PRODUCER'S SURPLUS AND RENTS IN THE U.S. DAIRY INDUSTRY

by

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ABSTRACT

The term "producer's surplus" is commonly used in the economics literature to refer to gains from trade to the suppliers of a particular good. While common, the term has been applied ambiguously and seldom is defined in a consistent manner.

This study provides a consistent and workable definition of the term "producer's surplus." In the short-run, producer's surplus is the sum of profit and quasi-rent that belongs to the firm or factor owners, or both, depending on the contract. In the long-run, it is a measure of the rents to specialized factors used in the production of the industry output, and is captured by the owners of the specialized factors.

An application, using the long run concept of producer's surplus, is provided. Rents in the U.S. dairy industry during 1950-1989 are estimated, and specialized factors receiving these rents identified. The estimated rents, in constant 1967 dollars, ranged from 2285.1 million in 1952 to 1596.6 million in 1988. Two empirical models are constructed to test the relationship between the estimated rents and possible specialized factors in the dairy industry: land and dairy cows. The empirical results support the hypothesis that dairy cows are a specialized factor in the dairy industry, but reject a significant relationship for land. It is also shown that, in the dairy industry, rent dissipation through competition in the political market and inventive activity are relatively insignificant.

CHAPTER 1

INTRODUCTION

One important contribution by the economics profession has been to identify to policy makers the economic consequences of policies they issue. The advice offered has often been based on cost benefit criteria -- a comparison of the total benefit from a decision, relative to its total costs. Key to applying this cost benefit criteria is an analysis of who receives the benefit, and how much. These calculated welfare measures should, of course, provide unambiguous information on both the size of the gain and identification of the beneficiaries. However, the term "producer's surplus," which is often used in cost benefit analyses to denote the benefit to producers engaged in the affected business operation, has serious conceptual problems.

The conventional definition of "producer's surplus" has most often referred to the short-run, and it is seldom clear who the producers are. Moreover, actual empirical measures of producer's surplus often employ long-run supply elasticities, and fail to identify what is actually being measured by the area below the price line and above the supply function.

Thus, the term "producer's surplus" in cost benefit analyses has not been consistently applied, and that can lead economists to incorrectly describe the consequences of a policy.

This thesis attempts to clarify the definition of "producer's surplus" in both short-run and long-run contexts. It will show that in the short-run, producer's surplus is the sum of profit and quasi-rent, belonging to the firm or factor owner, or both depending on the terms of the contract. In the long-run, producer's surplus is rent that accrues to specialized factors of production, and is captured by the owners of these factors. To illustrate these concepts, an application using the U.S. dairy industry is offered. Although previous studies have estimated producer's surplus in the dairy industry, the authors of these studies do not attempt to identify the specialized factors that receive the rents. The major objective of this application is to provide answers to:

1. What is the magnitude of rents in the U.S. dairy industry?
2. What specialized factors receive the rents?
3. To what extent are rents in this industry dissipated through competition in the political market, and in inventive activity?

The organization of this thesis is as follows. Chapter 2 defines the term "producer's surplus." Given this definition, estimates of rents in the dairy industry are offered in Chapter 3. Chapter 4 identifies the specialized factors receiving these rents, and Chapter 5 discusses rent dissipation. Chapter 6 presents the conclusion of this thesis, with suggestions for future studies.

CHAPTER 2

DEFINING PRODUCER'S SURPLUS

Introduction

The term "producer's surplus" has been used for many years. Alfred Marshall, in Principles of Economics, first published in 1890, wrote, "... another side of the surplus which a man derives from his surroundings is better seen when he is regarded as producer, whether by direct labor, or by the accumulated, that is acquired and saved, material resources in his possession. As a worker, he derives a worker's surplus, ... As a capitalist, he derives a saver's surplus ..." (Marshall, 1961, p. 830-831). Although Marshall's statement is not clear, it seems that by "producer's surplus" he meant the rent-to-inputs of production, namely rent-to-labor ("worker's surplus") and rent-to-capital ("saver's surplus"). Modern economists, however, have often devised different interpretations, among which the most common is that producer's surplus is the total short-run benefit to producers, and is adopted by most economics textbook authors. For example, Landsburg's textbook defines producer's surplus as "the area above the supply curve up to the price received and out to the quantity supplied," and refers to this measure as "the producer's gain from trade; the amount by which his revenue exceeds his variable cost of production." (Landsburg, 1989, p. 221). Similarly, Just et al. treat producer's surplus as "the total benefit to the producer from remaining in business," and claim that "the most common way to compute the benefit is simply to determine the area above the short-run supply curve and below price" (Just et al., 1982, p. 53). Accordingly, the standard textbook definition of producer's surplus seems to emphasize two elements. First, producer's surplus is the total benefit to producers, and second, producer's surplus is a short-run concept.

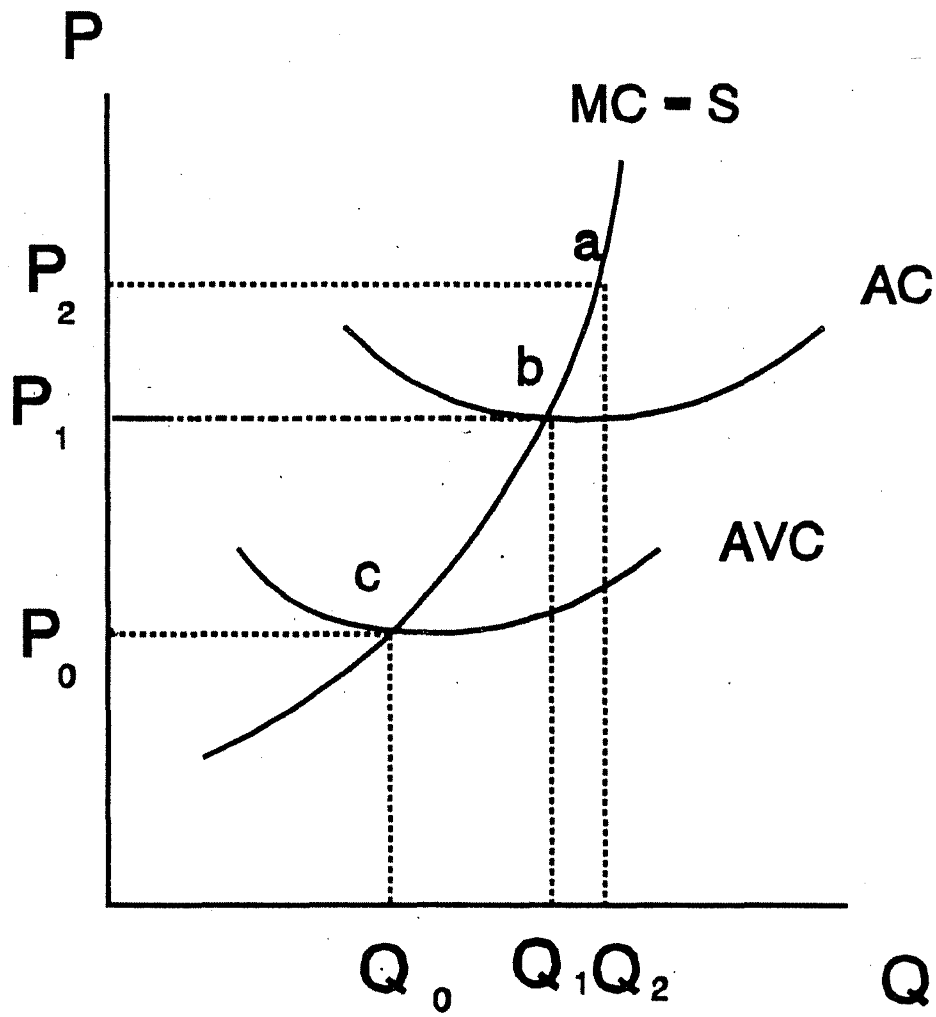
This definition, however, leaves much to be desired. In particular, what does "benefit" refer to, and who is the "producer" receiving the benefit? Does the concept of producer's surplus entail any economic meaning in the long-run? These are the questions that should be answered. Unfortunately, the fact that the standard definition of "producer's surplus" provides no unambiguous answer to these questions has been neglected. As a result, the concept of producer's surplus has been taken for granted, and used in misleading ways. The following analysis attempts to clarify the concept of producer's surplus by answering the questions stated above.

Identifying the Problem

Consider first a measure of the benefit. Imagine a competitive firm A, with two factors of production: labor (L) and capital (K). Assume firm A has a marginal cost curve (MC), an average total cost curve (AC), and an average variable cost curve (AVC) as shown in Figure 1. Further assume that in the short-run, capital is fixed and the cost of capital is sunk -- which means it has already been incurred and cannot be recovered, even if the firm should stop producing. Therefore, as long as the output price is higher than P_0 (the lowest point on the average variable cost curve), firm A continues to operate.

If in the first time period of operation the market price is P_1, then equating marginal cost to price, firm A will produce at b, where $P = P_1$ and $Q = Q_1$. At this point, firm A's total revenue is the area P_1bQ_1 and total variable cost is the area P_0cbQ_1. Since the fixed cost is sunk, the net benefit from operation is the difference between total revenue (area P_1bQ_1) and total variable cost (area P_0cbQ_1), i.e., firm A's fixed cost (area P_1P_0cb). This difference is often referred to as quasi-rent, since it differs from factor rents in that it does not persist in the long-run. As seen in Figure 1, quasi-rent (area P_1P_0cb) is measured by the area above the short-run supply curve and the price line, and according to the definition by Landsburg and Just <u>et al.</u>, it is the producer's surplus.

Figure 1 Producer's Surplus in the Short-run



If in the second time period, the market price increases to P_2, firm A will increase its output to Q_2. Again, the benefit from operation is the difference between total revenue (area P_2aQ_2) and total variable cost (area P_0cbaQ_2), i.e., the area P_2P_0cba. Clearly, the benefit is greater than the quasi-rent in the first time period by area P_2P_1ba. But is this increase a profit? Before we can answer this question, we must first consider what profit is.

According to Alchian and Allen, profit is an "unpredicted increase in wealth" (Alchian and Allen, 1969, p. 278). The key to understanding why profit should be "unpredicted" is the concept that the wealth value of a firm's assets is determined by the market expectation of the firm's future performance. If it is expected that the firm's net earnings will increase (decrease) in the future, the firm's current asset value will increase (decrease), i.e., the "future net earnings are capitalized into current value of assets." (Alchain and Allen, 1969, p. 328). Therefore, only an unexpected increase in wealth can be realized as profit.

Returning to the example shown in Figure 1, suppose that in the first time period the government made it known to the public that a close substitute of the product would be banned in the following time period. With this kind of public information, everyone would know that the demand for firm A's product would increase, and by how much. Thus, their expectations for firm A's future performance would be correspondingly higher. Consequently, the value of firm A's stock or ownership rights would increase. Now imagine that in the second time period demand increases as expected, and the price rises to P_2. Assuming a zero discount rate, firm A would find that the value of its assets has increased by the area P_2P_1ba. Since the cost of capital is sunk, the total short-run benefit is the total revenue net of total variable cost, i.e., quasi-rent to the capital. However, in this case, zero profit is made. In contrast, if the substitute good is destroyed by an unexpected natural disaster -- for example, an earthquake -- a profit can be made before people have fully realized the improved market conditions for the firm.

Defined as an unexpected increase in wealth, profit can also be viewed as the difference between evaluation and actual value of special resources. If at the time of trading, the market evaluation of a resource is lower (higher) than its actual value shown afterward, a profit (loss) is made by the resource buyer. As Alchian and Allen note, "If anyone makes a profit, it follows, by definition, that the earlier value placed on the resource was too low. And losses result from earlier overvaluation." (Alchian and Allen, 1969, p. 331). As long as people do not have perfect foresight, there will be a difference between expected and realized values, i.e., profit or loss. Thus, it follows that the total benefit from operation is the sum of profit and quasi-rent. The next question is: Who receives the rent?

Suppose firm A owns every resource it employs. In this case, it will gain all the benefit, both quasi-rent and profit. However, if firm A does not own the fixed input capital (K), but is only able to use K through a contract with capital owner B, how will the benefit from operation be distributed between A and B? The answer is that it depends on the contract. To illustrate, we discuss two commonly used contracts: fixed-rent and share.

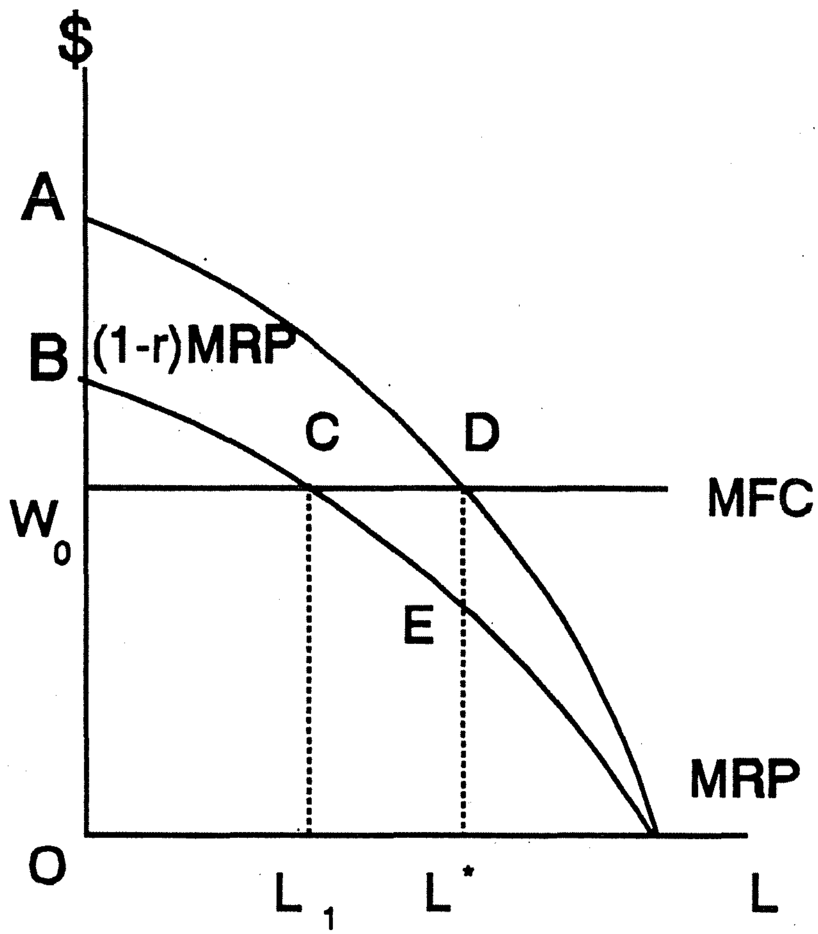
Assume B exclusively owns the particular piece of capital, K, and can transfer the right to property K freely in a competitive market. Assume further that among numerous competitors, firm A has the highest value for K, so that firm A and owner B decide to sign a contract to enable firm A to use the fixed capital K. They are free to choose either a fixed-rent contract (with which firm A pays a fixed amount to owner B), or a share contract (with which firm A pays a proportion of its output to owner B). Which contract will they choose?

Cheung answered the preceding question in 1968. He concluded that if there are no transaction costs, i.e., costs involved in negotiation and enforcement of the contract, and no risks, i.e., uncertainty concerning the firm's operation and market conditions -- it does not matter what kind of contract is chosen (Cheung, 1968, p. 1107-1122). Because transaction costs are not zero in the real world, the form of the contract chosen does matter. The case of zero transaction cost and no risk will be examined first.

Assume firm A has two factor inputs -- labor and capital -- and a horizontal marginal factor cost curve of labor, MFC = W_0, as shown in Figure 2. The marginal revenue product curve is labeled MRP. Under a fixed-rent contract, firm A will employ L^* units of labor. Total revenue is area AOL^*D, of which area W_0OL^*D is the total wage paid, and area AW_0D is the fixed rent paid to B. Under a share contract, if the share rate is r percent, firm A's actual marginal revenue product curve is (1-r)MRP. The firm's optimum point is at C, where its input of labor is only L_1, and firm A earns the extra area BW_0C. However, since the share contract must be agreed to by both parties, owner B will stipulate in the contract that firm A must input L^* units of labor. Since transaction costs are assumed to be zero, the agreement will be enforced perfectly. Moreover, the share rate will be determined so that the area ABED equals AW_0D. As with a fixed-rent contract, firm A is compensated for its opportunity cost of labor, and owner B receives payment for use of the capital equal to its opportunity cost if employed by some other party.

When transaction costs are positive, however, the choice of contract type matters because different types of contract will yield different returns to A and B. Under a share contract, the amount owner B receives depends on the actual

Figure 2 · A Share Contract vs. a Fixed-rent Contract



output of firm A. Since there is an incentive for firm A to hide real output and to input less than owner B's optimum, the cost of contracting and enforcing the contract is higher than that for a fixed-rent contract. With a share contract, the risks are shared by both firm A and owner B; with a fixed-rent contract, the risks are borne solely by firm A.

Under the assumption of risk aversion, "the choice of different types of contracts is determined by weighing the gains from risk dispersion and the transaction cost associated with different contracts." (Cheung, 1969, p.71). If the gains from risk dispersion are not sufficient to compensate for the difference in transaction cost between the two types of contracts, a fixed-rent contract will be chosen. Otherwise, a share contract will be chosen. Under a fixed-rent contract, if there is an unexpected increase (decrease) in the demand for the output, firm A will receive all the profit (suffer all of the loss). With a share contract, the profit (loss) will be shared by firm A and owner B proportionally, according to the share rate specified in the contract.

The conclusion drawn from this exercise is that the benefit from business operation in the short-run is the sum of quasi-rent and profit. Since either the firm or the factor owner can experience profits or losses depending on factor ownership and the contract through which the ownership is transferred or partially transferred, it is inexact -- if not incorrect -- to assign the entire benefit to an ambiguous agent called the "producer."

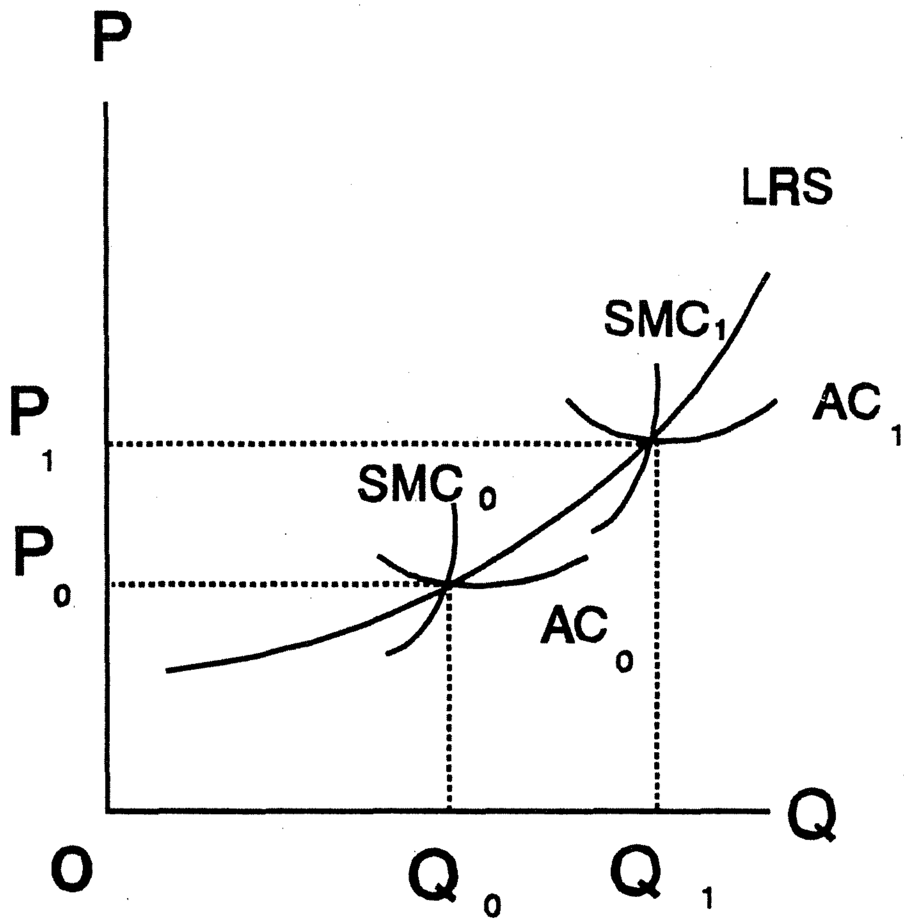
Thus far, the concept "producer's surplus" in the short-run context has been discussed. In practice, the long-run concept of "producer's surplus" -- measured by the area between long-run supply curve and equilibrium price line -- has been used in many economic analyses, especially in policy evaluation studies. This may be because such policies are thought to have long-run effects on the redistribution of wealth. This reasoning seems to have been accepted by Gardner, who suggests that "the long-run elasticity seems more appropriate as a determinant of intervention because commodity programs would be sought for their ability to generate producer rents for several years." (Gardner, 1987, p.300). Other researchers have used the long-run instead of the short-run concept of "producer's surplus" in their studies. For example, in their paper on the social cost of government milk regulation, Ippolito and Manson (1978) estimated the long-run supply elasticity of milk and using that estimate, calculated the social costs of regulation. Kaiser <u>et al.</u> (1988) took a similar approach in a paper on U.S. dairy policy. They estimated the long-run supply function of milk, and referred to the area above the supply curve and below the price as "producer's surplus." Other examples of producer's surplus being used in a long-run context are found. However, few authors have clearly explained what they mean by producer's surplus in the context of the long-run.

Benefits in the Long-run

Consider the simple case where prices of non-land factors are constant, where a firm produces using three inputs: labor (L), capital (K), and land (LD). Assume that the total quantity of land in the entire economy is great, but the quality of land varies. Then according to Ricardo (Nicholson, 1972, p. 334), the last acre of land in use (marginal land) is of the most inferior quality among all lands in use. Imagine the firm owns land of higher quality than the marginal land, and given free entry the marginal producer, i.e., the producer with the lowest quality land, will earn zero economic rent. In contrast, owners of infra-marginal land, i.e., those who own superior land, can earn positive rents. The rent can be treated as a return to the superior quality of the land, and it is referred to as Ricardian rent. Since the supply of superior land is limited, the rent can persist in the long-run. Under our assumption of fixed prices of L and K, the measure of the rent will be "identical with the area above the supply curve reckoned as a sum of money" (Mishan, 1968, p. 1275). This implies that the long-run concept of "producer's surplus" measures Ricardian rent and belongs to the owners of infra-marginal land.

Where prices of non-land factors are variable, the case is more complicated. Imagine a competitive increasing-cost industry with only two inputs: labor and capital (land is assumed away for simplicity). The long-run supply curve for this industry, LRS, is shown in Figure 3. Suppose that the supply of labor is perfectly elastic but that of capital is not. Suppose further that all n firms in the industry are homogenous. At the initial equilibrium price P_0, the industry produces Q_0, with each firm producing Q_0/n and making zero profit. Assume demand increases permanently, such that the price rises to P_1. If the increase in demand is unexpected in the short-run, it will bring profit to the existing firms. But in the long-run, a permanent increase in price is likely to attract new firms to the industry and/or output expansion by original firms. As a result, demand for capital K increases and, as the supply of capital is not perfectly elastic, its price will increase. Consequently, the industry's average cost curve will shift to AC_1, where the output of the industry is Q_1. If m new firms have entered at this time, each firm will produce $Q_1/(n+m)$, and again there will be zero profit. If the supply of a factor input is not perfectly elastic, the industry's long-run supply curve is upward-sloping because factor prices are being bid up as output expands. Moreover, at each point on the long-run supply curve, the zero-profit condition must hold. So, in contrast to the short-run supply curve, the long-run supply

Figure 3 Long-run Equilibrium with Changing Factor Prices



curve represents points that correspond to the industry's lowest average cost of producing, including any rent to specialized factors.

Is the area above the long-run supply curve still a measure of rent? Mishan (1968, p. 1275) argued that "in order to identify any quasi-rent, or rent, as the area above the supply curve, this curve must be conceived as a marginal curve exclusive of rent." While he agreed that when non-land factor prices are constant, the area above the long-run supply curve is Ricardian rent, he claimed that in more general cases, i.e., when factor prices are variable, the same area has no economic significance (Mishan, 1968, p.1277). The following mathematical models are constructed in an attempt to show that the area above the long-run supply curve has an economic meaning, and to clarify the economic interpretation of the concept "producer's surplus" in both the short-run and long-run.

Towards a Definition of Producer's Surplus

There are three models presented in this section. The first model pertains to the short-run, wherein the number of firms in the industry is fixed. The next two models apply to the long-run, and illustrate how varying assumptions about factor supply elasticities are important in understanding Mishan's criticism -- and why his criticism is not valid. All three models share the following assumptions, which are made to simplify the analysis:

1. It is a competitive industry consisting of homogeneous firms.
2. Each firm is a profit maximizer with a production function Q = Q(l, k, ld), where l, k and ld represent labor, capital and land, respectively.
3. The supply of land is fixed.

Consider first the behavior of the firm in the short-run. Assume that the only variable factor is labor, and its supply function is perfectly elastic. The representative firm operates as long as the output price is greater than its lowest average variable cost (AVC), and chooses the optimum amount of labor to maximize profit. The firm's objective function is

$$\max \ \pi = P \cdot Q(l,k,ld) - w \cdot l - i \cdot k - r \cdot ld, \tag{2.1}$$

where P = output price,

w = wage rate,

i = the price of capital,

r = rent for land.

The first order condition implies

$$P\frac{dQ}{dl} = w. \tag{2.2}$$

Assuming the second order condition is met, equation (2.2) can be solved for optimum amounts (denoted by an asterisk hereafter) of labor.

$$l^* = l^*(P,w,k,ld). \tag{2.3}$$

Substituting equation (2.3) into (2.1), we have

$$\pi^* + i\cdot k + r\cdot ld = P\cdot Q(l^*,k,ld) - w\cdot l^*. \tag{2.4}$$

Differentiating with respect to P provides the short-run supply function

$$Q^* = \frac{d(\pi^* + i\cdot k + r\cdot ld)}{dP}. \tag{2.5}$$

The area between the equilibrium price line and the supply curve is determined by the definite integral of Q^* with respect to P, from AVC, the firm's lowest average variable cost, to the output price P. Since at the lower limit of the integral output is zero, the definite integral equals the corresponding indefinite integral evaluated at the output price P,

$$\int_{AVC}^{P} Q^* dP = \pi^* + i\cdot k + r\cdot ld. \tag{2.6}$$

When P is unexpectedly higher than the firm's average total cost, π^* is positive. As explained in the previous section, this profit arises from uncertainty. Since both land and capital are assumed fixed, r·ld is the rent to land (ld), i·k is the rent to capital (k), and their sum is the quasi-rent. Given homogenous firms, the industry's sum of profit and quasi-rent is simply the number of firms in the industry times the profit and quasi-rent of the representative firm. Hence, the area above the industry's supply curve is equal to the expression in equation (2.6) times the number of firms in the industry. This result illustrates the previous conclusion that in the short-run "producer's surplus" is the sum of profit and quasi-rent.

The difference between the long-run and short-run scenarios is that in the long-run, more factors of production can vary, and firms can exit and enter the industry. Given homogeneous firms and competition, both quasi-rent and profit disappear in the long-run. This is the standard zero-profit condition required for long equilibrium in a competitive industry. Hence, producer's surplus in the long-run is conceptually different from the short-run measure derived above. Moreover, the divergence in the short-run and the long-run measures of producer's surplus will affect another commonly-used term: gains from trade (or social gain), conventionally defined as the sum of consumer's surplus and producer's surplus (Landsburg, 1989, p. 221). Utilizing the above result, it can be concluded that gains from trade in the short run are the sum of consumer's surplus, quasi-rent, and profit. In contrast, the following analysis indicates that in the long-run, producer's surplus is the rent to specialized factor(s); consequently, gains from trade in the long run are the sum of consumer's surplus and the rent to specialized factors.

Now, consider the long-run scenario and assume that both labor and capital are variable. Let each firm employ exactly one unit of labor, in which case the number of firms in the industry can be viewed as equal to the units of labor employed by the industry. To further facilitate the analysis, denote the total labor, capital and land employed by the industry as L, K, and LD, respectively. Hence, each identical firm's production function, Q = Q(1,k,ld), can be rewritten as $Q = (1, \frac{K}{L}, \frac{LD}{L})$. Under the assumption of constant returns to scale, the industry's production function is LQ = Q(L,K,LD).

Given the above production function, the industry can also be viewed as a single, multi-plant firm that operates subject to a zero-profit constraint. This approach is equivalent to assuming a fully-regulated industry, so that in the long-run, output price equals the marginal cost of producing and implicit factor prices are equal to their opportunity costs. This approach yields the same outcome as would prevail under perfect competition. Treating the industry as a single firm, however, facilitates the analysis and allows for a simple example to illustrate this section's main points.

Since the ultimate purpose of this model is to measure the area below the price line and above the industry's long-run supply curve, it is assumed that output price P is given. Consider first the case where the prices of labor and capital are constant at w and i, respectively. With a fixed supply of land, the opportunity cost of land is determined by all exogenous variables: output price (P), price of labor (w), and price of capital (i). In long-run equilibrium, the regulated firm produces at the point where its average total cost is lowest, and maximizes its profit by choosing K and L. The objective function for the firm is

(2.7) $$\max \pi = P\cdot Q(L,K,LD) - w\cdot L - i\cdot K - r(p,w,i)\cdot LD = 0.$$

The first order conditions are

(2.8) $$\frac{\partial \Pi}{\partial L} = P\frac{\partial Q}{\partial L} - w = 0,$$

and

(2.9) $$\frac{\partial \Pi}{\partial K} = P\frac{\partial Q}{\partial K} - i = 0.$$

Assuming the second order conditions are met, equation (2.8) and (2.9) can be solved for optimum amounts of labor and land to yield

(2.10) $$L^* = L^*(P,w,i,LD),$$

and

(2.11) $$K^* = K^*(P,w,i,LD).$$

Substituting equation (2.10) and (2.11) into equation (2.7) yields the profit function,

$$\pi^* + r(P,w,i)\cdot LD = P\cdot Q(L^*,K^*,LD) - w\cdot L^* - i\cdot K^*. \tag{2.12}$$

Given the above profit function, the long-run supply function of the firm is obtained by differentiating both sides with respect to P,

$$Q^* = \frac{\partial[\pi^* + r(P,w,i)\cdot LD]}{\partial P}. \tag{2.13}$$

The area between the equilibrium price and supply curve is determined by

$$\int_{P_0}^{P} Q^* dP = \pi^* + r\cdot LD. \tag{2.14}$$

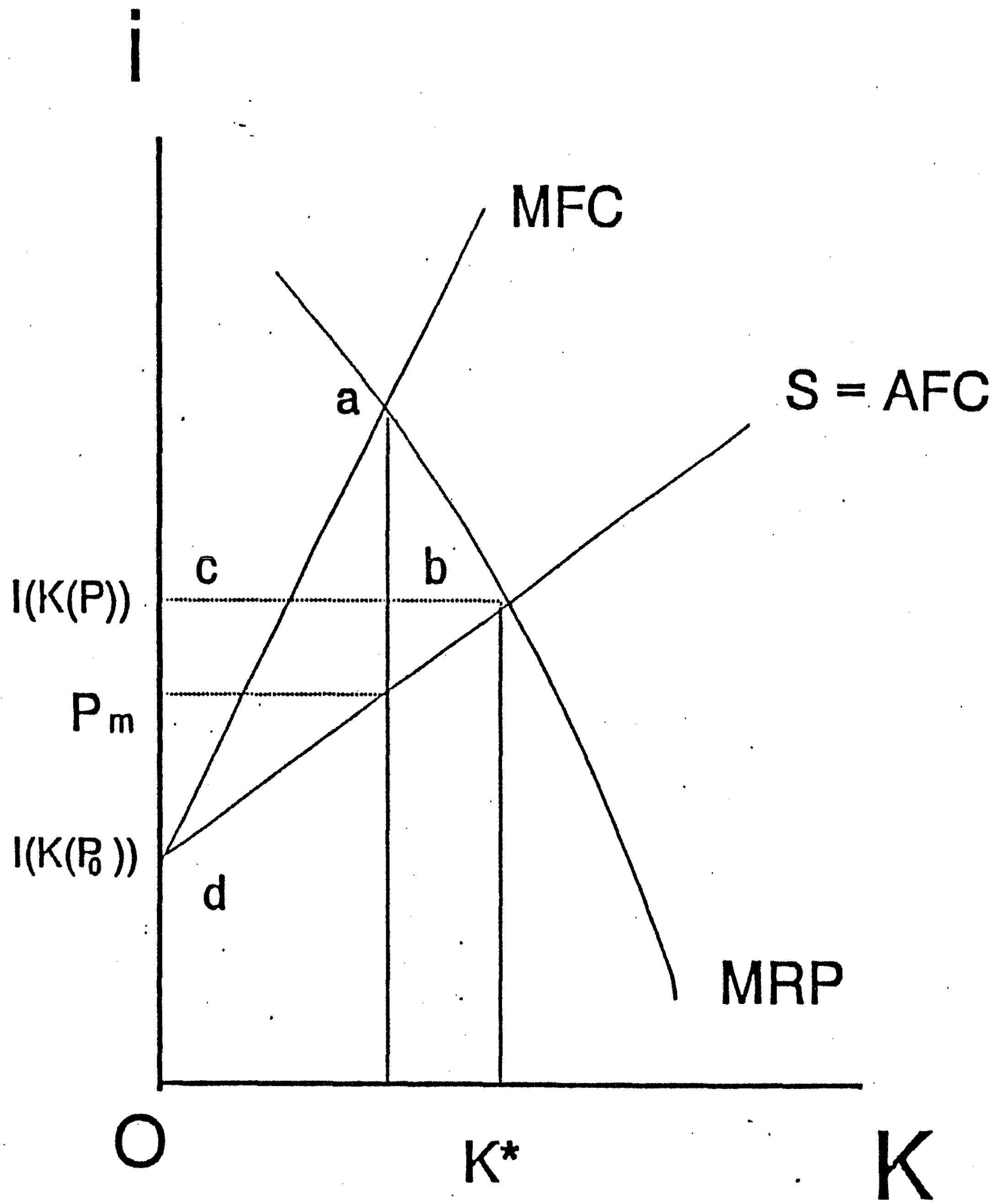
Since profit is zero in the long-run, the total gain from trade accruing to factor owners is the rent to land, r·LD, evaluated at the output price P. This result demonstrates the previous conclusion that with a factor supply fixed and other factor prices held constant, the long-run concept of producer's surplus measures the Ricardian rent, i.e., rent to the fixed factor, high-quality land.

Now consider the case where the price of capital is variable. This will allow for an examination of Mishan's conclusion that the area above the long-run supply curve has no economic significance. With a permanent increase in output price resulting from an increase in demand for the output, Q will expand through increased production by existing firms and/or entry of new firms. In the model offered here, output expansion is carried out through establishment of new plants by the firm, i.e., a change in L, and a change in each plant's employment of capital and land.

However, the assumption that the price of capital is a positive function of K, (i(K)), requires some elaboration. Suppose the firm faces an upward-sloping capital supply curve, S = AFC, as shown in Figure 4. This, in turn, implies there is some specialized factor used in production of the capital. In long-run competitive equilibrium, however, the suppliers earn zero profit. If the specialized factor is in fixed supply, like land in the previous model, it will receive a rent which is equal to the area above the capital supply curve and below the price line for i. Given these assumptions, the rent to capital will actually accrue to the specialized factor used in the production of capital.

Because there is an upward-sloping supply curve of capital, an increase in the demand for the final output will result in the price of capital being bid up. Accordingly, each point along the firm's long-run supply curve will represent a different set of factor prices and a different number of plants. Since we are attempting to replicate a competitive, one-firm industry, the firm can not be allowed to act as a monopsonist. Thus, we must force the firm to pay a price that equals its average cost of capital, not its marginal factor cost. As shown in Figure 4, given the firm's

Figure 4 A Competitive Factor Market Equilibrium



marginal revenue product curve (MRP), the constrained optimization point is b. At that point, the price of capital equals the firm's average factor price (AFC) with K^* units of capital employed. Note that it is not at point a, where an unconstrained profit maximizing firm would equate its marginal revenue product with its marginal factor cost of capital (MFC), and pay P_m per unit for capital. If the firm's derived demand for capital changes, the equilibrium points are along the firm's average factor cost curve (AFC), not the marginal factor cost curve (MFC).

Recall that when factor prices were exogenously determined, the opportunity cost of land was a function of output price (P), price of capital (i), and price of labor (w). In that case, the firm selected L and K to maximize its profit. The difference now is that the price of capital (i) is a function of capital employed, and as shown in Figure 4 the firm is constrained to pay the average factor cost of capital. Given this constraint, the firm's objective function is

(2.15) $$\max \pi = P \cdot Q(L,K,LD) - w \cdot L - i(K) \cdot K - r(P,w,i(K)) \cdot LD,$$

Subject to $$\pi = 0.$$

The first order conditions are

(2.16) $$\frac{\partial \pi}{\partial L} = P\frac{\partial Q}{\partial L} - w = 0,$$

and

$$(2.17)\qquad \frac{\partial \pi}{\partial K} = P\frac{\partial Q}{\partial K} - i - \frac{\partial i}{\partial K}K - \frac{\partial r}{\partial i}\frac{\partial i}{\partial K}LD$$
$$= P\frac{\partial Q}{\partial K} - i - \frac{\partial r}{\partial i}\frac{\partial i}{\partial K}LD$$
$$= 0.$$

Because of the constraint that forces the firm to pay a price equal to its average factor cost of capital, the first order conditions above are different from those of an unconstrained maximization. This constraint implies that the term $\frac{\partial i}{\partial K}K$ in equation (2.17) is set to zero. Assuming the second order conditions are met, equation (2.16) and (2.17) can be solved for optimum amounts of labor and capital,

$$(2.18)\qquad L^* = L^*(P,w,LD),$$

and

$$(2.19)\qquad K^* = K^*(P,w,LD).$$

Substituting equations (2.18) and (2.19) into equation (2.15) yields

$$(2.20)\quad \pi^* = P\cdot Q(L^*,K^*,LD) - w\cdot L^* - i(K^*)\cdot K^* - r(P,w,i(K^*))\cdot LD = 0.$$

Given the first order conditions, differentiating both sizes of equation (2.20) with respect to P yields

$$(2.21)\qquad \frac{\partial \pi^*}{\partial P} = P\left(\frac{\partial Q}{\partial L}\frac{\partial L^*}{\partial P} + \frac{\partial Q}{\partial K}\frac{\partial K^*}{\partial P}\right) + Q^* - w\frac{\partial L^*}{\partial P} - i\frac{\partial K^*}{\partial P}$$
$$- \frac{\partial i}{\partial K}\frac{\partial K^*}{\partial P}K^* - \frac{\partial r}{\partial i}\frac{\partial i}{\partial k}\frac{\partial K^*}{\partial P}LD - \frac{\partial r}{\partial P}LD$$
$$= Q^* - \frac{\partial i}{\partial K}\frac{\partial K^*}{\partial P}K^* - \frac{\partial r}{\partial P}LD.$$

Thus, the supply function is

$$Q^* = \frac{\partial \pi^*}{\partial P} + \frac{\partial i}{\partial K}\frac{\partial K^*}{\partial P}K^* + \frac{\partial r}{\partial P}LD. \tag{2.22}$$

The area between the equilibrium price line and the supply function is determined by

$$\begin{aligned} \int_{P_0}^{P} Q^* dP &= \pi^* + \int_{P_0}^{P} r \cdot LD \, dP + \int_{P_0}^{P} \frac{\partial i}{\partial K}\frac{\partial k^*}{\partial p}K^* dp \\ &= r \cdot Ld + \int_{K(P_0)}^{K^*(P)} \frac{\partial i}{\partial K}K^* dK \\ &= r \cdot LD + \int_{i(K^*(P_0))}^{i(K^*(P))} K^* di. \end{aligned} \tag{2.23}$$

As before, r·Ld evaluated at the output price P is the rent to land. The second term on the right side is the area above the capital supply curve (area cbd in Figure 3). Hence, the area between the industry's supply curve and the output price is equal to two components: the rent to land and the rent to the specialized factor employed in the production of capital.

The conclusion stated above can be illustrated further with a simple example using the Cobb-Douglas production function. Denote the firm's production function as

$$Q = AK^{\alpha}L^{\beta}LD^{\gamma}, \tag{2.24}$$

where $\alpha + \beta + \gamma = 1.$

Further, assume that the supply function of capital is

$$i = a + b\,K, \tag{2.25}$$

where a>0 and b>0.

Substituting equations (2.24) and (2.25) into first order condition (2.16) and (2.17), and setting A = 1, K can be solved

(2.26) $$K^* = B\,P^{\frac{1}{(1-\alpha-\beta)}},$$

where $$B = \left(\frac{\beta}{w}\right)^{\frac{\beta}{(1-\alpha-\beta)}}\left(\frac{\alpha}{i}\right)^{\frac{(1-\beta)}{(1-\alpha-\beta)}} LD^{\frac{r}{(1-\alpha-\beta)}}.$$

Differentiating both sides of equation (2.26) with respect to p, we have

(2.27) $$\frac{\partial K^*}{\partial P} = \frac{K^*}{P(1-\alpha-\beta)}.$$

Differentiating both sides of equation (2.25), we have

(2.28) $$\frac{\partial i}{\partial K} = b.$$

From equation (2.23), the area above the industry's supply function is

(2.29) $$\int_{P_0}^{P} Q^* dP = r \cdot LD + \int_{P_0}^{P} \frac{\partial i}{\partial K}\frac{\partial K}{\partial P} K^* dP.$$

Substituting equations (2.26), (2.27), and (2.28) into equation (2.29), we have

(2.30) $$\begin{aligned}\int_{P_0}^{P} Q^* dP &= r \cdot LD + b\int_{P_0}^{P} \frac{1}{P(1-\alpha-\beta)} * B^2 P^{\frac{2}{(1-\alpha-\beta)}} dP \\ &= r \cdot LD + \frac{1}{2}\, bB^2 P^{\frac{2}{(1-\alpha-\beta)}} \\ &= r \cdot LD + \frac{1}{2}\, bK^{*2},\end{aligned}$$

where r·LD, evaluated at the output price P, is the rent to land and the second term on the right side is the rent to the factor input K, measured by the area above the capital supply curve. The sum of the two terms on the right side is equal to the area above the firm's supply function. Hence, the Cobb-Douglas production function provides an illustration for the model. We can now conclude that, contrary to Mishan's conclusion, the area above the long-run supply curve does have an economic meaning -- it is a measure of rent attributable to specialized factor inputs.

In the above analysis, it is implicitly assumed that capital is supplied every period. Hence, there is no stock of capital as in the usual sense. Rather, capital depreciates fully each time period. In applications presented in Chapter 4, the capital -- namely cows in the dairy industry -- last for more than one time period, and thus some adjustment to this model will be necessary.

Conclusion

In this chapter, the concept of producer's surplus in both the short-run and long-run has been examined. It was shown that the concept of producer's surplus, although widely used, is not clearly defined. First, it has not been consistently applied, as short-run and long-run concepts measure very different things. In the short-run, it measures the sum of quasi-rent and profit, and in the long-run, it measures the economic rent to specialized factor inputs. Second, the notion of "producer" is ambiguous because it can represent either the entrepreneur (the firm), or the owner of factor inputs, or both. Finally, the term is unnecessary because the economic meaning of producer's surplus can be completely represented by other economic terms, namely profit, quasi-rent, and rent. So contrary to what is commonly believed, producer's surplus is generally not a good measure of welfare, because its use as a measure of producer's welfare can cause confusion and be misleading. As a consequence, in the following chapters when the long-run concept of producer's surplus is applied, it is referred to as rent rather than producer's surplus.

CHAPTER 3

THE U.S. DAIRY INDUSTRY: DEVELOPMENTS, MARKET MECHANISM, AND RENTS

This chapter presents an estimate of rents in the U.S. dairy industry. A brief history of the developments in the U.S. dairy industry during the past 40 years is provided with a discussion of federal regulations that have significantly influenced the output and prices of dairy products.

History of the U.S. Dairy Industry: 1950-89

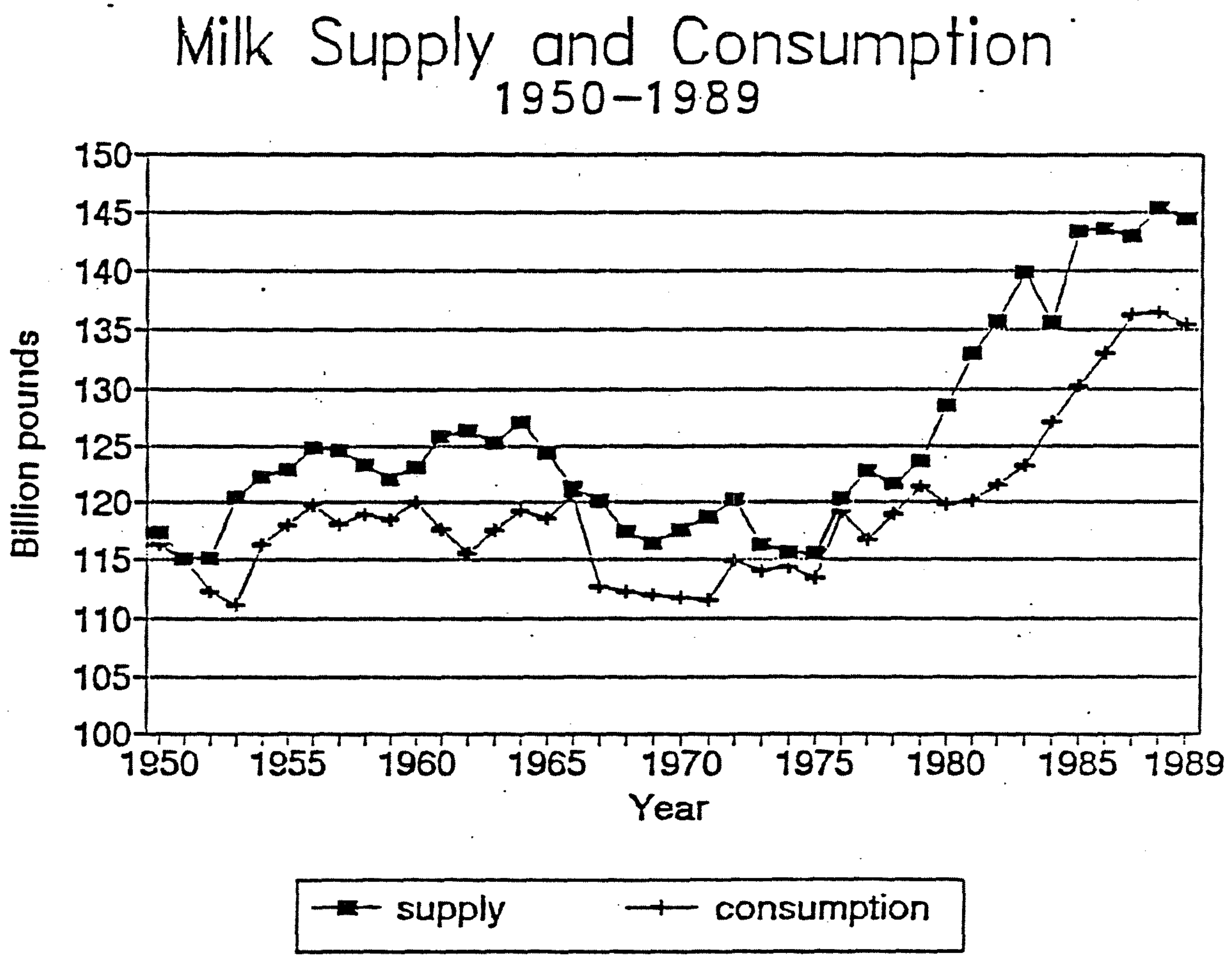
The dairy industry is one of the most important agricultural industries in the U.S. economy. For the past 40 years, dairy products have typically accounted for over 10 percent of the total cash income from all farm commodities (Fallert et al., 1990, p. v). In 1989, total receipts from the sale of dairy products amounted to 19.4 billion dollars, which represents more than 12 percent of total cash receipts from all farm commodities and ranks second only to that from cattle and calves of 36.7 billion dollars. Imports and exports of dairy products are small, with each amounting to about 2 percent of total production. More than half of the total U.S. milk supply comes from five states: Wisconsin, California, New York, Minnesota, and Pennsylvania.

As shown in Figure 5, the total supply of milk slowly increased during the 1950s and early 1960s, but dropped in the late 1960s with a low point occurring during the 1973-75 recession. Since then, the milk supply has increased. The bottom line in Figure 5 is total milk consumption. The difference between supply and consumption is net government removals (NGR) which reflect government purchases. These removals varied substantially during the 1980s.

The number of cows on farms generally declined during 1950-89, except for a slight increase in the early 1980s. Despite the decrease in the number of cows, the supply of milk has increased because milk production per cow has greatly increased. Increase in dairy productivity can be attributed mainly to improved genetic merits of cows and better management of dairy farming. Figure 6 shows that the number of cows dropped from almost 22 million head in 1950 to approximately 10 million head in 1989. Figure 7 shows that in the past 40 years milk production per cow has increased continuously, with the only exception being 1973, when feed costs increased substantially.

During the past 40 years, the supply of milk has always exceeded consumption, and so government stocks have grown. In response to the surplus and high program costs, the federal government introduced supply-management programs in the early

Figure 5



Milk Supply and Consumption
1950-1989
Billion pounds
150
145
140
135
130
125
120
115
110
105
100
1950
1955
1960
1965
1970
1975
1980
1985
1989
Year
supply
consumption

Figure 6

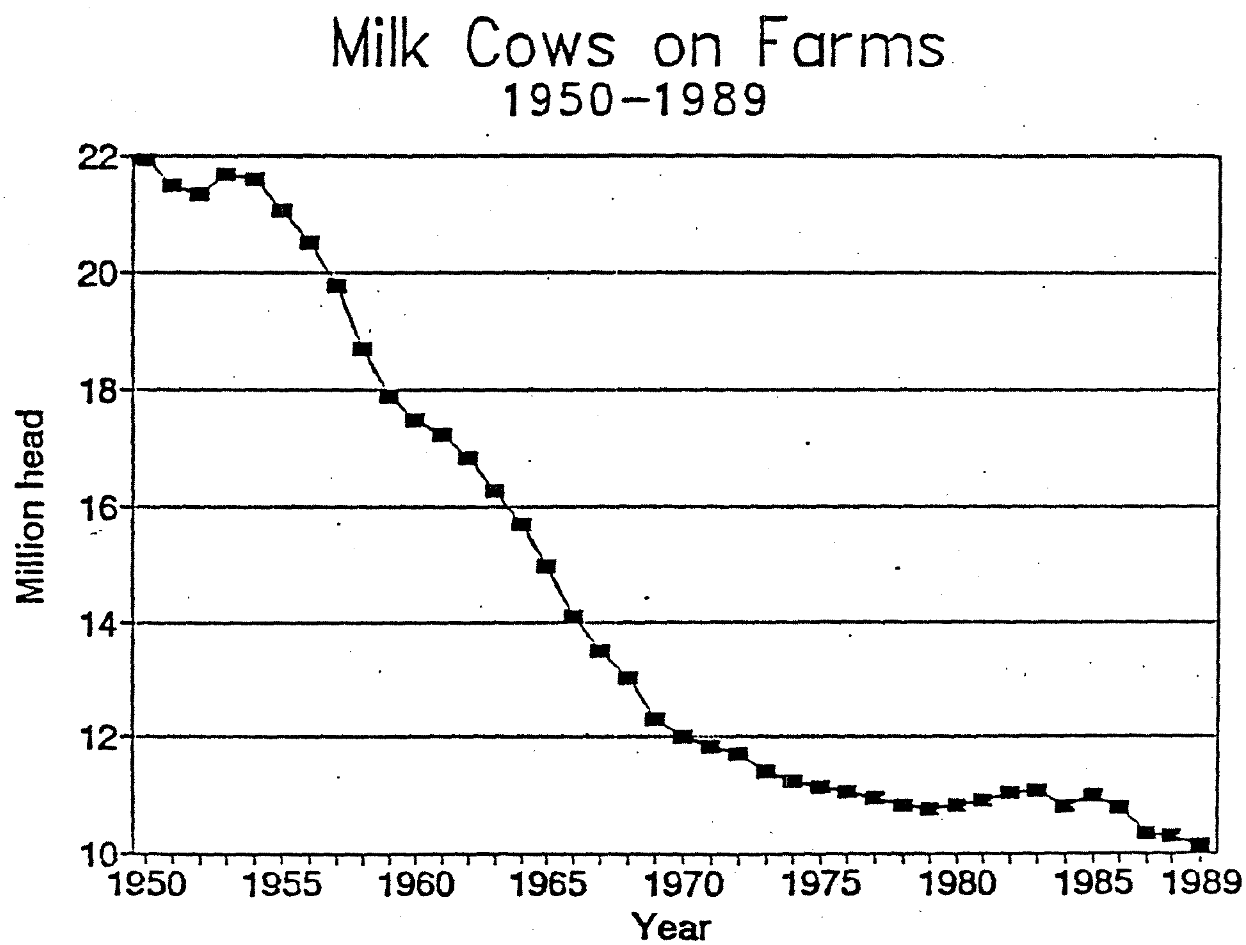
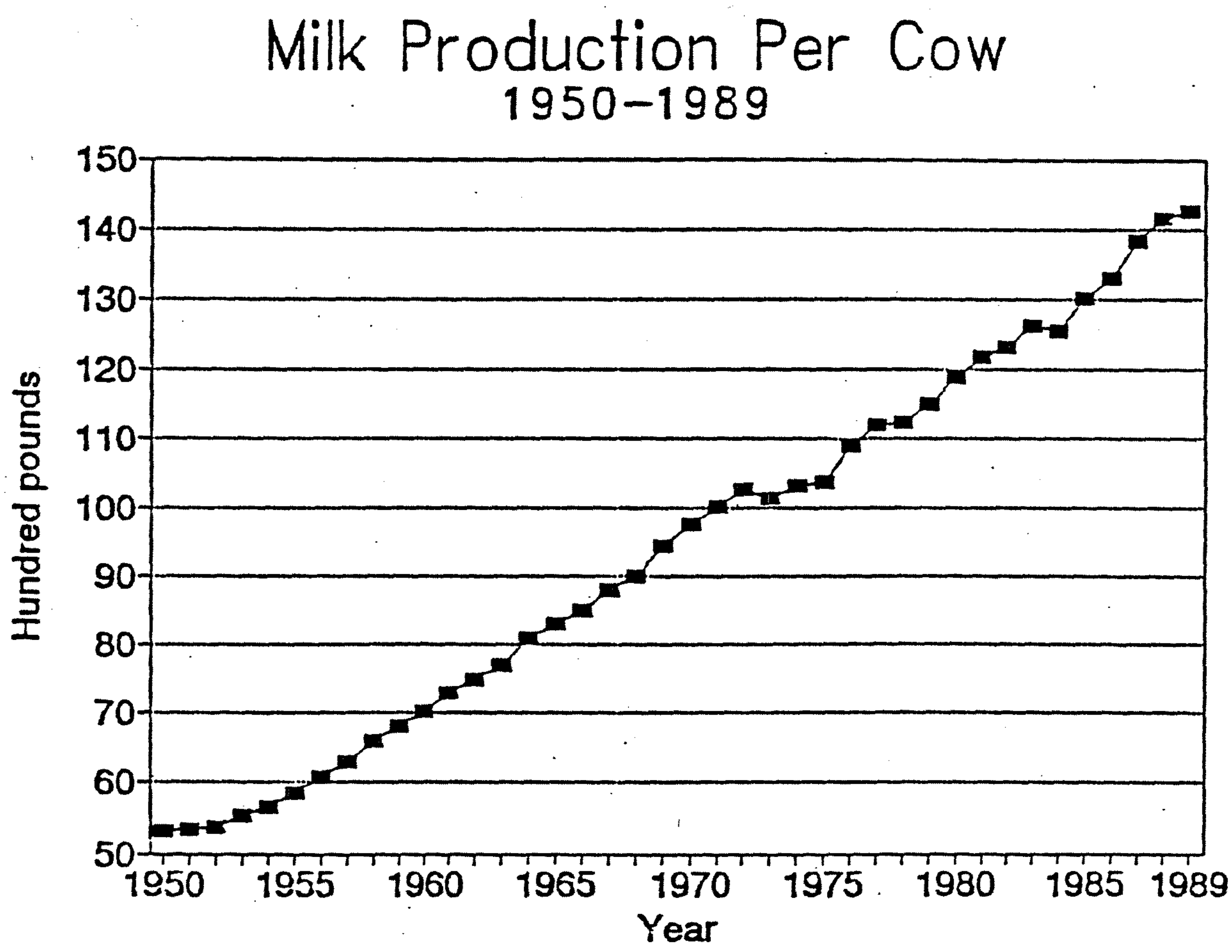

Milk Cows on Farms
1950-1989
Million head
Year
22
20
18
16
14
12
10
1950
1955
1960
1965
1970
1975
1980
1985
1989

Figure 7


Milk Production Per Cow
1950–1989
150
140
130
120
110
100
90
80
70
60
50
Hundred pounds
1950
1955
1960
1965
1970
1975
1980
1985
1989
Year

1980s. In 1984, a dairy diversion program was established to discourage milk production, and in 1986 and 1987, the Dairy Termination Program encouraged farmers to leave the industry. The effects of these programs are illustrated in Figures 5 and 6, which show that milk supply and cow numbers declined sharply in 1984 and 1986-87.

Government intervention has been a prominent characteristic of the U.S. dairy industry during the past 40 years. Through the federal dairy program, which is among the largest of the various agricultural commodities programs, the government has significantly affected milk prices and output -- and to a large extent, has shaped the development of the dairy industry. Hence, in order to fully comprehend the U.S. dairy industry, an understanding of the functioning of the federal dairy program is necessary.

The beginnings of the U.S. federal dairy program can be traced to the early part of this century when the Capper-Volstead Act (1922) was passed. The act provided for the establishment of farm cooperatives, and to increase sales of milk, the cooperatives introduced classified pricing. This system set milk prices according to designated usage, and remains one of the key features of the current dairy order system. During the depression of the 1930s, agricultural industries were affected more heavily than other industries. Milk price received by farmers dropped drastically, and so their income declined. Farmers then urged the government to stabilize the industry and to increase their income through programs that could increase the price of milk.

The objective of many government programs is to transfer wealth (Peltzman, p. 212). These transfers are generally the result of trades in the political market. The suppliers, politicians, agree to provide these transfers to maximize their political support. The buyers, interest groups, pay with both votes and money. Peltzman (1976, p. 211) has shown that vote-maximizing behavior implies that a regulator will not serve exclusively the interests of any one group. Moreover, regulation will tend to be more heavily weighted toward "producer protection" in a depression, and toward "consumer protection" in an expansion. The depression of the 1930s had allowed dairy farmers to be a successful special-interest group, and farmers exerted political pressure by trading votes and making compromises in an attempt to obtain favorable regulation. In 1937, the Agricultural Adjustment Act was passed and the dairy programs came into effect.

The objectives stated in the 1937 act were: to maintain orderly market conditions, to establish parity prices for farmers, to protect the interests of consumers, and to avoid unreasonable fluctuations in supply and prices (Fallert et al., 1990, p. 27). The dairy order may have helped maintain orderly market conditions in the early years of its operation because at that time, the cost differential between Grade A (high quality milk for fluid use) and Grade B milk (lower quality milk for manufacturing use) was large. Classified pricing was justified because the price differential between class 1 (milk for fluid use) and class 2 milk (milk for manufacturing use) was necessary to assure that Grade A milk would bring a higher price, commensurate with its higher costs. However, now the situation is quite different. With better and less-costly refrigeration technology, the cost differential between Grade A and Grade B milk has narrowed substantially. In fact, Grade B milk is vanishing as farmers can upgrade milk at a low cost, thereby taking advantage of the federal dairy order which is only applicable to Grade A milk. Regardless of the stated objectives, the current dairy order is supported by farmers primarily as a means to enhance incomes.

During its more than 50 year history, the federal dairy program had many amendments. However, within our period of analysis, i.e., 1950-89, the following aspects have basically remained unchanged.

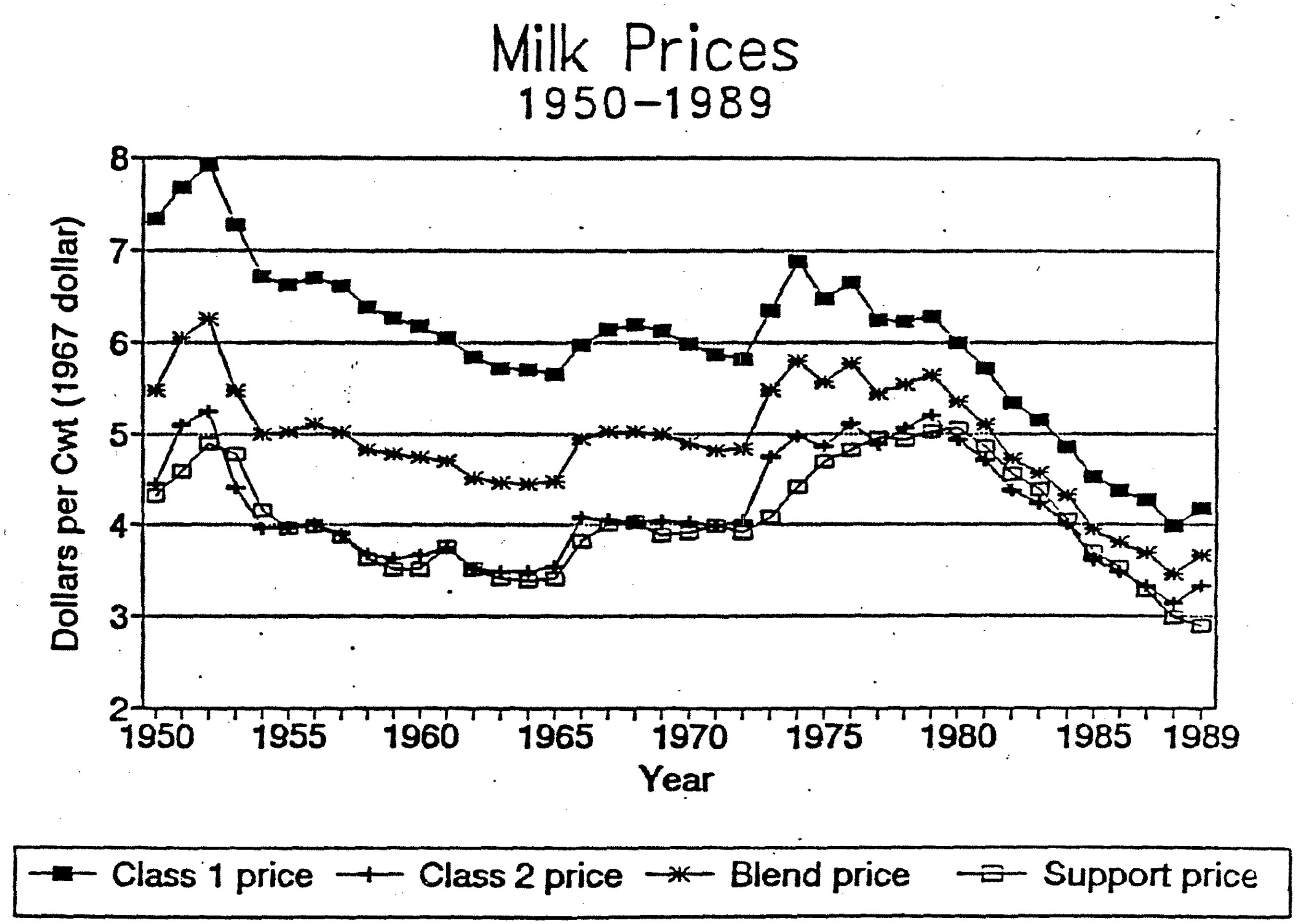
Applicable only to Grade A milk, the federal dairy order system contains two major parts: a price support program and a milk marketing order program. In the marketing order program, milk is designated into 3 classes according to how it is utilized. Class 1 represents milk for fluid use; class 2 represents soft products such as ice cream and cottage cheese; class 3 represents hard products like butter and cheese. To simplify our analysis, we hereafter define class 2 milk as all the milk used for manufacturing, i.e., for both soft and hard products. The price support program authorizes the Secretary of Agriculture to set a minimum farm level price for class 2 milk. Minimum prices of class 1 milk are set by adding fixed differentials to the minimum class 2 price. The differential between minimum prices of class 1 and class 2 milk increases with the distance from the market area of Eau Clair, Wisconsin, a low cost producing region. Before 1981, the minimum price was chosen on basis of parity prices, which are based on the purchasing power of a unit of milk in 1910-14. But after 1981, the parity basis was dropped and the class 2 minimum price was set on the basis of the average price of manufacturing grade milk in Minnesota and Wisconsin. The minimum price of class 2 milk is maintained through the government purchases of manufactured dairy products and hence, is often referred to as the support price.

Although milk processors pay higher prices for class 1 than class 2 milk, the dairy marketing program pools total revenue from sales of both classes, so farmers receive a uniform, average price, a blend price. This blend price is based on the proportion of sales for different uses within a given market area. The actual relationship of prices of class 1 and class 2 milk, the blend price, and the support price during the past 40 years (in real terms; deflated by CPI for nonfat items, 1967 = 100) are presented in Figure 8. If the blend price is higher than the free market equilibrium price, a surplus will be generated. The price support program pledges to remove the surplus from the market through Commodity Credit Cooperation's (CCC) purchases of manufactured milk (butter, cheese, etc.), so as to directly support the specified minimum prices. The federal dairy order pricing system is discussed in more detail in the following section.

Long-run Equilibrium in the Dairy Industry

For simplicity, regional pricing differences are ignored and the U.S. dairy market is treated as a single dairy order. The demand function for class 1 milk is denoted as $D_1 = Q_1(P_1)$, and the demand function for class 2 milk as $D_2 = Q_2(P_2)$. Since farmers receive a uniform blend price (P_b), the supply function is specified as $S = Q(P_b)$. If the minimum price for class 2 milk is set at P_2^0, adding a fixed differential to P_2^0 yields the minimum price for class 1 milk, P_1^0. Assuming that price regulations are binding, quantities demanded for class 1 and class 2 milk will then be $Q_1(P_1^0)$ and $Q_2(P_2^0)$, respectively. Since the price differential is not based on cost differential, the price support program is a form of price discrimination. If the higher price is charged in the market where demand is less elastic, total revenue for any given quantity of milk supplied will be higher than if prices were equal. The dairy program sets the price of class 1 milk higher than that of class 2 milk. If class 1 milk demand is relatively less elastic, total revenue increases, and so, the

Figure 8


Milk Prices
1950-1989
Dollars per Cwt (1967 dollar)
8
7
6
5
4
3
2
1950
1955
1960
1965
1970
1975
1980
1985
1989
Year
Class 1 price
Class 2 price
Blend price
Support price

blend price increases. Therefore, assuming inelastic demands, if the price for either class 1 or class 2 milk is increased, the blend price will increase -- farmers will expand their output, eventually generating a surplus. This surplus is then purchased by the government at P_2^0 and, less any sales by the government, it is net government removal (NGR). Given demand and supply functions, the equilibrium blend price received by farmers is obtained by:

$$Q(P_b) = Q_1(P_1^0) + Q_2(P_2^0) + NGR, \tag{3.1}$$

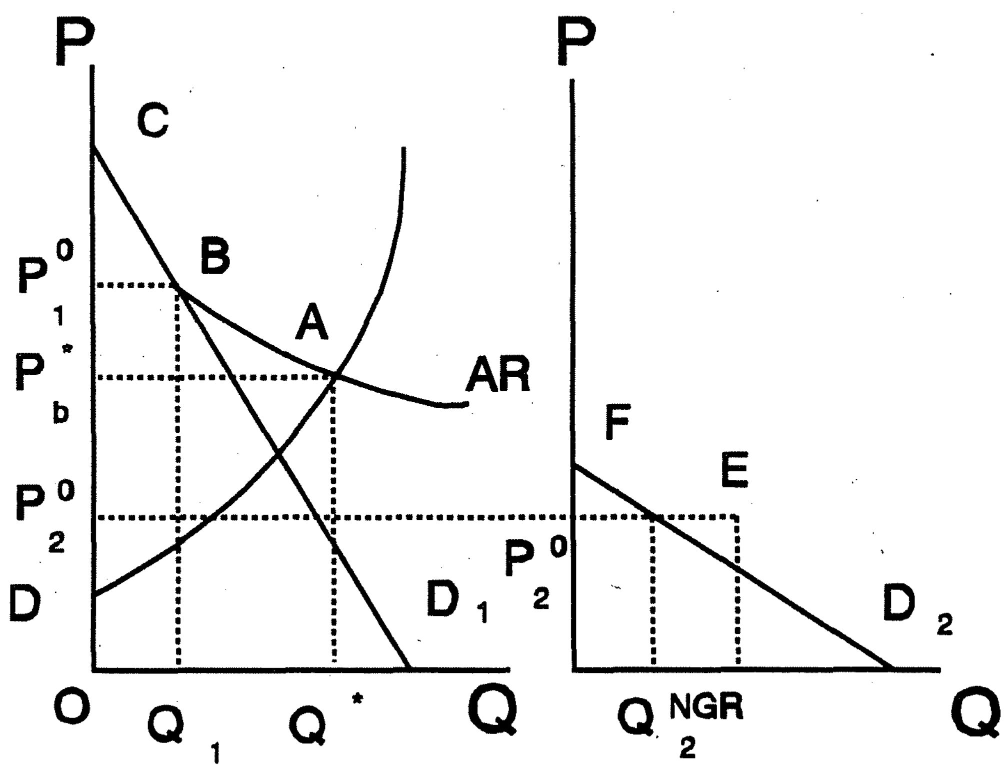
and

$$P_b = \frac{P_1^0 Q_1(P_1^0) + P_2^0 [Q_2(P_2^0) + NGR]}{Q_1(P_1^0) + Q_2(P_2^0) + NGR}. \tag{3.2}$$

Figure 9 shows how the equilibrium blend price is determined. The average revenue (AR) curve, or blend price function, is determined by varying NGR and the regulated equilibrium is reached at point A. The equilibrium price is P_b^*, and total output is Q^*, of which Q_1 is class 1 consumption, Q_2 is class 2 consumption. When $(Q^*-Q_1-Q_2)$ is positive, there is a surplus -- NGR -- which is purchased by the government.

Recall from Chapter 2 that, given a competitive industry, the total benefit from production is the rent to specialized factor(s) used directly or indirectly to produce the industry output. This rent can be measured by the area between the equilibrium price line and the industry's long-run supply curve. Similarly, rent in the U.S. dairy industry can be

Figure 9 Regulated Equilibrium in the U.S. Dairy Industry



measured by the area P_b^*DA in Figure 9. The following section provides an estimate of rent in the U.S. dairy industry.

Estimating Rent in the U.S. Dairy Industry

Figure 9 shows that once the supply function and equilibrium blend price are known, rent is determined by the definite integral of the supply function with respect to P, from $P = D$ to $P = P_b^*$. Data required to estimate the long-run supply function are available from Agricultural Statistics. These data are time series, covering the period 1950-89. Given the estimated supply function, a calculation of the rents in the U.S. dairy industry can be obtained.

The estimation model used in this section is adapted from models used by Lafrance and De Gorter (1985), and Kaiser *et al.* (1988). Both works specified the total supply function as the product of the number of milk cows and milk production per cow.

Since the price and quantity supplied are simultaneously determined by the interaction of producers and consumers in the market, applying the ordinary least square procedure to estimate an individual supply function may lead to biased and inconsistent parameter estimators. To solve the simultaneity problem, LaFrance and De Gorter used an instrumental variable approach. First, instrumental variables for the prices of class 1 and class 2 milk were obtained, and then the demand functions for both class 1 and class 2 milk were estimated.

With the estimated demand equations, an average farm price for all milk was calculated using predicted quantity values from the two demand functions. This average price was used as an instrumental variable for the blend price in the estimation of the supply function. In the supply function, both the number of cows and production per cow are functions of the blend price. In the model, the production per cow function (PPCOW) was specified as a quadratic function of grain and concentrated feed per cow, hay, and other roughage feed per cow. Cow quality was measured by the proportion of the total herd on test with Dairy Herd Improvement Association three years previously. Cow numbers (COW) were specified as a function of the relative price of utility slaughter cows to the price of corn lagged one year, real prices of inputs (feed and labor), and cow numbers lagged 1, 2, and 3 periods respectively.

In contrast, Kaiser et al. assumed that the blend price was exogenous in functions for cow numbers and production per cow. Thus, the two equations were estimated independently. Cow numbers (COW) were further specified as a function of the lagged ratio of the blend price to feed cost; a one-period lagged slaughter cow price, deflated by the index of price received by farmers, and cow numbers lagged 1 period. Production per cow (PPCOW) was written as a function of the lagged ratio of the blend price to feed cost, and a time trend.

Following Lafrance and De Gorter's and Kaiser et al.'s work, the standard definition of total supply of production per cow (PPCOW) times cow numbers (COW) was adopted for this study. In the PPCOW function, a linear trend was included to approximate technological advances, in the COW function, a lagged dependent variable is included to capture adjustment effects. Finally, LaFrance and De Gorter's approach is utilized to deal with the problem of simultaneity.

The following specification for PPCOW is used:

(3.3) $$PPCOW_t = a_0 + a_1 P_b/FC_t + a_2 T + e_t,$$

where P_b is the blend price, which is expected to be positively related to PPCOW. That is, a higher P_b acts as an incentive to increase productivity. FC is feed cost, which has a negative effect on productivity, and T is a time trend which captures technical changes. The error term is denoted by e_t.

The specification for COW function is,

(3.4) $$COW_t = a_0 + a_1 P_b/PC_t + a_2 D_{86-87} + a_3 COW_{t-1} + e_t,$$

where PC is the price of slaughtered cow, representing the opportunity costs of keeping the cow. A dummy variable, D_{86-87}, which equals 1 in year 1986 and 1987, and 0 otherwise, was included to capture the effect of the Dairy Termination Program for 1986-87. COW_{t-1} captures the stock adjustment effect or the capacity constraint.

In contrast to Kaiser et al., we do not assume that the blend price is exogenous. In order to deal with the potential problem of simultaneity in the estimation of PPCOW and COW functions, an instrumental variable for blend price was defined. Similar to LaFrance and De Gorter, we define the instrument for the blend price as

$$\hat{P}_b = \frac{\hat{P}_1 \hat{Q}_1 + \hat{P}_2 (\hat{Q}_2 + NGR)}{\hat{Q}_1 + \hat{Q}_2 + NGR}, \tag{3.5}$$

where $\hat{P}_1$ and $\hat{P}_2$ are instruments for the class 1 milk price (P_1) and the class 2 milk price (P_2), respectively. These two instruments were also used to estimate the demand functions, and in obtaining the predicted values $\hat{Q}_1$ and $\hat{Q}_2$ for the demand of class 1 milk (Q_1) and the demand of class 2 milk (Q_2), respectively.

Data used in this study are annual time series data from 1950-89, obtained from U.S. government publications. Appendix A contains a complete data set with sources. Appendix B shows how the variable %NONMETRO was generated. All prices (including the price indexes) and income were deflated using the CPI for non food items (1967 = 100). Table 1 presents estimated equations for the dairy demand and supply model. Equations 1-3 were estimated using ordinary least squares procedure. For Equations 4-6, it was necessary to correct for a first-order auto-regressive error structure. Values in parentheses are t-ratios. The Durbin-Watson statistic is denoted as D.W., and for regression equations containing a lagged-dependent variable, the Durbin-h statistic, D.H., is reported.

Table 1 Estimated Equations of Dairy Supply and Demand

1. Class 1 Milk Price

$$P_1 = -\,0.678 + 1.209\ P_{1s} - 0.294\ D_{73\text{-}76}$$
$$\quad (-2.25)\quad (22.15)\qquad (-2.2)$$

adjusted R^2 = 0.93 d.f. = 37
s.e.e = 0.24 s.e.e. / (mean of dep. variable) = 0.04

2. Class 2 Milk Price

$$P_2 = 0.44 + 0.904\ P_{2s} + 0.419\ D_{73\text{-}76}$$
$$\quad (2.24)\ (18.6)\qquad (2.24)$$

adjusted R^2 = 0.92 d.f. = 37
s.e.e = 0.17 s.e.e. / (mean of dep. variable) = 0.04

3. Per Capital Class 1 Demand

$$Q_1 = -0.053 - 0.44E{-}2\ P_1 + 0.0103\ PBEV + 0.13E{-}4\ INCOME$$
$$\quad (-2.13)\quad (-5.39)\qquad (2.6)\qquad (2.85)$$
$$+\ 0.31E{-}2\ \%YOUNG + 0.105E{-}2\ \%NONMETRO + 0.608\ Q_{t-1}$$
$$\quad (3.39)\qquad (4.47)\qquad (5.39)$$

Adjusted R^2 = 0.99 d.f. = 32
D.W. = 1.99 D.H. = 0.03
s.e.e.= 0.003 s.e.e / (mean of the dep. variable) = 0.012

4. Per Capital Class 2 Demand

$$Q_2 = 0.487 - 0.021\ P_2 + 0.475\ POF - 0.25E{-}4\ INCOME$$
$$\quad (4.03)\quad (-3.45)\qquad (2.21)\qquad (-2.24)$$
$$-\ 0.93E{-}2\ \%YOUNG + 0.19E{-}2\ \%NONMETRO + 0.404\ Q_{2(t-1)}$$
$$\quad (-4.01)\qquad (2.35)\qquad (2.83)$$

Adjusted R^2 = 0.96 d.f. = 32
D.W. = 1.95 D.H. = - 0.38
s.e.e.= 0.008 s.e.e / (mean of the dep. variable) = 0.02

5. Production Per Cow

$$LN(PPCOW_t) = -\,382.97 + 0.0577\ LN(PB/FC_t) + 50.772\ LN(T)$$
$$\quad (-18.51)\quad (1.7957)\qquad (18.62)$$

Adjusted R^2 = 0.998 d.f. = 36
D.W. = 1.81
s.e.e.= 0.013 s.e.e / (mean of the dep. variable) = 0.005

6. Cow Numbers

$$LN(COW) = 0.101 + 0.0314\ LN(PB/PC) - 0.032\ D_{86\text{-}87}$$
$$\quad (1.62)\quad (1.98)\qquad (-3.05)$$
$$+\ 0.9586\ LN(COW_{t-1})$$
$$\quad (41.8)$$

Adjusted R^2 = 0.997 d.f. = 35
D.W. = 1.86
s.e.e.= 0.013 s.e.e / (mean of the dep. variable) = 0.005

The standard error of the estimate is denoted as s.e.e. All estimation was performed with the econometrics computer program SHAZAM.

Equations 1 and 2 in Table 1 were used to obtain the instruments for P_1 and P_2. In equation 1, P_1 was regressed on the minimum price of class 1 milk (P_{1s}), and a dummy variable D_{73-76}, which equals 1 in years 1973-1976, and 0 otherwise. P_{1s} was chosen as an instrumental variable for P_1 because it is determined exogenously and indirectly supported by the federal government. Since it is a price floor, it should be closely related to the market farm level price (P_1). Because P_1 can, on occasion, exceed P_{1s}, the fit is not perfect. The dummy variable D_{73-76} is used to capture the structural change during the period 1973-1976, when an OPEC oil embargo and a domestic wage and price freeze were in effect (Lafrance and De Gorter, 1985, P. 823). This price control policy caused no variation in the observed market price of milk. The effect of this policy at the time was to prevent the class 1 milk price from increasing and the class 2 milk price from decreasing. Similarly, equation 2 was obtained by regressing P_2 on the minimum price for class 2 milk, P_{2s}, and the dummy variable D_{73-76}.

Equation 3 is the estimated demand function for class 1 milk. Based on the argument that consumers cannot fully adjust their behavior within one time period (one year), a partial adjustment model was chosen. The lag effect may result from habit formation and uncertainty about future prices and income. It is also assumed that the marketing margin -- the difference between the retail and farm level price -- is constant. With this assumption, the demand curve at the retail level could be obtained by simply shifting up the demand curve at the farm level by a constant margin. Therefore, the farm level demand function is specified as

$$(3.6) \qquad Q_{1t} = a_0 + a_1 P_{1t} + a_2 \text{PBEV}_t + a_3 \text{INCOME}_t + a_4 \text{\%YOUNG}_t + a_5 \text{\%NONMETRO}_t + r Q_{t-1} + e_{1t},$$

where Q_1 is per capita class 1 milk consumption, P_1 is the price of class 1 milk, PBEV is the price index (1967 = 100) for nonalcoholic beverages, INCOME is per capita disposable income, %YOUNG is the percentage of people under age 15 in the population, and %NONMETRO is the percentage of non metropolitan population. The variables P_1 and INCOME measure the traditional own price and income effects, respectively. PBEV measures the price effect of close substitutes for milk and the variables %YOUNG and %NONMETRO are included to account for demographic changes. To correct for potential simultaneity problems, a predicted value for P_1, obtained from Equation 1, was used as an instrumental variable for P_1.

The estimated demand equation for class 2 milk (Equation 4) contains a specification similar to that for estimating the class 1 milk demand:

$$(3.7) \qquad Q_{2t} = a_0 + a_1 P_{2t} + a_2 \text{POF}_t + a_3 \text{INCOME}_t + a_4 \text{\%YOUNG}_t + a_5 \text{\%NONMETRO}_t + r Q_{2(t-1)} + e_{2t}.$$

Here, Q_2 is per capita class 2 milk consumption, P_2 is the price of class 2 milk, and POF is price index (1967 = 100) for oil and fat. The predicted value for P_2 from equation 2 was used as an instrumental variable for P_2.

Given the estimation results for Equations 1-4, Equation (3.5) can be utilized to construct the instrumental variable ($\hat{P}_b$) for P_b. Substituting $\hat{P}_b$ for P_b in the specifications of PPCOW and COW yields the estimation equations 5 and 6 -- which are estimated in double logarithmic form.

All the independent variables in Equations 1-6 are significant at the 5 percent level except for LN(PB/FC) in Equation 5, and LN(PB/PC) in Equation 6, these are significant at the 10 percent level. All price variables have the expected algebraic signs, and the demographic changes appear to have significant impacts on milk consumption. It appears that young people consume more class 1 milk and less class 2 milk, and people living in non-metropolitan areas consume more dairy products.

Multiplying Equations 5 and 6 of Table 1 yields the supply function in double logarithmic form. The coefficient on the variable $\ln(P_b)$, obtained by this procedure, is the short run supply elasticity, and dividing the short run elasticity by 1 minus the coefficient of the lagged dependent variable, yields the long supply elasticity. Given the estimated parameters, the long run supply elasticity equals 2.15. Compared to estimates reported in other studies, this estimate is neither especially high or low. Reported long-run elasticity of supply have varied from .14 (Hammond, 1974), 2.2 (Dahlgran, 1985), and 2.53 (Chen et al., 1972).

Assuming that the supply curve passes through the origin, the estimated supply function can be rewritten as

(3.8) $$Q_s = k\ P_b^{2.15}.$$

where k represents all other factors that affect supply. Since data are available for quantity supplied each year and the corresponding blend price, k can be calculated by

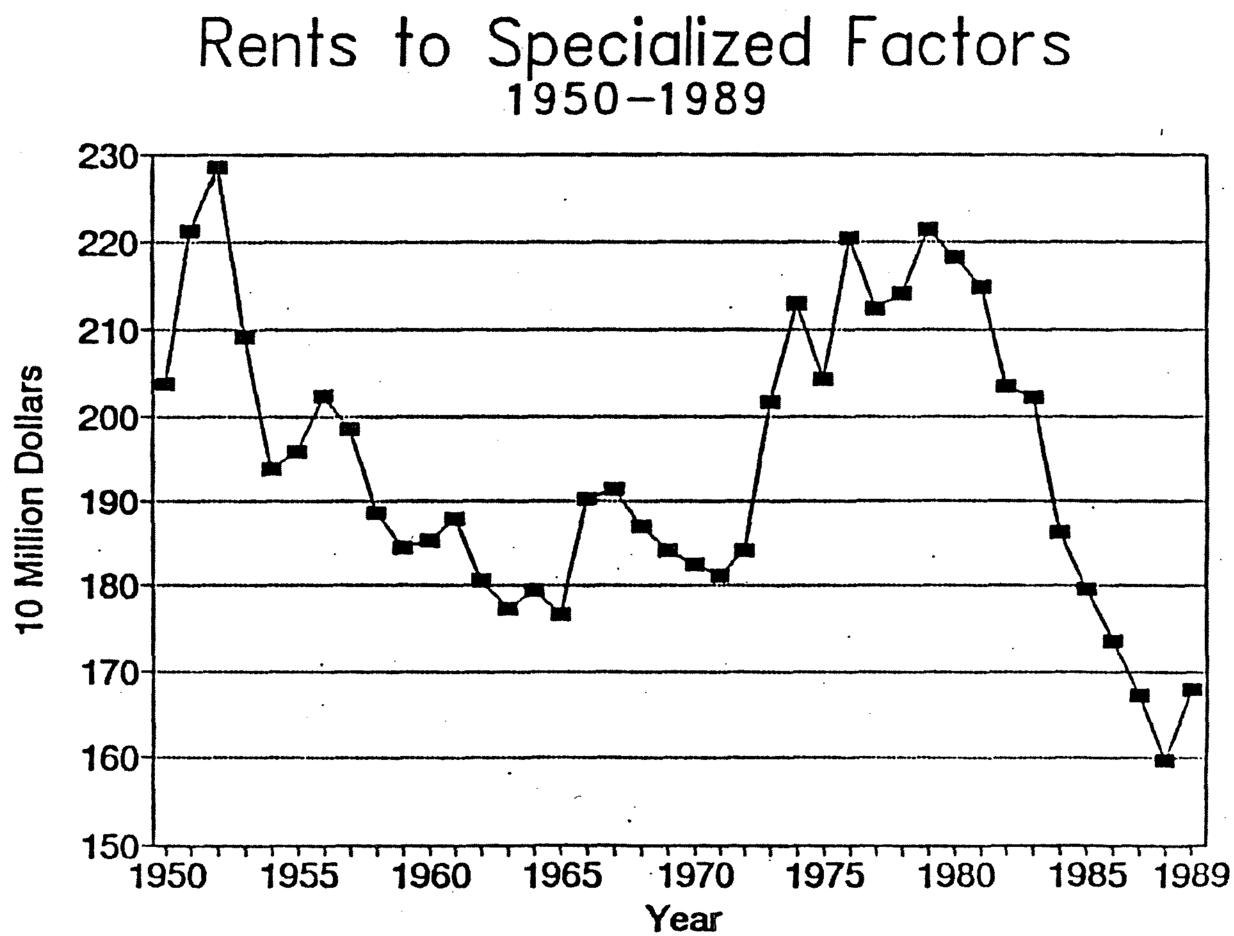
(3.9) $$k = \frac{Q_s}{P_b^{2.15}}.$$

As previously shown, the rent to specialized factor(s) can be determined by calculating the definite integral of the supply function with respect to P, from the price below which zero output is produced, to the equilibrium price. Since the estimated supply curve passes through the origin, the lower limit of integration is zero. Integrating equation (3.9) with respect to P, from zero to P_b, yields the estimated rent in the dairy industry:

(3.11) $$Rent = \int_0^{P_b} kP^{2.15}dP = \frac{k}{3.15}P_b^{3.15}$$

With values for k calculated from equation (3.9), the estimates of the annual rent in dairy industry for each year from 1950 through 1989 were obtained, and are presented in Figure 10.

Figure 10


Rents to Specialized Factors
1950–1989
10 Million Dollars
230
220
210
200
190
180
170
160
150
1950
1955
1960
1965
1970
1975
1980
1985
1989
Year

Conclusion

The first two sections of this chapter provided a brief description of the U.S. dairy industry during the past 40 years. A discussion of the functioning of the federal dairy order system was also presented. The third section presented the estimates of the milk supply function, and computed the annual rents in the U.S. dairy industry from 1950-89. The estimation results indicate that the supply curve of milk is upward sloping, with calculated annual rents ranging from a minimum of $1596.5 million in 1988 to a maximum of $2285.1 million in 1952. Why the supply curve of milk is upward-sloping and which factors receive the rents in the dairy industry are discussed in the next chapter.

CHAPTER 4

SOURCES OF RENT IN THE U.S. DAIRY INDUSTRY

In the previous chapter, annual rents in the U.S. dairy industry were estimated. This chapter considers what specialized factors may account for these positive rents. Empirical tests are performed to identify the specialized factors.

Sources of Rents: Specialized Factors

As shown in Chapter 2, the area below the price line and above an industry's long-run supply curve should be a measure of the rent to specialized factors in the industry. Geometrically, an upward-sloping, long-run supply curve implies positive rent to at least one factor of production. As Hirshlifer and Glazer (1992, p. 182) and others have shown, prices of certain specialized factors of production are bid up as industry output expands.[1] These factors earn an amount in excess of their opportunity cost, i.e., rent.

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1 Hirshlifer and Glazer refer to this situation as an external diseconomy.

As with the term "producer's surplus," the term "specialized factor" also requires a workable definition. Imagine an industry where all firms employ the same factor inputs. If each unit of a particular factor is identical and the factor supply perfectly elastic, there can be no rent attributable to that factor. If the supply functions of all factors are perfectly elastic, each firm that employs those factors will have the same average cost curve, and produce the same amount of output. The output price will equal the average cost, and the industry's long-run supply curve will be horizontal. In reality, however, factor inputs are not identical. In the dairy industry, factors have different qualities, such as management, land, and cows. Since some factors are more productive, and cannot be readily duplicated, farms will compete to hire high-quality factors. Consequently, the price of these factors will be bid up, and rents will accrue to their owners. Hence, farms face different factor prices and factor prices differ because qualities differ. That is the reason why farms are of different sizes. Factors which cannot be duplicated precisely, and whose prices will be bid up under competition, are referred to as "specialized factors."

Some factors, such as land, are specialized by nature. Creative human activity and investment, however, can also generate specialized factors. The dynamic process of technical advancement is an example. Consider first, however, a static, one-period change in technology. Imagine a competitive market where all firms employ an identical factor of production. If a new technology, which increases the productivity of this factor, is suddenly made available at zero cost, firms that are first to adopt it will have an advantage, and earn a profit. However, the profit will not persist. With increased information about the technology, an increasing number of firms will adopt it, and when all firms have adopted the technology, profits will be reduced to zero. Unless the right to the new technology is owned and a positive price can be charged for it, there will be no rent associated with the factor.

The situation is different, however, if technical advancement is a continuous process and there is a set of early adopters. One reason why technical advancement can provide early adopters with rents is that there is a group that can continuously stay ahead of the competition. This happens when the early adopters have an advantage or skill that their competitors do not have. Technical advancement can also provide rents when it is too costly to completely replace the old technology within any given time period. If technology replacement is carried out continuously, there can always be some factors of better quality than others. The existence of a distribution of technologies with different vintages is similar to having land of varying quality, and so implies the existence of rents.

Recall that in the U.S. dairy industry, estimates offered in Chapter 3 show that the long-run supply curve for milk is upward-sloping, and the annual rent in the industry, in constant 1967 dollars, ranges from $1596.6 million in 1988 to $2285.1 million in 1952. Since the milk supply function was estimated using a distributed lag structure, the annual rents were obtained by allowing the full adjustment to occur which means allowing time to approach infinity. Despite the use of an infinite horizon, the lag structure shows that 50 to 70 percent of the adjustment is completed in 16 to 29 years.[2] Hence, this form of distributed lag is not as restrictive as might be assumed. Given an upward-sloping supply function, basic price theory indicates that there must be some specialized factor(s) in the dairy industry. What could these specialized factor(s) be? It is observed that some dairy farms operate on higher-quality land and/or their cows are more productive -- suggesting that specialized factors in dairy production might include land and cows. But what could make these two factors specialized?

In the modern dairy industry, land is primarily used as pasture and for building dairy facilities. Conceptually at least, there should be some lands that are specially suited to dairy farming -- more fertile, located in a climate where the

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2 Given a geometric lag distribution, the time (T) when (1-r) percent of the adjustment is completed is calculated by the formula $T = \ln r / \log \lambda$, where λ is the difference equation coefficient, and r is the significance level. (Tomek and Cochrane, 1962, p. 722).

feed crops grow better, better suited for dairy housing and handling systems (storage, manure disposal facilities, etc.), or located closer to transportation facilities. Since the supply of higher-quality land is likely limited, land could be a specialized factor in the U.S. dairy industry.

Dairy cows, by definition, are "cattle which are especially equipped for the production of milk" (Cambel and Marshall, 1975, p. 42). Dairy cows are only used in dairying, and although sold for meat when culled, they are considered inferior to beef cattle as meat producers. This biological uniqueness makes dairy cows specialized. However, biological uniqueness does not guarantee rents. If there is competition, and the supply of cows is perfectly elastic, the price of a cow will equal the marginal and average cost of raising it, leaving no possibility for rent. In practice, however, cows are not homogenous, suggesting an upward-slopping supply schedule.

Most of the cows in the U.S. dairy industry belong to one of five breeds: Holstein, Guernsey, Jersey, Ayrshire, and Brown Swiss (Campbell and Marshall, 1975, p. 46). Each breed has unique characteristics, and even cows of the same breed are not of the same quality. Some produce higher milk yields, some are more efficient in reproduction, and some are more resistant to disease. Why some cows are better than others and whether heterogeneity of cows can persist in the long-run (thus providing an upward-sloping long-run supply curve of milk) depends on the breeding practices used on the animals.

It is believed that cows were domesticated for milk production around 9000 B.C. or earlier (Campbell and Marshall, 1975, p. 25). The early settlers brought cows to America in the 17th century, and farmers have since attempted to increase their cows' productivity. Advances in technology, such as computers and artificial insemination in dairy breeding, have greatly improved the genetic merits of today's dairy cattle. This improvement has never stopped. With continuing genetic improvement, superior cows have been bred that exceed existing breed averages for production and conformation.

The basic method of genetic improvement entails choosing and mating outstanding sires (bulls) and dams (cows) so that their offsprings have the desired traits. Traits are controlled by a large number of genes and genetic improvement is increasing the proportion of desired genes. In general, desired traits are those that have economic value and can be affected genetically. The extent to which a trait can be improved genetically depends on the heritability of the trait. Heritability describes what fraction of the difference in a trait is attributable to the difference in genetic value (Campbell and Marshall, 1975, p. 126). For example, the heritability of milk yield is 0.25, meaning that 25 percent of the variation is attributable to the difference in the genetic merit of the cow and 75 percent to the difference in environment (such as management and climate). A heritability statistic over 0.2 is normally considered to be high, and improvement of a trait with high heritability is accomplished relatively easily. The sale of milk is the major source of income for most dairy farmers, so desired traits of cows are those associated with milk production.

Once it is decided which traits to select, sires and dams that are superior in these traits are chosen. Experience shows that improving desired traits by choosing cows is limited, thus genetic improvement depends mainly on the selection of superior bulls. The choice of a bull is done through a progeny test which measures the genetic merits of the bull's daughters compared with those of other bulls. Besides the progeny test, pedigree selection, which looks at the genetic merits of a bull's close ancestors, is another tool for identifying a superior bull.

Although selection, especially selection of superior bulls is the key to improving the genetic potential of dairy cows, correct selection does not automatically lead to better cows. This is because during meiosis, a large variety of gene combinations can be produced, which lead to various quality spermatozoa and ova, and as a result, the offsprings are of various quality. However, the probability of getting better offsprings is greatly increased if truly superior parents are selected.

The accuracy of selection can be improved by complete and correct dairy production records, as these records are fundamental to identifying genetically superior animals. Computers have greatly improved dairy production records, and thus increased the possibility of making a sound selection. Another procedure that has improved the quality of a herd is artificial insemination (AI), whereby semen from progeny-tested superior bulls is used. Besides improving the accuracy of selection, AI provides a much wider selection of bulls. It has been estimated that the genetic merit of cows bred by AI are approximately 5-7 percent superior to cows bred by natural mating (Leaver, 1983, p. 27).

Neither computers nor AI were simultaneously adopted by all farmers. Hence, those who utilized these techniques early had a better chance to breed genetically improved cows through accurate selections. With these genetically improved cows continuously replacing inferior cows, the quality of dairy herds is constantly improving. However, it is too costly to replace all cows at once. The normal turnover rate is between 25 and 33 percent with 3 to 4 years required to replace a herd.[3] Generally, better quality and average quality cows require the same amount of investment for housing, equipment, and labor. Thus, the price of high quality cows will be bid

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[3] Data provided by Professor Terry Jaye at Utah State University and Utah Department of Agriculture.

up, and if the breeding costs are not correspondingly higher, owners of high quality cows will earn a rent.

This analysis suggests that biological features, constant advances in technology, and dairy replacement costs all contribute to the heterogeneity of dairy cows. It seems that during the past 50 years these factors have persisted and explain an upward-sloping supply function of milk.[4]

Identifying Specialized Factors in the Dairy Industry

Two specialized factors have been considered that could receive rents in the dairy industry -- land and dairy cows. The following empirical tests indicate whether these two factors are, in fact, related to this paper's estimate of rents in the dairy industry.

The first test helps to determine whether dairy land is a specialized factor in the U.S. dairy industry. Assuming a fixed supply of land, the theoretical model presented in Chapter 2 indicates that annual rental value to the specialized factor land r·LD should be used when testing the relationship between land and estimated rents. Accordingly, the following equation is proposed:

(4.1) $$R_{dairyt} = a_0 + a_1 RV_{ldt} + e_t,$$

where R_{dairyt} = estimated annual rent in the U.S. dairy industry in year t,

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[4] As shown in Figure 7, production per cow has increased over time, suggesting the quality of cows has been constantly improving.

RV_{ldt} = the rental value of dairy land in year t,

e_t = error term.

If dairy land is the only specialized factor in the U.S. dairy industry, the annual rental value of dairy land (RV_{ldt}) should equal the annual rents in the dairy industry R_{dairyt} -- implying a_0 equals zero, and a_1 equals one. If there are other specialized factors in the industry, however, equation (4.1) will be misspecified. Omitting a relevant variable yields an estimate of a_1 that is biased and inconsistent, unless the left-out variable is not correlated with RV_{ld}. If the left-out variable is positively (negatively) correlated with $RV_{ld,}$ the OLS estimate of a_1 will be biased upward (downward).

Unfortunately, data on the rental value of dairy land are not available. However, a proxy can be obtained from data on the total value of dairy land, given certain conditions. Assume dairy land has an infinite productive life, and that its rental value is the same each year, and accruing at the beginning of the year. Assume further that the real interest rate is constant over time. Accordingly, the total value of dairy land can then be written as

$$(4.2) \qquad TV_{ld} = \sum_{t=1}^{\infty} \frac{RV_{ld}}{(1+r)^{(t-1)}} = \frac{RV_{ld}}{1 - \frac{1}{1+r}} = \frac{(1+r)RV_{ld}}{r},$$

where TV_{ld} = total value of dairy land,

RV_{ld} = annual rental value of dairy land,

r = real interest rate,

t = time (years).

If the total value of dairy land (TV_{ld}) and the real interest rate (r) are given, rearranging equation (4.2) yields the rental value of dairy land (RV_{ld}):

$$RV_{1d} = \frac{r}{1+r} TV_{1d}. \quad (4.3)$$

The U.S. Census of Agriculture contains data on the quantity (acres) of all land in dairy farms, and on the value per acre of dairy land and buildings. Multiplying these values provides the total value of dairy real estate, which was used to approximate the total value of dairy land. As total real estate value is greater than the value of land used in dairy farms, and assuming buildings are valued at cost, the OLS estimate of a_1 will be biased downward. Data are available only for the census years between 1950 and 1987, i.e., 1950, 1954, 1959, 1964, 1969, 1974, 1978, 1982 and 1987, so for those between census years, estimates were made by assuming a constant annual growth rate between two adjacent census years. With data on the real estate values and assuming a 3 percent real interest rate, annual rental value of dairy real estates was calculated.[5] To be consistent with procedures used to

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5 Barro (1990, p. 162-163) reported that during 1950-88, the annual real interest rate on short-term U.S. securities was 1.98. Since the long-term interest rate should be relatively higher, 3 percent was used; a range of 2 to 5 percent is used later in this chapter to calculate the rental value of cows.

estimate rents in the dairy industry, rental value of dairy real estates was deflated using the CPI for non-food items (1967=100). Using the calculated values for RV_{ld}, equation (4.1) was estimated. After correcting for a first order auto-correlated error structure, estimation results are,

$$R_{dairyt} = 1613.9 + 0.71RV_{ldt} \quad (4.4)$$
$$(7.53) \quad (1.54)$$

Adjusted $R^2 = 0.75$ Degree of freedom = 38

D.W. = 1.42

Numbers shown in parenthesis are t-ratios and D.W. is the Durbin-Watson statistic (after correcting for serial correlation). At the five percent level, these results do not indicate a statistically significant relationship between rental value of dairy land and rent in the U.S. dairy industry.[6] However, since there were missing data and/or available data may be incorrect, it could be argued that these results are suspect.

An alternative test to examine the relationship between and land the estimated rents is to look at the relationship between the price of milk received by farmers and the price of dairy land. If land is specialized, the price of dairy land should be positively related to the price of milk received by farmers. To test for this relationship, the following equation is employed:

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6 At the five percent level of significance, the critical value for t with 38 degree of freedom is 2.02.

(4.5) $$P_{ldt} = a_1 + a_2 P_{milkt} + e_{t,}$$

where P_{ldt} = price of dairy land,

P_{milkt} = the price of milk received by farmers,

e_t = error term.

The proxy for P_{ld} used for this test is the average estimated value per acre of farm real estate in Minnesota, obtained from The Minnesota Rural Real Estate Market in 1990. Minnesota is a major sate for milk production, and farmers in Minnesota receive a price that is close to the support price for class 2 milk. Thus, P_{milk} was approximated by the support price for class 2 milk. Both P_{ld} and P_{milk} were deflated by the CPI for non-food items (1967=100). Equation (4.5) was estimated correcting first order auto correlation. The estimation results are,

(4.6) $$P_{ldt} = \underset{(1.64)}{1.5} + \underset{(0.87)}{0.17}P_{milkt}$$

Adjusted R^2 = 0.96 Degree of freedom = 38

D.W. = 1.98

The t-statistic on the price of milk received by farmers is not statistically different from zero at the five percent level. Thus, this indirect test also fails to reveal a significant relationship between price of land and rent in the dairy industry.

In addition to the previously described tests, it is noteworthy that the census data (see Appendix A) indicate that the amount of land used for dairy farming has declined over time, suggesting that its price is unlikely to be bid up as milk output expands. It can be concluded that the evidence presented does not support the hypothesis that land is a specialized factor in the dairy industry.

Next, whether cows are a specialized factor is considered. Unlike land, there are costs associated with producing cows, and so this issue is similar to the theoretical model presented in Chapter 2 where capital (K) was produced each period and its supply curve was upward sloping. Cows, however, produce milk for more than one period (year), and hence, a measure of annual rental value of cows is required. There is no readily available estimate of the rental value of cows. But, data on the average price for a dairy cow (V_{cow}) is available from Agricultural Statistics. Treating these prices as the values of a single young cow (one that has just started producing milk), annual rental values of a cow can be calculated with certain assumptions incorporated.[7]

Assume that return or rental value of a cow is equally distributed over its productive life, and that there is a salvage value at the end of the productive life. Assume further that the real interest rate is constant. Accordingly, the present value of a single cow can be written as

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[7] In principle, the average price is obtained from prices of all cows sold in the market. However, according to the National Agriculture Statistics Service, the majority sold are younger cows.

(4.7) $$V_{cow} = \sum_{T=1}^{T} \frac{RV_{cow}}{(1+r)^{T-1}} + \frac{SV}{(1+r)^{T}},$$

where V_{cow} = total value of a young cow,

RV_{cow} = annual rental value of a cow,

r = real interest rate,

SV = salvage value of a cow,

T = average length of a cow's productive life (years).

Data on price-per-hundred-weight of utility beef meat, and the average weight of slaughtered cows, are available from <u>Agricultural Statistics</u>. Multiplying these values yields the salvage value of a cow (SV).

If V_{cow}, T and r are known, then RV_{cow} can be calculated. Multiplying RV_{cow} by the number of cows on the dairy farms yields the total annual rental value of cows (TRV_{cow}). It is important to note, however, that the calculated rental value of cows is a gross, not net measure. In principle, the cost of breeding and raising a cow should be estimated, and an amortized value deducted from V_{cow}. Unfortunately, there are no known studies which report or estimate the cost of breeding and raising a milk cow. This omission is important when interpreting the results of the following equation which tests for the relationship between the rental value of cows and the estimate of rents in the dairy industry:

(4.8) $$R_{dairyt} = a_0 + a_1 \, TRV_{cowt} + e_t,$$

where R_{dairyt} = estimated annual rent in the U.S. dairy industry in time t,

TRV_{cowt} = annul rental value of cows in time t,

e_t = error term.

If cows are the only specialized factor of production, the coefficient on TRV_{cow} should be less than unity. Compared to land, there are omitted costs for breeding and raising a cow, and when those costs are not accounted for, a_1 will be biased downward. Nevertheless, the specification outlined above should identify whether there is a positive relationship between R_{dairy} and TRV_{cow}. Of course, the magnitude of TRV_{cow} depends on our assumptions about the key parameters. As an illustration, by assuming a 33 percent turnover rate (meaning a cow's average productive life to be 3 years), and 3 percent interest rate, a corresponding annual rental value of cows (TRV_{cow}) was calculated. After deflating, the calculated values for TRV_{cow} were used to estimate equation (4.8). The estimation results obtained, after correcting for a second order auto correlation, are

$$(4.9) \qquad R_{dairyt} = \underset{(22.13)}{1754.3} + \underset{(3.26)}{0.359}RV_{cowt}.$$

Adjusted R^2 = 0.81 Degree of freedom = 36

D.W. = 1.64

These results indicate a statistically significant positive relationship between R_{dairy} and TRV_{cow}.

Since the magnitude of the annual rental value of cows (TRV_{cow}) depends on both the length of a cow's productive life (T) and the real interest rate (r), additional regressions were undertaken to determine how sensitive the coefficient of RV_{cow} is to changes in T and r. With T ranging from 2 to 5 years, r ranging from 2 to 5 percent, 16 different TRV_{cow} values were calculated, and 16 different regressions were run. The summary statistics for all regressions, such as R^2, t-ratio, and the Durbin-Watson statistic were similar to those reported in estimation (4.9). However, the coefficients of TRV_{cow} differs. Those coefficients are presented in Table 2. The numbers in parenthesis are t-ratios.

Table 2 shows that the coefficient of TRV_{cow} increases with the increased years of a cow's productive life, and increases in the real interest rate. This is because both a longer productive life and a higher real interest rate imply a lower annual rental value.

The 16 estimations described above all failed to reject a significant positive relationship between the rental value of cows and this study's estimated rents in the dairy industry. Nevertheless, the information that can be inferred from these coefficients is quite limited. The estimated coefficients are less than one, and thus could imply that breeding and raising costs are high or, if cows are not the only specialized factor, TRV_{cow} could be negatively correlated with the other specialized factors. Despite these drawbacks, the results indicate that dairy cows are a specialized factor in the dairy industry, and that at least part of the rent

Table 2 Coefficients of TRV_{cow}

	Years of cows' productive life			
Interest rate	2 years	3 years	4 years	5 years
2%	0.217 (2.93)	0.339 (3.06)	0.468 (3.20)	0.605 (3.33)
3%	0.227 (3.06)	0.359 (3.26)	0.501 (3.46)	0.652 (3.65)
4%	0.236 (3.19)	0.377 (3.26)	0.530 (3.46)	0.693 (3.98)
5%	0.244 (3.31)	0.394 (3.65)	0.556 (3.97)	0.727 (4.29)

accrues to the owners of the cows. If the same values for T and r are used, as were used to estimate equation (4.8), the proportion of the rent in the dairy industry attributable to milk cows is 0.28.[8] Since the rental value of cows includes breeding costs, the proportion of rents assigned to the dairy cows is probably less than the ratio indicates.

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[8] Using the same ranges for a cow's productive life (T) and real interest rate (r), as used in the 16 regressions, the proportion of rents attributable to cows ranges from 0.174 to 0.430.

Conclusion

The first section of this chapter demonstrated that the reason for positive rents in the dairy industry is the existence of specialized factors(s), which could include land and cows. The empirical work in the second section supported the hypothesis that dairy cows are a specialized factor in the dairy industry, but rejected a significant relationship between land and our estimated rents. As discussed, there could be relevant variables (other specialized factors) omitted from the estimation equations. The ratio of rent attributable to cows over total rent suggests that there could be other specialized factors. One possibility could be management expertise.

A successful dairy manager combines cows, land, labor, and other inputs into a profitable dairy farm. Managers are different in terms of intelligence, industriousness, or relevant knowledge, etc. In the long run, however, the difference among managers can be narrowed. With enough incentives, the less industrious managers might work harder, and the less informed managers might invest more toward education and obtaining more knowledge. There are some special abilities (e.g. foresight), however, that may be unobtainable by investment of any kind. Since these abilities can not be duplicated, and therefore their advantage cannot be competed away, they may be termed "innate skills" (Johnson and Libecap, 1982, p.1011). These skills could make management expertise a specialized factor even in the long-run. Although some measures have been employed to assess management performance -- for example, Goodger et al. (1984) used an index based on expert opinions -- the opportunity cost of management would be extremely costly to determined. Hence, this study did not attempt to construct an empirical model to investigate the relationship between rent and management expertise. Nevertheless, the possibility that management expertise could be a specialized factor in the dairy industry cannot be ruled out.

CHAPTER 5

RENTS GENERATED BY THE FEDERAL DAIRY ORDER AND RENT DISSIPATION IN THE U.S. DAIRY INDUSTRY

The analysis presented in previous chapters indicates that there are substantial rents in the dairy industry. Rents in this market were estimated to range, during the past 40 years, in terms of 1967 dollars, from 1596.6 million in 1988 to 2285.1 million in 1952. A question that remains, however, is whether all those rents were actually captured by specialized factors in the dairy industry. It has been argued that at least some were attributable to the specialized nature of dairy cows, but, because the U.S. dairy industry is highly regulated, some rents may have been dissipated in efforts to obtain the regulations. This chapter discusses what proportion of rents in the dairy industry were likely generated by regulation, and how rents in the industry may have been dissipated through competition in the political market place. Also examined is whether competition to innovate may have resulted in rent dissipation.

Rents generated by federal regulations are defined here as the difference between rents in the regulated and unregulated market. Rents in the regulated market were estimated in Chapter 3 and rents in an unregulated market can be estimated by simulating free market equilibrium, using the estimated demand and supply functions presented in Chapter 3.

Multiplying both sides of the per capita demand function for class 1 milk and the per capita demand for class 2 milk by total population provides the aggregate demand functions for class 1 and class 2 milk, respectively. Then summing the two demand functions yields the aggregate demand function for milk. The free market equilibrium blend price and quantity are obtained by solving the aggregate demand function, and the supply function (estimated in Chapter 3) simultaneously. With the free market equilibrium prices, rents in the unregulated market are measured as the area above the supply curve, and below the equilibrium price line. A comparison of the rents in regulated and unregulated markets is provided in Table 3.

Table 3 shows that the annual increase in rents due to the federal dairy order ranged from 62 million dollars in 1952 to 316 million dollars in 1983, and rents generated by regulation varied from 2.81 to 15.65 percent of total rents. The average rent generated by regulation was 170.6 million, or 8.88 percent of the total. During the past two decades, several sharp drops occurred in rents generated by regulations. These drops reflect changes in the federal program. In particular, the dairy diversion program, started in 1984, and the Dairy Termination Program (DTP) started in

Table 3 Comparison of Rents in Regulated and Unregulated Markets (In Millions of 1967 Dollars)

Year	Rents in Regulated Market	Rents in Unregulated Market	Rents Due to Regulation	Percentage of Rents Due to Regulation
1950	2036.5	1962.9	73.6	3.62
1951	2211.3	2149.2	62.1	2.81
1952	2285.1	2152.4	132.7	5.81
1953	2091.3	1830.4	260.8	12.47
1954	1937.9	1761.0	176.9	9.13
1955	1957.6	1793.3	164.2	8.39
1956	2022.6	1846.9	175.7	8.69
1957	1985.7	1782.9	202.8	10.21
1958	1885.2	1724.7	160.6	8.52
1959	1844.4	1700.2	144.2	7.82
1960	1852.0	1716.7	135.2	7.30
1961	1877.0	1662.5	214.6	11.43
1962	1805.6	1548.7	256.9	14.23
1963	1772.4	1567.2	205.2	11.58
1964	1794.7	1591.6	203.1	11.32
1965	1766.1	1595.6	170.5	9.65
1966	1902.4	1816.4	86.0	4.52
1967	1913.3	1687.0	226.2	11.82
1968	1870.1	1686.6	183.5	9.81
1969	1841.8	1675.0	166.8	9.06
1970	1824.9	1644.7	180.2	9.87
1971	1811.7	1611.2	200.5	11.07
1972	1840.6	1674.8	165.8	9.01
1973	2016.3	1902.2	114.0	5.66
1974	2128.9	2017.9	110.9	5.21
1975	2042.4	1930.4	112.0	5.48
1976	2204.1	2113.4	90.7	4.11
1977	2124.2	1948.2	176.0	8.29
1978	2140.6	2037.2	103.4	4.83
1979	2213.5	2125.5	88.0	3.98
1980	2182.6	1969.4	213.2	9.77
1981	2147.2	1868.6	278.5	12.97
1982	2033.3	1749.7	283.6	13.95
1983	2021.7	1705.3	316.4	15.65
1984	1861.4	1693.7	167.7	9.01
1985	1795.8	1570.1	225.7	12.57
1986	1735.4	1554.1	181.3	10.44
1987	1672.6	1551.6	121.0	7.24
1988	1596.6	1454.0	142.6	8.93
1989	1678.2	1525.7	152.6	9.09
Mean	1943.1	1772.5	170.6	8.88
St.Dev.	169.9	189.8	59.7	3.13

1987, allhad substantial impacts on rents. However, farmers who participated in the dairy diversion program were paid $10 per hundred weight to reduce marketing of their milk. Farmers were paid by DTP to sell their herds and leave the industry. Since these side payments were not accounted for in this study's estimate of rents, the drops do not necessarily mean that farmers were worse off. Rents generated through regulations such as those in the dairy industry, however, do not imply an increase in total social wealth. Rather, they are a transfer of wealth in the political market place. Such wealth transfers can "lead people to employ resources in attempting to obtain or prevent such transfers." (Tullock, 1967, p. 231).

Ignoring any loss in total social wealth due to distortional effects, and assuming only two groups in the society, transferring an amount to one group implies taking the same amount away from the other group. Thus, the group hoping to receive the transfer will employ resources in various activities (such as lobbying) to secure the transfer. These activities will be carried out until their marginal cost is equal to the value of the marginal return to increasing the probability of receiving a transfer. Such activities are often referred to as rent-seeking. The group that opposes the transfer may employ resources in a similar manner to prevent its wealth from being taken. Becker (1983, p. 372-400) has analyzed competition among interest groups for political influence. He argued that "political equilibrium depends on the efficiency of each group in producing pressure, the effect of additional pressure on their influence, the number of persons in different groups, and the deadweight cost of taxes and subsidies." Groups employ resources in the competition for political favors. The resources used in the political competition are usually considered to be wasted. Thus part, if not all, of the transfer of rent to the winning group could be dissipated, both in terms of the interest group's net returns, and in the social total.

The extent to which rent is dissipated depends, in part, on the relative ability of the two opposing groups to impose their political will on one another. Generally, the winning interest group is thought to be sufficiently small in size so that the free-rider problem can be overcome. This is equivalent to arguing that small groups are better able to organize their individual members to support lobby activities. In the case of the dairy industry, the losing group (tax payers) is large in size, but in contrast, the winning group (which contains the owners of dairy cows) is small and well organized through dairy cooperatives. Consequently, although the winning group employs resources in lobbying, it is unlikely that it would need to spend all of the potential wealth transfer to win favorable regulation. Data from the Federal Election Commission (Oct. 31, 1989) indicate that for the 1987-88 election cycle, campaign contribution made by the top 16 dairy political action committees were, in 1967 dollars, 0.94 million, while rents generated by regulation during 1985-89 ranged from 121 million dollars in 1987 to 225.7 in 1985. Although political action committee contributions do not represent all payments to politicians, the data suggest that the rents dissipated in competition among interest groups is likely to be small.

Another potential area for rent dissipation has to do with inventive activity. As shown in Chapter 4, some rents in the dairy industry are likely due to technological advancement. A commonly accepted argument is that rents resulting from technological advancement can be dissipated if there is competition to be the first. To determine the extent to which rents attributable to technological advancement in the dairy industry may have been dissipated, it is useful to first understand how rent can dissipate in the process of competing to be the first.

Suppose that there is a potential cost-saving technology and it can be developed by using resources. If the inventor is able to obtain a priority right (e.g. a patent right) for his invention, the inventor would be willing to expend resources equal to the net present value of the invention to obtain that right. If the inventor did expend the full value of the invention in perfecting a patent, the total social gain would be zero. Consider, however, the case where the cost to the inventor of inventing and developing the cost-saving device is likely to be low relatively to the present value of the cost savings. In that case, it would seem that a net benefit or gain was obtainable. But, if there are numerous inventors, each competing to obtain the patent first, the sum of their individual expenditures could approach the entire present value of the patent. Thus, when property rights to an invention are defined in this manner, competition to be the first inventor can result in the dissipation of rents.

This analysis assumed a stable demand function for the final good. Barzel (1968, p. 348-55) also showed how rents to inventive activity could be dissipated in a dynamic setting. He argued that if the demand for the output was increasing, competition could lead to premature adoption of a new cost-saving technology. This premature use of resources is wasteful, resulting in the dissipation of rent.

Although the potential for wasteful competition exists, competition among farmers in the U.S. dairy industry to obtain priority rights to a new breed of cow is likely to be small. Most dairy research is funded by the government, carried out at universities, and discoveries provided free to farmers. While early adopters can get a profit, exclusive rights such as a patent right are not provided to them. Those who constantly adopt new technologies early can earn a rent. But gains due to early adoption of technological advances in breeding will be capitalized in the newly-bred cows, and belong to the owners of the cows. Since there is little incentive for farmers to engage in inventive activities in the U.S. dairy industry, the dissipation of rents, if any, should be small.

Even if the potential for rent dissipation through inventive activity is likely to be small, technological advancement could eventually lead to a reduction in rents in the dairy industry. With technological advancement in breeding, cows could become less diversified over time and reduced heterogeneity implies that the supply of milk could become more elastic over time. In that case, total rent in the U.S. dairy industry would decrease. While this assertion is yet to be tested, it can be concluded that technological advancement has allowed for, and even strengthened, the heterogeneity of cows. As argued above, rents attributable to cows have been mostly captured by the owners of the cows, but these rents would likely disappear if cows become more homogeneous. Hence, continuous achievement of better breeds is critical to maintain rents attributable to cows in the dairy industry.

CHAPTER 6

CONCLUSION

This chapter provides a summary of the results of this study, and problems are addressed. Finally, some suggestions are made for future studies.

One of the major objectives of this thesis has been to clarify the definition of the term "producer's surplus." Definitions were provided in both short and long-run contexts. With this accomplished, the long-run concept of producer's surplus -- a measure of rents to specialized factors of production -- was used to develop a model for the estimation of rents in the U.S. dairy industry. With the estimated rents, an effort was made to identify specialized factors receiving those rents.

Chapter 2 showed that the short run concept of producer's surplus is simply a measure of the sum of profit and quasi-rent. When correctly specified, the long-run definition refers to a measure of rents to specialized factors. This clarification is important, because the long-run and short-run concepts of producer's surplus refer to different measures of benefits, and can also imply different beneficiaries. In

Chapter 3, the supply function of milk was estimated and using estimated parameters, total rents in the dairy industry were computed. Over the time period 1950-89, the estimated rents ranged from $1586.6 million to $2285.1 million. In Chapter 4, two empirical models were constructed to test the relationship between the estimated rents and two possible specialized factors were considered candidates to receive those rents. The empirical results do not reveal a significant relationship between land and the rents in the dairy industry, but the hypothesis that dairy cows are a specialized factor in the U.S. dairy industry was not rejected. In Chapter 5, evidence was presented showing that rent dissipation through competition in the political market, and in inventive activity, are likely to be a small part of the total rents in the industry. Hence, it appears that the majority of rents are captured by specialized factors in the industry.

Some of the potential problems with this study can be identified. Although relatively standard specification was used for the estimation procedure, more detail and refinements in the estimation of the supply function of milk could yield different results. The specification used by LaFrance and de Gorter (1985), for example, contains more explanatory variables than were used in this study. Nevertheless, it is unlikely that minor alterations in the specification of the supply function would result in significantly different results for the elasticity of supply. Given the manner in which the rents were calculated, the supply elasticity is key to the results presented in this thesis. A more troublesome aspect regards calculation of these rents -- the supply function was forced to pass through the origin. This was a strictly arbitrary assumption, and altering it can have a substantial impact on the magnitude of the rents. It was also assumed that the rental values of both land and cows are constant each year, and that cows are replaced at a constant rate over time. In reality, the replacement rate appears to have increased over time. Although these problems do not alter the conclusion that there is a positive relationship between rents in the industry and the value of dairy cows, the estimated magnitude of rents may be biased. While this study has identified dairy cows as a specialized factor in the U.S. dairy industry, the proportion of total rents to dairy cows remains questionable. Solving this requires not only accurate estimates of rents in the industry, but also estimates on the cost of raising dairy cows.

Future studies could attempt to perfect the estimation of rents by identifying other possible specialized factors, and try to determine how rents are distributed among specialized factors. Many of the problems identified would be difficult to correct, suggesting that a truly reliable measure of rents would be very costly to obtain. The theoretical model could also be improved upon -- it may prove useful to explore the problem of producer's surplus by relaxing some of the assumptions made in this study. For example, what would the outcome be if capital in the model is not exhausted each time period? What would happen if there is monopoly in the output market and/or monopsonist power in some of the factor markets? The answers to these questions could contribute to a better understanding of producer's surplus.

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APPENDICES

Appendix A: Data Summary

Table 4 Data on Prices of Milk (Part 1)

YEAR	P1[1]/CPINF $/CWT	P1s[2]/CPINF $/CWT	PB[3]/CPINF $/CWT	PBEV[4]/CPINF $/CWT
1950	7.34	6.34	5.47	1.22
1951	7.68	6.78	6.05	1.26
1952	7.92	6.93	6.26	1.24
1953	7.28	6.22	5.47	1.25
1954	6.72	5.81	4.99	1.48
1955	6.61	5.86	5.02	1.32
1956	6.71	6.04	5.10	1.36
1957	6.60	5.81	5.02	1.30
1958	6.38	5.51	4.82	1.18
1959	6.27	5.49	4.77	1.05
1960	6.17	5.50	4.74	1.03
1961	6.04	5.47	4.70	1.02
1962	5.85	5.29	4.50	0.99
1963	5.72	5.20	4.46	0.99
1964	5.71	5.23	4.45	1.10
1965	5.65	5.22	4.48	1.07
1966	5.98	5.74	4.94	1.04
1967	6.14	5.85	5.02	1.00
1968	6.18	5.97	5.02	0.98
1969	6.12	5.90	4.99	0.95
1970	5.98	5.78	4.89	1.01
1971	5.87	5.65	4.81	1.00
1972	5.82	5.64	4.83	0.96
1973	6.34	6.14	5.46	1.00
1974	6.88	6.51	5.80	1.08
1975	6.47	5.96	5.57	1.14
1976	6.64	6.39	5.77	1.28
1977	6.24	5.94	5.45	1.81
1978	6.23	5.96	5.54	1.78
1979	6.28	6.05	5.64	1.67
1980	6.00	5.64	5.35	1.62
1981	5.73	5.43	5.09	1.52
1982	5.33	5.07	4.72	1.47
1983	5.14	4.92	4.55	1.45
1984	4.85	4.63	4.32	1.42
1985	4.51	4.29	3.95	1.40
1986	4.36	4.14	3.81	1.45
1987	4.26	4.09	3.69	1.37
1988	3.99	3.79	3.46	1.31
1989	4.17	3.92	3.66	1.30

1. $P_1 = [P_b * \text{Supply} - P_2 * (\text{Supply} - Q_1)] / Q_1$
   Source: <u>Agricultural Statistics</u>, 1962-90.
2. Source: <u>Federal Market Statistics</u>, various issues.
3. Source: <u>Agricultural Statistics</u>, 1962-90.
4. Source: Bureau of Labor Statistics.

Table 5 Data on Milk Prices (Part 2)

YEAR	P2[1]/CPINF $/CWT	P2s[2]/CPINF $/CWT	POF[3]/CPINF $/CWT	CPINF[4] INDEX
1950	4.44	4.32	124.47	0.711
1951	5.09	4.58	136.72	0.757
1952	5.24	4.89	113.29	0.775
1953	4.41	4.77	111.65	0.790
1954	3.95	4.15	116.86	0.795
1955	3.95	3.95	113.05	0.797
1956	4.01	3.98	113.44	0.811
1957	3.90	3.88	114.68	0.838
1958	3.68	3.63	110.85	0.857
1959	3.63	3.51	103.78	0.873
1960	3.66	3.50	97.40	0.888
1961	3.75	3.76	103.23	0.897
1962	3.52	3.50	101.87	0.908
1963	3.49	3.40	97.72	0.920
1964	3.50	3.38	96.14	0.932
1965	3.53	3.41	101.69	0.945
1966	4.07	3.82	103.21	0.967
1967	4.06	4.00	100.00	1.000
1968	4.04	4.03	93.68	1.044
1969	4.04	3.89	88.92	1.101
1970	4.03	3.92	90.23	1.167
1971	3.98	3.98	94.35	1.221
1972	4.04	3.92	92.69	1.258
1973	4.74	4.06	98.70	1.307
1974	4.96	4.41	124.84	1.437
1975	4.86	4.68	126.42	1.571
1976	5.11	4.81	103.70	1.675
1977	4.88	4.94	107.29	1.784
1978	5.05	4.93	109.83	1.912
1979	5.19	5.02	106.39	2.130
1980	4.92	5.05	98.85	2.440
1981	4.70	4.85	98.71	2.706
1982	4.37	4.54	90.01	2.884
1983	4.23	4.38	88.20	2.983
1984	4.01	4.05	92.35	3.113
1985	3.63	3.71	90.91	3.233
1986	3.49	3.53	87.58	3.286
1987	3.34	3.28	85.89	3.401
1988	3.15	2.99	86.28	3.542
1989	3.34	2.90	88.47	3.703

1. Source: Agricultural Statistics, 1962-90.
2. Source: Agricultural Statistics, 1962-90.
3. Source: Bureau of Labor Statistics.
4. Source: Economic Report of the President. 1950-90.

Table 6 Data on Quantities of Milk

YEAR	SUPPLY[1] BIL LBS	Q_1[2] BIL LBS	NGR[3] BIL LBS	Q_2[4] BIL LBS
1950	117.302	41.6	1.000	74.70
1951	115.181	42.8	0.125	72.26
1952	115.071	43.7	2.700	68.67
1953	120.521	44.6	9.375	66.55
1954	122.294	46.1	5.975	70.22
1955	122.919	49.2	4.875	68.84
1956	124.864	50.7	5.100	69.06
1957	124.563	51.8	6.375	66.39
1958	123.282	52.1	4.325	66.86
1959	121.977	52.4	3.425	66.15
1960	123.102	53.0	3.115	66.99
1961	125.734	52.6	8.022	65.11
1962	126.325	53.3	10.748	62.28
1963	125.335	54.3	7.772	63.26
1964	127.020	54.9	7.677	64.44
1965	124.339	55.4	5.665	63.27
1966	121.283	55.4	0.645	65.24
1967	120.109	55.4	7.427	57.28
1968	117.421	53.7	5.150	58.57
1969	116.402	52.8	4.479	59.12
1970	117.538	52.0	5.774	59.77
1971	118.759	51.9	7.268	59.64
1972	120.217	53.2	5.345	61.65
1973	116.313	52.4	2.185	61.72
1974	115.734	50.5	1.346	63.87
1975	115.562	51.1	2.036	62.40
1976	120.438	51.5	1.236	67.70
1977	122.866	51.4	6.080	65.41
1978	121.682	51.2	2.743	67.76
1979	123.611	51.3	2.119	70.18
1980	128.606	50.9	8.800	68.95
1981	132.974	50.2	12.861	69.90
1982	135.781	49.3	14.282	72.15
1983	139.953	49.7	16.814	73.43
1984	135.668	50.6	8.645	76.42
1985	143.389	52.0	13.174	78.20
1986	143.651	52.6	10.629	80.39
1987	142.960	53.4	6.705	82.83
1988	145.364	54.4	8.856	82.10
1989	144.427	55.3	8.969	80.15

1. Source: Agricultural Statistics, 1962-90.
2. Source: Agricultural Statistics, 1962-90.
3. Source: Dairy Situation and Outlook, various issues.
4. Q_2 = Supply - Q_1 - NGR.

Table 7 Data on Miscellaneous Variables

YEAR	INCOME[1]/CPINF DOLLARS	%YOUNG[2] %	%NONMETRO[3] %	POP[4] MILLION
1950	1917.018	26.92	70.59	152.271
1951	1941.876	27.44	68.46	154.878
1952	1963.871	27.98	66.39	157.553
1953	2016.456	28.49	64.39	160.184
1954	2010.063	29.00	62.45	163.026
1955	2107.905	29.50	60.57	165.931
1956	2171.393	29.94	58.74	168.903
1957	2177.804	30.32	56.97	171.984
1958	2168.028	30.51	55.25	174.882
1959	2233.677	30.77	53.59	177.830
1960	2246.622	31.04	51.97	180.671
1961	2283.166	31.33	50.40	183.691
1962	2353.524	31.04	48.88	186.538
1963	2403.261	30.89	47.41	189.242
1964	2542.918	30.72	45.98	191.889
1965	2674.074	30.49	44.59	194.303
1966	2792.141	30.15	43.25	196.560
1967	2861.000	29.72	41.95	198.712
1968	2948.276	29.24	40.68	200.706
1969	2974.569	28.75	39.45	202.677
1970	3017.138	28.26	38.26	205.052
1971	3095.823	27.80	37.11	207.661
1972	3213.037	27.22	35.99	209.896
1973	3459.067	26.54	34.91	211.909
1974	3405.706	25.84	33.85	213.854
1975	3392.107	25.17	32.83	215.973
1976	3460.896	24.52	31.84	218.035
1977	3540.919	23.92	30.88	220.239
1978	3684.100	23.38	29.95	222.585
1979	3656.808	22.91	29.05	225.055
1980	3513.934	22.53	28.17	227.757
1981	3491.870	22.29	27.32	230.138
1982	3459.085	22.14	26.50	232.520
1983	3560.510	22.02	25.70	234.799
1984	3740.122	21.86	24.93	237.001
1985	3804.207	21.70	24.17	239.279
1986	3944.005	21.53	23.44	241.625
1987	3965.010	21.49	22.74	243.934
1988	4066.629	21.56	22.05	246.329
1989	4112.881	21.63	21.39	248.762

1. Source: Economic Report of the President, 1950-90.
2. Source: Statistical Abstract of the U.S, 1950-90.
3. Predicted value using data from Bureau of Labor Statistics.
4. Source: Statistical Abstract of the U.S, 1950-90.

Table 8 Data on Land

YEAR	LAND[1] MIL ACRES	$P_{L\&B}$[2] $/ACRE	V_{Ld}[3]/CPINF MIL DOLLARS	P_{Ld}[4]/CPINF $/ACRE
1950	97.190	86.6	11782.73	119.5
1951	N. A.	N. A.	11625.22	130.8
1952	N. A.	N. A.	11928.26	138.1
1953	N. A.	N. A.	12292.30	132.9
1954	97.212	105.7	12831.40	142.1
1955	N. A.	N. A.	13517.19	151.8
1956	N. A.	N. A.	14029.04	155.4
1957	N. A.	N. A.	14338.65	164.7
1958	N. A.	N. A.	14807.28	171.5
1959	89.166	152.09	15351.34	179.8
1960	N. A.	N. A.	15591.15	174.5
1961	N. A.	N. A.	15945.17	173.9
1962	N. A.	N. A.	16272.95	175.1
1963	N. A.	N. A.	16591.86	175.0
1964	83.296	189.94	16919.86	178.1
1965	N. A.	N. A.	17099.62	181.0
1966	N. A.	N. A.	17123.69	189.2
1967	N. A.	N. A.	16967.96	194.0
1968	N. A.	N. A.	16654.62	202.1
1969	64.933	274.39	16182.78	202.5
1970	N. A.	N. A.	16572.69	194.5
1971	N. A.	N. A.	17193.79	190.0
1972	N. A.	N. A.	18114.66	197.1
1973	N. A.	N. A.	18925.99	228.0
1974	54.077	497.00	18685.31	294.4
1975	N. A.	N. A.	19339.49	334.2
1976	N. A.	N. A.	20524.41	398.2
1977	N. A.	N. A.	21804.93	445.1
1978	49.734	885.03	23021.06	465.0
1979	N. A.	N. A.	21824.61	488.3
1980	N. A.	N. A.	20120.98	459.0
1981	N. A.	N. A.	19161.25	484.1
1982	49.853	1098.43	18987.59	408.8
1983	N. A.	N. A.	17327.89	357.0
1984	N. A.	N. A.	15673.05	297.8
1985	N. A.	N. A.	14244.95	212.2
1986	N. A.	N. A.	13229.18	156.7
1987	44.007	932.42	12064.98	141.1
1988	N. A.	N. A.	10934.99	147.7
1989	N. A.	N. A.	9872.95	156.9

1. Land used in dairy farms. Source: U.S. Census of Agriculture.
2. Value per acre of dairy land and buildings. Source: U.S. Census of Agriculture.

3. Total value of dairy land. Data for years between census years were estimated by forcing a constant growth rate between two adjacent census years.
4. Estimated value per acre of farm real estate in Minnesota. Source: <u>The Minnesota Rural Real Estate Market in 1991</u>.

Table 9 Data on Cows

YEAR	COW[1] MIL HEAD	COWP[2] $/HEAD	PC[3] $/CWT	WEIGHT[4] 100 LBS	FC[5] $/CWT	PPC[6] 1000 LBS
1950	21.944	278.481	N. A.	9.89	4.38	5.314
1951	21.505	326.288	31.74	9.92	4.69	5.333
1952	21.338	313.548	23.92	9.90	4.89	5.374
1953	21.691	224.051	15.24	9.70	4.38	5.542
1954	21.581	187.421	13.97	9.58	4.16	5.657
1955	21.044	183.187	13.79	9.75	3.93	5.842
1956	20.501	188.656	13.45	9.89	3.75	6.090
1957	19.774	198.091	15.99	9.92	3.62	6.303
1958	18.711	245.041	20.85	10.18	3.42	6.585
1959	17.901	266.896	20.01	10.45	3.33	6.815
1960	17.515	251.126	17.24	10.32	3.27	7.029
1961	17.243	249.721	17.45	10.43	3.24	7.290
1962	16.842	243.392	16.93	10.27	3.22	7.496
1963	16.260	233.696	16.01	10.46	3.27	7.700
1964	15.677	224.249	14.21	10.41	3.23	8.099
1965	14.954	224.339	15.28	10.16	3.20	8.304
1966	14.093	254.395	18.44	10.31	3.23	8.507
1967	13.501	260.000	17.22	10.39	3.22	8.797
1968	13.038	262.452	17.18	10.30	2.97	8.992
1969	12.307	272.480	18.43	10.30	2.87	9.434
1970	12.000	284.490	18.27	10.49	2.81	9.751
1971	11.839	293.202	17.71	10.40	3.23	10.015
1972	11.700	315.580	20.04	10.48	3.17	10.259
1973	11.413	379.495	25.11	10.54	4.34	10.119
1974	11.230	347.947	17.79	10.52	4.79	10.293
1975	11.139	262.253	13.42	10.09	4.25	10.360
1976	11.032	284.179	15.11	10.30	4.21	10.894
1977	10.945	282.511	14.19	10.33	3.92	11.206
1978	10.803	352.511	19.24	10.43	3.62	11.243
1979	10.734	490.141	23.52	10.68	3.64	11.492
1980	10.799	489.754	18.74	10.80	3.61	11.891
1981	10.898	443.829	15.50	10.83	3.53	12.183
1982	11.011	381.415	13.86	10.71	3.07	12.306
1983	11.059	341.938	13.19	10.77	3.14	12.622
1984	10.793	287.504	12.79	10.72	3.07	12.541
1985	10.981	266.316	11.85	11.03	2.60	13.024
1986	10.773	249.848	11.33	11.05	2.43	13.285
1987	10.327	269.627	13.18	11.09	2.26	13.819
1988	10.262	278.374	13.53	11.24	2.58	14.146
1989	10.127	277.343	13.42	11.38	2.54	14.244

1. Number of milk cows. Source: Agricultural Statistics, 1962-90.
2. Average price of a milk cow. Source: Agricultural Statistics, 1962-90.

3. Price of slaughter cows. Source: <u>Agricultural Statistics</u>, 1962-90.
4. Average weight of a slaughter cow. Source: <u>Agricultural Statistics</u>, 1962-90.
3. Feed price. $FC = P_b$ / Dairy product-feed price ratios. Source: <u>Agricultural Statistics</u>, 1962-90.
6. Production per cow. Source: <u>Agricultural Statistics</u>, 1962-90.

Appendix B: Generating the Variable %NONMETRO

The ratio of non-metropolitan population (by April 1, 1990 definition) to the total population is the percentage of the non-metropolitan population (%NONMETRO). Due to missing data, a time (T) trend was assumed and a regression of LN(%NONMETRO) on T was run. Using the OLS procedure, the estimation results are:

$$LN(\%NONMETRO) = 63.96 - 0.030617\ T$$
$$(20.0)(-28.4)$$

Adjusted R^2 = 0.9842 d.f. = 14

s.e.e. = 3.23 s.e.e / (mean dep. variable) = 0.099

The predicted values for %NONMETRO, obtained from this equation, were used to approximate the real observations of %NONMETRO.