4

Competitive Structure and Supply

THE COMPETITIVE STRUCTURE of agriculture is conducive to economic progress. U.S. agriculture has always been a competitive industry, just as is true of agricultures in other countries where decisions are made by masses of individual farmers and cultivators. In numbers of firms and homogeneity of product, it approaches the model of pure competition more than any other industry employing such large quantities of labor and capital. This competitive structure, under supplies of capital and technical knowledge with sufficient degree of elasticity, serves as both asset and liability. It is an asset in economic development, allowing gain to society generally and to farm families as part of the consumer sector. It is a liability in short-run level of profits for the industry since, given the supply inelasticity of certain resources, output presses continuously against a demand of low price elasticity.

Limitations in supply of knowledge and capital did restrain the rate at which the agricultural supply function increased in early periods of economic development in the United States. This restraint still applies in underdeveloped countries. Still, development of U.S. agriculture, in resources drawn in and products flowing out, was remarkable. It was aided by great elasticity of land and labor supply, with the public maintaining elasticity of the latter and encouraging more firms.

The competitive structure of agriculture no less encourages agricultural development today. The profit motive inspires progress in all industries, but in few more than agriculture's commercial sector where pure competition prevails and the individual firm has no measurable effect on industry output and price. Firms which compete in industries not characterized by pure competition do have short-run opportunity to establish price and to gear output to it. They can increase short-run profits through manipulations of prices, as well as through changes in technology, production structure and costs. This is possible especially for highly differentiated consumer products where a demand curve with slope much greater than zero faces the individual firm. It also is possible in producer's goods industries, such as steel, where the product is homogeneous but the small number of firms allows tacit management of price, with production being adjusted accordingly. Price is not given as datum to the firm or groups of firms in these cases. In 1960, for example, the steel industry produced at about 50 percent of capacity. While unit costs might have been lowered and steel output for economic development purposes might have been increased, had firms produced more at a lower price, the structure of the industry did not lead to this policy. Neither did competition among laborers cause them to sell more labor per week at a lower price, amidst unemployment, with demand for labor increased accordingly. These firm and industry policies, with price level highly fixed in the short run, are used to lessen the insecurity which would stem from dog-eat-dog competition. They do provide short-run stability in mass effect, as long as they do not lead to large unemployment. They do not, as pointed out previously, do away with competition.

Major competition still exists in development of new products, in adoption of new technology and in clamor for share of a total market at a given price. Over the long run, too, price does become flexible because of competition from other industry aggregates. Progress does occur in this competitive situation which is not pure. Incomes increase and security of degree prevails, although the major pulls of consumer preference and change continue. It is not, of course, inconsistent that firms, consumers and laborers simultaneously hold security, economic progress and level of income as goals. None of these goals, or others with which they compete and complement, is maximized, but an accepted combination has prevailed within these industries which are not pure competitive.

FIRM MOTIVATION IN PROGRESS

The firm in agriculture is not simply an inanimate complex of cost accounting and computers, generating short-run and long-run cost functions to establish the minima for the pure model. Typically, a household attaches to it. This household is the owner of resources, particularly labor of established skills, occupational preference and low short-run elasticity to the particular firm. It searches for technology which generates progress partly in order that it need not transfer its firm from the occupation. Since this firm-household complex has no control over price, it can increase profit or avert decline in income only by adopting new technology, a different mix of resources, to increase output by a greater proportion than costs. Or, it can try to reduce costs directly, without changing output, but techniques which reduce per unit costs subsequently serve to increase supply of the individual firm.

The individual firm in agriculture also can buy the services of more resources, increasing size and output, while retaining the same technology. The latter occurs continuously. However, at any given time more are searching for new technology, to increase output by a greater proportion than costs. The hope is simple: Increase in output, with price constant and the marginal cost of the resource less than its value return, will increase the individual's profit. But the constancy of price prevails only if most others do not follow a similar strategy. Whereas this is the hope for one farmer, it also is the hope of thousands of others. Consequently, price is not a constant for the industry. It declines absolutely, or lags behind upward movement of the general price level. This has been the history of U.S. agriculture from 1920 to the '60's. The competitive nature of the firm, in connection with low supply elasticities of factors in the short run, causes output to be high enough and price low enough that returns to factor are depressed below the nonfarm sector. While, in theory and fact, this should occur only in the short run, economic history is simply an interlocked sequence of short-run periods, with direction towards a distant long run which also is always changing in economic character. If we look back to Table 3.4 (page 100), and other data which can be marshalled for this purpose, one short run simply merges into another.

The search of farmers for techniques which increase input value by a smaller proportion than output has led to a continuous increase in supply. (See discussion of Figure 7.10 on page 298.) This is obvious in the data of Figure 2.4 and Table 2.13. Slight dips in output since 1920 have been mainly due to weather or extreme economic shocks usually for a single year. Run-of-the-mill decline of commodity price relative to resource price has not caused them. Increases in output came about under continual decline of this price ratio in the 1950's, not because farmers respond irrationally or are motivated only sociologically, but because new technology increased the marginal productivity of capital. More of capital representing new techniques thus can be used with increase in the resource/commodity price ratio. With increase in the price ratio, marginal productivity of resources must be kept higher, or the ratio of input to output must decline. And indeed this has happened since 1920. As Table 2.13 (page 71) indicates, there have been few years since 1940 in which input per unit of farm output has not declined. Measuring economic progress as the ratio of input to output, the consuming sector has indeed realized progress. With food produced under continuous per unit decline in aggregate input, and because of the burden of supply on inelastic demand, its real cost has declined.

The individual farmer's main hope for improving his income and welfare under the competitive structure of agriculture causes this progress to continue. This is true not because national economic progress is the primary goal in his decision making, but because the planning alternative open to him is one which leads to this end. He must be ever alert to find new technologies which allow him to increase output from a given collection of fixed resources. His hope is, as mentioned earlier, that with constant price he can increase output and revenue at a smaller increase in input costs. As most others do so too, total revenue declines under the inelastic demand for farm products. Still, the individual farmer would be worse off if he did not adopt new technology and increase his output, as long as the industry does so. A qualitative example and not a quantitative specification, is found in the demand and production functions in equations (2.1) and (2.2) and the equilibrium price in (2.6). The individual farmer has been producing q quantity of product. If he can increase his output to $1.2q$ and sell it at the price P_1, his revenue will be increased to the quantity $1.2qP_1$, or by 20 percent over the original quantity qP_1. Yet if all other farmers and the industry increase output from Q_1 to $1.2Q_1$, equilibrium price for the industry will fall to $.5P_1$. The individual farmer's revenue is then $1.2a \cdot .5P_1 = .6qP_1$, or a reduction of 40 percent. If however, he held output constant at q while the industry increased output to $1.2Q_1$ and price dropped to $.5P_1$, he is left with a revenue of only $.5qP_1$. His revenue declines by 40 percent if he increases output along with the industry, but by 50 percent if he does not do so. Hence, his "worse off" position is improved 20 percent if he too increases output, although it is less than the revenue which would have existed had both the individual and the mass held output constant. No single innovation or resource addition results in price and revenue declines of this relative magnitude, but this is the short-run qualitative effect of individual action under conditions of pure competition market and an inelastic demand. Over time, increase in output has accompanied increase in demand. But supply has shifted more rapidly than demand, causing agriculture's real terms of trade, reflected in resource returns, to decline or remain low relative to the nonfarm sector. Recent research shows the real income of nonpurchased inputs to have declined since 1947 and to have lagged factory worker real income since 1920.[1] The individual farmer is penalized if he innovates and adopts technologies leading to general economic progress, but the penalty is even greater if he does not do so. Progressive farmers who innovate before the masses realize net gain from progress, while the masses realize loss.(See discussion of equations (5.42) to (5.59) in the following chapter for a numerical example.)

While some farmers innovate and adopt new technology before others, the lag has become less as compared to decades of the past. Profits of innovation are relatively smaller and spread over less time than in earlier decades. In previous times, a new livestock ration or crop variety could be in existence for decades before it was adopted by the masses of farmers. Now, however, a new variety or feed additive is adopted by the majority of farmers in the course of two or three years.

[1] R. A. Loomis and G. T. Barton, *Productivity of Agriculture, 1870–1958*. USDA Tech. Bul. 1238, pp. 33–35.

Through developmental policy for agriculture, the American public provides a continuous flow of new technology to further this continuous and self-generating process of advance. It produces new techniques in the research services of the land-grant colleges and the USDA. It communicates this knowledge to farmers. With the high value which society places on progress, this will undoubtedly continue to be true, and the motives underlying innovation and change of the agricultural supply function will intensify as farm numbers continue to decline and the industry becomes increasingly commercialized.

Farmers have no choice in the timing and extent to which new technology will be introduced, in contrast to industries where the number of firms is small and individual firms guard technical developments with some secrecy. Not only does public production of innovations help assure progress in the sector, because of the competitive nature of agriculture, but this public investment also contributes greatly to maintenance of competition in farming. With knowledge of new technology freely available to all farmers, large or small, the advantages of extremely large-scale operations are partly nullified.

Increasingly, of course, private industry conducts research on new technology for agriculture. It does so in order to sell the materials of new technology and quickly presses this knowledge to farmers. As we indicate in a later chapter, this contribution of the private sector to innovation and technological progress of agriculture has increased greatly relative to the contribution of the public sector. (The public, therefore, has opportunity, as outlined in Chapter 16, to use more of its resources on research and education for adaptations of agriculture, which helps both the industry and general society to more readily and fully realize gains of economic progress.)

Competitive Structure and Economic Progress

The competitive structure and low price elasticity of food demand cause pressure on the individual to improve technology and increase output. Consequently, with magnitude of food demand tied closely to population, the strong trend is for each unit of output to be produced with fewer inputs, or at a lower real cost. Resources are thus saved, so that they can be diverted to other economic sectors where consumers desire larger growth as their incomes increase. With growing population, total food requirements or demand have increased, but it has been possible in recent times to produce this greater output with about the same total quantity of resource inputs (Tables 2.13 and 16.2).

As individual farmers use more capital resources and extend output against an inelastic demand, income per farm and person can be maintained only as there are fewer of both. This has been the main source of input or resource savings in agriculture over the years of 1940–59. Aggregatively, farmers remaining in the industry have, as an average, extended use of nonreal estate capital inputs by over 100 percent since 1940 (Table 2.8). These capital inputs represent both new technology and extension of existing technology. By individual categories, the percentage increase in inputs has been 135 for machinery, 142 for fertilizer and lime, 125 for feed and livestock and 37 for miscellaneous items. But at the same time, number of farms declined by 30 percent and farm labor by 47 percent. For the industry, increased value of nonreal estate capital inputs was approximately offset by the decline in labor inputs, with total value of inputs up only slightly while total output increased by 53 percent.

The drive by individual farmers to use new types of inputs, or extend use of nonland capital on the existing agricultural area, is a process which does not end, because the gains to the individual from extending output are partly or entirely dissipated as the masses follow this procedure and price and revenue are depressed in the manner explained above. The process becomes continuous as the individual perpetuates the search for methods to extend output and reduce unit costs, as a means for increasing profit through greater volume or greater profit per unit. But because of low demand elasticities, and in a growing economy where alternative resource employment is available at favorable rates, families with limited capital and managerial resources find they can increase income only or mainly by transfer to other industries. As they do so and income and resources are allocated to fewer remaining farms, economic gains to society are realized.

In general, labor inputs can decrease as capital is substituted for them. Too, with some surplus capacity of labor and machinery in major producing regions, farm consolidation can take place with a saving of inputs relative to total output. When two farms of 160 acres are consolidated, for example, the unit so created infrequently needs to duplicate the machinery of the previous two units. But even with a large decline in labor force and number of farms, the change in agricultural structure has not been great enough to bring factor returns in this broad sector up to the level of the aggregative nonfarm sector.

Factor Prices and Technical Improvement

Farmers adopt output-increasing technology not simply because of its discovery, but because it is profitable to do so, or unprofitable not to do so. Few, if any, adopt new techniques for the sake of being innovators. Largely they do so because of profit considerations. Profits can be increased through purchase of innovation materials only if their prices are favorable relative to commodities which they produce. And, aside from major depressions, this indeed has been the condition over recent decades (Table 2.10).

While all prices have increased due to inflation, prices of important categories of inputs did not increase as rapidly as farm commodities in postwar years. Accordingly, the real cost of these inputs decreased; their prices were lower relative to farm commodity prices than they were in prewar years. In general, too, the marginal physical productivity of capital increased because of technical discovery and adaptation.

The decline in real price of many capital inputs for agriculture is due to technological improvement and competition in firms and industries which produce these inputs. An outstanding example is that of fertilizer where a pound of nutrient had a much higher real price in 1935–39 than in 1955–59. It took only 70 percent as much farm product to buy a unit of fertilizer in the latter as compared to the former period, and its known marginal response was much greater. It was extremely profitable for the individual farmer to use much more of such inputs, even under an inelastic demand where greater aggregate output meant smaller industry revenue and less income per farm.

Technological improvement, in both agriculture and nonfarm sectors, is the important source of economic progress and rising per capita incomes. Without improvements in technology, limits to the size of national income would soon be encountered; or while national income might increase gradually with population and size of the labor force, per capita income would decline as population grew. Fortunately in the United States, particularly as a result of technological advance and improved skill of people, national income has grown more rapidly than population, with a consequent rise in real income per capita. Labor productivity has increased throughout the economy, as well as in agriculture. The nonfarm worker can obtain his family's food requirements with fewer hours of work than at any previous time in history. But also, because of technological progress in agriculture and other industries, farm people also can acquire nonfarm goods and services with a smaller outlay of labor than in previous decades.

This general type of progress, with more goods and services available with less human effort, is valued highly by American and other societies. It is desired no less in agriculture than in other industries. Agriculture has contributed importantly to this process, as labor has been freed for use in other industries and capital requirements per unit of food output have been kept relatively low.

The portion of gain in economic progress made to society by agriculture has not been made without sacrifice on the part of the latter. Other industries also contribute to the same process of economic progress and adjust labor and other resources accordingly. Down through history, changes in technology and demand have revolutionized the structure of some industries and diminished the absolute magnitude of others. Capital has been substituted for labor, or workers have shifted from industries with low income elasticities of demand to those where the elasticities are higher. (See Table 2.12).

With low price and income elasticities of demand, agriculture cannot expand as rapidly as others where income elasticities are higher. Because of low demand elasticities, a rate of growth in output which exceeds population growth (or expansion in foreign markets) severely depresses income. The demand for labor shrinks accordingly and migration must take place if (1) persons with limited opportunities in agriculture, because of lack of capital and managerial resources, are to take advantage of alternatives elsewhere in the economy which will reward their labor more bountifully and (2) those who remain in agriculture are able to operate with enough resources and on a scale which will provide satisfactory incomes. But this adjustment problem is extremely more difficult for farm people than for many industrial workers.

Especially important is the spatial nature of agriculture. It is more difficult for a Kansas wheat farmer, for example, to shift to employment in the electronics industry at San Francisco, than for a worker to shift between manufacturing or service industries within the city of Detroit. In the latter case, skills required in the two positions may be highly similar and the worker need not shift the location of his home. But the problem of facility in transfer of resources among alternatives under economic growth does not apply differentially only to labor. As mentioned in Chapter 1 for radios and hand washers, even capital resources and land have greater flexibility in most manufacturing industries than in farming. A firm producing button hooks and coffee grinders can somewhat readily shift its building and machine resources to thermostats and TV cabinets. A farmer cannot shift barns and cultivators so readily from crops to plastic bags or hi-fi sets. Decline in demand for a particular product is not of particular concern to the modern industrial firm; it expects as much and has a new product developed to replace it, using largely its existing labor force and plant. Plant and resources in agriculture are much more specialized to a particular product, and hence have low supply elasticity for it. Augmenting the short-run income effect of this low supply elasticity, again is the competitive structure of agriculture which prevents it from maintaining a price level and adjusting output to it. The constant quantity in the short run is more nearly output, with real price being variable. This is in contrast, as illustrated in Figure 4.1, to

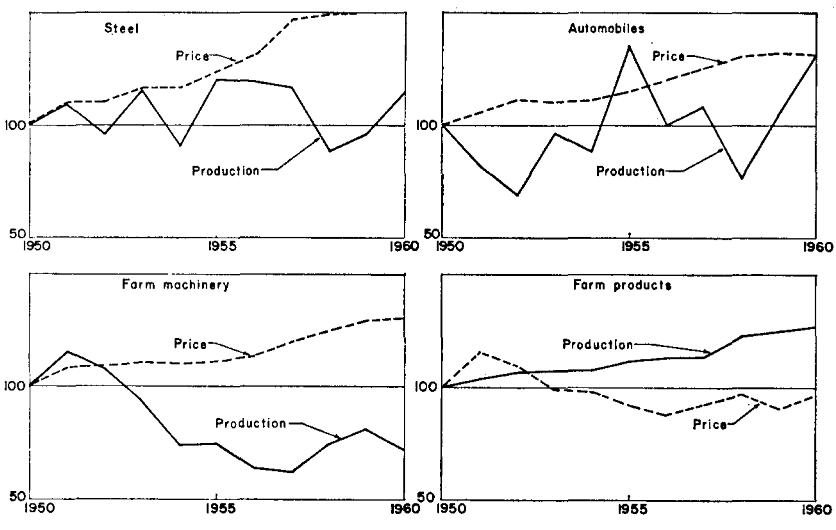

Fig. 4.1. Indices of Production and Price for Products of Four Industries, 1950–60 (1950 = 100).

certain other major industries where the extremely fluctuating short-run quantity is output, production being managed to maintain a desired price level.

AGRICULTURAL SUPPLY ELASTICITY

Superficially, the short-run income problems of agriculture are those of commodity supply elasticity. Much of public debate over American farm policy has hinged upon supposition of magnitudes of supply elasticity. American society has attempted to compensate agriculture for the income burden resulting from the constant contribution it makes to economic progress and low price elasticity of demand, through price supports greater than short-run market equilibrium prices. In both extended periods of price supports, the 1930's and since 1952, large public stocks accumulated and return to free market prices were posed as means of lessening these and their treasury costs.

A central issue of debate was how readily supply would adjust and how far prices would decline in a switch from support prices to free market prices. One proposition was that the process would be quite painless in the sense of a market price decline, an assumption of large price elasticity of supply. Another proposition was that it would be quite painful with a large price drop, an assumption of low elasticity. The significance of elasticity magnitude to extent of decline in production and price under this policy step is illustrated in Figure 4.2. Initially we have the demand curve D and the government support price of op_3, leading to annual output at level oq_4, with quantity oq_1 moving into consumption and q_1q_4 moving into storage. With great price elasticity of supply, expressed by curve S_1, shift from support price to free market price would reduce price

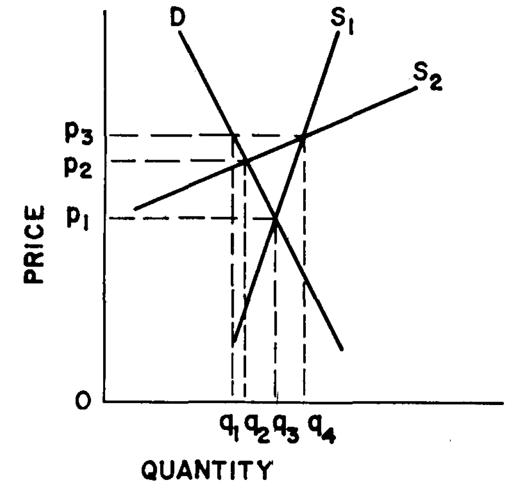

Fig. 4.2. Effects of Price Elasticity of Supply on Adjustment in Production and Price.

by a relatively small amount to op_2 and output by a relatively large amount to oq_2. With low supply elasticity, expressed by S_1, output would be reduced by a relatively small amount to oq_3 and price by a large amount to op_1. Obviously, then, supply elasticity has great relevance to policy mechanisms and magnitude of quantities important in farm income generation under a given demand regime.

Not only are supply elasticities important in policy questions such as the one posed above, but in ascertaining why supply presses so heavily on demand in the sequence of short runs which characterize the continuous adjustment of agriculture to a "moving long run" and a continuous depression of incomes and factor returns to levels below other major economic sectors. But the quantities involved are more than elasticity coefficients. They involve the entire structure and foundation of commodity supply in agriculture which we need to examine.

The problems of income are superficially those of commodity supply elasticity in the short run because elasticity itself is determined by other more fundamental quantities, namely, the elasticity of the production function and the elasticity of factor supply. Also, for short-run income problems, we also must understand how the supply function changes relative to the demand function and the relevant short-run elasticity quantities. But we should emphasize: the continuous short-run depression of income does not arise simply because the supply function moves to the right more rapidly than the demand function. Even under these conditions, income and resource returns could be maintained at some previous or comparable equilibrium level under particular regimes of factor supply and production function elasticities. We must eventually examine these more fundamental quantities. But before doing so, we must examine with less detail and formality the conditions of supply growth which can cause terms of trade and relative factor returns to be favorable to either agricultural producers or to food consumers.

Basis of Supply Elasticity

Again we turn to simple algebraic forms and static concepts for the industry in order to illustrate the dependence of supply elasticity on other quantities. (Other algebraic forms and decision environments lead to the same conclusions but are more difficult to manipulate.)[2]

$$Q_p = \pi X \tag{4.1}$$

$$X = sP_x^{.1} \tag{4.2}$$

$$X = \pi^{-1}Q_p \tag{4.3}$$

$$P_x = s^{-10}X^{10} \tag{4.4}$$

[2] See the footnote discussion of equation (1.1) to (1.5) for an explanation of the reason for the illustrative method which starts with the industry. We obtain the value $E_s = .1$ in (4.8) because the value of Q_s is (4.7). Hence, substituting Q_s for $.909^{.1}\pi^{1.1}sP^{.1}$ in (4.8), we obtain $E_1 = .1Q_sQ_s^{-1} = .1$

(4.5) $$C = K + P_x X = K + \pi^{-11} s^{-10} Q_p{}^{11}$$

(4.6) $$\frac{dC}{dQ_p} = 11\pi^{-11} s^{-10} Q_p{}^{10}$$

(4.7) $$Q_s = .991\pi^{1.1} s P^{.1}$$

(4.8) $$E_1 = .099\pi^{1.1} s P^{.1} Q_s{}^{-1} = .1$$

First, to examine the effect of factor supply elasticity upon commodity supply elasticity, we begin with the "higher elastic" or linear homogeneous production function in (4.1) and the factor supply function in (4.2). (We suppose π and s are larger than 1.0.) For the latter, a 10 percent change in price will cause quantity of factor to change by only 1 percent.

The amount of factor to produce a unit of commodity is (4.3) while factor supply price, the price of factor required for a given quantity of the factor, is (4.4). The total cost function is (4.5) where substitution of (4.4) for factor price and substitution of (4.3) for factor quantity gives the term at the right of (4.5). The corresponding marginal cost function is (4.6). By equating it to commodity price, P, and solving for quantity, the commodity supply function in (4.7) is obtained. Computation of

$$\frac{dQ_s}{dP}\frac{P}{Q_s} \quad \text{in} \quad (4.8),$$

the "own" price elasticity of commodity supply is indicated as E_1, a point directly evident from the power of P in equation (4.7). This is the coefficient when production has great elasticity (constant scale returns) and factor supply has low elasticity.

Now examine the case where the production function remains (4.1) but the factor supply elasticity is high as in (4.9). Derived as previously, the corresponding price elasticity of commodity supply E_2 is (4.10), a quantity much greater than (4.8) for low factor supply elasticity.[3]

(4.9) $$X = sP_x{}^{.8}$$

(4.10) $$E_2 = (.8)(.4444^{.8})\pi^{1.8} b P^{.8} Q_s{}^{-1} = .8$$

Now, using a given elasticity of factor supply, with the elasticity of production as the "variable" to be examined, we start with the extreme of factor supply equation in (4.11). The industry production function for comparison is one of low elasticity in (4.12). Its supply function is (4.13a), where the elasticity of supply is the power of P.

(4.11) $$X = sP_x$$

(4.12) $$Q_p = \pi X^{.1}$$

(4.13a) $$Q_s = 20^{-.053} s^{.053} \pi^{1.053} P^{.053}$$

(4.13b) $$E_3 = .053$$

[3] The value of .8 is derived in the manner of the numerical calculations outlined for equation (4.8) where $E_1 = .1$. In equation (4.10) the value of $.4444^8 \pi^{1.8} b P^{.8}$ is equal to Q_s.

The corresponding elasticity of commodity supply in respect to price, E_3, is (4.13b). Now compare this with the price elasticity of commodity supply arising when the production function has greater elasticity as in (4.14).

(4.14) $$Q_p = \pi X^{.8}$$

(4.15) $$E_4 = .667$$

Using the factor supply in (4.11) and the production function in (4.14) the derived price elasticity of supply for commodity, E_4, is (4.15).

In summary then, with a given elasticity of the production function (4.1), low elasticity of factor supply (4.2) gives a low price elasticity of commodity supply (4.8); high elasticity of factor supply (4.9) gives a high price elasticity of commodity (4.10). With elasticity of factor supply constant (4.11), low elasticity of the production function (4.12) gives low price elasticity of commodity supply (4.13), while high elasticity of production (4.14) gives high elasticity of commodity supply (4.15). At the very extreme of unit elasticity in production (4.1) and in factor supply (4.11), the elasticity of commodity supply would be infinite. Other algebraic forms would possess the same characteristics of commodity supply elasticity with respect to production and factor supply elasticity.

But the supply function has never remained fixed in U.S. agriculture. Developmental policy and market forces have continually shifted it to the right. It has most nearly been constant in countries lagging in economic development and with stagnant agricultural technologies. Hence both the elasticities and the changes in structure underlying commodity supply must be analyzed if we are to determine the effects and possibilities of population growth and economic development on real incomes to producers and food costs to consumers, or the policies necessary to modify either of these and still cause supply of farm product to be at levels deemed appropriate in agricultural or food policy. We discuss below the several supply environments which may exist, depending on shifts in the supply function and its elasticity.

Supply Function Constant

The supply function remains constant only if the production function and supply price of factors remains constant.[4] Supposing this to be true, we may have low commodity supply elasticity due to (1) low elasticity of the production function resulting from a fixed land area and no development of new techniques or resource forms or (2) low elasticity of factor supply because of restraint in land area and difficulty of attracting labor and capital into agriculture or in getting them to migrate from the industry.

Elasticity of commodity supply or demand in respect to price need not cause burden in family incomes and resource returns should certain con-

[4] To these two major conditions we should add that constancy in supply function exists only if institutions tenure and uncertainty remain constant. These points are discussed later.

ditions exist. Returns could be favorable, using various criteria, regardless of whether commodity supply elasticity were high or low. Unfortunately the necessary conditions are not attained in the short run for agriculture. Accordingly, real income tends to lag behind that of other economic sectors. One of the main conditions violated is that of factor supply elasticity. High elasticity of factor supply to agriculture could, of course, be attained with (1) great transferability of resources and (2) competitive conditions in other industries which do not restrict resource movement. The commodity supply function could shift to the right, with either high or low price elasticity, and resource returns could be maintained at a par with other industries if factor supply elasticities were sufficiently high. However, when factors become specialized to the industry they are much less adaptable to other industries and mobility and transfer is not accomplished as readily as the shift or reallocation of resources among manufacturing and service industries. Obviously, then, we must examine conditions of factor supply if we are to understand conditions of commodity supply and prices and incomes of agriculture. We do so in the next chapter.

Supply of commodity remains constant only if the production function and supply price of factors (perfectly elastic factor supply) remain constant. Either condition is highly unlikely, but is approached in underdeveloped countries where technology is more nearly static and an excess labor force exists without other employment opportunity. The supply function will change in the opposite environment: new knowledge of the production function; factor supply function less than perfectly elastic with growth in industries which compete in resources; and general change in the farm decision-making environment. The extent to which change in the commodity supply function of agriculture depresses prices and incomes depends on the rate of change in the supply structure relative to change in demand. Returns will be depressed, with rate of shift in supply function which exceeds that for demand function, not only if factor supply elasticity is low to agriculture but also if the noncompetitive conditions of other industries prevent flow of resources from agriculture. In the paragraphs that follow, we illustrate the effects of supply elasticity and rate of change in supply function on relative level of commodity price. (We will examine the effects of change in commodity supply and demand structure on factor returns subsequently.)

To illustrate these points, we use the simple "static" commodity supply and demand functions indicated in Table 4.1. Supply functions of both "high" (.8) and "low" (.1) own price elasticities are used. Similarly, "high" (.7) and low (.2) own price elasticities are used for demand. The value of r in the supply function can be looked upon as an "aggregation" of several of the right-hand terms in (4.7). Similarly, the c in the consumer demand function is derived from "aggregation" of effects of population, per capita income, etc. Functions of constant elasticity are used, not under the assumption that elasticity remains constant with time or quantity but to illustrate the qualitative impact of different elasticity magnitudes.

TABLE 4.1

EFFECT OF RELATIVE CHANGES IN SUPPLY AND DEMAND FUNCTIONS AND ELASTICITIES ON COMMODITY PRICE LEVEL

Supply Function	Demand Function	Equilibrium Price	Price Comparison
	Original functions		
(1) $Q_s=rP^{.8}$	$Q_d=cP^{-.7}$	$P_1=(cr^{-1})^{.67}$	
(2) $Q_s=rP^{.1}$	$Q_d=cP^{-.7}$	$P^2=(cr^{-1})^{1.25}$	
(3) $Q_s=rP^{.8}$	$Q_d=cP^{-.2}$	$P_3=cr^{-1}$	
(4) $Q_s=rP^{.1}$	$Q_d=cP^{-.2}$	$P_4=(cr^{-1})^{3.33}$	
	Shift in demand only		
(5) $Q_s=rP^{.8}$	$Q_d=\lambda cP^{-.7}$	$P_5=(\lambda cr^{-1})^{.67}$	$P_5=\lambda^{.67}P_1$
(6) $Q_s=\mathrm{r}\mathrm{P}^{.1}$	$Q_d=\lambda cP^{-.7}$	$P_6=(\lambda cr^{-1})^{1.25}$	$P_6=\lambda^{1.25}P_2$
(7) $Q_s=rP^{.8}$	$Q_d=\lambda cP^{-.2}$	$P_7=\lambda cr^{-1}$	$P_7=\lambda P_3$
(8) $Q_s=rP^{.1}$	$Q_d=\lambda cP^{-.2}$	$P_8=(\lambda cr^{-1})^{3.33}$	$P_8=\lambda^{3.33}P_4$
	Shift in demand and supply		
(9) $Q_s=\Gamma rP^{.8}$	$Q_d=\lambda cP^{-.7}$	$P_9=(\lambda\Gamma^{-1}cr^{-1})^{.67}$	$P_9=(\lambda\Gamma^{-1})^{.67}P_1$
(10) $Q_s=\Gamma rP^{.1}$	$Q_d=\lambda cP^{-.7}$	$P_{10}=(\lambda\Gamma^{-1}cr^{-1})^{1.25}$	$P_{10}=(\lambda\Gamma^{-1})^{1.25}P_2$
(11) $Q_s=\Gamma rP^{.8}$	$Q_d=\lambda cP^{-.2}$	$P_{11}=\lambda\Gamma^{-1}cr^{-1}$	$P_{11}=(\lambda\Gamma^{-1})P_3$
(12) $Q_s=\Gamma rP^{.1}$	$Q_d=\lambda cP^{-.2}$	$P_{12}=(\lambda\Gamma^{1}cr^{-1})^{3.33}$	$P_{12}=(\lambda\Gamma^{-1})^{3.33}P_4$

Starting with supply and demand functions of high elasticity on line 1, an increase in demand by proportion λ as on line 5 will change equilibrium price from P_1 to P_5, with the latter being $\lambda^{.67}$ times the former, an increase in commodity price of a smaller proportion than the shift in demand. In contrast, if we start with low supply elasticity and large demand elasticity as on line 2, an increase in demand by λ proportion on line 6 causes price in equilibrium to be $\lambda^{1.25}$ greater than the initial price for this setting, an increase for price greater than for demand. With the elasticity combination on line 3, the price increases by the same proportion as demand. But with initially low price elasticity for both supply and demand as on line 4, an increase in demand by λ proportion increases commodity price to $\lambda^{3.33}$ ratio of original price, a much greater proportion than the shift in demand. Quite obviously, then, with a fixed supply structure in agriculture, growth in demand will increase farm prices and food costs, in an amount depending on the elasticities of supply and demand (for other forms of functions as well as those used). Prices increase most under conditions of low elasticity of both functions. Of course, both functions change in growing economies, and we need to examine the bottom portion in Table 4.1 where changes in proportion of Γ for supply and λ for demand are assumed. With equal proportionate changes in supply and demand and elasticities remaining constant, the equilibrium price will not change irrespective of the magnitude of supply or demand elasticity. The magnitude of $(\lambda\Gamma^{-1})^n$ in the right-hand column is equal to 1.0 where $\lambda=\Gamma$. Hence, given an economy otherwise in static equilibrium and lacking changes in the price level due to inflation, commodity price will not decline if equal shifts in supply and demand prevail. If, however, changes in supply or demand are unequal, $\lambda \neq \Gamma$, commodity prices will not remain constant. If increase in demand exceeds increase in supply, equilibrium price will increase with the proportion depending on supply and demand elasticities. If Γ exceeds λ, as it has in the U.S. for the last decades, commodity price will decrease to the extent specified by price elasticities. Suppose, for the initial example on line 1, that demand increases to $\lambda = 1.08$ between two periods and supply to $\Gamma = 1.2$ that of the initial period on line 9. Equilibrium price in the second period then will decline to $(1.08/1.2)^{.67}$ or .931 proportion of the former price if supply and demand elasticity are at the high levels of .8 and .7 respectively and remain constant in the two periods. If supply elasticity is high (.8) and demand elasticity is low (.2) as on lines 3 and 11, the increase will cause price to decline even more, to (1.08/1.2) or .9 proportion of former price. The relative decline in price is even more, to $(1.08/1.2)^{3.33}$ or .704 proportion of former price where both elasticities are low (line 4) and remain of initial magnitudes (line 12). If demand shift exceeds supply shift, low elasticity of supply and demand will cause price to increase, more than if the elasticity coefficients were large. Suppose, for example, that $\lambda = 1.32$, $\Gamma = 1.2$ and $\lambda\Gamma^{-1} = 1.1$. With high original elasticities (line 1), price will change to $1.1^{.67}$ or 1.066 proportion of its original magnitude. But with low supply elasticity (line 2), it will increase to $1.1^{1.25}$ or 1.127 proportion of its original magnitude (line 10). Under low elasticities for both functions (line 4), it will increase to $1.1^{3.33}$ or 1.374 proportion of its original magnitude (line 12). Unfortunately from American agriculture, λ has been smaller than Γ.

More typically, supply and demand functions for farm commodities change in elasticity as economic growth and development occur. Price elasticity of demand declines as consumer income grows to allow abundance and variety in diets. Starting from a supply function based on "fixed land area and given technology," long-run supply elasticity itself is likely to increase under economic development, especially if elasticity of capital and labor supply can be made to grow. Within this framework, long-run elasticity may grow while short-run elasticity remains low. Let us examine outcomes under these possibilities. Starting with low supply elasticity and high demand elasticity (line 2) shift in supply exceeding that for demand and elasticities constant, the comparative results are lines 2 and 10. With $\Gamma = 1.2$ and $\lambda = 1.08$, the new equilibrium price, P_{10}, is only $.9^{1.25}$ or .888 proportion of the former price. However, if supply elasticity increases (from line 2) to .8 and demand elasticity declines to .2 as on line 11, with $\Gamma = 1.2$ and $\lambda = 1.08$, the elasticity changes may cushion or accentuate the drop in commodity price, depending on whether c is smaller or larger than r. The price resulting on line 11 is $P_{11} = .9c^{-.25}r^{.25}P_2$. Hence, whether the counteracting effects of increasing supply elasticity and decreasing demand elasticity cause price to decline more than if elasticities remained constant depends, in our example on the magnitudes of c and r, on the original multiplier of demand and supply, as well as on Γ and λ. If either Γ and c are large relative to λ and r, with elasticities changing in the magnitudes indicated, equilibrium price will decline.[5]

A somewhat parallel case is that in which demand function shifts to the right but its elasticity lessens, while the supply function shifts in similar direction but its elasticity remains constantly low. This is a hypothesis somewhat similar to one projected for U.S. agriculture.[6] Hence, suppose for our comparison the original situation is line 2 of Table 4.1. With change in supply and demand and decline in demand elasticity, the new situation is line 12. Price for the latter, P_{12}, is

$$\left(\frac{\lambda}{\Gamma}\right)^{3.33}\left(\frac{c}{r}\right)^{2.08}$$

proportion of the former, P_2. With Γ equal to λ, equal proportionate shifts in supply and demand and elasticity declining by the magnitude indicated, equilibrium price will decline if the original multiplier or coefficient of demand is low relative to supply, but increase if the opposite is true. For example, where c is less than r and $(c/r)^{2.08}$ is less than 1.0, equilibrium price will decline even if Γ is equal to λ; but even more if Γ is greater than λ. Obviously, then, all of the coefficients in supply and demand determine the extent to which commodity price will be maintained, increased or depressed as supply and demand functions shift to the right with the variables which change with time.

It is likely that while the supply function for the individual commodity may have increased in elasticity, with greater and more adaptable managerial skills and market orientation, the elasticity of the aggregate supply functions remains uniformly low in the short run as it moves rightward. Greater mobility or supply elasticity of labor, as evidenced in the great off-farm migration of labor in recent decades, alone should have the effect of increasing commodity supply elasticity. However, it also is likely that the dominating reservation prices and factor supply elasticities for aggregate supply elasticity in the very short run now are those of land and specialized capital. With families and labor withdrawn from agriculture, neighboring farmers take over their land and capital equivalent and retain them in production. Also, the supply and demand functions which exist at a given point in time are not, as in our example and as most frequently forced in empirical estimation, of constant elasticity. Hence, with rightward shift in the aggregate supply function at a greater rate than demand, equilibrium quantities increasingly fall at

[5] In the more general case, $P_{11}=\lambda\Gamma^{-1}c^{-.25}r^{.25}P_2$ while $P_{10}=(\lambda\Gamma^{-1})^{1.25}P_2$. Hence, P_{11} exceeds P_{10} if

$$\frac{\lambda r^{.25}}{\Gamma c^{.25}} > (\lambda\Gamma^{-1})^{1.25} \quad \text{or if} \quad \frac{\Gamma}{\lambda} > \frac{c}{r}\,.$$

For our numerical example, P_{11} will be larger than P_{10} if c/r is less than 1.1 (i.e. less than $1.2 \div 1.08$). For a larger c/r ratio, P_{11} will be less than P_{10} when $\Gamma = 1.2$ and $\lambda = 1.08$.

[6] *Cf.* W. W. Cochrane, *Farm Prices, Myth or Reality,* University of Minnesota Press, Minneapolis, 1958, pp. 42–60.

points of lower price elasticity on the demand function. The relative speed in supply increase and lower demand elasticities both cause downward pressure on prices.

BASIS FOR CHANGE IN SUPPLY

Supply elasticity and rate of change in supply, given the demand function or its rate of change, determine the level of commodity price. Depressed commodity prices may or may not result in depressed resource returns and incomes, depending on factor supply elasticity. Hence, in later chapters, we must analyze further the relationships between supply elasticity for resource and commodity, and the relationships between commodity price and resource returns. Also, we must analyze the alternatives and prospects in change of demand structure. But before we do so, we continue with examination of change in the commodity supply function and elasticity since these are the quantities ordinarily given first attention in farm and food policy. The attempt in countries with a farm problem and relative decline in commodity price and factor return, aside from attempt to increase demand at more rapid rate, is to check rate of increase in supply. The hope of countries with a food problem and relative increase in food price and resource return, aside from checking population increase, is to speed the rate of increase in the supply function.

Static Setting

The two major supply shifters in a static economic setting, and similarly in a dynamic setting except for greater lag in response, are change in the productivity of particular resources and changes in factor prices relative to product prices. This point is readily apparent for any form of production function, but again is easily illustrated with the simple form in (1.1) where the corresponding resource requirements equation is (1.2). Substituting (1.2) for X in the total cost equation, taking the derivative to obtain marginal cost, equating this to product price and solving for quantity, the supply function becomes (1.4). Given the supply function in (1.4) output will increase with magnitude of commodity price, P. However, the supply function changes only with change in coefficients of the production function, π and b for (1.1), and with change in factor price, P_x, relative to product price.[7] The rate at which supply increases depends,

[7] We have illustrated with an algebraic form simple to follow. In a more general sense, the same statements apply to other forms of function. For example, the production function in (4.16) results in the static supply function in (4.17), where steps of equations (1.3) through (1.6) are used in derivation.

$$Q_p = a + bX - cX^2 \tag{4.16}$$

$$Q_s = a + .5c^{-1}b^2 - .5c^{-1}\sqrt{P_xP^{-1}} \tag{4.17}$$

Again in (4.17), it is obvious that any effort leading to increase in marginal resource productivity in (4.16), increasing a and b or decreasing c, or to decreasing in resource price will increase the supply function in the sense of greater output at given price. An increase in P alone, P_x and the production coefficients remaining constant, will increase output but will not change the supply function. In case $c=0$ for (4.16) or $b=1$ for (1.1), constant returns to scale exist and the production function has unit elasticity while the supply function has infinite elasticity.

then, on the rate at which the production coefficients are increased or factor price is lowered, for the simple production-supply environment indicated.

In the early years of agricultural development policy, the U.S. public caused supply to grow by increasing the quantity of a particular resource, X or land, and effectively increasing π in equation (1.1) by inflow of labor to agriculture. It also kept a factor price, P_x or land price low, sometimes causing it to decrease in real price. With a mammoth rate of population growth, real prices for food were kept low, although they were favorable to the economic development of agriculture. In the last half century, increase in the production coefficients, such as π and b in (1.1) have been brought about especially by public research to improve technology. The general nature of technological research can be indicated by the general production function in (4.18). A total of n resources enters into the production process and includes such specific factors as seed of one variety, nitrogen in a particular form, labor in June, labor in October, soil moisture from a previous period, moisture at the present, hand hoes, tractor plows of a given size, etc. At a given time, we know the existence and production coefficients or parameters for factors X_1 through X_g.

$$(4.18) \qquad Q_p = f(X_1, X_2, \cdots X_g, X_{g+1}, \cdots X_h, X_{h+1}, \cdots X_n)$$

Resources X_{g+1} through X_h are known but their production coefficients are not. Resources X_{h+1} through X_n are not yet known or cannot be controlled in quantity. Thus, prediction of the productivity parameters for resources in the category X_{g+1} through X_h allows their introduction into the production function in nonzero or larger quantities. Discovery of resources X_{h+1} through X_n or control of their magnitude serve similarly, once their productivity coefficients are established. Given favorable prices of these factors, their use has the effect of increasing the supply function, in the sense that they are the equivalent of increase in π or b in (1.1) and a or b in (4.16).[8]

The great revolution in structure and supply of U.S. agriculture over the last half century has come about through this process. Effectively, in the sense of (1.1), we have been able to make great strides in increasing the productivity coefficients so that magnitude of Q_s in (1.4) is increased for a given level of real commodity price. The rate of increase in the productivity coefficients has not been alone the result of market mechanisms. Importantly, it also has been a function of resources used in public

[8] More exactly, where we have functions such as

$$(4.19) \qquad Q_p = sX_1^{b_1}X_2^{b_2} \cdots X_n^{b_n}$$

$$(4.20) \qquad Q_p = a_{11}X_1 + a_{12}X_1^2 + \cdots a_{1m}X_1^m + \cdots a_{n1}X_n + \cdots a_{nm}X_n^m + \cdots b_{12}X_1X_2 + \cdots b_{n-1,\ n}X_{n-1}X_n$$

where π in (1.1) and a in (4.16) represent the effect of those resources which are present in nonzero and fixed quantity. The magnitudes π and a_{11} are increased as greater resources quantities are added to the collection. More particularly, however, productivity of a given resource is increased as suggested in (4.20) as new resources or their productivity are discovered and they are entered into the production function in nonzero quantities.

agricultural research institutions for this purpose. Increasingly, however, research in the private sector also has added to change in productivity supply coefficients. Discovery of a resource in the category $X_{h+1} \cdots X_n$, or discovery of the productivity effect of one in the class $X_{g+1} \cdots X_h$, allows, if its productivity is high enough relative to its price, an increase in demand for it. For example, if we start with the production function in (1.1), the total value function is formed by multiplying it by P, product price. Taking the derivative of the total value function, the marginal value productivity of the resource becomes (4.21).

$$MV = b\pi PX^{b-1} \tag{4.21}$$

$$X = (b\pi PP_x^{-1})^{1/(1-b)} \tag{4.22}$$

Setting the marginal value product in (4.21) equal to the factor price, P_x, and solving for X, we obtain the factor demand equation in (4.22). More of X will be used, aside from uncertainty and institutional effects or lack of knowledge, if commodity price is higher or the production coefficients, b and π, are larger. Factor demand also will grow if P_x, factor price, can be reduced. Accordingly, input-producing firms do invest in research to accomplish these discoveries of greater b and π or lower P_x.

While the motivation of scientific discovery in public institutions is only remotely related to the market, although directly related to the unknown realms of the production function, that of public firms is tied closely to the market and pricing system. If profit potential exists in the sense of high resource productivities in the yet-unknown realms of the agricultural production function, private firms will be drawn to conduct research in it. The profitability of this research depends quite largely on the marginal productivity of the resource to be discovered and the manufacturing production function and factor costs involved in its fabrication. Given the competitive nature of agriculture, efforts of researchers in public institutions and private firms to increase or discover productivity coefficients will result in increase of the agricultural supply function, if market conditions allow pricing of the resource represented at low level relative to its productivity. Private firms must balance investment in research directed towards greater knowledge of the agricultural production function against that of other economic sectors and products. Research workers in public agricultural institutions need not.

Role of Production Function and Public Sector

Public effort in shifting the supply function is quite apart from any predetermined or planned rate of change in agricultural output to attain a particular price level. U.S. public policy has only emphasized that the agricultural supply function be moved rightward. This decision was implicit in early agricultural developmental policy resting on land acquisition and distribution and more recently by investment in public research and education. Activity to shift the supply function has in no way been related to rate of shift in the demand function. The shift has not directly been managed at a particular rate, to feed growth in supply at a rate to maintain farm commodity prices at a particular level, or to push food prices down to a particular level. Once set in motion, aside from slight public excursions in decreasing supply to attain a particular price level through compensation policies, the process of supply increase stemming from technical discovery has been quite largely market oriented and dependent. With a population plagued by hunger and with economic development being a prime goal, a society would pursue this process with extreme vigor, uncovering new technologies and improving market mechanisms to cause rapid shift of the agricultural supply function. But in a well-fed society where greater food per capita has little marginal urgency, economic development as reflected in technical improvement should have no particular priority for agriculture over other industries.

The goal per se of general economic development, given abundance of food per capita, would be furthered equally by public concentration on technical development and shift of the supply function for nonfood commodities. It is not less important that labor productivity in building trades be increased, as compared to agriculture where society has served as an important catalyst to the market in increasing manpower productivity. Society also must make a choice, having succeeded in shifting the food supply function to an extent that the real price of food and the price elasticity of demand are low, whether it should pursue this investment alternative with greater vigor, or whether it should devote more investment to research and market improvements which extend length of life. In total welfare of society, is it more important to have fewer people who live fewer years amid a food surplus, or have more people live more years amid only ample food supplies?

Role of Factor Prices and Private Sector

The American public has taken responsibility for one set of variables which result in shift of the supply function, variables which relate to the production function. The private sector has had responsibility for the second general category of variables which similarly shift the supply function, namely, the price of resources which represent new farm technology. Had the input-furnishing industries been backwards or of sufficient monopolistic degree, increases in factor prices could have offset increase in productivity coefficients. Suppose, for example, in derivation of (1.4) from (1.1) and competitive factor price, an increase (multiplication) of the production function by Γ proportion and an increase in factor price by proportion β. If the increase in factor price is held to $\beta = \Gamma^{1/b}$, the supply function will remain constant. For $\beta > \Gamma^{1/b}$ the supply function will shift to the left regardless of technical improvement which increases marginal resource productivity. Factor prices need not remain constant or decrease to allow rightward shift in the supply function. They need only increase at a less rapid rate than productivity, in our case at a rate smaller than $\beta < \Gamma^{1/b}$.[9]

Factor prices have remained favorable relative to productivity changes in American agriculture. Evidently input industries have been sufficiently competitive (without being pure competition) for this, with the public sometimes stepping in to assure competition.[10] But perhaps equally or more important has been improvement per se in the production function involved in manufacturing inputs whose use represents improved farm technology. While inflation increased the price of all commodities from 1940–60, prices of hybrid corn, fertilizers, chemicals and similar inputs declined relative to the commodities they produce, after 1940, as compared to the period 1920–40. Even the price of machinery has been highly favorable relative to its productivity and farm product prices since 1940. (See Table 2.10). We discussed earlier the extent to which general economic development was financed by surplus of agriculture in earlier periods. To an important extent this function has shifted to the agricultural input industries, partly because they produce resources previously of farm origin, but also because an increasing proportion of the agricultural product must be imputed back to the resources so represented.

Role of Public Sector in Supply of Knowledge Resource

A supply function exists conceptually and effectively, for technical and other knowledge required in agricultural improvement. Knowledge can be obtained at a low price or cost to the farmer when it is produced and communicated by public agencies in magnitudes which bring it close at hand. However, it never has a zero real cost because time and other outlays are required to "go fetch it." The real cost increases as the supply is restricted and, relatively, is much greater in backward as compared to advanced agricultures. To obtain as much technical information as is available in the county seat to the U.S. farmer, the Indian farmer would have to travel far and at a much greater sacrifice in consumption. Transformation of it into understandable and usable form would add further to the real cost, relative to the U.S. farmer with his greater translating ability based on public investment in education.

The supply of technical knowledge is not restricted to that provided through public mechanisms, even in the United States. At a price, the farmer can buy newspapers, farm magazines, radios, books and television sets which provide him with knowledge. He can even hire a farm

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[9] With b smaller than 1.0, the elasticity of factor demand in respect to its own price is always greater than unity. We do not propose this as a condition of agriculture, or that the relations of Γ and β above are those which must hold true. We use the function and example only because (1) we wish to show the interrelations between factor pricing and resource productivity in commodity supply and (2) the function used is simple to manipulate for this purpose (without devoting more lines and pages to more complex equations).

[10] For example see J. W. Markham, *The Fertilizer Industry*, Vanderbilt University Press, Nashville, Tenn., 1958.

management service. This also is true in Asia or Africa. Many of the same media are potentially available but at a much higher real price. The Indian villager could obtain technical knowledge for rice via television, but the price is that of an airline or ship ticket to Tokyo. Technical knowledge also is provided by private enterprise or markets in the U.S., but is much lacking in the underdeveloped agricultures. This source is currently of great importance in development of U.S. agriculture, perhaps even more important than knowledge supplied through the public sector. This source and its importance often is overlooked by the American agricultural expert who goes abroad and attempts to explain the rapid pace of technical progress in the U.S., or by the foreigner who comes here to identify the organism responsible for our upsurge in technology. Both emphasize that the "answer" is in the public facilities of our experiment stations and extension services. But if only these were duplicated in countries with backward agricultures, the result would not be increase in commodity supply of the U.S. magnitude because the public sector now provides only a portion of the total supply of technical knowledge.

The private sector in the U.S. provides knowledge as a joint product with the agricultural resources and materials which it produces and sells. It calls this knowledge, and its effects, to the attention of farmers through salesmen, newpaper and billboard advertising and investment in good will devices. The number, investment and variety of such "salesmen" is much higher in the private sector than in the public sector of knowledge supply in the United States. This knowledge is generally a joint product with the materials or resources produced by firms furnishing inputs to agriculture. Hence, it comes at a high or low real cost, depending on the price of its "joint material."

Knowledge of the production function and existence of favorable factor/product price ratios are necessary conditions for adoption of relevant technologies. But a sufficient condition also must be added; namely, the availability of capital for purchase of the inputs. One element of U.S. farm policy since 1920 has been to increase the supply and lower the cost of capital funds represented by credit. Certainly these were the main ingredients of the tremendous upsurge in U.S. agricultural technology from 1940 to 1960.

Knowledge was retailed to farmers in effective fashion by the public sector through extension education and by the private sector in advertising and salesmanship. Too, vocational agriculture, 4-H work and advanced education generally made the farmer of the 1960's, much more than his father, a "receptive" resource for use of this new knowledge.

The capital and equity position of farmers became more favorable than at any previous time in American history, as available statistical evidence proves. Then, as the data in Table 2.10 indicates, the relative prices of products and of factors representing new technology was extremely favorable in the post World War II period. Farmers reacted to these changes in price structure and knowledge just about as the economists would predict: machinery and other new technology substituted for labor; aggregatively, fertilizer and other chemical and biological inputs substituted for land, although public price and storage policies kept the effect from being fully realized. Individual farm operators increased their demand for the land, and farm size increased accordingly.

SHORT-RUN AND LONG-RUN SUPPLY ELASTICITY AND INCOME PROBLEMS

The major price and farm income problems of agriculture are not those of commodity supply functions and elasticities in the long run, but are those of the short run. While the long-run supply function may have large elasticity, farm income problems arise because the short-run supply function has low elasticity. One short run continually gives rise to another. Agriculture is faced with a continuous sequence of short runs, linked in important degree to each other, as they progress towards the long run. But equally important, change in national economic structure and in the production function and factor prices of agriculture gives rise continuously to new long runs. Had technology and factor prices remained constant at 1920 levels, American agriculture might now be well adapted to this setting. It would be prosperous, having to draw labor and other resources into it. However, even though outmigration was remarkable from 1940 to 1960 labor input has been no better adjusted to current farm technology and factor prices than it was in 1929, or even in 1950. This sequence of short runs and long runs, with supply elasticity at low level in each new short run, never allows labor returns of agriculture to catch up with other sectors, as indicated by the data of Chapter 3.

Long-Run Elasticity in Respect to the Production Function

Society has two alternatives in respect to farm price and income problems which arise because of low elasticity of commodity supply in the short run. It can push the supply function to the left, leaving short-run elasticity at low level; or it can attempt to increase the supply elasticity. A third major choice, one which does not rest on manipulation of the supply function, is increase in the demand function. All policies, direct and remote, which relate to attempt at improvement of commodity price and farm income fall in one of these three categories. We reserve the analysis of demand and alternatives for a later chapter.

Our discussion of equations (1.1) through (1.4) indicated the quantities and variables which must be manipulated if the supply function is to be managed in rate of shift to the left or right. We now examine more particularly the basis for differences in short-run and long-run supply elasticity and the variables of relevance in increasing output responsiveness. One set of basic phenomena involved is that of the production function. We illustrate the relevant quantities which differentiate short-run and long-run elasticity in this respect.

Returning to the production function in (1.1), we examine a long-run setting by letting $\pi = rZ^v$, where Z previously has had fixed value, and the long-run production function is (4.23).

$$Q_p = rX^bZ^v \tag{4.23}$$

$$X = v^{-1}bkZ \tag{4.24}$$

$$Z = \left[r^{-1}\left(\frac{v}{bk}\right)^b Q\right]^{1/(b+v)} \tag{4.25}$$

$$Q_s = \left[r(bP_x{}^{-1})^b(vP_z{}^{-1})^c P^{b+v}\right]^{1/(1-b-v)} \tag{4.26}$$

$$E_1 = \frac{b+v}{1-b-v} \tag{4.27}$$

$$E_s = \frac{b}{1-b} \tag{4.28}$$

Setting the marginal rate of factor substitution to equal the factor price ratio and solving for X in terms of Z, we obtain the isocline equation in (4.24). Substituting this value into (1.4) and solving for Z in terms of Q we obtain (4.25). With Z so obtained substituted into the total cost function where P_x and P_z are factor prices and P is commodity price, the long-run supply function is derived in (4.26). It compares with the short-run supply function in (1.4). The long-run elasticity thus is (4.27) and compared to the short-run elasticity in (4.28), derived from (1.4). Quite obviously, (4.27) is larger than (4.28) since $b+v$ is greater than b and $1-b-v$ is smaller than $1-b$. The long-run elasticity is much greater, as it would be for any form of function, than that of the short run, with both supply functions derived from a given long-run production function. In (1.3) the magnitude of Z is fixed, as is commonly the case of many multiperiod resources in agriculture. Obviously, then, supply elasticity grows as "variability of resources" increases.

One answer to problems of low supply elasticity due to the production functions involving fixed inputs would appear to be either (1) wait until the fixed resources is worn out or (2) transfer it out of agriculture. But neither of these attacks is very fruitful for resources specialized to agriculture in the short run. A fixed resource such as land hardly wears out, and many buildings last a half century. A machine may see a generation of men enter and leave agriculture. But even if the "wear out" period averaged only 10 or 20 years, farmers of the decade hardly relish depressed price and income because of low supply elasticity over the waiting period.

The transfer out is similarly clouded by time. The particular form of many specialized resources, even skills of labor, are not always adapted to employment in other industries. Barns in southern Ohio or crawler tractors in Kansas have little productivity in an electronics or food freezing plant. Accordingly, their value may be mainly that of scrap steel and lumber, or even kindling. These uses establish their reservation prices and they will remain in employment as long as their marginal value product is this high. Once committed to these forms for agriculture, supply of these resources is extremely inelastic (zero elasticity for returns down to this level) just as returns were high for Marshall stones.[11] It is this inflexibility and inelasticity of fixed factors that holds them in production, with level of output augmented and commodity supply elasticity lowered accordingly.

Price and income of agriculture then are depressed under the continuous march of short-run supply functions, at rates exceeding shift of the demand function (a point which we wish to examine in more detail in a later chapter). But even as the short run gives way to the long run, as resources of fixed form wear out or transfer and supply is changed accordingly, problems revolving around low short-run supply elasticity are not eliminated. New resources forms are added, but also are specialized and have low reservation prices. While horse-drawn cultivators eventually were worn out or sold for salvage, two-row tractor cultivators took their place and had low value outside of row cropping. Their replacements, four-row cultivators, serve similarly. Labor possesses similar qualities, although of smaller relative margin between reservation price based on opportunity in other industry and original price to agriculture. The particular problem is perhaps at a minimum for a multiperiod resource when the commodity or consumer value, as in the case of beef cows, establishes a rather high reservation price against the same resources used further in production.

Low Factor Supply Elasticity and Flexible Factor Prices

With the farm supply function moving rightward more rapidly than demand and the short-run supply function of low elasticity, commodity prices become depressed and resource returns are kept below levels of other sectors. But the inelasticity of commodity supply also can be overemphasized as a force leading to maintenance of agricultural output at levels which depress prices unduly in terms of level of factor returns. It is, in fact, possible for short-run commodity supply functions to have an important degree of price elasticity, yet have output maintained at a high level simply because factor prices are highly flexible and decline at about the same speed as commodity prices.

Flexibility in factor price of this extent arises in highly competitive markets where the short-run supply of factors has extremely low elasticity. One of its effects is maintenance of agricultural output at high or constant levels even with severe decline in commodity prices such as in major recession. The point is illustrated in Figure 4.3 where we assume the original demand function D_1. Now, if due to extended unemployment, a condition cushioned in effect on food demand by unemployment com-

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[11] Alfred Marshall, *Principles of Economics* (Fifth Printing), Macmillan Co., New York, 1953, p. 423.

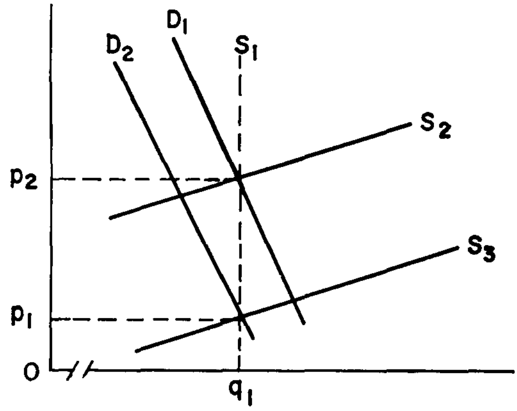

Fig. 4.3. Effect of Factor Price Flexibility.

pensation, the demand curve shrinks to D_2, we have these outcomes: If supply elasticity were zero, as denoted by S_1, output would be maintained at oq_1 level, even with decline of price from op_2 to op_1 level. However, these same quantities can occur even under high supply elasticity. Suppose, for example, that the initial supply function is S_2 and the demand function is D_1. Demand declines to D_2 but, without change in technology or the production function, supply changes to S_3 because of decline in factor prices. Shift in the supply function, due to decline in factor prices, causes output to be maintained at oq_1 even though price drops from op_2 to op_1. And this maintenance of output at reduced commodity price occurs under high price elasticity of commodity supply. We do not infer great short-run supply elasticity for U.S. agriculture in aggregate. Our emphasis is on the importance of supply elasticity for factors and factor price flexibility in causing maintenance of output and resource employment even under depressed farm prices and incomes.

In the absence of major recession, the picture is somewhat different from that in Figure 4.3, but of the same general character. Under population growth, demand moves continually to the right; but with low short-run elasticity of factor supply, rapid injection of technical change into the industry can result in greatly depressed prices, prices which are far below long-run equilibrium prices in level of resources return. This environment is best illustrated by resort to some simple algebra, rather than the geometry of Figure 4.3. Supposing the original production function to be (1.1), where X represents magnitude of services from a multiperiod resource, neglecting for the moment single-period resources and the extent of discount in inputs due to uncertainty and related phenomena. At original supply price of the multiperiod resource from nonfarm industry, the per unit price of resource service is P_x. But after the resource becomes specialized to agriculture, its reservation or sale price to outside industry becomes only βP_x, with β less than 1.0. Hence the new short-run supply function is (1.4), if the flow of services can be varied by period and are not absolute in quantity, multiplied by $\beta^{b/(b-1)}$. Since the exponent is negative (b is less than 1.0), output will be greater at a particular product price (the initial supply function is divided by a fraction smaller than 1.0). Without change in the production function and aside from change in demand, short-run supply shifts to the right, beyond that consistent with the original resource price of P_x. Decline of the supply price of resource to a "within industry" level, based only on reservation price and salvage value from outside, causes short-run supply elasticity to increase, but the shift in the supply function causes output to be maintained.

Since resources specialized to agriculture have low alternative return, they remain in the industry even at great decline in return. Return declines at a rate parallel to that of commodity prices, or even at a faster rate where nonproduction fixed costs are high. The competitive nature of agriculture causes the reservation price of these resources to be based largely on their value return, a quantity that fluctuates with commodity price. As in the case of Marshall's stones, they will take no less return than their alternative employment value in other industries (discounted for preferences, transportation costs, etc.). They will have no higher value or return than that representing the price at which they can be supplied from outside industries. But between these two extremes their return, or value based accordingly, can fluctuate up and down with commodity prices, the resources remaining in agriculture. The short-run supply function is shifted to the right accordingly and output is maintained at even declining price.

Land is an extreme example of a resource specialized to agriculture. Land prices were maintained or increased in the face of falling commodity prices during the 1950's mainly because of changed technology and extended cost economies in farm size. Farmers wishing to increase size for this reason could pay higher prices for acreage added, in terms of the net value return, than for their initial acreage. Operation of the large unit was typically allowed with fixed machinery and labor on hand and only purely operational costs contributed to marginal costs for the added unit. But an even broader market in land services is represented by rental prices, particularly share renting. Here the price of the resources service falls precisely as commodity prices fall. The ratio, to the tenant, of factor-price/commodity-price is maintained as the latter fluctuate.

Machines and buildings already in agriculture, in resource form having physical productivity mainly only in the industry, annually furnish a greater proportion of services than new units brought into agriculture. For buildings, the price is tied closely to land and fluctuates as above. For machinery and power, price of second-hand items fluctuates, between the extremes of salvage and new price, largely with farm prices and income. Feed prices, free from support and of major use as a resource in the industry, fluctuate with livestock prices. Breeding stock follows a similar pattern in respect to meat products. While labor is of more adaptable form than other multiperiod resources, even it has important degree of lag in transfer to other sectors, given a gap in returns between agriculture and other sectors. Prices for multiperiod resources already in agriculture thus are determined by commodity prices and factor productivities within the industry, and are little related to those of other economic sectors.

Resources transformed in single periods and supplied from outside agriculture have an entirely different short-run pricing structure (as do multiperiod resources supplied from outside in the long-run). Supply price then is based on resource productivities and prices in competing industries throughout the economy. Employment of these resources fluctuates more with commodity price than does employment, land, building and machine services. However, limits on short-run change in demand of these single-period resources exists for two reasons. Since their short-run supply price is determined mainly outside agriculture, a fairly constant return is imputed to them even under depression of commodity price, with the brunt of the diminished residual income falling mainly on the fixed or rentier multiperiod resources specialized to agriculture.

Many of these resources have high physical productivity and the individual farmer can use them in the face of price depression (i.e. the marginal productivity for the particular strata of resources outweighs price depression). An example is improved seeds and chemicals. During the 1950's, a period of decline in commodity prices, farmers could profitably add fertilizer not only because it was priced favorably but also because its physical productivity was extremely high. Few use a particular resource to a point where its value productivity touches its price, Cornbelt farmers realizing as much as a 200 percent return on the last margin of fertilizer used per acre. With commodity price cut in half, they could still use fertilizer profitably. (Empirical predictions show some temporary contraction with sharp breaks in price and income, although a general upward trend has existed even with declining terms of trade to agriculture.) Other single-period resources are extreme technical complements of multiperiod resources having low supply elasticity. If the relatively fixed supply of land and machines of any one year is to be used, tractor fuel and seed also must be used, but only if their return is as high as their outside supply price.

Because of this broad complex of low reservation prices and low supply elasticities of multiperiod resources, the agricultural plant remains highly fixed in output response. Withdrawal of individual firms need not cause the supply function to shift to the left in the short run; even the opposite being the likelihood. As a family abandons agriculture and withdraws its labor, other resources are not immediately withdrawn similarly. Its machinery and breeding stock are sold to be used by other farmers and its land is rented or purchased by a neighbor to extend his farm size.

Persons who leave agriculture typically are those with fewest managerial and capital abilities and greatest income disadvantage relative to employment in other industries. Those who remain and take over their resources apply more capital and management of particular forms, and attain an even greater output from the land and at lower real supply price. The latter is possible because of the existence of underemployed labor and machine resources in much of U.S. agriculture, with additions to farm size requiring costs marginal only to land, seed, etc. In fact, with this reorganization and change in agricultural structure, the change in capital may be more in its form than its amount. The remaining operator can invest more capital in improved seed and fertilizer than the transferring operator, but need not replace his machinery and labor where he has unused capacity of these.

An Iowa study illustrated that the shift in resource use under farm consolidation resulted in this very pattern.[12] Land market data of the 1950's also show that a major part of land purchases represent this general process of farm enlargement by remaining farmers. The immediate effect of labor and firm withdrawal from agriculture undoubtedly is to shift the short-run supply function to the right, with this shift per se being maintained until particular resources are depreciated or the distributed lag pattern of their transfer causes some rebound in the level of supply price.

Other Aspects of Distributed Lag in Output Response

There is no question that agriculture has long-run aggregate supply functions, each representing a point in the continuum of technologies or factor prices expressed over time, of less than infinite slope. Factors will be pulled into agriculture if consumer demand is high relatively, or ejected from the industry in the opposite case. Given 25 years and less of calendar time, output unquestionably could well be adapted to the economic environment. But income problems are still those of the short run, in either economic or calendar context.

The problem of supply response is in time required for a given short-run realm to completely shade into its corresponding long-run realm, with the complication that long-run realms also change. Fixed resources do not suddenly become exhausted of services, with supply short run changing to long run by the "suddenness" of lightning. Neither do all surplus labor resources with attachment to agriculture suddenly overthrow their immobility yoke and shift overnight to other industries. The process is gradual, with change less complete in the near-term and often being almost minute for buildings and land, and more complete in the long run.

A large category of adjustments in agriculture follow the time path of the function, illustrated in Figure 4.4A, with rate of change speeding up, under increase in general market communication and lessening of inflexibilities, but eventually dying away as extent of adjustment approaches its limit, Q^*. In empirical measurement for the individual, the time path may more nearly be approximated as Figure 4.4B. The varia-

[12] See Randall Hoffmann and Earl O. Heady, *Farm Consolidation in Southwest Iowa*, Iowa Agr. Exp. Sta. Bul. (forthcoming).

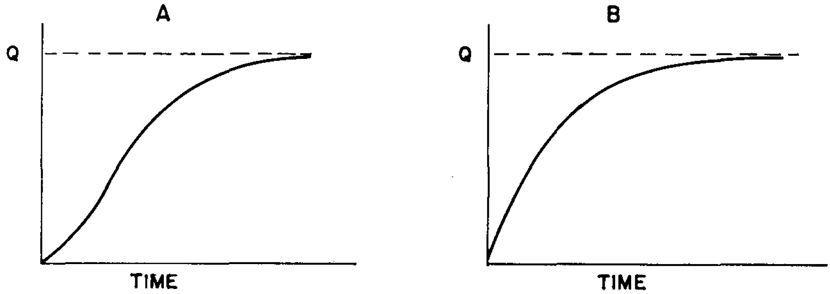

Fig. 4.4. Time Paths of Adjustment.

bles giving rise to this greater extent of adjustment in the long run are many, some already having been discussed.

A normal distribution in remaining life or unexhausted services of fixed resources would lead to the pattern in A for the industry, as would also the pure mechanics of communication, compounded with individual contacts at the outset but dying away later as the number of relevant individuals to be contacted declines. Given a permanent change in price or productivity, expectations may give rise to either type of time path, perhaps with B most appropriate if change conforms with expectations and the degree of uncertainty declines with time. The decision maker may "go only part of the way" in the first period with subsequent change in later periods. Capital restraints, psychological aversion to change or contractural and institutional restrictions may serve similarly. Likewise, the costs of rapid adjustment may be greater than those of delayed adjustment.[13] To an important extent, price change and elasticity of expectations, as well as the particular expectation model employed, also can lead to lag of adjustment, with change distributed over time in the manner above. In general form, the individual may react in the manner of B, while the industry reacts in the manner of A due to the pure communication mechanics mentioned above. In theory and quantitatively, it can be shown that the relative extent of response does change with time, the magnitude of elasticity growing between short run and long run, with long run distinguished as much by calendar time and transition between production periods as by distinction between fixed and variable resources in the classical sense. The formulation applies best to changes in prices and resource returns which are expected to be permanent in a particular direction and much less to repeated changes in opposite direction with complete reformulation of expectations required.[14]

[13] See Marc Nerlove and K. L. Bachman, "The Analysis of Changes in Agricultural Supply; Problems and Approaches," *Jour. Farm Econ.*, Vol. 42, p. 538.

[14] See Earl O. Heady, "Uses and Concepts in Supply Analysis," Heady, *et al.* (eds.), *Agricultural Supply Functions*, Iowa State University Press, Ames, 1961.

A logical illustration is as follows where the supply relation is expressed simply in (4.29), where Q_t is output in current period and P^* is expected price for the same period.[15] (The same relationship prevails for the previous period and the subscript $t-1$ need only be substituted for t.)

$$Q_t = a_0 + a_1 P_t^* \tag{4.29}$$

$$P_t^* - P_{t-1}^* = \beta(P_{t-1} - P_{t-1}^*) \tag{4.30}$$

It is expected that managers revise their expected price in proportion to the error made in predicting last year's price as illustrated in (4.30) where β is a coefficient of expectation. Thus, from (4.30), P^* can be expressed as (4.31).

$$P_t^* = \beta P_{t-1} + (1 - \beta) P_{t-1}^* \tag{4.31}$$

Or, following Koyck, we can illustrate the expected distributed lag in output response as follows, where we suppose a general supply model as in (4.32) where Q_t and P_t are output and prices at period t.

$$Q_t = a + b_0 P_t + b_1 P_{t-1} + b_2 P_{t-2} + \cdots b_n P_{t-n} \tag{4.32}$$

If the variables in (4.32) are in logarithmic form, the long-run elasticity of supply is (4.33) where b_t has the proportion to b_{t-1} in (4.34a).

$$E_1 = \sum_{i=0}^{\infty} b_i \tag{4.33}$$

$$b_t = \delta b_{t-1}, \qquad 0 < \delta < 1 \tag{4.34a}$$

As time passes, price converges geometrically as the relation of (4.34a) prevails. It follows from equations (4.32) and (4.34a) that output in period t is related to prices of previous periods as in (4.34b).

$$Q_t = a + b_0 P_t + b_0 \delta P_{t-1} + b_0 \delta^2 P_{t-2} + \cdots b_0 \delta^n P_{t-n} \tag{4.34b}$$

If equation (4.34b) is lagged by one period and multiplied by δ, the relation in (4.34c) for the previous period prevails.

$$\delta Q_{t-1} = a\delta + b_0 \delta P_{t-1} + b_0 \delta^2 P_{t-2} + \cdots \tag{4.34c}$$

By subtracting (4.34c) from (4.34b), the supply relation for the current period becomes (4.34f), where output now is a function of price in the period and output in the previous period.

[15] *Cf.* L. M. Koyck, *Distributed Lags and Investment Analysis*, North Holland Publishing Co., Amsterdam, 1954; M. Nerlove, "Distributed Lags and Estimation of Long-run Supply and Demand Elasticities," *Jour. Farm Econ.*, Vol. 40.

(4.34d) $$Q_t = a(1 - \delta) + b_0 P_t + \delta Q_{t-1}$$

In other words, δ is the adjustment coefficient, relating output of the current period to that of the previous period. Or, this logical distributed lag can be illustrated simply in the dynamic model of Nerlove in (4.34e) where Q_t is actual output in period t while Q_t^* is long-run equilibrium output in the same period (what output would be if "history could be overcome") and γ is a coefficient of adjustment relating output in the current (t) period to that of the previous ($t-1$) period.

(4.34e) $$Q_t - Q_{t-1} = \gamma(Q_t^* - Q_{t-1})$$

This relation supposes that in each period, producers adjust output in proportion, γ, to the difference between the actual output of the last period and the long-run equilibrium output. In other words, Q_t will differ from Q_{t-1} by an amount equal to γ times the difference between the "desired amount" this year and the actual amount last year. Under static expectations, the long-run supply quantity and relation is that in (4.34f).

(4.34f) $$Q_t^* = a + bP_t$$

(4.35) $$Q_t = a\gamma + b\gamma P_t + (1 - \gamma)Q_{t-1}$$

By substituting equation (4.34f) into (4.34e), we obtain the supply equation in (4.35) which, in simple manner, specifies output in the current period to be a function of price in the period (or in relation to prices of previous periods as specified in earlier equations for b_t) and output of the previous period. Equation (4.35) has the same general form as (4.34f) if we substitute $\gamma = 1 - \delta$ and $b\gamma = b_0$. With variables in logarithmic form, the value of $b\gamma$ is the short-run elasticity coefficient in respect to current period price, P_t. The value of $1 - \gamma = \delta$, computed as a regression coefficient for Q_{t-1} and equal to δ for empirical analysis, can be used to compute b from $b\gamma$ as[16]

(4.36) $$b = \frac{b\gamma}{1 - \delta} = E_1$$

where b also serves as the long-run elasticity coefficient of output in respect to its own price. The value of $b\gamma$ suggests the percentage by which output is expected to change with price in the short run, while b indicates the percentage change expected over "sufficient time for complete adjustment away from the past."

In summary, then, the models above provide logical basis for suggesting the distributed lag pattern of adjustment in output, given some ex-

[16] If $1 - \gamma$ is estimated as a regression coefficient in (4.35) and is equal to .8, then $\gamma = 1 - .8 = .2 = \delta$. Then if $b\gamma = .4$, we have

$$b = \frac{.4}{.2} = \frac{b - \gamma}{\delta} = 2.0.$$

pectation of a long-run equilibrium price. It is expected that most adjustments in production structure follow some such path or modification of it, with change in one period related to that of previous periods and resource commitments, over a longer period of time and after the initial "shock" of large sudden changes (such as complete abandonment of price supports or a sharp recession) is overcome.

One problem in agricultural supply is to get a reasonably reliable expectation of future economic structure and price before farmers so that they can gauge decisions and adjustments accordingly. Too few farmers have come to understand the changing environment of agriculture under economic growth and the approximate equilibrium level of factor and product prices. But they have reason—their educational services have not informed them sufficiently. Accordingly, many who could commit resources in another direction have not done so under widespread lack in knowledge of long-run equilibrium structure. Even given this knowledge, adjustment in agricultural supply would still not be by "sudden stroke," with all problems of prices and income erased accordingly. Even given some accuracy in expectations, after initial impact of shocks turned loose in the market, adjustment of the majority of producers and the industry does not flash to approximation of equilibrium price consistent with changed economic structure. With expectation of an equilibrium price and corresponding long-run equilibrium output, Q^*, adjustment would still be gradual, as in Figure 4.4, for the individual. The change in output, Q_t, of a particular period towards the desired equilibrium output, Q^*, can only be gradual in agriculture. (Given the stock of services represented in many resources, the fact that their flow is a function of time and the fact that reservation prices of multiperiod capital resources are much lower than their new supply prices.)

The services given off by multiperiod resources representing the major capital agriculture (and the products they produce) are typically complementary among a restricted number of periods. The services are of flow nature, and if service and product is forthcoming this year, it also is forthcoming next year. This is true of a tractor, a dairy barn or a wheat drill, although a competitive component is expressed over a longer period of time. However, the competitive element is expressed only over longer periods. A two-year-old tractor is good for services in a third year regardless of services employed in the second year, although its life may be cut from 20 to 19.

Outputs in some periods are more clearly competitive, in such cases as fallow or continuous cropping of wheat in the Great Plains. Yet the services and products of the majority of capital in agriculture, including land, are complementary over a time span of a few years. This relationship, plus a low reservation price based on the particular form of capital resources, allows a short-run supply elasticity to be much less in a period of declining prices and contraction than in a period of improving prices and expansion. In expansion, output increases along a given short-run supply function and by movement from one to another supply function as a result of added capital and technology. During contraction, technology and the new or added resource inputs it represents holds the short-run supply function to the right, but the movement is dampened by slackened rate of general capital investment. Given the services which flow from a stock of resources specialized to agriculture, adjustment is down a highly inelastic short-run supply function, or in jump between supply functions which still shift to the right with reduction in factor price (Figure 4.3).

The forces towards dampened commodity prices from contraction along a given short-run supply function have never been great enough to consistently offset (1) the forces towards expansion through favorably priced new technology and (2) rightward shift of short-run supply functions from declining prices of resources already specialized to agriculture. Figure 4.5 illustrates this point quite clearly (the relation between prices paid and production is a distortion of true supply relationship, or response of output to price, because of similar trend in input prices due to inflation and in output due to technical improvement.)[17] The greatest deviations in output trend have been due to weather. While small reductions in output have lagged sharp breaks in price, extended periods of lower prices have not been accompanied by extended reduction in output.

With the extended decline in price relatives during the 1950's, output continued to grow as supply functions shifted rightward, overweighting

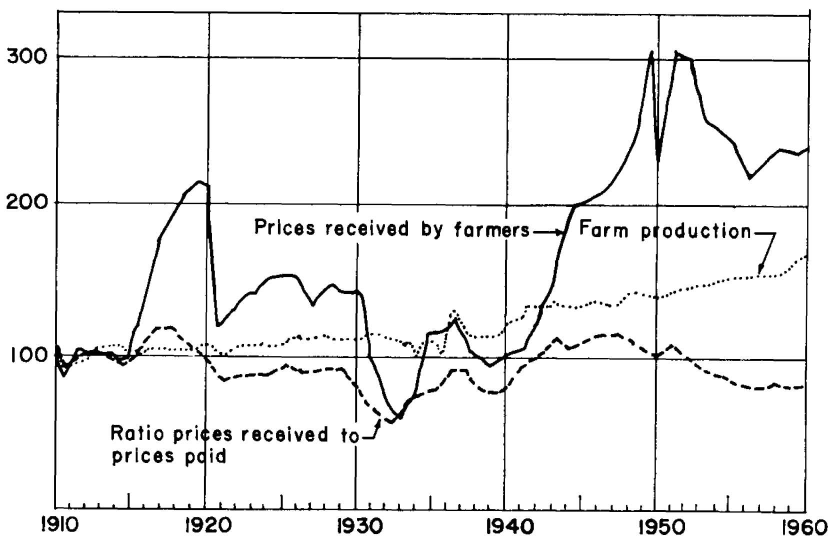

Fig. 4.5. Indices of Prices Received, Prices Paid and Total Farm Production, 1910–60 (1910–14 = 100).

[17] The ratio of prices received to prices paid does not include the implicit costs of resources already specialized to agriculture and is faulty, in a formal supply sense, for this reason. With implicit prices included, the ratio of price received to prices paid would follow quite a different path.

any tendency for production to be contracted along extremely inelastic particular supply function. The same was true during the 1920's and 1930's, aside from deviations due to drouth in the latter period. Of course, periods of depressed price relatives have not been long enough to specify how rate of output growth might be modified by tightened factor/product price ratios. U.S. agriculture still has tremendous slack in structure, allowing the supply function of regions to shift further. (As less efficient managers leave, farms grow larger and remaining operators use different resource mixes to lower per unit costs for a particular price regime.)

It appears possible that even though we exclude commercial farms of low output, such as those with gross income of less than $5,000 in Table 2.6, farm numbers may be decreased by as much as 40 percent, with the acreage so released operated by remaining farms with approximately the labor and machinery they had on farms in the 1950's. If farmers absorbing land area from migrating operators employed the same biological technology, with only difference in machine technology and fixed costs, the short-run supply functions would not change under consolidation. But where biological technology is different and gives higher per acre yields and lower unit costs, as is the typical case, the industry short-run supply function is shifted immediately through consolidation and increase in farm size.

U.S. agriculture has never gone through a long enough period of severe price depression and decline in food demand for possible long-run differentials in elasticities of supply to be reflected in contraction. Certainly downward adjustment in output would be great under a protracted period of extremely low prices and contracted food consumption. For example, if low-cost hydroponics and artificial photosynthesis developed to produce half the nation's food and prices adjusted accordingly, not only would labor and capital inputs decline, but also agriculture's aggregate output would diminish. But contraction in output is not necessary as long as food demand increases and low-cost substitute sources are not available. Policy problems arise, then, not in prospect that the production index in Figure 4.5 will decline, but in terms of the rate at which it will increase under favorable or unfavorable price ratios.

Growth in food output exceeded growth in demand by only a small percentage from 1940 to 1960. However, the low price elasticity of demand causes the excess to have great burden on prices. It is not evident that the reduced price ratios of the 1950's had any measurable effect in slowing down the rate of growth. The low elasticity of supply in a period of supply in a period as short as a decade and the forces leading to shift in short-run supply functions overrode lower prices. This is not to say that the elasticity is low over a long period, or that output cannot be affected within a period as short as a decade. By making the supply of technical knowledge more elastic, the public has caused short-run supply functions to shift rightward more rapidly. By making labor and capital resources more elastic to the industry (e.g. by "buying" specialized forms and diverting them from agriculture), it could similarly cause the short-run commodity supply function to be more elastic, with the rate of growth or magnitude of output in a particular calendar time period thus being less.

PROSPECTS IN OUTPUT AND SUPPLY

The tendency towards growth in output which exceeds growth in demand is predicted for U.S. agriculture in the 1960's. The basic question is not one of whether the nation can feed itself in the 1960's and '80's. It can do so easily, and, as indicated in Chapter 2, the prospect is that a sufficient stock of technical knowledge exists to carry output to 1975 consumption levels without strain.[18] Without new technological knowledge, but a greater average spread of that already in existence, 1975 food requirements of the nation still can be met.[19] Even if the production function remained constant, greater food could still be forthcoming. With no change in the aggregate production function and factor prices, the supply function would be constant. But a constant supply function does not mean constancy of output, except for a function of zero elasticity. The ultra short-run supply function of agriculture is highly inelastic. But the supply function involved when farm acreage is held constant, with more of resources in conventional technological form applied to it, certainly is not of zero elasticity.

More food could be produced, but at a lowered marginal productivity of conventional (already known) nonland resources and a higher equilibrium price of food. Resources could be pulled into agriculture and into industries producing more inputs of conventional form for agriculture. But the food could be produced. The difference is this: The current system of simultaneous growth in demand and change in the supply function through technological advance is similar to movement between lines 4 and 12 in Table 4.1. If supply did not change but demand did, the movement then would be the equivalent to a jump between lines 4 and 8. Equilibrium in food demand would still exist, "requirements" would be met, but food would be priced higher. With shift in demand but not shift in supply (line 8), food price would be the original price (line 4) increased by the ratio $\lambda^{3.33}$, a proportionate increase greater than for demand. If the future period (line 8) were near enough so that present owners of farm resources still existed, they would have greater profit with increase in price of food to $\lambda^{3.33}$ proportion of initial price. Food consumers would be worse off in (1) paying higher prices and a greater proportion of their incomes for food and (2) requiring more resources in agriculture and having fewer to produce other goods and services.

[18] Also see W. W. Wilcox, *Agriculture's Income and Adjustment Problem*, Economic Policies for Agriculture in the 1960's, Joint Economic Committee, U.S. Congress, Washington, D. C., 1960.

[19] *Cf.* O. R. Rogers and G. T. Barton, *Our Farm Production Potential, 1975*, Agr. Info. Bul. No. 233, USDA.

The nation could feed itself up to year 2000, even without technical improvement (an unlikely occurrence), but at an increasing real cost of food and with a large section of resources drawn into agriculture. The facts evidently are, however, that sufficient new technology exists, or can be more widely applied, to allow surpluses, in the sense of the 1950's, during the 1960's. Food for adequate nutrition and at low real cost can be readily attained up to 1975 on the basis of existing technology.[20] (Our current exports could be diverted to domestic use also.) Current investment in technological knowledge thus, in terms of potential of "food price squeeze," is for the consumers beyond 1980, perhaps the year 2000, even though a given supply function would allow them adequate nutrition, but at higher real food costs.

Fortunately, societies do invest with future generations in mind. The basic question is not whether these investments should be made for the future, but how those who suffer capital value and income losses, as supply of the near future is pressed against demand functions of low elasticity, can be treated equitably or compensated in appropriate amount to guarantee positive-sum utility outcome from this facet of economic growth. These are the basic problems of long-run supply complex in a society which prefers economic growth, or which requires it on basis of international sympathy or politics.

From our initial analysis of supply, the quantities which can be manipulated to affect price and income and welfare of farmers or consumers under growth become obvious. Attempt can be made to shift the demand function as or more rapidly than supply, opportunities which are analyzed in Chapter 6. The rate of shift in the supply function might be managed in a rate consistent with positive-sum outcome over farm income, consumer welfare and national progress goals. (See Chapter 16.) Or, after it has shifted, the supply function can be modified through legislative controls, such as legal restraints on particular outputs or inputs. Finally, the structure of supply can be affected by altering the structure of factor prices and supply. Which alternative should be selected depends on (1) the extent to which society has a particular set of over-all national objectives, (2) the extent to which market bargaining power in the hands of various economic groups requires offsetting policy for other groups to guarantee positive-sum utility outcomes over the entire community and (3) the extent to which compensation is publicly desired and is acceptable to redress the losses which fall on one group as a result of gains spread to society in total. These are points to be analyzed subsequently.

Optimum Supply Elasticity

An industry attempting to maximize revenue and income would try to establish the "optimum degree of supply elasticity." Neither the highest nor the lowest elasticity magnitude would be desirable, but a level which is consistent with demand conditions. If the land-grant colleges

[20] *Ibid.*

and the USDA, in their publicly financed research and education, had farm revenue as a single goal, an efficient framework for their activity would be to determine and bring about this optimum supply elasticity. We can illustrate it in both long-run and short-run context. In Figure 4.6 suppose that D_1 is the initial demand curve and I_2 is an isorevenue curve. At the point of tangency of the two, price elasticity of demand is unity. At output of oq_2 and price of op_1, revenue is maximized. A smaller or larger output (and larger or smaller price) would reduce revenue as indicated by isocurve I_1. (Points of intersection a and b both fall on the

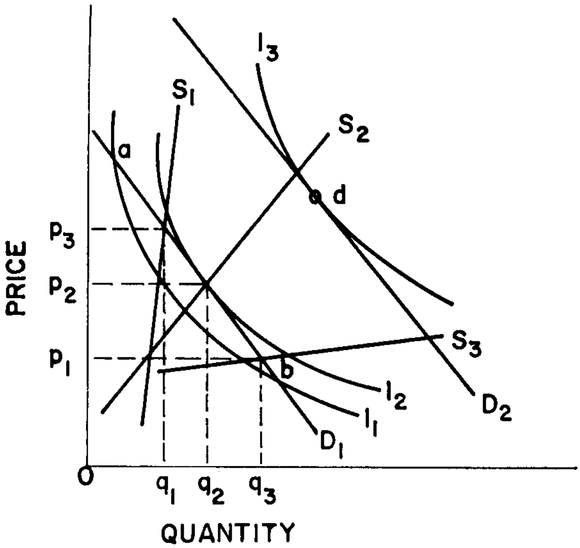

Fig. 4.6. Optimum Supply Elasticity.

smaller revenue curve I_2.) If the supply function is S_2, with output of oq_2 and price of op_2, revenue is maximized. If, however, supply is more elastic, as represented by S_3, the lower price of op_1 and greater output of oq_3 fetch smaller revenues. This also is true for less elastic supply functions such as S_1, where output of oq_1 and price of op_3 denote intersection of D_1 by revenue curves of smaller value than I_2. Even with an increase in demand, revenue will not necessarily increase most by causing supply to remain of low elasticity. For example, with increase in demand to D_2, revenue would be smaller if output followed along S_1 rather than S_2. In the new short run, a supply function is required which intersects point d if revenue is to be maximized.

Rate of Supply Modification

Nations faced with problems in modification of supply functions have two major sets of variables which can be altered: prices or supplies of factors and magnitudes of technical coefficients. In India the question is: How rapidly can supply elasticities be increased and functions shifted to the right to keep up with growth in population and to keep food prices at reasonable level for consumers? In the U.S. the question under surplus and high government support prices has been: How long is the period required before substitution of other mechanisms for high supports can draw the supply function back to level that prices and factor returns can be in magnitudes consistent with resource earnings in other sectors? A parallel question is: How low is the elasticity of the short-run food supply function and how drastically would prices fall, and how much time would be required for important recovery of prices, if control of commodity supply and resource commitment were relegated completely to the market? More fundamentally, the question is one of the extent and rate to which supply functions for particular factors in agriculture might be shifted leftward and/or made more elastic. It also is a question of the costs of relocation for people and the resources which attach to them. It is a problem of the persistence of resources in particular physical form to remain in agriculture and production during their life, because they have no other use of important monetary return. It is a set of problems readily solved over several decades or generations and perhaps of small concern in the long stream of economic growth. But it is a problem of important magnitude to particular farm families who have small resources and must decide whether they are to be among those in exit from the industry in bringing about restraint on supply or whether they are to remain and cause pressure on supply. The income increment or decrement that they realize in either case is important to them, if not to students of economic growth. It is a problem of important magnitude to farmers with greater resources who face sharp cuts in income and capital values. In the over-all sense, the problem can be tackled in cold scientific detachment as the small deviations from trend in centuries-directed economic development. Or it can be tackled in closer attachment to actual families with real aspirations and to human concerns. Both are required in the real world, whether the supply problems at hand arise in economics of low development such as India or high development such as the United States.

RATES AND TYPES OF SUPPLY CHANGE

The income problems of commodity cycles arise because the supply function of short runs are highly elastic for individual commodities. The industry income problems of agriculture under economic development arise because elasticities of short runs are low for agricultural output in aggregate. Short-run elasticity for the individual commodity is high because resources are easily adapted among individual enterprises and the supply function of resources to the product is highly elastic. Land, cultivators and manpower have great adaptability between corn and soybeans. Feed grains are readily shifted among livestock enterprises, and the elasticity of substitution of combines, soil and tractor fuel are highly constant between wheat and grain sorghum. The reward to land for growing corn cannot be lowered far before this resource and its technical complements will be shifted to soybeans. But just as the resources are highly adaptable and factor supply elasticity great for interproduct shift of resources within agriculture, the opposite holds true for agriculture in aggregate. The one problem exists because, given the expectation models used for products with discrete production periods, commodity supply has great elasticity; the other problem exists because commodity supply elasticity is so low.

The difference of adaptability of resources among commodities and between farm and nonfarm products can be better illustrated by this simple example. Suppose a production function for each of n commodities of the general form in (4.37), where Q_i is output of the ith commodity and X_i is the amount of given resource mix used for it. The corresponding resource requirements equation is (4.38).

$$Q_i = a_i X_i^{b_i} \tag{4.37}$$

$$X_i = a_i^{-1/b_i} Q_i^{1/b_i} \tag{4.38}$$

With $\overline{X}$ quantity of resource available, the production possibility curve is (4.39) for two commodities, and the marginal rate of product substitution is (4.40).

$$Q_1 = a_1 \overline{X}^{b_1} - a_1 a_2^{-b_1/b_2} Q_2^{b_1/b_2} \tag{4.39}$$

$$\frac{dQ_1}{dQ_2} = - b_1 b_2^{-1} a_1 a_2^{-b_1/b_2} Q_2^{b_1/b_2-1} \tag{4.40}$$

If the $b_i = 1.0$, the substitution rate will equal $a_1 a_2^{-1}$, a constant, with the magnitude depending on the two coefficients.[21] If $b_i \neq 1.0$, the rate of product substitution will not be constant and will change depending on the amount of the fixed collection of resources allocated to each product. But over farms and without major restraint on resource quantity, the derived production possibility curve has a form similar to that in Figure 4.7a for farm commodities which do not exhaust the land area adapted to them. It has form as in Figure 4.7c, where the area of adapted land is limited. (If it is extremely limited in particular soil type but other soils also can be used, the production possibility curve will have even greater curvature.) The production possibility curve for transfer of resources between agriculture and nonagricultural activity also can be constant over a wide range, but the marginal rate of substitution is low, as in Figure 4.7b, when it refers to machinery, buildings and land already in agriculture. In Figure 4.7a the reservation price ratio for product 1 is

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[21] The statements applied to the particular form of production function apply similarly to any other form with

$$\frac{dQ_i}{dQ_j} = -\frac{dQ_i}{dX_j} \bigg/ \frac{dQ_i}{dX_i}$$

represented by the slope of p_1p_2, the price of product 1 needing to be high enough relative to price of product 2 to cause the isorevenue line to have slope less than p_1p_2, before resources will be shifted to product 1. But for farm commodity against nonfarm commodity, the price of farm product needed to cause resources to be used for the former rather than for industrial product can be much lower. As indicated in Figure 4.7b, the isorevenue curve with slope greater than p_3p_4 is one with a low price of farm commodity relative to nonfarm commodity.[22]

Individual Commodity Supply Elasticity

Examination of supply functions for individual commodities, capable of empirical measurement without confounding of other structural changes as in long-run functions, indicates that farmers do respond to realized and expected commodity and factor prices and changes in the production function. Further, while short-run response to price change is relatively high, long-run elasticity is even higher, as expected from theory. For major commodities available, data allow estimation of response functions such as that in (4.41), after (4.32), where Q_t is U.S. spring hog farrowings in year t, and P_h, P_c and P_b are prices of hogs, corn and beef in year $t-1$.[23]

$$(4.41) \qquad Q_t = -3873 + 297P_h/P_c - 93P_b/P_h + .22\,Q_{t-1}$$

With observations in original quantities (millions), β in the equation is .78, and the direct short-run elasticity of hog farrowings in respect to price, computed at the arithmetic mean of the period 1938–56, is .65. Other commodities with longer production periods indicate similar elasticity of response, as against price of the commodity and other enter-

[22] If we were talking about resources as steel and lumber, rather than discs or farmers, the production possibility curve for Figure *b* would have much less slope, and a greater price of farm product relative to nonfarm product would be needed to bid their use to agriculture. We have used extreme examples of substitution, although the production possibility curve is linear over important ranges of interproduct allocation of resources. But considering different qualities of resources, and different products in aggregate sectors for which resources can be used, the production possibility curve in both cases will have some curvature as in *C*. As the curvature of production possibilities increases, the marginal rate of product substitution also changes more rapidly. The elasticity of supply of one commodity, against its own price, will be affected accordingly. This point perhaps should have been emphasized in text equations of supply functions of single commodities. However, we did not include price variables for competing commodities in order to keep the steps simple and to keep emphasis on the "aggregate farm product."

[23] See Gerald W. Dean and Earl O. Heady, *Changes in Supply Functions and Elasticities in Hog Production*, Iowa Agr. Sta. Bul. 471.

A similar function computed for eggs over the period 1924–59 is that below, where P_e is eggs price, P_f is feed price, R is an index of technical change and Q_t now refers to egg output for the U.S. The short-run elasticity in respect to P_e/P_f is .184 and the long-run elasticity is $.184 \div (1-.752) = .737$ where observations are in logarithms.

$$Q_t = -.91 + \underset{(.063)}{.184}\,P_e/P_f + \underset{(.068)}{.229}\,(P_e/P_f)_{t-1} + \underset{(.068)}{.410}\,R + \underset{(.085)}{.752}\,Q_{t-1}$$

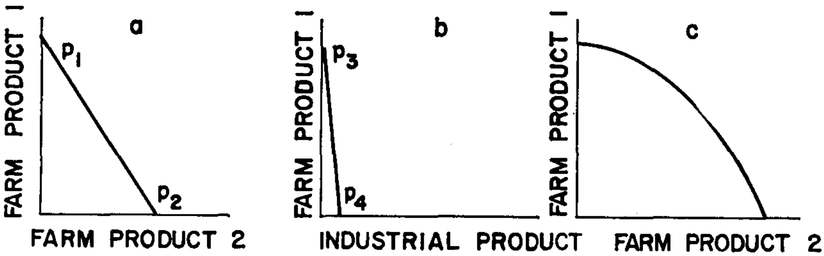

Fig. 4.7. Production Possibility Curves for Adjustment.

prises.[24] For example, Nekby found the short-run price elasticity (on own price) for animal food products to be .32. The corresponding long-run elasticity was 1.60. Against price of competing products, the short-run elasticity was −.14 and the long-run elasticity was −.68. There was less difference between short-run and long-run elasticities for fruits.[25] Farmers obviously are price and market oriented, even if less so than some corporation firms and the models of elementary texts. They reallocate resources with relative speed, depending on the production and payoff period dating from initial investment, among different commodities. And managerial acumen is increasing with greater market orientation. Regardless of increased scale of farm and product specialization, elasticity for the commodity is being maintained or increased. In the study cited above, for hots and the particular function, short-run supply elasticity to hog price increased from .46 to .65 between the periods 1924–37 to 1938–56.

Given the expectation models used so broadly by farmers, somewhat smaller elasticities of short-run supply response for individual commodities would lessen fluctuations in production, price and income. The extent of fluctuation in output and price for numerous commodities is too great for greatest benefit of both consumers and all producers. Particular types of price and storage policies would allow some of this instability to be removed, elasticities for individual commodities remaining high.

The Aggregate Function

The great adaptability of machines, buildings, land and labor, feed and other resources existing in agriculture among commodities, a cause of great supply elasticity for individual products, adds to the low elasticity of farm output in aggregate. This condition, and the fact that farm commodities are good substitutes in consumption for stomachs of limited capacity, causes surplus problems of one sector of agriculture soon to spill over into other sectors, or for supply, price and income problems to

[24] For example, see R. Barker, *Dairy Supply Functions*, Ph.D. Thesis, Iowa State University, Ames, 1960.

[25] B. Nekby, *The Structural Development of American Agriculture*, Ph.D. Thesis, Iowa State University, Ames, 1961. Also, see Marc Nerlove, *The Dynamics of Supply*, Johns Hopkins University Press, Baltimore, 1958.

be quite general to the industry rather than specific to the commodity. There are, of course, important exceptions resting on particular regional advantages and lack of substitutability among commodities. The difference which arises for various commodities is illustrated in Figure 4.8a, where S_a is a short-run supply function for farm commodities in aggregate, S_m is for a major crop such as wheat or corn and S_n is for a minor crop such as flax.[26]

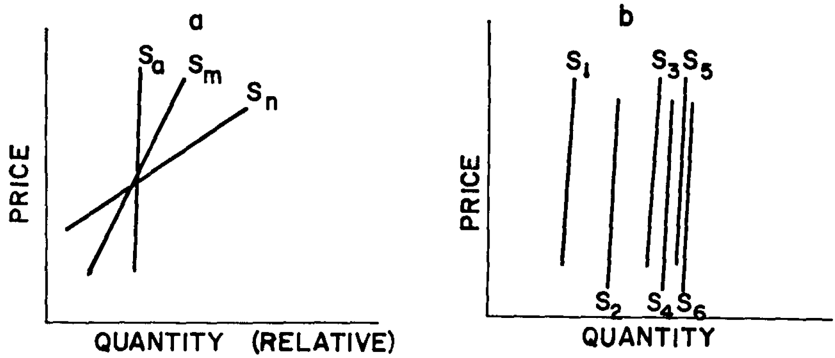

Fig. 4.8. Types of Short-Run Supply Functions.

In this setting, two price environments give response in output which causes the short-run aggregate supply function to appear to have zero elasticity or to be backward sloping. Both of these environments occur when a transitory increase in demand is withdrawn and farm commodity prices plummet relative to prices for factors from outside agriculture, but output is maintained or even increased. One has been experienced frequently following wars, with a parallel situation in major depressions. The other prevails, or might prevail, as governments withdraw or lower price supports, thus decreasing public demand for commodities in storage.

Again, if we look back to Figure 4.5, the major price decline in the early 1920's did not result in a commensurate decline in aggregate output if, in fact, output even declined as a result of price reduction. Neither did large price declines in the early 1930's, or in the 1950's, result in immediate or delayed downward trends in production. The effect of time in the immediate years of these periods was to cause output to follow the gradual upward trend. Under the usual formulation of supply models, lagged response of output to price decline is expected. But the lagged or delayed action of restrained production did not come about later in the 1920's, 1930's or 1950's. (The major declines in output were due to unfavorable weather and yields and not in planted acreage.) Production pushed upwards under less favorable price relatives even as labor inputs

[26] The same relative differences exist among commodities in extremely short-time spans when their production periods are different; with S_a referring to orchards, beef or range grass; S_m to beef, dairy or hogs; and S_n to broilers, peanuts or lettuce.

were decreased. This upward trend was due largely, of course, to new technology, or a remixing of the capital fund in agriculture, perhaps with a small substitution of present output for future output in the severe declines.

It appears that response to price had greater velocity, in expected direction, during periods of sharp upward swing in price, given sufficient lag for new investment and change in plans. An explanation behind the greater "upward" elasticity is provided in Figure 4.8b. With more favorable prices, or their expectation, farmers can bid more resources into agriculture from the input-furnishing industries, after sufficient lag to allow consolidation of investment decisions, to acquire or accumulate capital and to develop capital in the case of commodities such as beef or trees with longer transformation periods. The supply, for resources such as new tractors and similar physical items brought into agriculture, is relatively elastic. As a declining portion of the national economy, agriculture can easily bid more resources (as steel, tractors, lumber, barns, etc.) into the industry under favorable ratios, or readily slow down their acquisition under unfavorable prices. Since more resources can be drawn in with ease, short-run farm supply functions move rightward, with the speed or large jumps suggested by the difference among short-run aggregate supply functions S_1, S_2 and S_3. War periods especially have given demand and price spurts which were transitory. And agriculture has always shown great elasticity of supply during these expansion periods.

This was true in ancient times, with grasslands turned to grains in the twelfth century wars of England. It was equally true in the twentieth century wars of the U.S. where inputs were available for elastic expansion of output. But the contraction is a different problem. As prices turn unfavorably after demand decline, the multiperiod resources are already in agriculture. Their supply function has little elasticity. Hence, while new purchases are checked, used ones remain and output still expands as indicated by the smaller difference or jumps between S_3, S_4, S_5 and S_6. New technology in seeds, fertilizer and rations allows the addition; but so does the change in structure of agriculture growing out of decline in farm operators and labor force, the consolidation of farms and the market transfer of fixed resources into the hands of farmers with greater managerial and capital resources. Too, in this complex of rapid increase under favorable prices and continued (if slackened) shift under less favorable prices, capital accumulation and equity position favor it. With higher prices, farmers' savings and equity position increases, improving their capital position and lowering the degree of uncertainty so they can more readily add durable capital items and invest in new technology.[27] Too, those who remain after the initial impact of price decline are in capital position to apply better technology than those who release resources and leave the industry.

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[27] For details on these points see Earl O. Heady, *Economics of Agriculture Production and Resource Use*, Prentice-Hall, New York, 1952, Chaps. 15 to 17.

Response to Price

Agriculture does respond to price in both directions. But the structure of production and supply functions for resource services and the changes in prices of these factor services cover up much of this response in the aggregate data under technological advance. (The resource service production function is one wherein services flow forth whether or not the factor is used, and cannot be captured at a later time if they are not used.) Farm employment has declined rapidly in confrontation with (1) declining farm income and favorable employment opportunity elsewhere and (2) favorable prices of farm machinery. Purchases of fertilizer have had temporary dips from the upward trend (a trend due to greater knowledge of response) in periods of highly unfavorable price relatives. The complex of commodity and resource prices within and outside agriculture caused the amount of land in farms to decrease by nearly a third between 1920 and 1960 in the four states of Massachusetts, Connecticut, Rhode Island and New York.

As mentioned previously, if technology brought low-cost and palatable substitutes for farm foods, with the real price of farm commodities dropping drastically, farm output and inputs would decline. But the extent of price decline and the length of time required for resources to withdraw in an extent allowing rebound of returns to levels of other economic sectors is the basic question of agricultural supply. It was obvious and necessary, under the rate of surplus accumulation and the mounting of public storage and program cost in the 1950's, that the price to which supply responds be geared closer to that corresponding with consumer preferences over the aggregate mix of goods in the economy. Price supports in the structure of the 1950's did not solve the problem of output to which they were directed; they only increased it, not only in the manner prescribed by theory in level of price, but also because they had an effect in increasing certainty of price expectations and farmers' willingness to commit resources to new technology. They did not come to grips with the basic problem of factor supply. Product supply in the short run would have been caused to increase in elasticity and decrease in magnitude more by public purchase of second-hand tractors, barns and labor services. (This is a possible compensation means consistent with the principles outlined in Chapters 8 to 11.) Supply elasticity and reservation prices of these resources to agriculture would then have increased.

While it is true that agriculture in aggregate does respond to price and that supply elasticity could be improved by certain market improvements and institutional changes, the competitive nature of the industry and the pressure for individual firms to innovate and adopt technical improvement, as their main control in income improvement, complicates the problem and represents a tempo not easily arrested. The historic persistence of low returns in agriculture relative to other industries, both worldwide and over many decades, underscores that the "length of run" is indeed lengthy. Land without industrial or urban employment opportunity will remain in agricultural use as long as its net marginal return is greater than zero (or greater than taxes), although it may shift to crops with smaller cash costs. In the short run, it even tends to hang in the same crop.

Two studies relate to the extent of inelasticity in short-run response and "shake down" in price which might be expected in a near future period, before sizeable response in output and resource structure could be realized. An Iowa study estimates that if price supports were withdrawn and surplus stocks were immobilized, the effect over two years would be price declines of around 40 percent for feed grains and livestock, with some increase in output under abandonment of production controls.[28] The two years would be a true "shake down" period, with prices, production and inputs recovering direction with some lag. Over a two-year period, from 1959–60 to 1962–63, hog prices were projected to decline from $15.70 to $11.00, beef cattle from $23.00 to $12.00, eggs from 31.50 to 28.3 cents, milk from $4.05 to $2.67, corn from $1.13 to .60, wheat from $1.72 to .74 and cotton from 35 to 21 cents. Prices existing in the latter period would be sub-equilibrium in the sense that they serve as "shake down" levels, with some adjustment taking place over a longer period of time. Income of agriculture would decline greatly since cash costs initially would remain near existing levels. Total cultivated acreage would adjust but little remaining nearly at levels of the earlier period. Income would drop also under the estimates explained below, except more farmers would have moved out and some improvement would take place in income per farm family.

Two joint committees of Congress suggest the extent of recovery in a period as long as five years.[29] Under these estimates, prices in 1965 would decline by the following percentage from 1959: hogs by 23, broilers by 30, corn by 38, wheat by 50, cotton by 35, rice by 30 and milk by 12. Supply would still be so large at these prices that, on average, returns to resources in agriculture would be lower than in 1959, and much lower than for other occupations, given the resource prices in agriculture at the outset. More needs to be known empirically about long-run supply elasticity, the above studies resting on projections of scant knowledge. However, belief of low elasticity in the short-run period is widespread.[30]

The burning policy question relating to these supply quantities is: How much time must elapse before supply and resource structure adjust "downward" to allow comparable resource returns? Accompanying questions of no less importance are: Which strata of agriculture would

[28] G. Shepherd, Arnold Paulson, *et al.*, *Production Price and Income Estimates and Projections for the Feed-Livestock Economy Under Specified Control and Market-Clearing Conditions*, Special Report No. 27, Iowa Agr. and Home Econ. Exp. Sta.

[29] See *Economic Policies for Agriculture in the 1960's, Implications of Four Selected Alternatives*, Joint Economic Committee of Congress, Washington, D.C., 1960, pp. 38–40. Also, see Senate Document 77, 86th Congress, 2nd Session, Jan. 20, 1960.

[30] *Cf.* M. R. Benedict and E. K. Bauer, *Farm Surpluses: U.S. Burden or World Asset*, Univ. of Calif. Div. of Agr. Sci., 1960, p. 90; and J. H. Alder, *Stabilization Policy in Primary Producing Countries*, Kyklos, Vol. 11, p. 157.

bear the cost of the "shake down?" To what extent, and in which manner, could they be compensated, equitably and acceptably? How could resources released be best guided to employment advantageous to themselves, and the preferences of consumers and national goals or responsibilities? The time period required for adjustment depends, of course, on the market and policy environment provided to guide adjustment. The policy question is not so much, given low short-run elasticity, whether elasticity of supply has sufficient long-run magnitude to bring resource use and output into rough conformance with consumer wishes, but rather one of how transition from a surplus situation such as that of the early 1960's might be made without throwing an inequitable portion of the cost of adjustment into the laps of particular farm families. To turn prices abruptly loose in the market would accomplish this transfer, but with bankruptcy of many families. The important social question is more nearly: Does a democratic society have other less painful means of solving a major structural maladjustment?

The basic U.S. problem in commercial agriculture cannot be solved by price, storage and production policies of the nature used over the three decades 1930–60. These suppose too nearly that the situation is temporary and the rate of increase in supply will slow down, to be overtaken by increase in demand. They are temporary in the sense that they could not be expected to be sensible for an agriculture with two decades ahead when it can extend supply beyond domestic demand. At the outset of this chapter we mentioned that commodity supply was only the superficial, the directly apparent, problem of agriculture. Problems of commodity supply are fundamentally those of resource supply. Hence, we turn in this direction for better understanding of the phenomena underlying the problems of commercial agriculture.