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SIZE OF FARM AND ECONOMIC DEVELOPMENT

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SIZE OF FARM AND ECONOMIC DEVELOPMENT*

Disagreements about economic advantages of small versus large farms appear wherever land reforms are being debated. Policy measures, such as subdivision of large farms or establishment of cooperative farms, are partly justified on the basis of arguments advocating or opposing small scale organization in agriculture. The officially sponsored "Studies in Economics of Farm Management" (29) in India have provided a wealth of data for the analysis of different sized farms. Particular attention has been focussed on the negative relation between size of farm and production per acre which these studies show; a number of articles have discussed the significance of these findings (9, 15, 16, 20, 21, 22, 23, 27).

The relation between farm size and production per acre is a result of the adjustment of farmers to conditions that they face. The fact that production per acre varies suggests that available alternatives must be somewhat different in the case of small and large farms. In 1955, S.R. Sen, in pointing to the relevance of small scale Japanese agriculture as a model for the countries of South and East Asia, based his argument on the low land-man ratio and limited employment opportunities outside of agriculture on one hand and possibilities of increasing yields on small farms on the other (28, p. 919).

There are important alternative ways in which farm production can be organized. These alternatives are available in several distinct and relatively independent dimensions: 1) capital can be substituted for labor, 2) the combination of crop and livestock enterprises can be varied, 3) a number of different yield-increasing inputs and practices can be used, and 4) the scale of the farm firm can be large or small. Even within areas which are homogeneous with respect to natural conditions such as soils, climate, topography, etc., all of these alternatives are generally available.

This article attempts to show how the differences among farms (with respect to the above dimensions) can be explained as adjustments to the economic situation in which different kinds of farmers find themselves. This provides a theoretical explanation for the higher production per acre on smaller farms; such higher production is achieved primarily by a more intensive combination of crop and livestock enterprises and represents an adjustment to relatively small amounts of land per family worker. However, such tendencies for negative association between size and output per acre can be counteracted and even reversed if larger farms have made greater advances in the adoption of yield-increasing technology than smaller units.

The production function considered in this article is one in which output depends on four types of inputs: 1) labor, 2) land, 3) labor-saving capital, and 4) land-saving (yield-increasing) capital.[1] Output will be taken to mean a combination of different crop and livestock products with the understanding that the combination of products can be varied to make best use of the resources available.

With the use of these concepts two questions will be considered: 1) how does the organization of the farm firm respond to changing factor prices in the course of economic development, and 2) how and why does the organization of small farms differ from that of large farms.

Substitution of Capital for Labor: Mechanization

The first three sections deal with the significance of variable proportions of land, labor and labor-saving capital; land-saving capital will be considered later. This section is concerned with the substitutions between labor and capital. Land is assumed constant. In Figure 1, the isoquant represents different combinations of labor and capital that are capable of obtaining a fixed quantity of output from a fixed acreage. Thus, the output per acre (intensity of land use) is assumed constant.

The following may illustrate these assumptions:

1) The total amount of land, the proportion of land allocated to individual crops and the yields of individual crops are assumed to be constant for all points on the isoquant. This is the meaning given to fixed intensity of land use in this section. In turn the above specifications determine the amount of plowing, seeding, weeding, harvesting, the season in which the work is to be performed and the care with which the work is to be done.

2) The points on the isoquant represent different combinations of labor and capital capable of accomplishing the required tasks of plowing, seeding, etc., on the fixed amount of land. With the most labor-intensive techniques, many workers with hoes and other hand tools would be required. By using more capital per worker, the necessary work could be done with fewer workers. Thus, the use of bullocks, horses, small tractors and large tractors determines other points on the isoquant. The capital input on the y axis can be measured by the total annual cost for each source of draft power and the equipment that is used with it.[2]

The least-cost combination of labor and equipment is determined by relative factor prices of labor and capital. It is profitable to use less equipment per worker where labor is plentiful and wages are

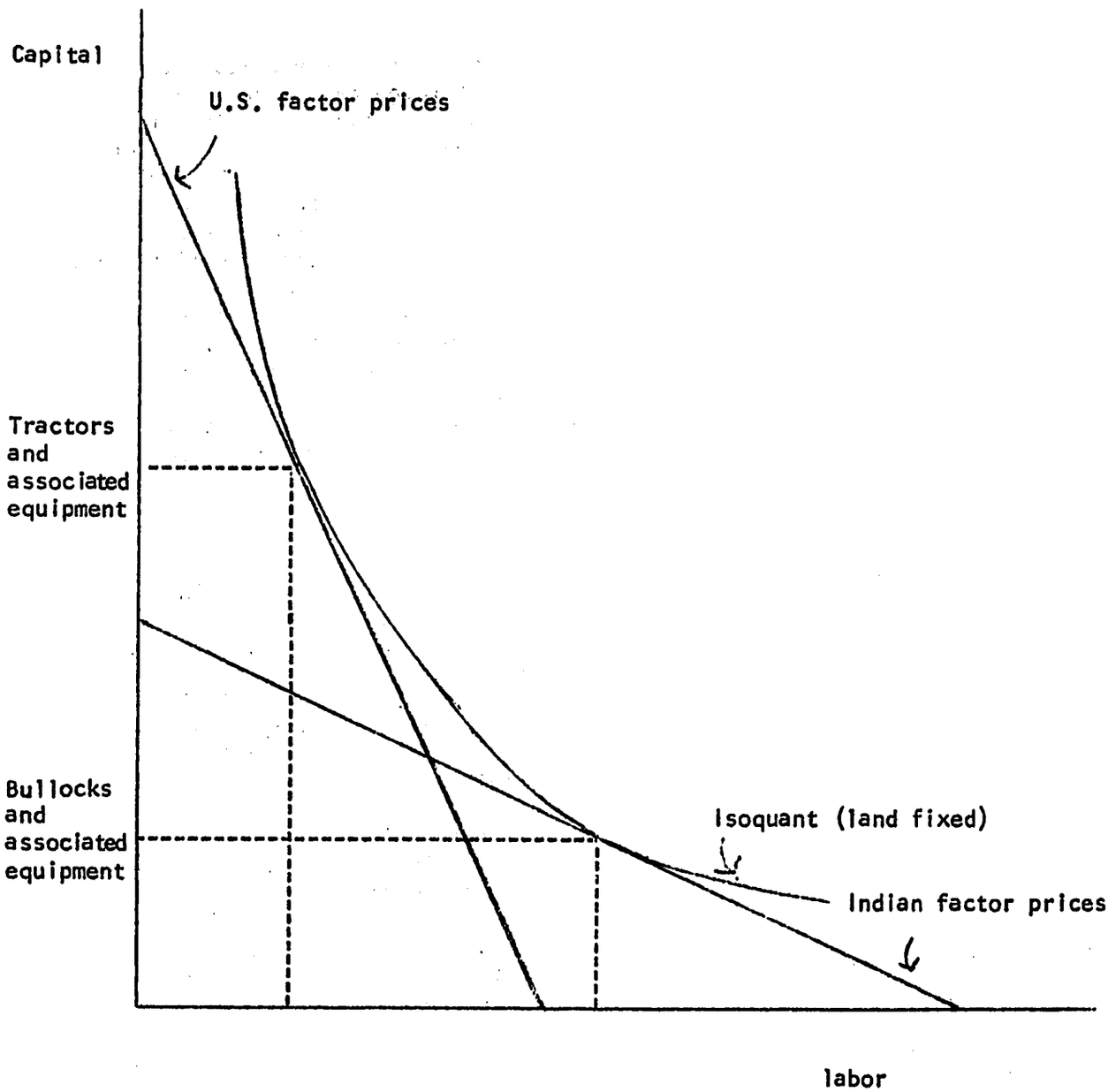

Figure 1. · Differences in farm organization between economies with different relative factor prices.

low. However, these conditions change in the course of economic development. Wages rise as sufficient non-agricultural employment is created to siphon off farm workers.

Mechanization enables each worker remaining in agriculture to farm more land. Indeed, increases in the acreage each worker can handle is usually a symptom of increased substitution of capital for labor. Acres per worker is a much better basis than size of farm for indicating how farm organization differs among economies with very different wage levels: low wage economies may have larger average farm sizes than more developed economies, but they will have smaller acreages per worker. As shown in Table 1, the characteristic difference between Indian and U.S. agriculture is that on large Indian farms (in Madhya Pradesh) there are about 16 acres per worker, while on large U.S. farms (in Illinois) there are about 220 acres per worker.[3] On the other hand a farm of 100 acres in India is very different from a farm of the same size in the U.S. In the regions represented in Table 1, the 100 acre Indian farm employs more than six workers, while the 100 acre U.S. farm is not large enough to provide adequate income for one worker. The Indian farm of 100 acres is much more like a combination of several Indian farms of 16-25 acres than it is like a U.S. farm of 100 acres.

Actually, average size of farm serves reasonably well to indicate that Indian agriculture is organized under conditions of much lower returns to labor than those prevailing in U.S. agriculture. Average size of farm is equal to acres per worker times the number of workers per farm. Most farms in both India and the U.S. use primarily family labor. Average farms in each country are likely to employ about the same number of workers, thus making the size of farm proportional to acres per worker in these two agricultural economies.

However, average size of farms will not indicate the level of development if the agricultural sector is dominated by farms employing many workers. Chile is a good example of a country with large farms but relatively small acreage per worker. In the dominant agricultural region, the Central Valley, farms over 500 acres contain 73.1% of the cultivated land and employ 44.5% of the agricultural workers with an average of 32 workers per farm. Yet there are only an average of 14.2 acres per worker on these large farms.[4] It is the latter figure and not size of farm that reflects adjustment to relatively low wages of labor in Chile.

Since acres per worker and not size of farm is the variable directly responsive to changing factor prices, the size of farm need not necessarily increase in the course of economic development. On large farms the number of workers can be reduced as capital is substituted for labor. No increase in size of farm need be made. Or larger-than-family farms could be broken into family farms, while acres per worker remained constant or increased. Such changes, whether resulting from private land market transactions or from land reforms, are not in themselves inimical to economic develpment of agriculture.

TABLE 1

Acres Per Farm Worker In Three Economies

INDIA (Madhya Pradesh)[a]			U.S. (Illinois)[b]			CHILE (Central Valley)[c]			
Ave. size of farm (acres)	No. of workers per farm	Acres per worker	Ave. size of farm (acres)	No. of workers per farm	Acres per worker	Size of Farm (acres)	"Equivalent" irrigated acres per farm	No. of workers per farm	"Equivalent" acres per worker
2.9	1.8	1.6	81	1.1	74	0-12.5	1.6	1.4	1.1
7.3	1.6	4.4	152	1.3	117	12.5-50	6.4	2.6	2.5
12.5	2.2	5.7	221	1.4	158	50-125	19.8	4.1	4.9
16.9	2.4	7.0	295	1.7	174	125-250	38.5	5.8	6.6
24.2	2.4	10.0	374	2.1	178	250-500	94.3	11.0	8.6
34.5	2.9	11.8	453	2.4	188	500-1250	251.1	20.1	12.4
43.3	3.2	13.5	539	2.5	216	1250-2500	481.7	32.9	14.6
59.6	3.7	15.9	701	3.2	219	2500-5000	562.3	40.8	13.8
100.0	6.4	15.6				5000-12500	801.2	56.5	14.2
						12500 and over	1264.0	76.0	16.6
Ave. all farms 21.4	2.5	8.7					39.0	4.6	8.5

[a]From Parthasarathi (20); article uses unpublished data from Studies in Economics of Farm Management for 1955-56.

[b]From Mosher (18); account-keeping farms selected for size and uniform soil quality.

[c]From Bray (2); data for all farms in ten provinces of the Central Valley from the 1955 Census of Agriculture.

"Equivalent" irrigated acres are equal to the sum of a) acres of irrigated land and b) acres of unirrigated cultivated land times 0.1.

In an agricultural sector dominated by family farms, however, increase in acres per worker necessitates an increase in average farm size. Farm enlargement, in turn, makes possible both the migration of rural people in excess of natural increase and the consolidation of land into larger farms by those who remain in agriculture. The reorganization of U.S. agriculture since 1920 is a good illustration of this process. During this period capital per worker increased continuously as tractors first replaced horses and mules and as bigger tractors and farm machines have been replacing smaller ones. Size of farm and acres per worker both increased considerably. But most farms continued to be family farms and there was little change in the number of workers per farm. Size of farm increased as a consequence of substitutions of capital for labor and not because there was a decisive change in the relative position on the long-run average cost curve of farms using family labor and of farms with a larger labor force.

Intensity of Land Use on Small and Large Farms

Figure 1 of the previous section illustrates the substitution of labor-saving capital for labor and the determination of the least-cost combination of labor and capital; for this purpose the intensity of land use was taken as given. However, the same least-cost labor-capital combination (as determined in Figure 1) may be appropriate for a range of different intensities of land use and for different sizes of farms; in the first case more units of the combination of labor and capital are applied to an acre of land, in the second more units of labor and capital and land are put under central management without substantial changes in the proportion of labor to capital in either case. Data from the Punjab in Table 2 provides an example. In this case, while farms varied from less than five to more than fifty acres, and while the farm size groups varied in output per acre (Table 3), the ratio of bullock to human labor was nearly constant.

What is being suggested is that in many situations the economic decision about how much draft power and equipment is to be combined with each worker is independent of the economic decision about how many combined units of labor and equipment to apply to an acre of land or how many units of labor, equipment and land to combine into the organization of the farm firm. These decisions are independent if the slopes of the isoquants in Figure 1 remain approximately the same with different intensities of land use and on different sizes of farms.[5] Under such conditions the prices of labor and equipment, in a given economy, dictate approximately the same combinations of labor and capital throughout a large range of farm sizes and land use intensities.

Figure 2 is constructed on the basis of this argument. One unit of the input on the x axis represents a least-cost combination, in fixed proportion, of labor, draft power and equipment. For example, the fixed proportion between labor and capital might be one man, a

TABLE 2

Ratio of Bullock to Human Labor, Punjab, India

Size of farm	Days of human per acre	Days of bullock labor per acre	Days of bullock labor per day of human labor
0-5	53.2	30.0	.56
5-10	44.8	28.1	.63
10-20	37.0	24.0	.65
20-50	29.0	18.9	.65
50 and over	20.5	13.7	.67
All farms	32.4	21.1	.65

Source: First two columns from Randhawa (23, p. 29); third column is equal to the ratio of the first two.

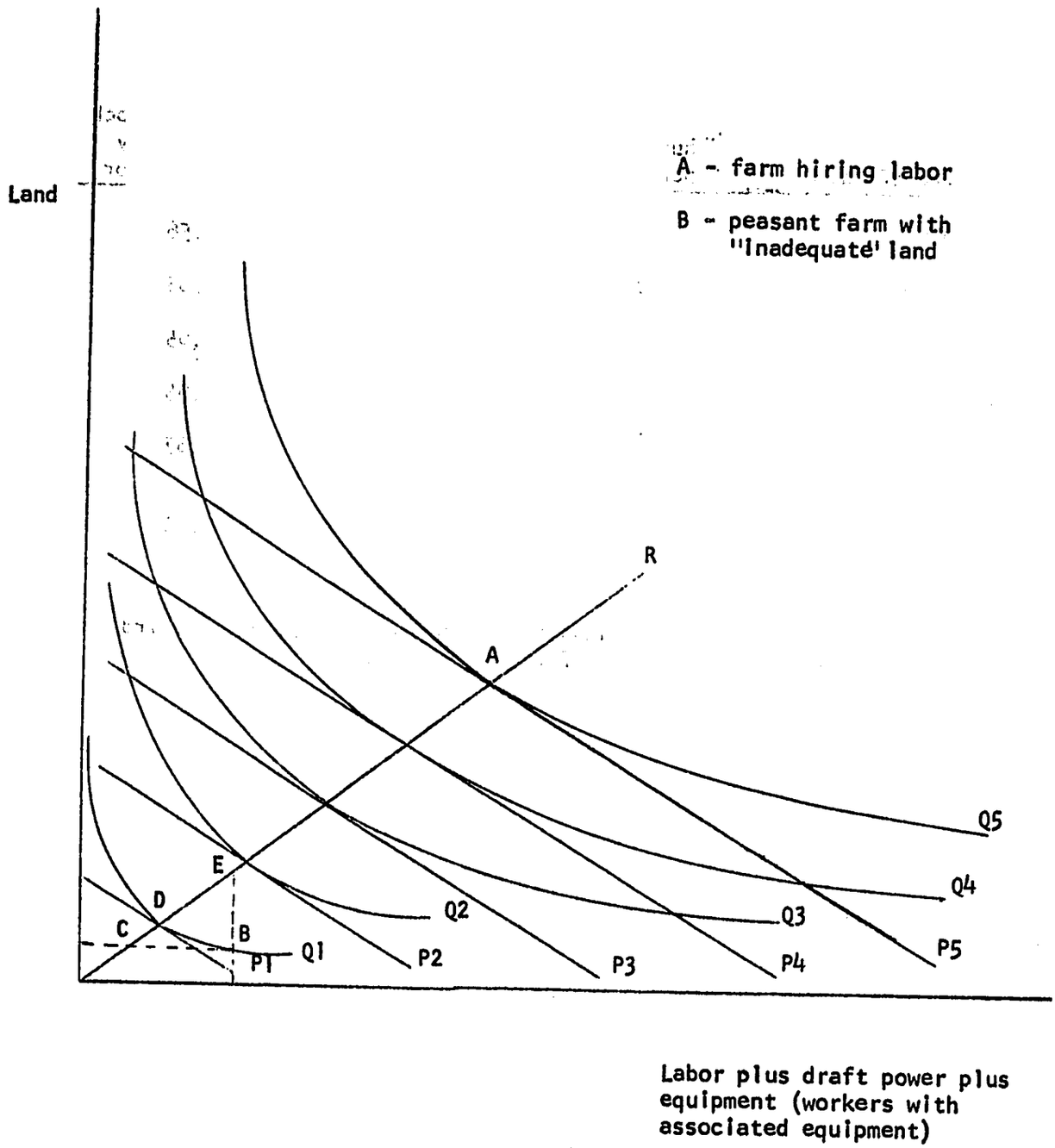

Figure 2. Differences in farm organization between large and small farms within the same economy.

team of bullocks and the usual bullock-drawn equipment. A movement to the right along the x axis would then represent a proportional increase in workers, bullocks and bullock-drawn equipment. In the remaining portions of this section references to changes in the labor input should be understood to refer to changes in both labor and capital.

Figure 2 represents a range of possibilities for intensifying land use and for organizing farms of different size. Points on an isoquant using much land and little labor represent extensive land use and small output per acre, movement along the isoquant (more labor and less land) represents intensification of land use.

Greater intensity is more commonly achieved by greater use of more labor intensive crop and livestock combinations and by more double-cropping than by increasing yields of individual crops.[6] We can illustrate by resource programming with variable labor and equipment, fixed land, and a choice among a number of alternative crop and livestock enterprises. As more labor and equipment becomes available, the income-maximizing program shifts to crop combinations requiring more labor and capital per acre; the shifts achieve less output per worker and more output per acre.[7]

From the solutions of the variable resource programming described, a family of isoquants (such as those in Figure 2) could be derived. Any isoquant would then represent a fixed value of output net of variable costs. The composition of output (the crops and livestock produced) would be free to vary.

The relative factor prices of 1) land, and 2) the package of labor and capital, determine the optimum intensity of land use. The expansion line OR (Figure 2) represents the least-cost combinations of land and the package of labor and capital which maintain 1) the optimum proportions between factors, and 2) the optimum land use intensity.

If farms of different size were organized to achieve least-cost production, then a large farm with ten workers would have approximately ten times as much land, labor and capital as a one-man farm, and acres per worker should be approximately the same on all farms. In Table 1 the two largest farm size groups in both India and the U.S. do show constant acres per worker, but acres per worker are smaller on smaller farms. Thus, the largest farms seem to be located on expansion path OR, while smaller farms are below OR. In Figure 2, point A can be taken to represent the larger and point B the smaller farms.

These results are not surprising. On the large farms, the farm manager is faced with a decision about how many workers to hire. It pays him to hire additional workers as long as their marginal product exceeds their wage. If the decisions of employers approximate those which are theoretically expected, then large farms should be organized with the factor proportions indicated by Line OR.

But on small farms, labor is largely provided by the family which often owns the land and capital as well. Reorganization of these small farms to achieve the least-cost combination represented by OR can be achieved in either of two ways: a) by some members of the family labor force taking off-farm employment at the prevailing wage (movement toward C), or b) by renting or purchasing more land to combine with the available family labor (movement toward E). Such reorganization would be advantageous to the farm family if the adjustment opportunities were open to it. However, in most underdeveloped countries the pressure of population on the land probably prevents either adjustment from taking place.

The following conclusions can be drawn: 1) at market prices of inputs, farm B is a high cost farm; the lowest cost for the same output is with farm organization at point D in diagram, 2) output per acre is higher on farm B than on larger farms; farm organization at point C achieves the same output per acre as larger farms; with the same acreage, output at B is larger than at C, 3) marginal productivity of labor and capital on farm B is less than marginal productivity on larger farms and marginal productivity of labor is less than the wage though it need not be zero; with land available to farm B, marginal productivity of labor equal to the wage would have been achieved with the farm organization represented by point C, 4) average product per worker on farm D is less than on larger farms as can be shown by comparison of points B and E in Figure 2.[8]

The above conclusions provide a possible explanation for the results in the Indian Studies in Economics of Farm Management. In terms of Figure 2, most Indian farms are located somewhere below the line OR.

The Punjab data presented in Table 3 illustrate the four conclusions derived above from Figure 2: 1) the smallest farms show the highest cost in relation to value of output, 2) value of output per acre is inversely related to farm size, 3) the average output per day of labor and the net labor return per day increase with size of farm. The last measure suggests that marginal productivity of labor increases with size of farm.[9]

These conclusions lead to three considerations. First, the economic decision about the use of labor is different on small and large farms. On small farms the basic economic decision is how to obtain the most income (or food production) from the available family labor and other family owned resources. Labor use on the farm is not limited by the factor market cost of labor. Any additional use of family labor which increases production or income benefits the family. The relevant opportunity cost of labor is determined by the labor requirements of alternative crop and livestock enterprises and by the amount of land (shadow prices in an income-maximizing program). The factor market

TABLE 3

Output and Costs per Acre and Per Man-day by Size of Farm

Punjab, India

Size of Farm (acres)	Cost of Inputs per acre (Rs.)	Value of output per acre (Rs.)	Value of output per man-day (Rs.)	Net labor return per man-day (Rs.)
0-5	240	200	3.77	.69
5-10	203	186	4.15	1.04
10-20	180	173	4.67	1.33
20-50	154	154	5.32	1.66
50 and above	127	143	6.98	2.68
All farms	165	163	5.02	1.53

Source: M.S. Randhawa, (23). Article uses data from Studies in Economics of Farm Management. Cost of inputs includes inputed values for family labor and family owned land and capital. Net labor return per man-day is equal to total value of output minus all costs other than labor divided by man-days of family and hired labor.

wages become relevant only if off-farm employment is readily available; only then does the prevailing wage become a measure of opportunity costs. This is in contrast to farms on which labor is hired, and where the decision about how many workers to hire is relevant. To restate, the efficiency of the organization of small farms cannot be judged by measurements of costs which are based on prevailing wages if off-farm employment is not readily available at these wages.

The second conclusion is that intensive use of self-employed labor on small farms is desirable in countries experiencing population pressure. The whole labor force cannot obtain wage employment at a subsistence wage, if the ratio of population to resources is so high that marginal productivity of labor is less than subsistence.[10] In such cases, it is the more intensive organization of family farms which offers access to income to many of those who do not find wage employment, and helps to maintain wage levels in the labor market.[11]

The third conclusion is that information from organization of existing small and large farms cannot be used directly to judge the economies of size in agriculture. To determine such economies, data is needed from farms which are free to reorganize to achieve the least-cost resource combinations for any level of output. The argument above implies that small farms are not free to recombine resources. Their organization is more a consequence of limited off-farm opportunities, than an example of how to produce small outputs at low costs.[12]

Economies of Size

Figure 2 implies that output can be changed proportionately by increasing (or decreasing) all inputs in the same proportion. Such conditions give rise to constant costs per unit of output in firms of all size.

More commonly a firm's long-run average cost curve (LRAC) is thought to have a least cost point at some specific level of output. Diseconomies to the left of the optimum level of output are due to indivisibility of some factors of production and due to losses in efficiency from not being able to use the optimum division of labor. Increased costs due to indivisibility arise when output is too small to require full-time use of a single unit of the most efficient form of capital. For example steel furnaces of different size can be designed, but a furnace to produce half the output of the most efficient unit will cost more than half of the cost of the latter. Division of labor can be viewed as giving rise to an imperfectly divisible form of organization. Efficient assembly line organization requires a certain minimum number of workers, so that each worker can be assigned a specialized task, and the number of workers at each task is adjusted to achieve a smooth flow of the product over the assembly line. A

smaller work force would make it impossible to use optimum specialization and would result in a smaller output at a higher cost per unit of product.

The above reasons account only for higher unit costs to the left of the least-cost point on the LRAC curve. With outputs to the right of that point, these factors are not relevant since inputs can be increased proportionately and assembly lines can be multiplied. The higher costs of larger output are due to greater difficulties of management in coordinating a more complex organization.

In analyzing the impact of technology on farm size, Brewster has argued that division of labor offers little advantage in agriculture, while on the other hand, managerial difficulties of large scale organization in agriculture are greater than those in industry. (3) Brewster bases his conclusions on the following characteristics of farming: 1) the distinct steps in the agricultural production process are seasonal and have to be performed in their appropriate time period. Even with a large labor force, individual workers cannot specialize but must shift from task to task in accordance with seasonal requirements. There are some tasks (such as harvesting) in which several workers can work together more efficiently than the same number of men working separately, but even these do not require large numbers of workers. Also, because of the seasonal nature of such opportunities for division of labor, they are usually met by exchange of work among farmers, hiring custom operators, or employing temporary workers without giving rise to permanent specializations among workers. Thus, the farm firm differs greatly from the industrial firm. In the latter it is possible to have all tasks performed simultaneously as materials move from worker to worker with no need to shift workers to tasks. 2) the managerial difficulties in farming are due to a) the fact that the workers are spread over a relatively large area, b) their work cannot be supervised by controlling the rate of flow of materials over an assembly line, and c) supervision is made even more difficult because of problems in standardizing and routinizing the separate steps in the production process due to the biological nature of that process (3, pp. 70-74).

Of course, indivisibilities of draft power and equipment are operative in agriculture as in industry. Many small Indian farms probably do not have enough land to fully employ a team of bullocks. Similar indivisibilities arise with the use of tractors, other machinery, irrigation wells, etc. The use of such indivisible items of capital on small farms generates higher costs either because of excess capacity, or because smaller equipment tends to be less efficient.[13]

Since the use of either animal or mechanical sources of power in agriculture usually requires the labor of only one or two workers, the higher costs of indivisibility of capital occur primarily because the amount of land is insufficient to fully employ capital and labor, and not because efficient use of capital requires more labor than provided by a farm family. On the basis of the above considerations, the

distribution of farms by size should probably be subdivided into three groups: 1) larger-than-family farm, 2) "adequate" family farms -- those with enough land to provide remunerative employment for family labor and the indivisible units of capital, and 3) "inadequate" family farms -- those which do not have enough land.

The analysis thus far leads to the conclusion that economies of size are achievable on farms large enough to be considered adequate family farms. Below this size costs are higher because insufficient amounts of land are combined with labor and capital. Above this size, the proportions of land, labor and capital remain approximately the same and unit costs can remain constant until increasing management difficulties raise costs. Exceptions to this may occur in some types of farming in which it is more economic to use forms of capital or division of labor which require a larger labor force than a family family can provide.

The above and the discussion of the preceding section suggest a separation of two issues in determining the characteristics of the long-run average cost curve (LRAC): 1) indivisibilities of capital create decreasing costs over a portion of LRAC (to the left of point A in Figure 3) and determine the point at which such diseconomies are overcome and LRAC flattens out (flat LRAC) between A and B, followed by rising costs after B due to increasing difficulties of management), and 2) the least-cost application of labor and labor-saving capital to land (intensity of land use) affects the level of LRAC without, however, generating economies or diseconomies since land is highly divisible.

Economic development leads to shifts in the LRAC as a result of increases in labor costs and substitution of capital for labor (mechanization). With mechanization, indivisibilities are overcome at a higher level of output; point A on LRAC shifts to A' (Figure 3). Thus the minimum size of least-cost output increases in terms of size measured by output and by acres but not in terms of size of the labor force per farm. The acreage and output of "adequate" family farms increase, without necessarily changing the comparative advantage of family farms and farms with a larger labor force.

The second issue has already been discussed at the end of the preceding section. By the criteria of prevailing factor prices the larger farms represent points on the LRAC. But if the opportunity costs of labor are less than the prevailing wage rates, then the larger farms are farming land too extensively and they represent points above the LRAC. With either set of factor prices higher costs due to indivisibilities of capital and labor can be expected on the smallest farms.

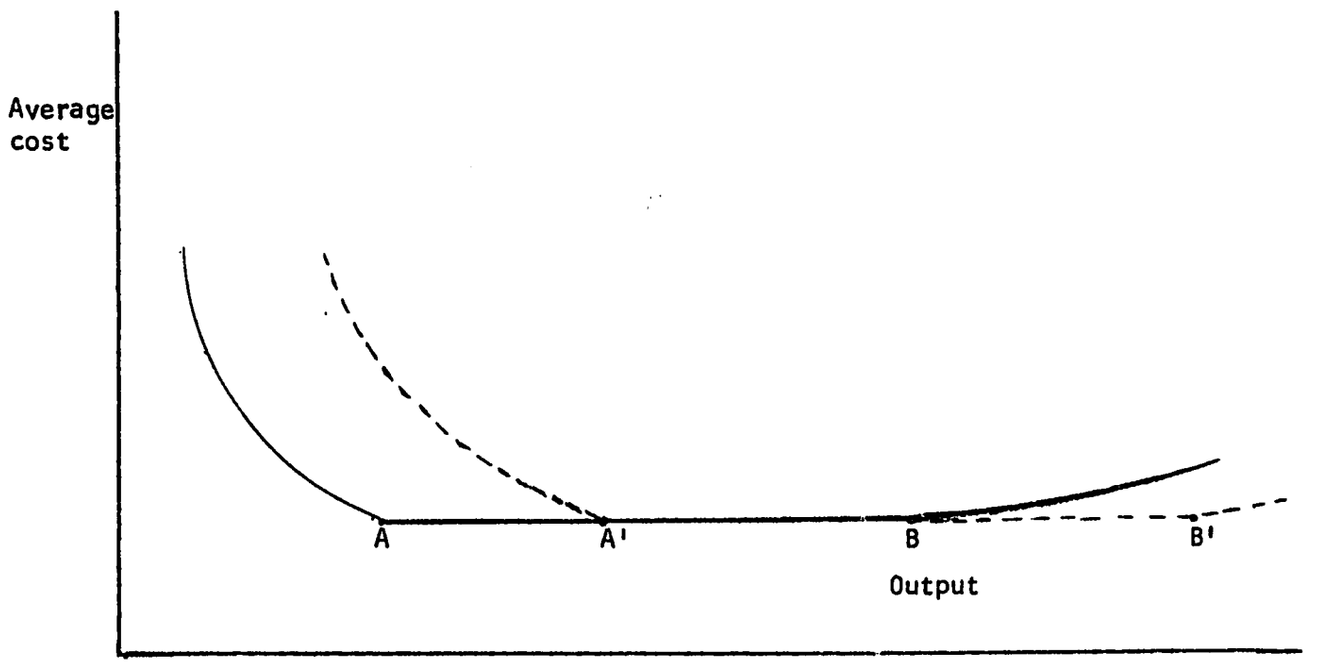

Figure 3: Shift in the long run average cost curve in agriculture due to the substitution of capital for labor.

A and A' represent approximately the same labor input, with more capital per worker in A'.

Substitution of Capital for Land: Yield Increasing Technologies

So far the argument has considered only three of the four groups of inputs in the agricultural production function (land, labor and labor-saving capital). The fourth group includes various capital inputs which primarily increase yields. These yield-increasing inputs have little effect on labor requirements per acre, though they do increase production per worker. They include seed of improved varieties, fertilizer, insecticides, etc. The use of these inputs represents not only a change in factor proportions within a given production function, but also the introduction of new technologies (shift in the production function). The profitable use of these inputs is usually highly interdependent. Thus, use of fertilizer is most profitable with new varieties of crops which are bred to give a greater response to fertilizer while meeting water requirements and protection from plant diseases are likely to become more critical for the higher yielding, well fertilized varieties.

Two characteristics of the new inputs bear on their applicability to farms of different size. First, most of the new inputs are highly divisible and can be used equally profitably on large and small farms including the inadequate family farms. Second, for the development of the new inputs and the technology of using them, agriculture has to depend on state and private effort in research and extension, manufacture and distribution of inputs, reinforced by provision of credit and development of marketing. Even large farms cannot perform these developmental functions (25). Thus, the introduction of these inputs into agriculture does not affect the competitive efficiency of farms of different size.

While small farm size presents no barriers to the use of yield-increasing inputs and new technology, there are differences in actual extent of use of these inputs by small and large farmers (5). The progressive farmers in underdeveloped countries are more often found among the larger farmers. However, the majority of large landowners may well be tradition-bound and conservative in their approach to the management of their farms. The better performance of larger farmers may be due to a number of factors including education, greater wealth, better access to market and credit, and greater self-assurance, ambition, and willingness to experiment among rural classes with higher social status and greater wealth.

The value of output per acre is a function of both a) greater use of yield-increasing inputs and technology (non-conventional inputs) per unit of land, and b) greater use of labor and equipment (traditional inputs) per unit of land. The latter accounts for the larger output per acre on smaller farms. Greater use of modern yield-increasing technology on larger farms can counteract or even reverse the negative relation between output per acre and size of farm. However, differences in the value of output per acre can in turn be separated into several components: differences in yields, enterprise

combinations, degree of double-cropping, and in prices received. As indicated above, the intensification of land use on smaller farms is most likely to take the form of more double-cropping and a higher proportion of more labor-intensive enterprises, while greater use of modern technology should be most apparent in yields of individual crops. The Punjab data analyzed by Randhawa supports the above hypotheses: a) the largest farms had the highest yields of wheat and cotton, and b) the smaller farms had more double-cropping and approximately the same enterprise combinations as larger farms (23, pp. 24 and 28). The net result in this case was a negative relation between size of farm and value of output per acre.

Conclusions and Implications

Four important dimensions in farm organization have been described: 1) substitution of labor-saving capital for labor (mechanization), 2) farm size as measured by number of workers per farm, 3) extent to which new yield-increasing inputs and technologies have been added to land, labor and equipment, and 4) intensification of land use on smaller farms resulting from the application of large amounts of labor and equipment to insufficient land. Farms in different economies and in different time periods may differ in all or several of these dimensions. The schematic arrangement in Table 4 is an attempt to illustrate the differences between typical farms in several countries in terms of the first three dimensions.

Changes over time can also be described in terms of this schematic arrangement. The development of Japanese agriculture was primarily along the dimension of constantly increasing use of yield-increasing technology with little change either in mechanization or in the number of workers per farm. U.S. agriculture since 1920 changed along two dimensions, substitution of capital for labor and greater use of yield-increasing technology, with very little change in the number of workers per farm; the proportion of family farms in U.S. agriculture has remained constant. The Bolivian land reform of 1952 was a change from large haciendas with many workers to small peasant farms using family labor with very little change in the other two dimensions. Collectivization of agriculture in the U.S.S.R. involved change from peasant family farms to large collective and state farms with many workers and substitution of power and equipment capital for labor (but not to the extent as in U.S. agriculture), with as yet insufficient increase in use of yield increasing technology. The recent Russian emphasis on fertilizers and increasing food production per acre bears testimony to plans for moving further in this particular dimension.

Thus, organization of farm firms is multidimensional and complex. Differences in such measures as outper per acre, net return per man-day and ratio of the values of output and inputs can arise in several ways. It is important to identify the conditions responsible for the

TABLE 4

Three Dimensions in Farm Organization

Modern yield increasing technology	Low mechanization (low wage level)		High mechanization (high wage level)	
	Small labor force per farm; primarily family workers	Large Labor force per farm	Small labor force per farm; primarily family workers	Large labor force per farm
Little used	India	traditional haciendas of Latin America		Soviet Union
Intensively used	Japan		U.S.	

differences in the above measures before concluding much about the comparative efficiency of farms of different size. Among the conditions which can give rise to a relation between size of farm and the above efficiency measures are the following: a) limited off-farm employment opportunities resulting in greater amounts of labor in relation to other inputs on small farms, leading to more intensive land use, b) differences in productivity of land with a higher proportion of smaller farms on more productive land (15), c) differences in rate of adoption of modern technology on farms of different size, and d) differences among farms of different size in access to markets and to credit. Research on size of farms should attempt to identify the effect of these underlying conditions on the measures of economic efficiency.

From the point of view of development policy, are policy-induced changes in size of farm useful for promoting more rapid development? This in turn is a question of the extent to which size and organization of farm firms are the consequences of the existing state of development and to what extent they are conditions influencing the rate of development. It seems useful to consider these matters with respect to the different dimensions of the organization of farm firms.

The amounts of labor-saving capital per agricultural worker and the greater intensity of land use on smaller farms represent adjustments of farm organization to off-farm conditions such as external employment opportunities and population growth. On the balance, the labor-intensive smaller farms seem desirable as sources of employment. When economic development increases non-agricultural employment opportunities, these dimensions of farm organization can be expected to adjust with little need for policy intervention. In any case these changes in farm firms usually occur in late rather than early stages of economic development. In early stages, the small size of the non-agricultural sector makes it difficult to employ all of the increase in the labor force outside of agriculture; agricultural employment is likely to grow or at best remain stable (7).

The adoption of yield-increasing technology is appropriate to early stages of economic development. In the course of development the agricultural sector is faced immediately with increased demand for food due to growth in population and in per capita incomes. If the supply of agricultural land is limited, then the response to this demand has to be met largely by yield-increasing technologies or by imports of food.[14] This task is much more important than improvement in the allocation of traditional resources (primarily labor) within agriculture and between agriculture and the rest of the economy.

Changes in size of farm do not seem to be a major prerequisite in the adoption of yield-increasing technology; size of farm does not create cost barriers nor are increases in land-man ratio required for such technological changes. The problems do not seem to be primarily in the domain of internal structure of farm firms. Two other types of

relations appear to be more important. One, stressed by T.W. Schultz, emphasizes relations between the agricultural and non-agricultural sectors: research, education (investment in human agent) combined with effective organization of extension, supply of inputs, marketing facilities and supply of credit (17, 25). The other, stressed by students of the diffusion of innovations, emphasizes communication theory and social structure. The latter studies view the acceptance of new technology as a process taking place over time. For U.S. agriculture, typical results show that older, less educated, poorer farmers on smaller farms are later adaptors than other farmers (24). But size of farm enters as a variable because farmers on smaller farms are usually disadvantaged in access to education and credit, and are less likely to play a leadership role in the social structure of the community; this is not an inherent consequence of farm size.

At any point in time, there are large differences among farmers in various efficiency measures. The reasons for these differences include: a) differences in management ability of farmers with respect to well-known alternatives within traditional technology, and b) differential adoption of new technology. Development does not make these differences disappear, but primarily takes the form of shifting the range of yields and rates of use of non-conventional inputs to a higher level (11). The important developmental policies are those which contribute to such a shift in the range of performance by farm firms of all sizes. Size of farm becomes important, if it can be shown that size per se inhibits adoption of modern technology. Size of farm is not the most important factor if either a) smaller farms always lag in adoption of innovations behind larger farms but the gap isn't widening, or b) the gap widens but, rather than being caused by farm size, can be attributed to unequal access to education and to government, cooperative and private agencies providing credit, marketing and extension services to farmers.

Active innovative management for the development of agriculture is partly located outside of the farm firms in agencies responsible for research, extension, supply of inputs, marketing and credit. Of course, these agencies have to perform their functions well, and need to be adapted to the needs of the farm families that they attempt to serve. The division of responsibilities between the farmers and these agencies means that the latter advise and supply services but do not direct the decisions made on farms. By contrast, cooperative farming is an attempt to establish innovative management in direct control over farm production decisions (16, pp. 121-122).

The temptation of rapid development by direct control of production decisions carries the price of making mistakes on a larger scale and difficulties in supervising labor. As long as large scale farming does not possess inherent long-run cost advantage, and farm operations are difficult to supervise, it is probably better to avoid the risks of large scale management decisions, and to concentrate public effort on research, provision of information and improvement in other agencies serving farm people.

Development, characterized by the adoption of yield-increasing technology, should be possible on farms differing in size, with or without changes in the distribution of farm sizes. Division of large farms into smaller units need not impede development. In such cases it is important to preserve superior management which may exist on some large farms, and typically land reforms provide exemptions for progressively managed farms. But what is required is management which makes greater use of yield-increasing technology, not management which mechanizes and, by decreasing employment, achieves greater production per worker. Also the new operators of small farms created by land reforms would need management assistance and adaption of markets and service agencies to fit their needs.[15]

Of the four described dimensions in the organization of farm firms two, mechanization and the greater intensity of land use on smaller farms, are primarily the result of the current state of economic development and can be expected to change in response to further development, and one, use of yield-increasing technology, is applicable to different farm sizes and depends primarily on the success of developmental policies concerned with fostering education, research and agricultural service agencies. With respect to the fourth dimension, the number of workers per farm, the above analysis indicates no general reasons why family farms need to diminish in importance (or should not be increased in agricultural economies now dominated by large farms) as development proceeds.[16] Development requires increased output per farm, and under appropriate conditions, increased land area per farm, but the above changes do not require an increase in the number of workers per farm.

FOOTNOTES

*Many of the ideas in this article were first formulated in 1959-1961 while I was visiting professor in the Department of Economics, Punjab University, under the auspices of the Ford Foundation. In this I was greatly assisted by the faculty and students of the Department of Economics, particularly Professor S.B. Rangnekar, head of the department, R.K. Diwan (then lecturer) and S.S. Johl (then research scholar). My interest in this topic was first stimulated by the article of S.R. Sen on the "Meaning of Technical Changes in Agriculture in Asian Environments" (28). Further important influences in the development of my ideas came from the supporting evidence in G. Parthasarathi (20), reactions to the arguments of M.S. Randhawa (23), and the formulation of ideas in M.L. Dantwala (4) and Erven J. Long (16). It needs adding that the argument developed below does not fully meet the issues raised in the excellent article by A.M. Khusro (15). I have benefited from the comments of Professor Eldon Smith of the University of Kentucky and of several faculty members and students of the University of Wisconsin, particularly Professors Peter Dorner, Kenneth Parsons, John Schmidt, William Thiesenhusen and Eugene Wilkening. I am grateful to the Ford Foundation for supporting my assignment at Punjab University.

[1]For the distinction between these two forms of capital see A.K. Sen (26).

[2]For the formulation of the isoquant of Figure 1 see Heady (10, Figure 3.1, p. 95).

[3]Acres per worker will also differ among regions within an economy due to such factors as soil fertility, rainfall, availability of irrigation and distance from market. Acres per worker will be less in regions which are more fertile or closer to market, etc. The expected relation is the Ricardian one of more intensive land use of more productive soils, which achieves equalization of returns to labor and other variable inputs in regions differing in physical productivity and distance from markets. Differences between regions will be further influenced by degree of immobility of labor and other inputs.

Ideally, therefore, the statement in the text should refer to acres per worker in regions that are identical in physical productivity and access to markets and differ only in the factor prices which prevail in the economies in which they are located. No claim is made that such a similarity exists between the regions of India and the U.S. from which the data of Table 1 is obtained. All that is asserted is that a very large part of the difference in acres per worker is due to different factor prices in the two countries.

[4]Data derived from Bray (2). While data refers to farms with 500 acres or over of total land, the percent of land held by these farms and acres per worker refer to "equivalent" irrigated land as computed by Bray. "Equivalent" acres were obtained by adding irrigated land and 0.1 times the acres of unirrigated cultivated land. This weight is based on the ratio of the values of each type of land. Irrigated land is 39 percent of all cultivated land (2, pp. 32, 45). Since all land inputs are converted to equivalents of the most intensively used land, the Chilean acres per worker are in fact considerably larger than the Indian data in Table 1.

[5]This sentence requires a number of qualifications. The labor-capital isoquant (Figure 1) may be different for different regions and for soils of different fertility within a region. Even with uniform land and climate different isoquants exist for different operations such as plowing, sowing, irrigating, harvesting, etc. This means that at a given set of factor prices, some operations may become mechanized while others depend on hand labor or animal power. What is being asserted is that within a region, the same appropriate mix of labor and equipment will be used on bigger and smaller farms and for more and less intensive land use. See the Punjab data (Table 2) and the linear programming example below for illustrations. Indivisibility of equipment introduces yet further qualifications which are discussed in footnote 12.

[6]However, Hopper's study reports intensification of land use which achieves increases in yields of individual crops. His study of a village in eastern U.P. shows large variation in the number of plowings given to fields before sowing. The purpose of additional plowings is to conserve moisture by reducing weeds and thus increase yields. For example, he reports that in the case of wheat, fields were plowed from 6 to 15 times (12, p. 615). On the other hand, in the Punjab data, analyzed by Randhawa, greater doublecropping is the principal way of intensifying land use on smaller farms (23, p. 28).

[7]Since land is highly divisible while equipment is not, it would be easier to generate different land use intensities by linear programming of a situation in which labor and equipment are given while land is variable. In this case, increase in the amount of land would be associated with more extensive land use, achieved by change in the combination of crop and livestock enterprises.

[8]See A.K. Sen (26, p. 245), quoted in Khusro (15, pp. 61-62).

[9]These considerations also provide a basis for arguing with Khusro's conclusion that differences in output per acre can be attributed to differences in quality of land (15, pp. 63-73). He is correct in showing that smaller farms have more valuable (and thus presumably more fertile land) than larger farms and that this is one factor in the higher output per acre on smaller farms. But if difference in land values were the only factor, then we should expect approximately equal returns to

labor on farms of different size. Yet all the data in the Studies of Economics of Farm Management (see example in Table 3) indicate much larger returns per worker on larger farms. This fact suggests that the number of workers per acre on smaller farms exceeds the number which would have been justified by the larger land values, and therefore the larger man-land ratios contribute to the high levels of output per acre on these farms.

[10]See Georgescu-Roegen for a discussion of the consequences that 1) capitalist wage-employment, 2) feudal share-renting (tithe), and 3) peasant proprietorship have for employment and incomes in over-populated economies. The first of these brings unwanted leisure, the last excess capital equipment on small holdings (8, pp. 33-37).

[11]Landowning farmers can increase their income by accepting part-time off-farm employment at wages equal to the marginal productivity that their remaining labor can achieve on their own farms. This situation can generate market wages which are below subsistence levels. Thus, the mere fact of peasant proprietorship is not sufficient to provide an explanation of an institutional wage at or above subsistence, and additional explanation is required.

[12]The second and third conclusions are different ways of stating the same issue. The third conclusion accepts prevailing factor prices as the basis for organizing least-cost farm firms. Then larger farms represent points on the long run average cost curve, since their organization depends on factor prices, but the small farms do not represent points on that curve. The second conclusion points out that factor prices may not indicate correctly opportunity costs, and that labor costs lower than prevailing wages may be relevant for organizing least-cost firms. By that argument the long run average cost curve shifts in such a way as to use more labor and less land per unit of output. Then larger farms using hired labor would no longer represent least-cost organization since they use land too extensively. Some, but not all, of the smaller farms would then represent least-cost organization, while the smallest farms would be farmed too intensively, and the largest farms relying on family labor would be farmed too extensively.

[13]Farm firms can adjust to insufficiency of land combined with indivisibility of equipment in two different ways: 1) labor, draft animals and equipment proportions may remain the same as on larger farms, but land use can be intensified, and 2) the amount of capital per worker may be reduced a) by exchange arrangements and renting of bullocks, and b) by shifting to less effective forms of imperfectly divisible capital (decreased feeding of bullocks, use of buffaloes for draft power, greater use of hand labor, etc.). In the latter cases the non-land inputs per acre of land are not increased as rapidly as in the first case, and therefore, intensity of land use would not rise as rapidly on smaller farms. Such decreases in capital per worker on smaller farms represent a movement to the right in the isoquant of Figure 1, and thus invalidate the assumption that labor and capital proportions remain the same in Figure 2. Thus the problems of indivisibility create an interdependence between the isoquants in each Figure, and generate decreasing unit costs over a portion of LRAC.

The proportions of human and bullock labor in Table 2 suggest that in the case of India, labor and capital proportions show little variation among different sizes of farms. In other countries, and particularly in Latin America, large farms which have mechanized some of their farming operations coexist with much smaller farms on which animal power or hand labor is used.

[14]The earlier stage of agricultural development, emphasizing yield-increasing technology, corresponds to phase II of Johnston and Mellor (13, pp. 582-589). The later stage with decreased employment in agriculture corresponds to their phase III. It should be noted that development and adoption of yield-increasing technology continues even in phase III, since population increase and rises in per capita income require increases in total agricultural production, and not only increases in productivity per worker.

[15]There are a number of important experiments and proposals for 1) temporary arrangements to bridge the transition from large farms to independently-operated small farms in cases of parcelization of large farms, and 2) permanent arrangements mid-way between cooperative and individual small-scale farming. Both approaches provide management assistance to small farmers and serve to introduce new technology, and the second makes it possible to combine central use of large machinery for some farm operations with responsibility of individual farm households for other operations. Among countries in which these approaches have been tried are: Sudan (Gezvia), Egypt, Tunisia and Chile.

[16]Both the number of workers per farm and the tenure arrangements now present in each underdeveloped country are largely produced by factors other than the attained level of economic development and are subject to pressures for change for reasons other than the issue whether it is or isn't profitable to increase production on the farm firms that now exist. These characteristics of farm organization are related to the social structure and to political and social as well as economic change. The analysis of these relations would require extended treatment on different lines than those pursued above. Some of the following issues are relevant. Owners of large farms in underdeveloped countries are not usually persons who acquired such ownership because, by active management, they could get higher returns than other potential owners. Such ownership is often vested in certain classes of the traditional social structure or is due to political power. Unrest and pressures for land reform can result from the breakdown of the traditional social system. One pattern of change is the weakening of the sense of obligation to tenants and workers combined with more active management of farms by large landowners which can result in decreased employment and greater insecurity of access to income on the part of the lower rural classes. Or the contrast between the emerging social system in urban areas and the traditional social structure can create severe strains in the latter. Thus, in the case of Japan, Dore attributes much of the tenant unrest in the 1920's and 1930's to the coexistence of a continuing superior-inferior

status relation between landlords and tenants on one hand with compulsory education and universal conscription on the other (6, chapters 2 and 15; 14, pp. 69-71). Such situations create great pressures to change the tenure and size of farms by governmental policy.

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