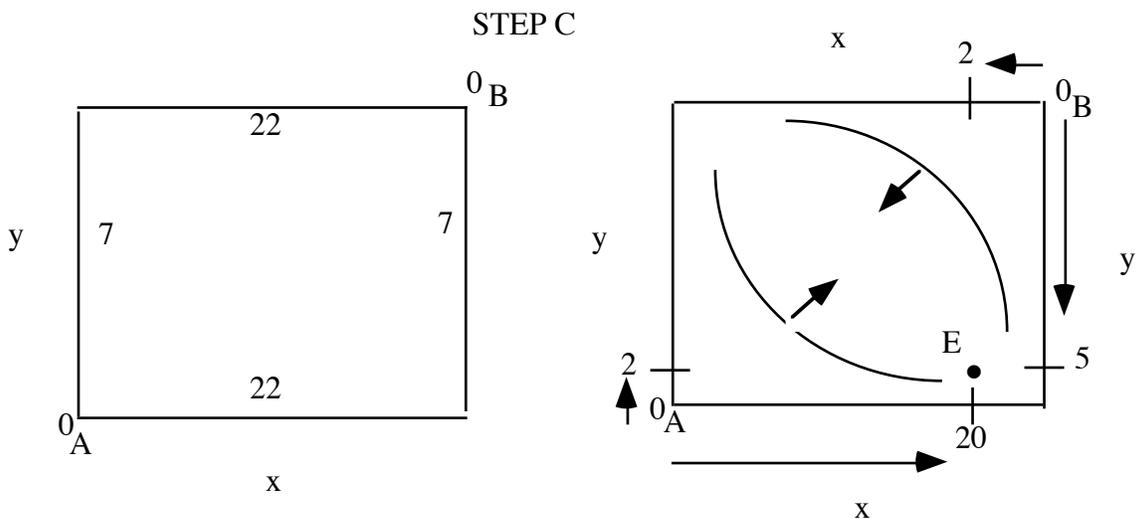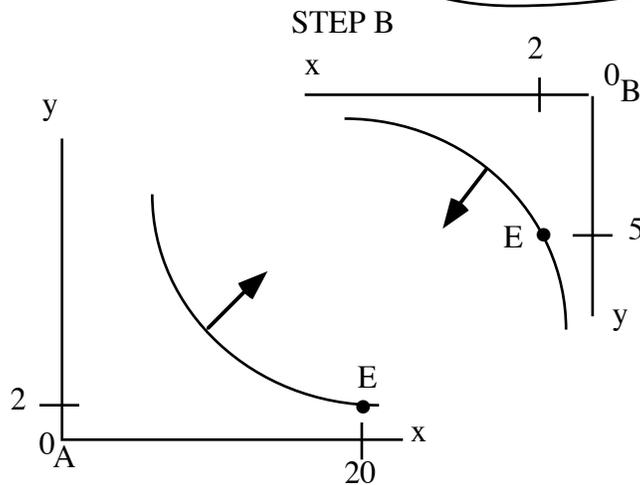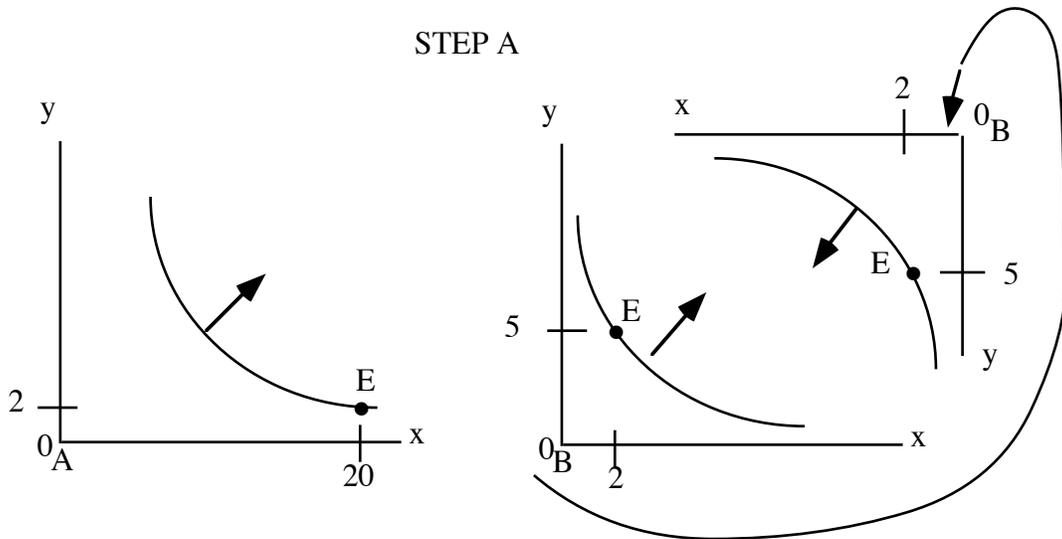
STEP C

In the diagram on the right above in Step C, the endowment point for this economy is depicted, point E, and two indifference curves, one for each agent, are depicted. Utility is increasing in the direction of the arrow for each agent. B's indifference curves are upside down and reversed relative to A. Utility for an individual agent increases as we move away from the

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agent's origin. So as we move in a northeast direction we move through A's indifference map to higher indifference curves. Similarly for B; as we move in a southwest direction we move through his indifference map to higher indifference curves. Notice that A's part of the diagram is always the easiest to figure out - just measure from A's origin just as we did when we studied consumer behavior in chapter four. To understand what B's part of the diagram is telling us remember that we measure from B's origin. So B's endowment includes 5 units of y and 2 units of x, at the endowment point, E, measured from his origin. Also notice that at the endowment point A has most of good x to begin with while B has most of good y, yet, both have utility for both goods.

      We argued earlier that trading makes agents better off. What happens if the two agents trade with one another? Suppose we start at point E in the diagram and A trades 5 units of x for 3 units of y. B is trading 3 units of y to receive 5 more units of x. This essentially moves us from point E to point A in the diagram below. In fact, any trade moves us away from point E to another point inside the Box. If A gives up some x for more y and B gives up some y for more x, then a trade between A and B will move us in a northwest direction from the endowment point.
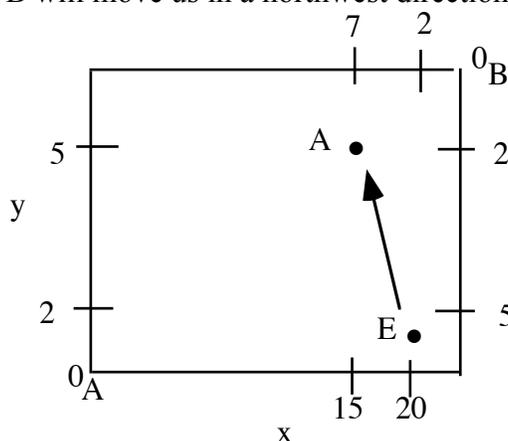

      More formally, we assume that A and B both have tastes or preferences for the two goods and their may differ from one another. We can represent their tastes by a utility function and an indifference map just as we did in the theory of the consumer according to $U^A(x^A, y^A)$ and $U^B(x^B, y^B)$, where $U^A(x^A, y^A)$ is A's utility, $U^B(x^B, y^B)$ is B's utility, x^A is A's consumption of x, y^A is A's consumption of y, and similarly for x^B and y^B. To simplify, in the **pure exchange model** we simply assume there is a total amount of the two goods available, as represented by the endowments, and that each agent has some of both goods, for simplicity.

      To use the Edgeworth Box to depict the gain to trading consider the following. Suppose we start at the endowment point E. A has a lot of x but only very little y, B has a lot of y but only a small amount of x. If A gives up some of her x for more y, and B gives up some of his y for more x, we move in the direction of the arrow from point E to A. A's indifference curve is depicted as usual. B's indifference curve is the dashed curve. As we move from E to A both agents move to a higher indifference curve and are, therefore, better off after the trade.

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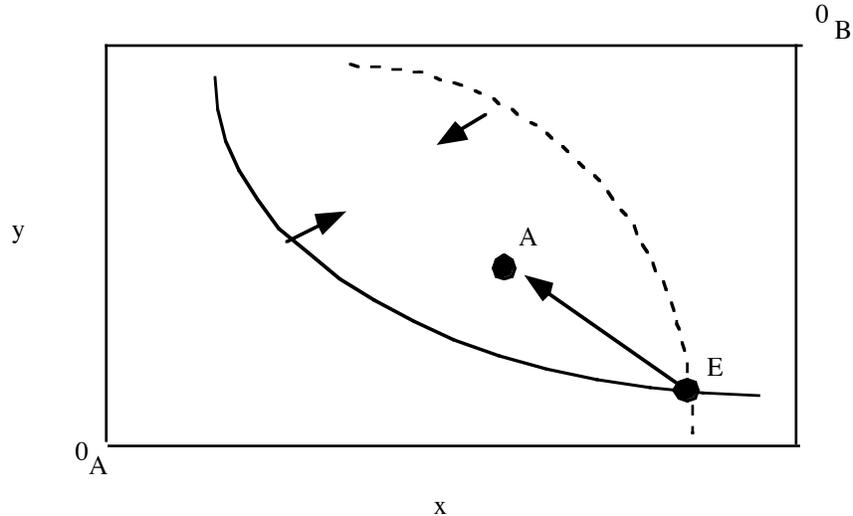
The two agents will continue trading until they are in equilibrium as at point A* below. In equilibrium the supply of each good must equal the demand for it. If not, then we don't have a general equilibrium; both markets for x and y must clear. Notice that the line connecting E and A* can be interpreted as a price line with slope - p_x/p_y. Both A and B are better off at A* than they were at E so competitive trading has made them both better off.
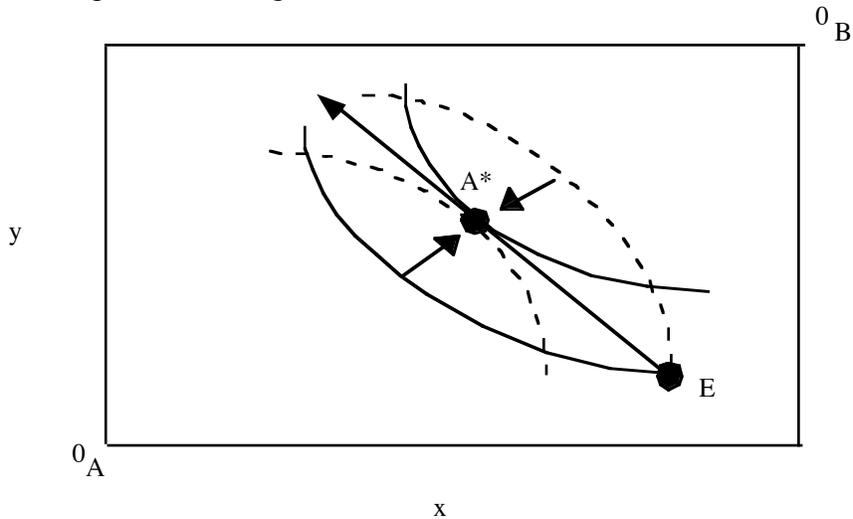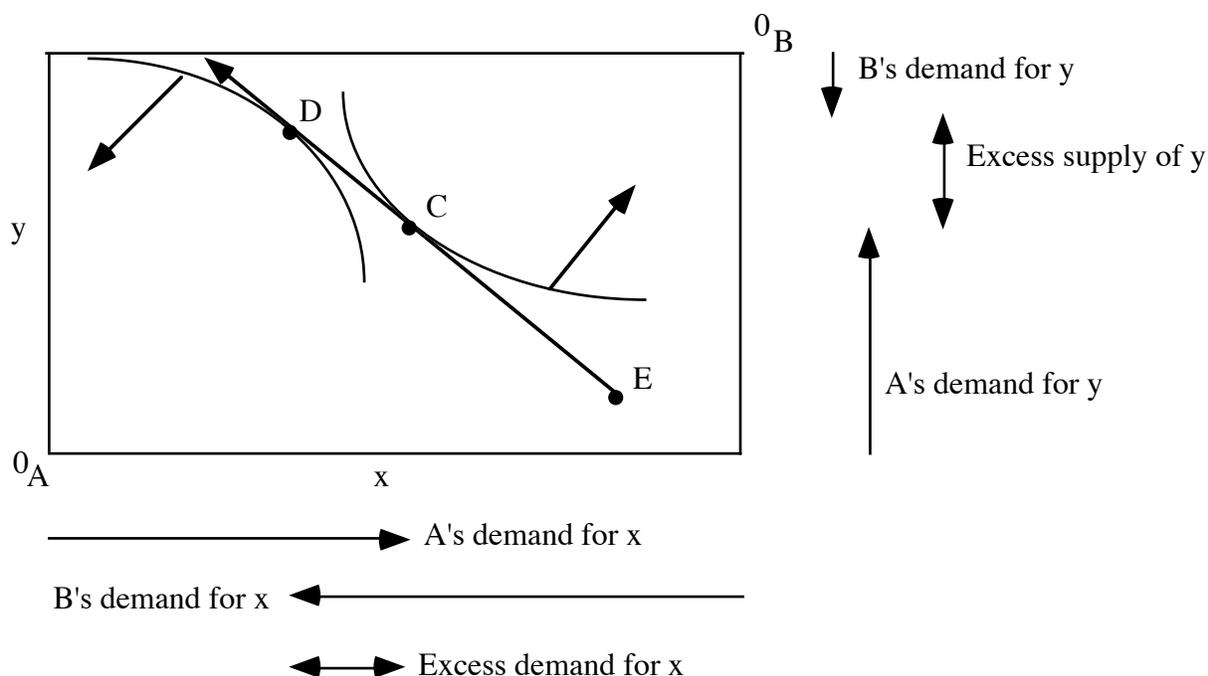

Since x = total supply of good x, y = total supply of good y, $x^A + x^B$ = total demand for x, and $y^A + y^B$ = total demand for y, at A* we have a general equilibrium in both markets simultaneously,

$$x = x^A + x^B, \text{ i.e., supply of x equals demand,}$$
$$y = y^A + y^B, \text{ i.e., supply of y equals demand.}$$

For A* to be an equilibrium, A's indifference curve has to be tangent to the price line at A* and B's indifference curve has to be tangent to the price line at A*. Suppose that's not the case as in the diagram below. A is tangent at point C and B is tangent at point D. Apparently, at C and D agents A and B both

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The diagram shows an Edgeworth box with origin 0_A at the bottom-left and 0_B at the top-right, with axes labeled y (vertical) and x (horizontal). Points D, C, and E are marked inside, with a price line through them. To the right and below are arrows indicating: B's demand for y, Excess supply of y, A's demand for y, A's demand for x, B's demand for x, and Excess demand for x.

demand a lot of x so there is greater demand for x than supply of x, $x^A + x^B > x$. On the other hand, both demand only a small amount of y and so the total demand for y is less than the total supply, $y^A + y^B < y$. So given the price line, there is an excess demand for x and an excess supply of y. We would expect relative prices to change under such circumstances; the price of x should rise and the price of y should fall.

Application: How do agents trade in a simple economy? Imagine a world where there are a lot of people of types A and B walking around looking for someone to trade with. An A type person has to locate a B type person and once they find one another, they can trade; A gives up some x for y and B gives up some y for x. However, if an A person finds another A person, they can't really benefit from trading because they have the same endowment and so no trade will take place. This form of exchange is known as **barter exchange**. Unfortunately, it can be difficult to find someone to trade with so the **transactions costs** of trading in a barter economy are very high.

In modern economies people use fiat or unbacked money to trade. So both A and B can exchange their endowments for money and then use the money to buy whatever they want. This is the sense in which **money facilitates trade**. If everyone is willing to accept money, it is much easier to trade. A doesn't have to find B in order to trade; she can sell her endowment to an A person, or anyone for that matter, and then use the money to buy more y if she wants.

Sometimes the monetary system can break down. In that case, trading will also break down. For example, in a hyperinflation (high inflation rate where the prices double every day, for example) money becomes worthless. People then resort to barter instead. We suffered through three rounds of bank failures in 1930 - 1932 before FDIC insured deposits at banks. Some have argued that this exacerbated the Depression making it worse than it otherwise would have been.

4.3   A Production Economy
We can extend this analysis by including production of both goods. The production possibilities frontier (PPF) tells us the total amount of production. We imagine an economy where individuals are endowed with labor, capital, and other inputs that they sell to receive income.

They use the income to buy outputs they can consume that are produced by firms. Firms buy inputs and use them to produce outputs, x and y. Profit maximization leads to GDP line that is tangent to the
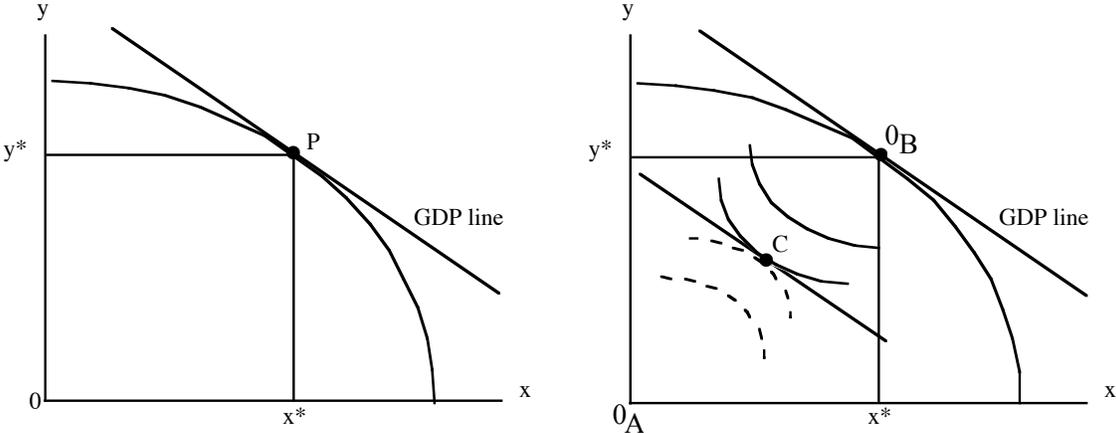

PPF at point P, as depicted on the left, where "P" stands for production. This tells us how much x and y have been produced, x* and y*. This also gives us an Edgeworth Box **inside** the PPF for distributing the goods between consumers A and B, as depicted on the right, where "C" stands for consumption. A's "origin" for the Edgeworth Box is at the origin of the PPF diagram. B's origin is at the production point P. We imagine that A and B sell their endowment of inputs, labor and capital, to the firms to earn income that can be exchanged for outputs they wish to consume so they eventually attain the consumption point C in this trading. The PPF tell us how much of each good has been produced. The Edgeworth Box informs us about how the two goods are distributed across the two consumers for the purpose of consumption. At point C, the two goods are almost evenly distributed. However, in the diagram below, A is able to buy most of both goods using her income at point C'. We would describe A in that situation as "rich" and B as "poor." (To model this we would assume A is endowed with most of the capital and "skilled" labor while B has little capital and is endowed with "unskilled" labor. A receives most of the income and is able to buy most of both goods relative to B as a result. Hence, A is rich while B is poor.)
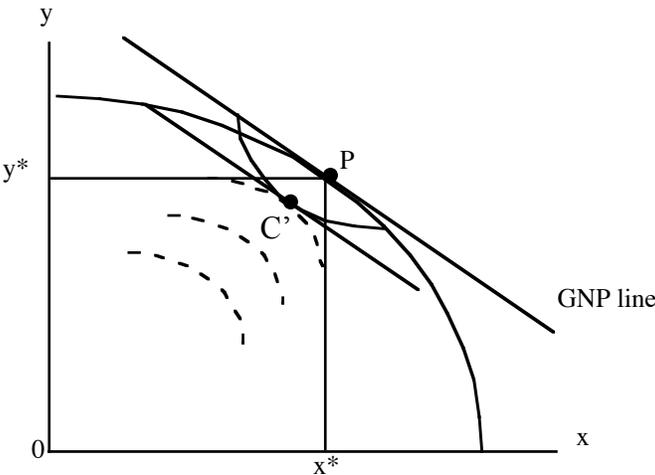
The Edgeworth Box is a simple way of depicting a competitive economy. Assume that consumers own the resources, e.g., labor, capital, raw materials, and they sell or rent their resources to firms in exchange for income. Firms use the inputs to produce output they can sell on output markets. Consumers demand the output and use their income to buy it. All agents, consumers and firms, are assumed to be competitive in the sense that each person takes prices as

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given. If markets don't clear, then relative prices adjust. Prices rise for goods in great demand and fall for goods that are in excess supply.

Consider the example in the following diagram. In the left hand part, relative prices signal producers to produce at point P, and x* and y* are produced. However, consumer A consumes
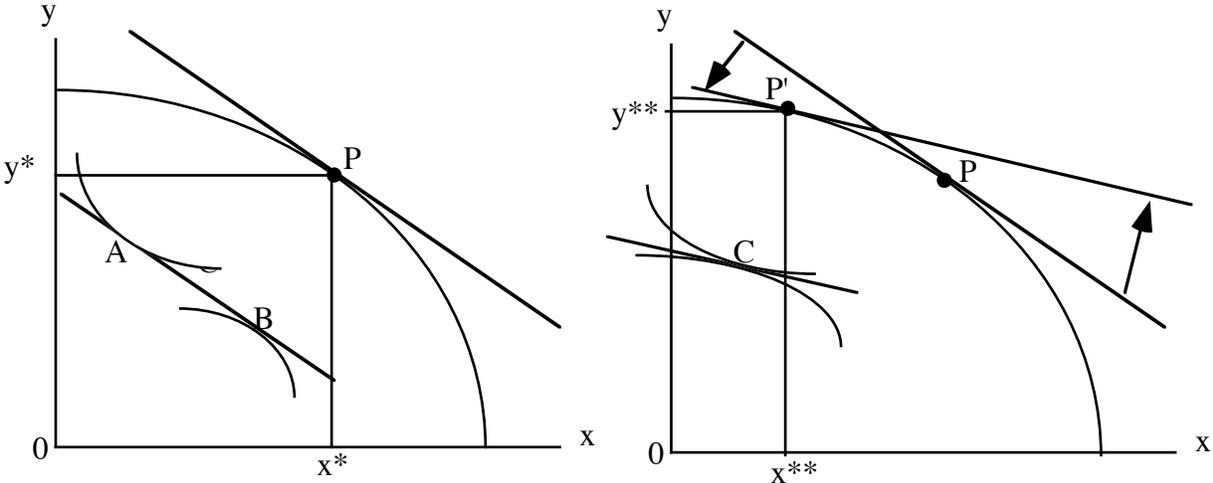
at point A while B consumes at point B. Supply does not equal demand in either market. In fact, $x^A + x^B$ = total demand for x < x* = total supply of x, and $y^A + y^B$ = total demand for y > y* = total supply of y. How will the economy respond? The price of x should fall, the price of y should rise, and the relative price of x to y should fall. This will signal producers to produce more y and less x. So resources will shift from the production of x to y. The GDP line will become less steep and will swivel from P to P'. This yields a new Edgeworth Box and it appears that A's indifference curve is tangent to the price line at the same point as B's indifference curve so the economy is in a general equilibrium at point C.

(To put numbers on this example to make the analysis more clear, suppose at the production point P in the diagram on the left above x* = 20 and y* = 30. At point A person A would like to consume 5 units of x and 25 units of y. At point B person B would like to consume 5 units of x and 20 units of y. (Remember: A's origin for the Edgeworth Box is always the origin of the PPF diagram while B's origin is always the production point P.) The total demand for x is only 10, which is less than the total supply of the good that has been produced, 20 units. The total demand for y is 45, which is greater than the total supply that has been produced, 30 units. So production at P and consumption at A and B cannot be an equilibrium. There is too much demand for y and too little demand for x at the given relative prices in the x and y markets. So consumers bid up the price of y and firms wishing to sell x lower their price to make sales. So the relative price ratio p_x/p_y falls and the GDP line becomes flatter.)

The starting point of much economic analysis is the model of a competitive economy. This is not because we really believe the entire economy is competitive but that it is a good starting point to begin an analysis. We can use the model to help inform us as to when there might be a problem with a real economy and to make predictions.

4.4   Pareto Optimality

An allocation is a listing of the goods each person receives. For example, if x = 22, y = 7, x^A = 7, y^A = 6, x^B = 15, y^B = 1, then the allocation is (7, 6, 15, 1), which is point D below.

Consider an Edgeworth Box as depicted below. Each point is an allocation because it states exactly how much of each good each person gets. Suppose we start at point A. Is there a

way of making both agents better off? Yes, we can move to C*. In the move from A to C* both people reach a higher indifference
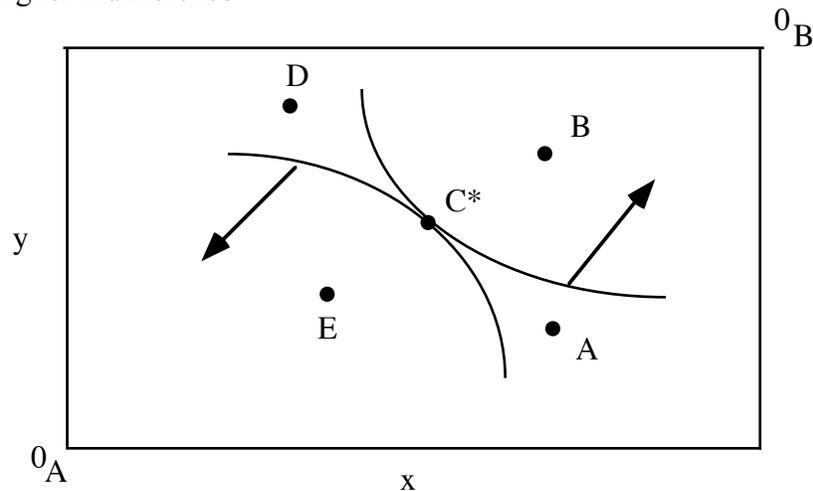

curves so they are both better off. The same is true at D. So C* is said to be "Pareto Superior" to A and D because both people are better off at C* than they are at A or D. (Pareto was the guy who invented this notion of optimality.) However, suppose we are at C*. Can we move away and make everyone better off? No. If we move to B, person A is better off but person B is worse off. Just the opposite is true if we move from C* to E. We say that B and E are "Pareto non-comparable" to C*. A point like C* is sometimes said to be Pareto optimal because it is impossible to move away from C* and make someone better off without making someone else worse off.

As it turns out there are an infinite number of points or allocations that exhibit the same properties as point C* where the indifference curves of the two agents are tangent. It is called the **contract curve**. All of the points like C* and C** on the contract curve depicted below are points of a common tangency between two indifference curves. This means that a Pareto optimal allocation like C*, where it is impossible to make someone better off without making someone worse off, is characterized by the MRS being the same across consumers, i.e.,

$(U_x/U_y)^A$ = MRS of y for x for person A = $(U_x/U_y)^B$ = MRS of y for x for person B

at a point like C* or C**.

As it turns out, the competitive equilibrium, where consumers and firms behave optimally and markets clear so that supply equals demand, is Pareto optimal. In the figure below, the two consumers start out at the endowment point E and trade under competition until they reach A*. No one has any market power. Once at A* it is impossible to make one person better off without making the other person worse off. So allocation A* is Pareto optimal.

How does this generalize to a real economy. Imagine that production occurs at the beginning of the day every day and ask : what happens just after production has taken place? Trades have to be made. A types who have produced a lot of x must find y types who have produced a lot of y. Once an A type person finds a B type, a trade can take place. In reality,

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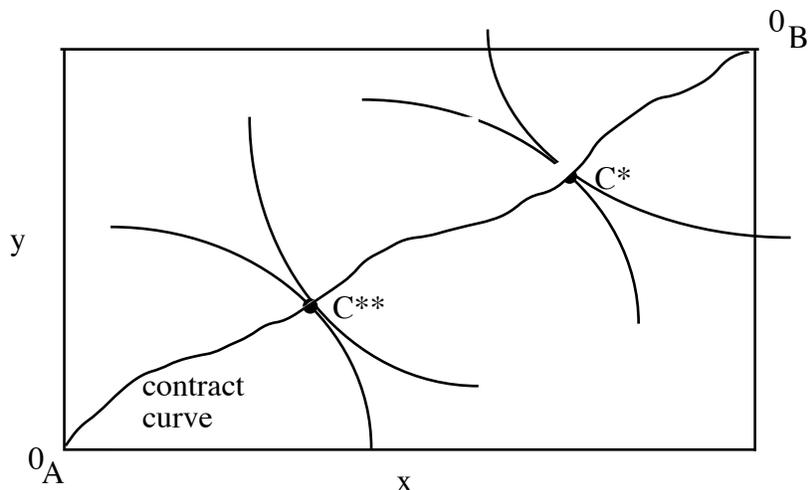
people own resources that they sell in exchange for money. They then use the money to buy the things they want. Two transactions are actually taking place : labor for money and money for a television set, and food, and clothing, and so on. Yet, the same principles still apply. As we saw in Chapter 3, a person can choose how much to work and how much time to take in leisure optimally by maximizing utility subject to a budget constraint and a time constraint.

The outcome involves a tangency point between a price line (budget line) and an indifference curve, just as in the diagram above. And, similarly for the person on the other side of the transaction.

The key is that people, consumers and firms, act in their own best interest and try to maximize their own payoff to the transaction. In equilibrium everyone is satisfied with the transactions they have made and no one can do any better for himself or herself. It is impossible for anyone to come along and rearrange these transactions and make someone better off without making someone else worse off. And so the transactions that we observe are said to be Pareto Optimal.
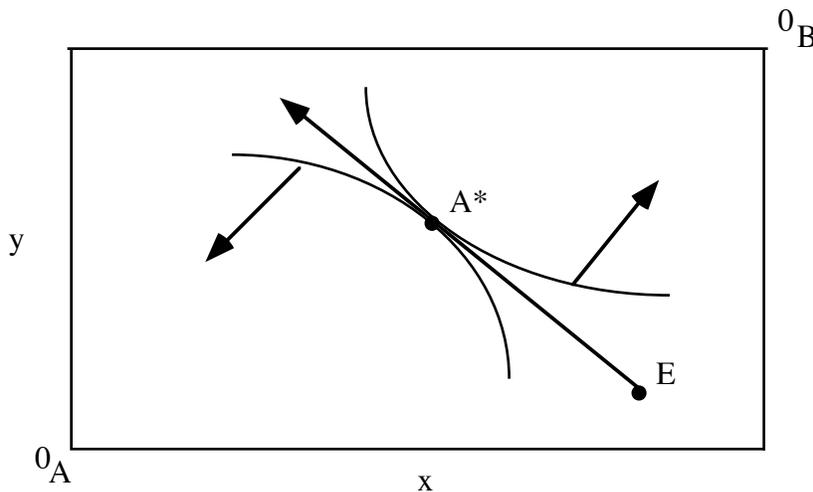
Under competition, consumers maximize utility subject to their budget constraints. From our work in consumer theory at the beginning of the semester we know that $U_x/U_y = MRS$(of y for x) $= p_x/p_y = MRT$. Since this is true for consumer A and for consumer B,

$$(U_x/U_y)^A = p_x/p_y \text{ and } (U_x/U_y)^B = p_x/p_y.$$

It follows that,

$$(U_x/U_y)^A = (U_x/U_y)^B.$$

Each consumer's indifference curve is tangent to his own budget line but since each faces the same relative prices, the slope of their budget lines is the same. Therefore, the slopes of their indifference curves must also be the same. It follows that A* above is on the contract curve! This means it is impossible to rearrange consumption between A and B under competition and make both people better off. So the behavior of consumers under competition matches up with an optimal allocation.

We could extend this to production and competitive firms. As long as firms charge a price equal to the marginal cost of production, the decisions of the firms will be optimal. It will be impossible to rearrange resources across sectors of the economy so as to produce more of everything. Thus, $p_x = MC_x$ and $p_y = MC_y$. But it follows from this that
$p_x/p_y = MC_x/MC_y = MRT$(of y into x) = slope of PPF.

Finally, we can combine conditions and see the following result,
$$MRS\text{(of y for x)} = (U_x/U_y)^A = (U_x/U_y)^B = MC_x/MC_y = MRT\text{(from y into x)}.$$
This means that under competition, the marginal rate of substitution of y for x, which governs consumer behavior, is equal to the marginal rate of transforming resources from y into x, which governs the firm's behavior. Therefore, a competitive equilibrium matches up with an optimal allocation. In fact, this is the **first fundamental theorem of welfare economics**; a competitive equilibrium is Pareto optimal.

The **second fundamental theorem of welfare economics** is that any Pareto optimal allocation on the contract curve can be supported by a competitive equilibrium. Consider the pure exchange model depicted below and endowment point E. If agents trade competitively, the economy ends up at point A. However, at A it appears person A has most of everything and
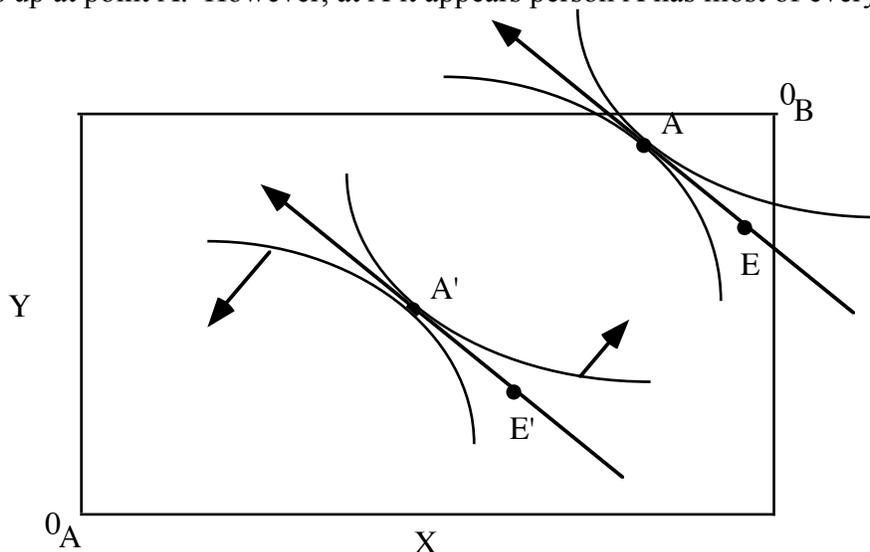
person B has very little. We would be tempted to label A a rich person and B a poor person. Some might regard this as inequitable. If we redistribute from E to E' by taxing away some of A's endowment of both goods and transferring them to B, we can then allow people to trade freely and the economy will end up at point A'. Many would regard this as more equitable than point A in the diagram. (Of course some would not. The point is that any allocation on the contract curve, can be supported as a competitive equilibrium with the appropriate redistribution of resources.)

Thus, our model of a perfect economy appears too good to be true. Consumers behave efficiently, firms behave efficiently, transactions occur, and the interaction between consumers and firms is efficient and leads to an outcome that cannot be improved upon. The real question is how does our model of a perfect economy match up with a real economy? How might a real

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economy fail to meet the conditions of our perfectly functioning economy? What problems can arise in the real world?

Some of the problems that can occur in real economies are:

A.	an unequal income distribution,
B.	monopoly,
C.	problems associated with imperfect information,
D.	public goods that the market either cannot provide or provides inefficiently,
E.	externalities like pollution and war, and
F.	excessive unemployment.
G.	Coordination failures.

The existence of any of these problems will mean that the resulting allocation that is the outcome of the private market system under competition is not Pareto optimal and we can rearrange production or consumption so as to make everyone better off.

Take pollution as an externality, for example. Suppose one firm pollutes the air or water and this affects other people adversely. As we will see, the competitive outcome may not be optimal in this setting because the polluting firm is not taking into account the full social cost of production since he is ignoring the cost imposed on those who suffer from the effects of the pollution. Since the private producer faces the private cost of production and not the social cost, his output decisions will be inefficient from a social point of view. Typically, too much of the polluting good will be produced and its price will be too low. There are ways of rearranging production that can maintain the profitability of the polluting firm and compensate those who are adversely affected by the pollution. Unfortunately, many times this requires some sort of government intervention. Without intervention, the polluting firm has no incentive to clean up its own pollution because this will raise its costs and cut into its profits. Some sort of government intervention will usually be required because the private market system typically does not provide a solution to this sort of externality problem.

As a concrete case in point, farmers in eastern Washington and northern Idaho are allowed to burn their wheat fields after the harvest in the fall. This turns out to be a cost effective way of preparing for the next growing season. Yet, this creates a significant air pollution problem. Left alone, this externality will mean that the farmers are not facing the true social cost of their production activity since they are imposing a negative externality cost on people with respiratory problems. In that case, society is producing too much wheat at too low a price. If farmers had to use other methods than burning that did not impose costs on others like asthma sufferers, the costs of producing wheat would be higher and this would be reflected in a higher price for bread, and so on. This outcome would require some sort of government intervention, however, because the farmers are taking an action that makes some people worse off and have no private incentive to undertake a higher cost method of producing.

A coordination failure occurs when the individual's incentives do not coincide with the group's incentives. The classic prisoner's dilemma is a case in point. Two individuals are discovered at the scene of a crime. The police take them back to the police station and put them in separate rooms to interogate them. Each prisoner faces a choice: say nothing, or make a deal with the police for a reduced sentence. Each prisoner knows the incentives faced by the other prisoner. They are both better off if each says nothing because they will receive only a minor sentence, or possibly none at all. On the other hand the individual may be better off if he cuts a deal by confessing and giving up the other prisoner. If both cut a deal, however, based on their individual incentive, they are each worse off since the police have a confession from both.

As an example of a corrdination failure, consider two firms, A and B, who are choosing price. They can choose a low price or a high price. However, choice of price will affect their shared market. If both charge a high price, quantity demanded falls an this may reduce their payoff. If both charge a low price their revenue may not cover cost causing their payoff to be

low. The payoffs are as depicted in the table below. A's payoff is the first number in each pair, B's payoff is the second number. If A chooses a low price and B chooses a high price, A gets a payoff of 4 and B gets a payoff of 1. We are looking for a Nash equilibrium (after John Nash of a Beautiful Mind) where no one has an **individual** incentive to deviate. A chooses a row and B chooses a column so we list A's choice first in an ordered pair and B's choice second. Is (high price, high price) a Nash equilibrium? No. Why? Because A has an incentive to choose a low price if she thinks B will choose a high price because she gets 4 instead of 3. B has the same incentive; he will choose a low price if he thinks A will choose a high price because he also gets 4 instead of 3. Therefore, (high price, high price) is not a Nash equilibrium since both will choose not to be there. Is (low price, high price) a Nash equilibrium? No because if B thinks A will choose a low price he should choose a low price since he gets 2 instead of 1. The only Nash equilibrium when agents act on their own is (low price, low price) with payoffs of (2, 2). If A deviates her payoff falls from 2 to 1. Similarly, for B.

		B	
		low price	high price
A	low price	2,2	4,1
	high price	1,4	3,3

Suppose the firms act together. How can they maximize total payoff? By agreeing to both charge a high price. Under a Cartel arrangement they should get together and both charge a high price so each can get 3 which is better than the Nash equilibrium where each gets 2 instead. So the coordination failure occurs because individual choice leads to a Nash outcome (2, 2) which is worse than what the group could get acting as a group (3, 3). This is true of a variety of situations.

For the prisoner's dilemma game the payoffs are

		Prisoner B	
		make a deal	no deal
Prisoner A	make a deal	-3, -3	-1, -4
	no deal	-4, -1	-2, -2

- 3 means the prisoner spends 3 years in jail. Th eonly Nash equilibrium is where both prisoners make adeal and as a result the police have confessions from both and serve 3 years in jail. The group has an incentive not to make a deal and receive only two years in prison. Make sure you understand why the Nash equilibrium is (make a deal, make a deal) and the coordinated outcome is (no deal, no deal).

The upshot is that when any of these problems exist, the competitive economy is not necessarily producing in a socially efficient manner. We can typically find ways of improving the efficiency of the economy. But, some sort of intervention will be required.

4.5   Making Predictions
Suppose we pose the question of what happens if we open the economy to trade. Before trade the economy is producing at point P and consuming at point C. After trade the GDP line swivels around the PPF to P'. Now it is possible for the economy to consume outside the PPF

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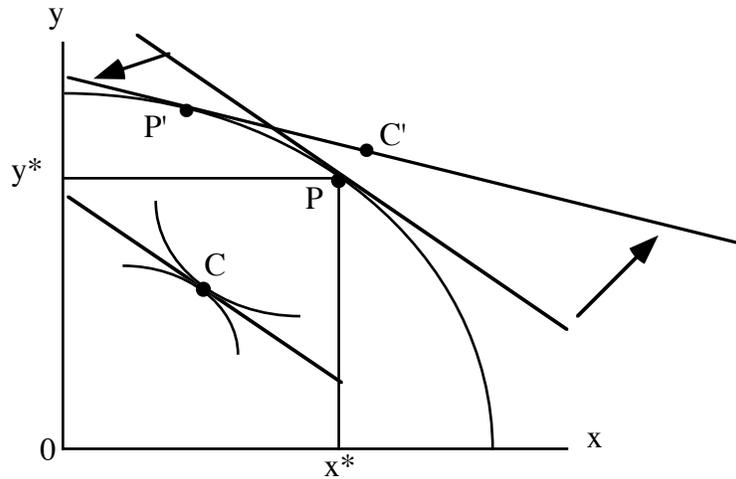
like point C'. There are more goods for everyone to consume than there were before trade. Production shifts away from x toward y. So producers of x will be worse off while producers of y will be better off. Clearly, given that there is more of both goods available, we can tax some who benefit and transfer to those who are made worse off. One concrete policy we could pursue would be to subsidize retraining efforts for people who lose their jobs when trade opens up.