Chapter 3

Equilibrium and Efficiency

In chapters 1 and 2 I examined the behavior of consumers and producers. In this chapter I shall put them together and investigate whether they find an equilibrium, and if so, whether that equilibrium is efficient. I will assume—unless stated otherwise—that producers and consumers all face the same prices and that those prices are larger than zero. I shall denote the quantity of corn and wheat demand C_D and W_D, respectively, and the quantity of corn and wheat supplied C_S and W_S, respectively.

3.1 Producer Revenue and Consumer Income

In chapter 1, for simplicity, I assumed that producers have no costs. I shall now relax this assumption and assume that producers do have costs but essentially ignore them (chapter four will provide a more satisfactory model of producer behavior). I assume in particular that producers incur a cost of TC when they produce their output. This TC represents the wages and rent that they must pay to produce corn and wheat. Using TC, I can write the equation for the iso-profit lines as follows.

$$\pi = P_C C_S + P_W W_S - TC \tag{3.1}$$

I can rearrange equation 3.1 into slope-intercept form to get equation 3.2.

$$C_S = \frac{\pi + TC}{P_C} - \frac{P_W}{P_C} W_S \tag{3.2}$$

If I know the PPF for all the producers in the economy, I can use the iso-profit lines described by equation 3.2 to determine the quantity of corn and wheat that will be produced for a given pair of prices P_C and P_W.

Now take a closer look at equation 3.1. The two terms on the left-hand side, π and TC, are income that is earned by consumers. TC consists of payments to workers and landowners while π is income that is earned by entrepreneurs. Thus, any production bundle generates exactly the amount of revenue necessary to purchase it. That is, $\pi + TC = Y$.

3.2 Aggregating Consumers

The total income earned by consumers, Y, is split among all of the consumers in the economy. In most economies there are many consumers, but I shall assume that there are only two to keep the algebra simple. I shall also assume that consumers spend their entire income (savings will be examined in chapter 6).

If both of my consumers spend their entire income, the following must be true.

$$\begin{aligned} Y_1 + Y_2 &= P_C C_1 + P_W W_1 + P_C C_2 + P_W W_2 \\ Y &= P_C(C_1 + C_2) + P_W(W_2 + W_2) \\ Y &= P_C C_D + P_W W_D \end{aligned} \tag{3.3}$$

Equation 3.3 is the aggregate budget constraint. It tells me how much my society of two consumers can afford (if there were more than two consumers, the algebra would be messy, but the result exactly the same). I can rearrange equation 3.3 to get the slope-intercept form of the aggregate budget constraint.

$$C_D = \frac{Y}{P_C} - \frac{P_W}{P_C} W_D \tag{3.4}$$

The Y-axis intercept of the aggregate budget constraint is Y/P_C and the slope is $-P_W/P_C$. If you look back at section 3.1, you will see that the Y-axis intercept of an iso-profit line is $\pi + TC$ over P_C and the slope is $-P_W$ over P_C. Since $Y = \pi + TC$, it must be that the highest iso-profit line that intersects the PPF is the same as the aggregate budget constraint. Figure 3.1 illustrates the situation.

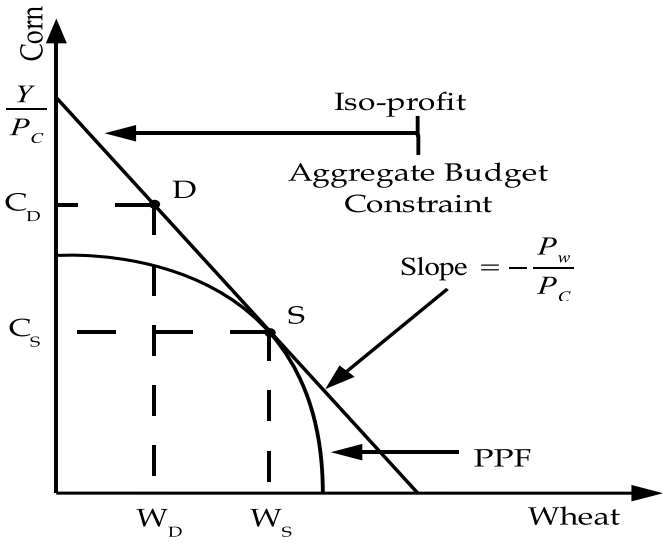

Figure 3.1: Disequilibrium

Figure 3.1 also illustrates something that is clear from the algebra of the iso-profit lines and the aggregate budget constraint: supply need not equal demand. Producers will choose to produce at the intersection of the highest possible iso-profit line and the PPF. Consumers may choose any point on the aggregate budget constraint. The point that they choose depends upon their preferences and it need not equal the point chosen by producers.

Definition 2 *The market for a good is in* equilibrium *if the supply of the good is equal to demand for the good; otherwise it is in* disequilibrium.

In figure 3.1, both the corn and the wheat markets are in disequilibrium. In the corn market, consumers demand more corn than producers supply ($C_D > C_S$). In the wheat market, producers supply more wheat than consumers demand ($W_D < W_S$). When, if ever, will these markets be in equilibrium?

3.3 Equilibrium in One Market

It is easier to examine equilibrium—and disequilibrium—using supply and demand curves than using the PPF. Recall that I derived the supply curve for

wheat, for a fixed price of corn, by changing the price of wheat and recording the amount of wheat produced at each price. I found that the supply curve for wheat is upward sloping (see figure 1.3).

I derived the demand curve for wheat, for a fixed price of corn and a fixed income, by changing the price of wheat and recording the amount of wheat consumed at each price. I now have two consumers instead of one though, so to derive the demand curve for wheat, I must sum the amount of wheat that each consumer demands at each price of wheat, while keeping their incomes and the price of corn fixed.[1]

Figure 3.2 shows the process of determining one point on the demand curve for wheat. The first pane of the figure shows the budget constraint and an indifference curve for consumer one; the tangency point of these two objects is consumer one's consumption bundle. The second pane of the figure shows the same thing for consumer two. The third pane shows the total amount of wheat demand by the two consumers at the price of wheat implicit in the slope of the consumers' budget constraints. (The total amount of wheat demand is the sum of the two horizontal distances W_1 and W_2).

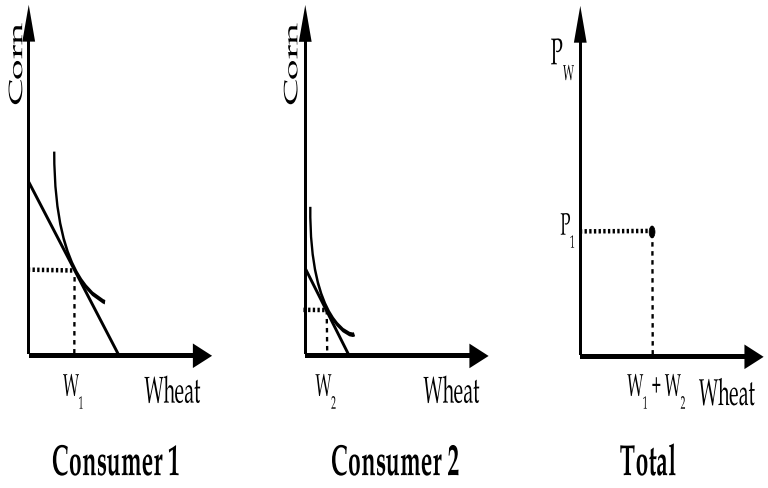

Figure 3.2: Deriving the Demand Curve for Wheat

[1]To get around the thorny problem of Giffen goods, I shall assume that corn and wheat are normal goods (this precludes them from being Giffen goods).

If I repeat the process shown in figure 3.2 enough times, I can derive the demand curve for wheat. I've assumed wheat is a normal good, so the demand curve for wheat will be downward sloping: as prices fall, the quantity demanded rises. Figure 3.3 combines the demand and supply curves for wheat and highlights the equilibrium price P^*.

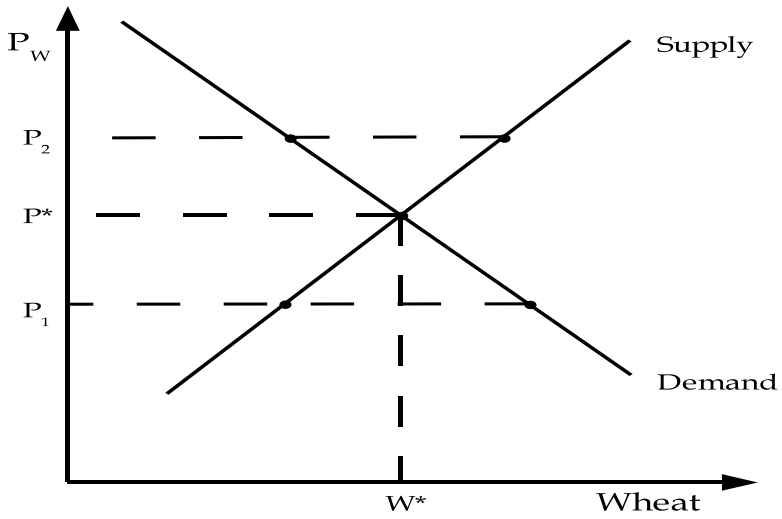

Figure 3.3: Supply and Demand

If the price of wheat is lower than P^* (e.g., P_1), the quantity of wheat demanded will be larger than the quantity of wheat supplied: $W_S < W_D$. Producers will therefore raise the price of wheat, stimulating more wheat production and reducing demand. They will keep raising the price of wheat until the supply of wheat is greater than or equal to the demand for wheat.

If the price of wheat is higher than P^* (e.g., P_2), $W_S > W_D$. Producers will cut the price of wheat, increasing demand and depressing wheat production. They will keep cutting the price of wheat until the demand for wheat is greater than or equal to the supply of wheat.

If the price of wheat is equal to P^*, $W_D = W_S$ and the market for wheat is in equilibrium. When this is the case, producers will not change the price of wheat. When the price isn't equal to P^*, producers will change the price of wheat and the wheat market will go through the adjustment process detailed above.

3.4 Equilibrium in Two Markets

Suppose that the economy is in the disequilibrium depicted in figure 3.4.

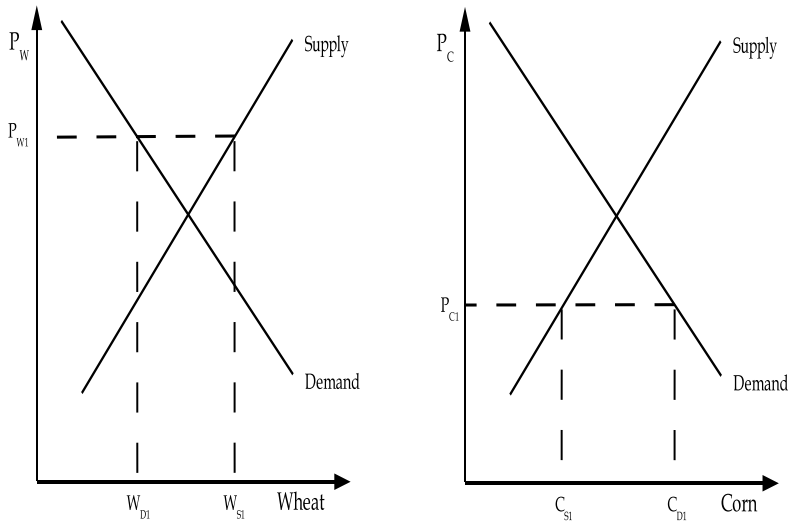

Figure 3.4: Disequilibrium in the Corn and Wheat Markets

When producers bring their corn and wheat to the market, they will realize that there is an oversupply of wheat and an undersupply of corn. Their response will be to raise the price of corn (from P_{C1} to P_{C2}) and reduce the price of wheat (from P_{W1} to P_{W2}). The price ratio $-P_W/P_C$ will therefore become closer to zero, flattening the iso-profit lines. As figure 3.5 shows, this will increase production of corn and reduce production of wheat, as production moves from S_1 to S_2.

Figure 3.5 also shows the adjustment made by consumers: they move from D_1 to D_2. Unlike the adjustment made by producers, I can't be sure that consumers will behave in this way: aggregate demand is made up of many small consumers, each of whom may react in a different way. Nevertheless, it seems reasonable to assume that a rise in the price of corn will reduce demand for corn and that a fall in the price of wheat will increase demand for wheat. If one accept that consumers behave in this way, I can redraw the demand and supply curves (we must redraw them because both prices have changed) as shown in figure 3.6.

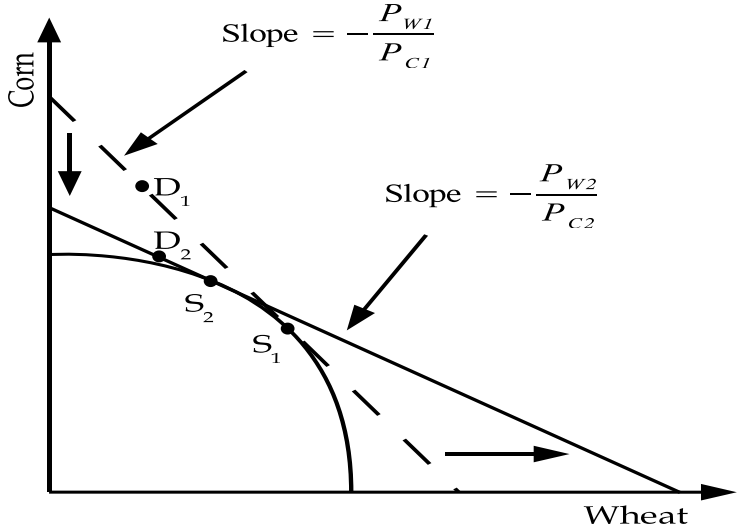

Figure 3.5: An Adjustment

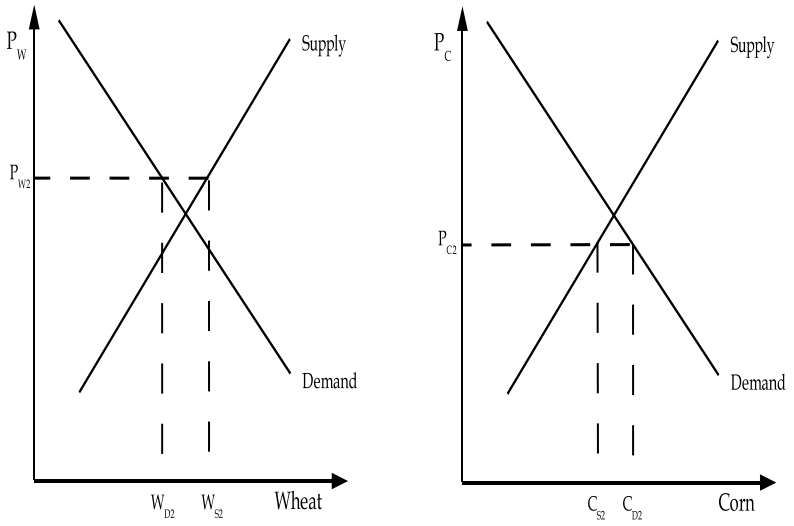

Figure 3.6: The New Disequilibrium in the Corn and Wheat Markets

The corn and wheat markets are still not in equilibrium, but the gaps between supply and demand have been reduced. Producers will again raise the price of corn and reduce the price of wheat. These changes will continue until both markets are in equilibrium.

3.5 Efficiency

The previous section examined equilibrium in the corn and wheat markets; this section will explore efficiency in the corn and wheat markets. I defined Pareto efficiency in the previous chapter, but it is such a critical definition that I define it again below.

Definition 3 *An allocation of goods is* Pareto efficient *if it is impossible to make one person better off without making someone else worse off.*

I shall begin by re-examining efficiency in consumption. Imagine that two consumers come into a room and that I assign them both a bundle of corn and wheat. They are then allowed to trade with each other if they wish to do so. If they can find a mutually beneficial trade, the allocation that I chose was inefficient. Figure 3.7 shows my initial allocation and a mutually beneficial trade. In the original allocation consumer one received the bundle A and consumer two received the bundle B. Consumer one gave consumer two C units of corn and received W units of wheat.

The trade shown in figure 3.7 made both consumers better off because it moved them to higher indifference curves. As we know from the previous chapter, they were able to find a trade because the slopes of their indifference curves at their consumption points were not equal. The slope of a consumer's indifference curve at her consumption point is the units of corn that she must receive (give up) to compensate her exactly for losing (receiving) one unit of wheat. As such, it represents her relative valuations of corn and wheat. If consumers value corn and wheat differently (the slopes of their indifference curves at their consumption points are different), they can generally find a mutually beneficial trade. If they value corn and wheat in exactly the same way (i.e., the slopes of their indifference curves at their consumption points are the same) they cannot find a mutually beneficial trade.

Figure 3.8 illustrates a situation in which my two consumers face the same prices. Because they face the same prices, the slopes of their budget constraints are equal. The indifference curve of each consumer is tangent to

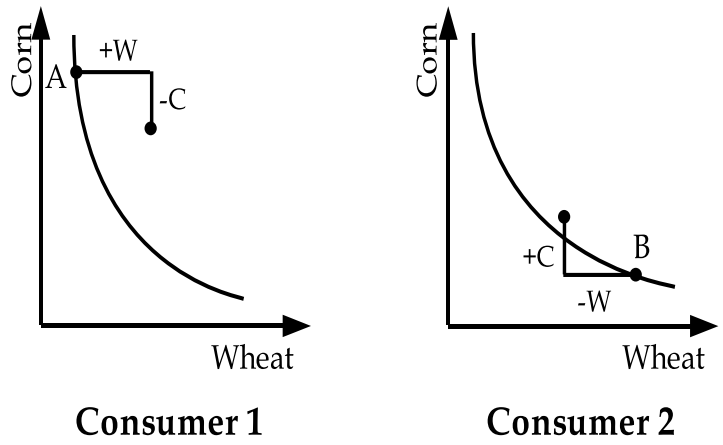

Figure 3.7: An Inefficient Allocation and a Mutually Beneficial Trade

her budget constraint, so the slope of her indifference curve at the point of consumption must be equal to the slope of her budget constraint. Thus, my two consumers value corn and wheat in exactly the same way and cannot find a mutually beneficial trade—the allocation is efficient. This is the case whenever consumers face the same prices.

I have shown that there will be efficiency in consumption if consumers face the same prices: but what about the production side of the economy? Recall that the slope of the PPF represents the economy's ability to transform corn into wheat. If this rate is not equal to the rate at which consumers value corn and wheat, the allocation is inefficient.

Figure 3.9 illustrates such a case and shows an efficiency improving trade. Consumer two is originally at point A and the economy as a whole is at point B. The proposed trade reduces wheat production by W units and increases corn production by C units. It then takes the W lost units of wheat away from consumer two and gives her the C extra units of corn in return. This trade makes consumer two better off because it moves her to a higher indifference curve. The trade doesn't affect consumer one since her consumption bundle doesn't change—consumer two absorbs the entire change in production. Thus, the trade makes consumer two better off without

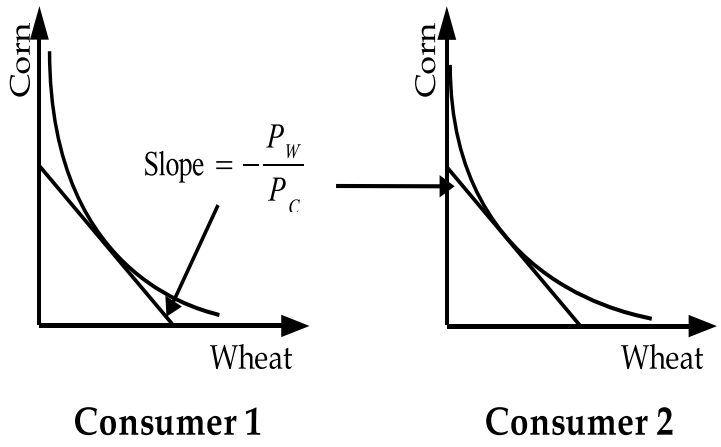

Figure 3.8: An Efficient Allocation

hurting consumer one, meaning that the original allocation was inefficient.

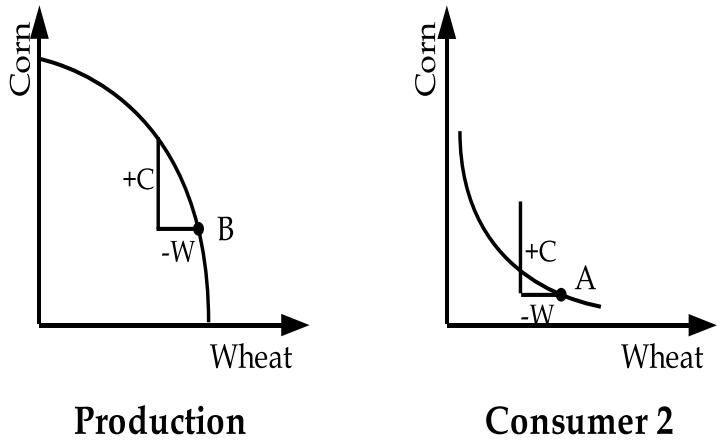

Figure 3.9: An Inefficient Allocation and an Efficiency Improving Trade

I shall now assume that producers face the same prices as consumers, as shown in figure 3.10. Since consumers face the same prices, I know that the consumption side of the economy is efficient—my consumers can't make a trade that makes one of them better off without making the other one worse off. The production side is also efficient, since the slope of the PPF at its tangency with the iso-profit line is equal to the slope of the consumers' budget constraints, and hence the slopes of their indifference curves at their consumption points.

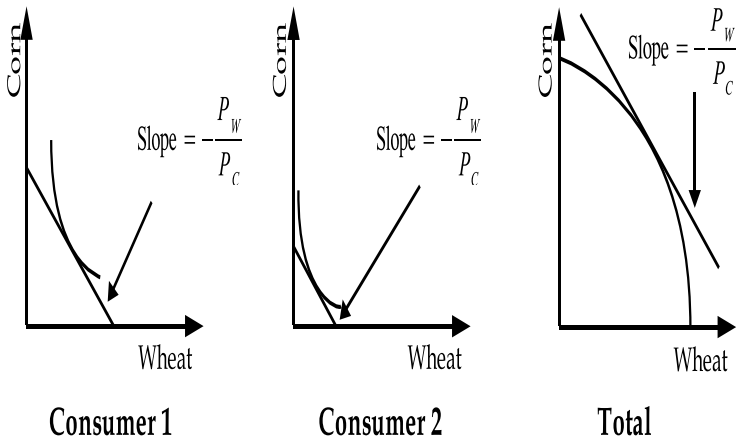

Figure 3.10: An Efficient Allocation

I can also represent this critical result algebraically.

$$\left(\frac{\Delta C}{\Delta W}\right)_1 = \left(\frac{\Delta C}{\Delta W}\right)_2 = \left(\frac{\Delta C}{\Delta W}\right)_E = -\frac{P_W}{P_C} \tag{3.5}$$

Equation 3.5 shows that consumer 1's relative valuation of corn and wheat ($\Delta C/\Delta W_1$) is equal to both consumer 2's relative valuation of corn and wheat ($\Delta C/\Delta W_2$) and the economy's ability to turn corn into wheat: ($\Delta C/\Delta W_E$). Thus, no mutually beneficial trades are possible and the allocation is efficient. Any equilibrium in which consumers and producers face the same prices will be efficient.

3.6 Problems

1. (a) Define the terms "normal good" and "inferior good."

   (b) Define the term "Giffen good."

   (c) Figure 3.11 shows a consumer's initial consumption bundle (point α). It also shows how her budget constraint changes when the price of wheat falls. Will her consumption of wheat increase or decrease?

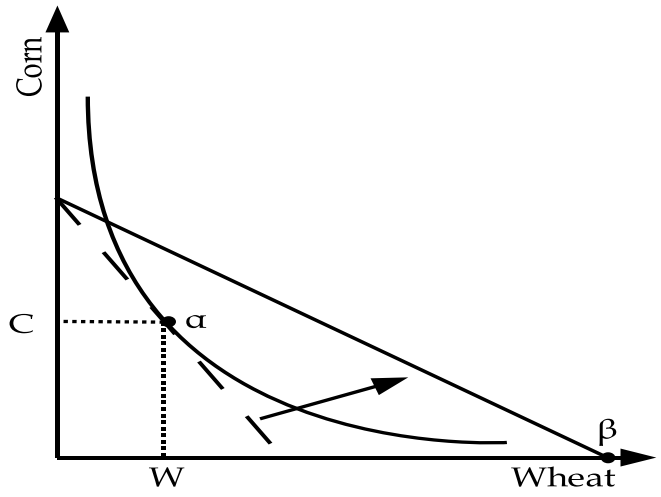

Figure 3.11: A Fall in the Price of Wheat

   (d) Figure 3.12 shows the effect on the consumer's budget constraint if the price of wheat falls but I change her income so that she can still afford her original consumption bundle. Will she increase her consumption of wheat?

   (e) Figure 3.13 shows the effect on the consumer's budget constraint if I keep prices the same but change her income so that she can afford the maximum amount of wheat that she could afford in part 1c (point β). Will she increase her consumption of wheat?

2. Figure 3.14 depicts a situation in which the corn and wheat markets

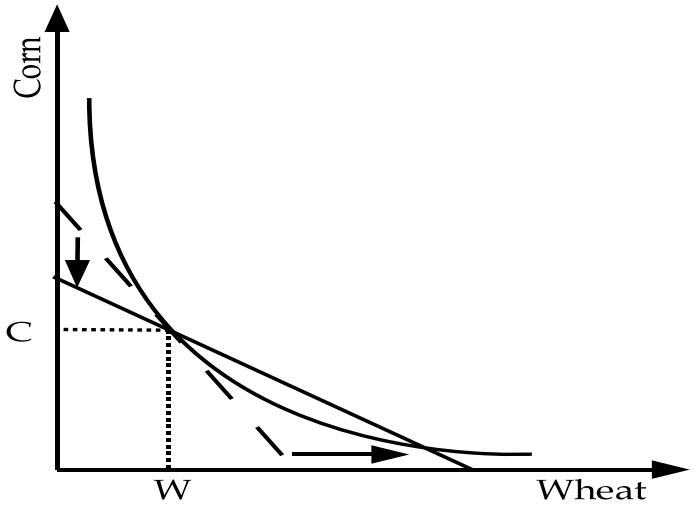

Figure 3.12: A Compensated Budget Constraint

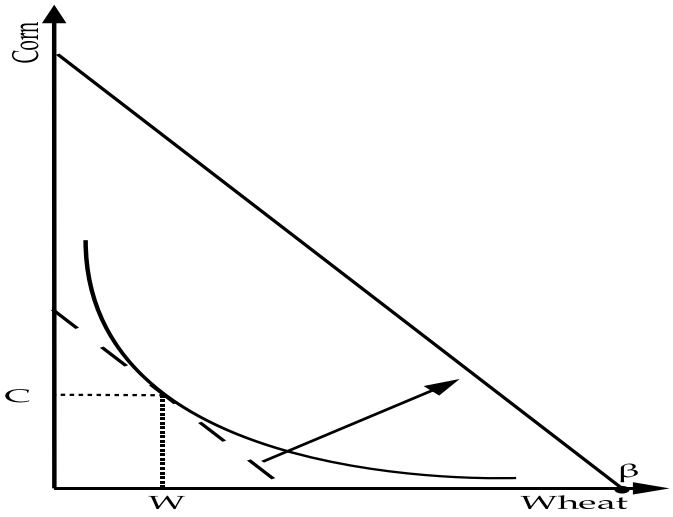

Figure 3.13: A Compensated Budget Constraint

are in disequilibrium. Suppose throughout this question that corn and wheat are normal goods and that they are substitutes.

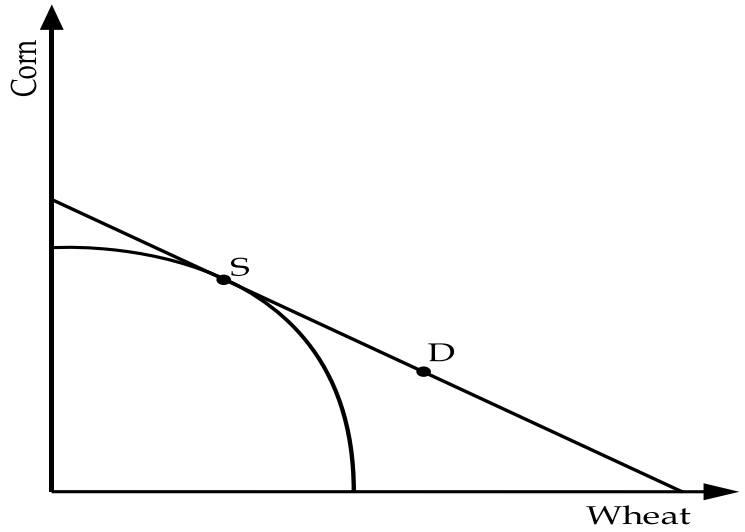

Figure 3.14: Disequilibrium in the Corn and Wheat Markets

(a) Depict the disequilibrium in the corn and wheat markets using supply and demand curves.

(b) Suppose that the corn producers refuse to change their price and that the wheat producers increase their price. Using supply and demand curves, show what will happen in each market. Are the two markets closer to an equilibrium?

3. (a) The allocation in figure 3.15 is inefficient. Prove this by finding a trade that makes one consumer better off without making the other consumer worse off.

(b) Is your new allocation efficient (i.e., can you find another trade that makes one consumer better off without making the other consumer worse off)? If not, find a trade that will result in an efficient allocation; if so, explain why.

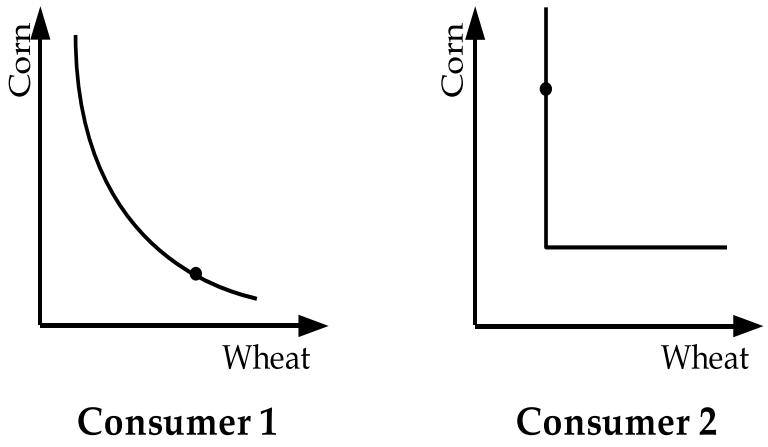

Figure 3.15: An Inefficient Equilibrium

3.7 Solutions

1. (a) A good is normal if a consumer's demand for it increases when her income increases; it is inferior if her demand for it decreases when her income increases.

   (b) A good is a Giffin good if a consumer's demand for it falls when its price decreases.

   (c) It is impossible to tell. The consumers new consumption bundle can be anywhere between points A and B on her new budget constraint in the first pane of figure 3.16. If her new consumption bundle is to the left of W, wheat consumption decreases. If her new consumption bundle is to the right of W, wheat consumption increases.

   (d) Her consumption of wheat increases. Her new consumption bundle can be anywhere between points E and F on her new budget constraint in the second pane of figure 3.16. All of these points imply an increase in her wheat consumption.

   (e) Her new consumption bundle can be anywhere between points G and H on her new budget constraint in the third pane of figure

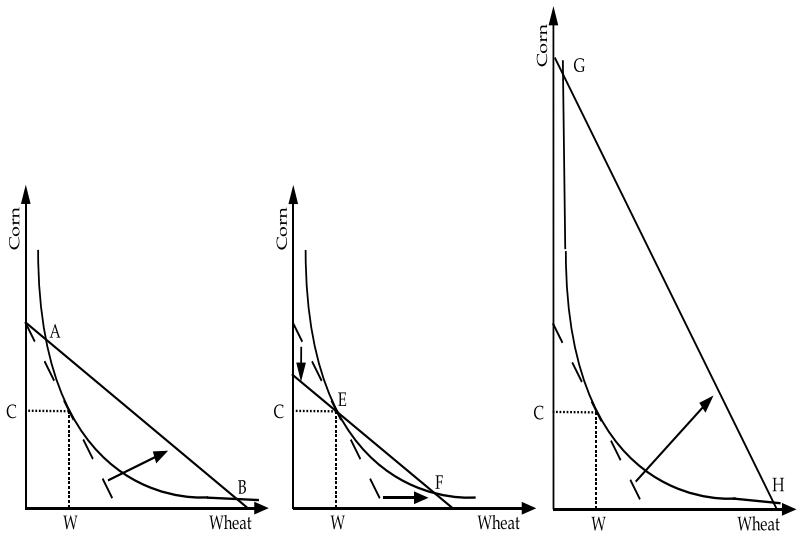

Figure 3.16: Several Budget Constraints

3.16. If wheat is a normal good, her consumption of wheat will increase (i.e., be to the right of W); if wheat is an inferior good, her consumption of it will decrease (i.e., be to the left of W).

The answers to this question provide the intuition necessary to understand why a normal good cannot be a Giffen good. When the price of wheat falls, there are two effects: the substitution effect (substituting relatively cheaper wheat for corn) and the income effect (since wheat is cheaper, the consumer is relatively richer). The substitution effect always increases the consumer's demand (as in part 1d) while the income effect may increase or decrease demand (as in part 1e). But if a good is normal, the income effect must also increase demand and so demand as a whole must increase. Thus, a normal good cannot be a Giffen good.

2. (a) Figure 3.17 shows disequilibrium in the corn and wheat markets.

   (b) The price of corn doesn't change, so it is easy to draw the effect of an increase in the price of wheat in the wheat market: demand decreases and supply increases. This reduces the gap between supply and demand, as shown 3.18.

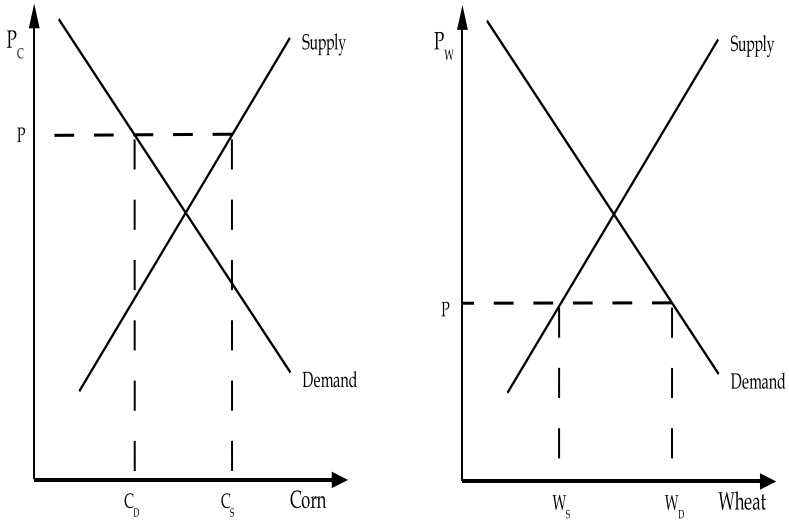

Figure 3.17: Supply and Demand for Corn and Wheat

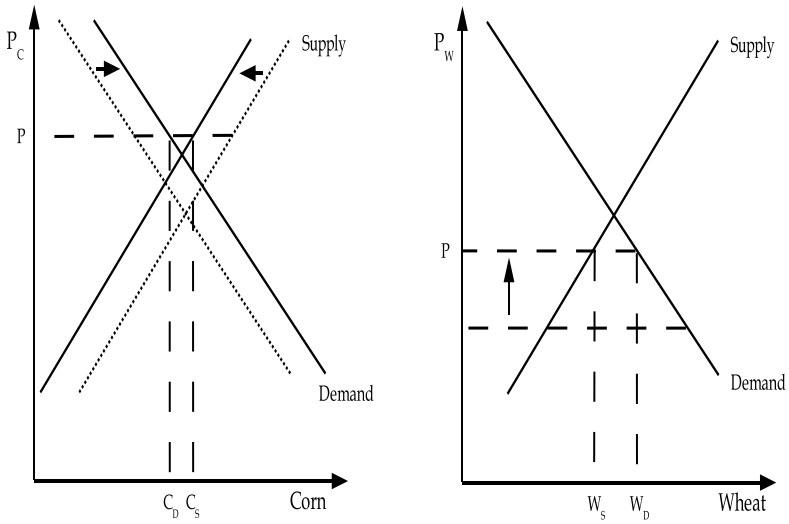

Figure 3.18: Several Budget Constraints

The effect in the corn market is a bit more complicated. Since the price of wheat has changed, we must redraw our supply and demand curves. The supply curve shifts to the left because the price of corn has decreased relative to the price of wheat, making corn production relatively less profitable at every price of corn. The demand curve, meanwhile, shifts to the right because the price of corn has decreased relative to the price of wheat, making corn relatively cheaper at every price of corn (since corn is a normal good and a substitute for wheat, this means that the demand for corn increases at every price of corn). Thus, the gap between supply and demand in the corn market also decreases, even though the absolute price of corn did not change.

3. Figure 3.19 shows a trade the makes consumer one better off without hurting consumer two. Consumer two gives up C units of corn but is no worse off because she views corn and wheat as complements and she had more corn than wheat initially. Consumer one receives C units of corn and he moves to a higher indifference curve.

   The resulting allocation is also efficient. To make consumer two better off, we must give her both corn and wheat. But this would make consumer one worse off, since he would lose both corn and wheat. On the other hand, if we subtract any corn or wheat from consumer two, she will be worse off. This makes it impossible to make consumer one better off without hurting consumer two. Thus, we cant find any mutually advantageous trade.

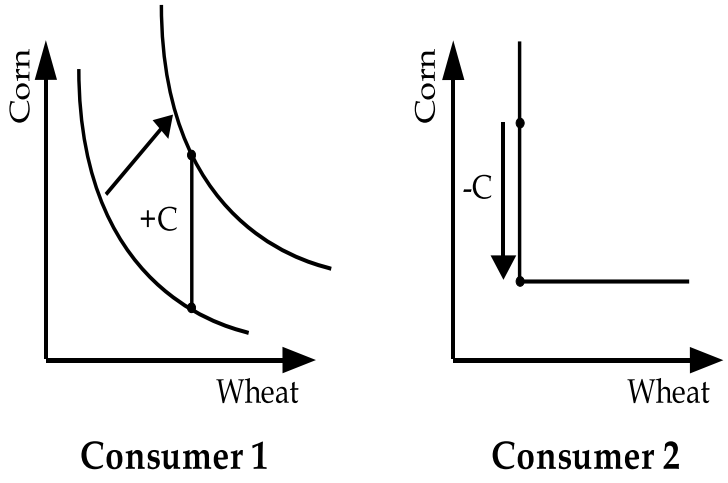

Figure 3.19: A Pareto Improving Trade