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INTERRELATIONSHIPS BETWEEN AGRICULTURAL STRUCTURE AND RURAL DEVELOPMENT

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Interrelationships between agriculture and the rural community sectors which surround and service it have had historic importance. In early stages of agricultural development, these interrelationships were complementary and positive. As farming arose above the subsistence stage, it began to produce a marketable surplus. Persons outside of farming were able to provide purchasing, storage, transportation, and other services which helped transmit the surplus of local farm products to consuming centers. Similarly, with marketable surpluses the rural farm sector was able to purchase both producer and consumer goods. Employment and income generation in the rural community thus was generated by the community farm sector. Generally, too, under certain institutional conditions, agricultual surpluses provided the basis for taxation which allowed investment in schools, roads, and other public services and infrastructure. In early days of agricultural development, these services based on taxation flowed outward, rather than from national, state, and provincial levels down to the agricultural community.

Over a long period, the further development of agriculture brought forth added income and employment to the rural nonfarm sector. Too, the simultaneous development of the farm sector and the rural community sector serviced and complemented each other. It fostered greater education, human services, recreational opportunities and population levels in the rural community. This process evidently continues as long as the development of agriculture grows out of improved organization of farming and biological improvements. Eventually, however, when economic and agricultural development progress far enough, this symbiotic relationship between farming and the rural community nonfarm sector may wither or even turn into a competitive one. In recent decades, only a few rural communities in a few countries have been able to absorb the full population growth of the community. A good many have been able to maintain a growing community labor force but not to absorb the full natural population growth rate. Complementarity between farm sector development and the rural community nonfarm sector can be maintained through this phase, however. It is a phase which still prevails in a number of developing

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countries. This complementary phase tends to remain as long as the real cost of capital is sufficiently high relative to the price of labor and farming remains a labor intensive sector still under forward progress.

Once, however, the real price of capital declines sufficiently relative to the price of labor, this complementary relationship between agricultural development and rural community welfare may dampen or evaporate. Technological development of farming can even cause deterioration of the rural nonfarm communities' income and employment opportunities. The real price of capital can decrease because as a characteristic of economic growth, capital increases in supply and declines in real price. Or it can increase because of human capital development which causes people to have more valuable functions as organizers, managers, supervisors, service operators, and skilled functions other than generating the energy and manipulations of animals—the historic functions of human labor in agriculture. Under these changes in relative capital and labor prices, capital rapidly begins to substitute for labor. If biological innovations occur at a sufficient speed, they may cancel the effect of lower cost capital items in substituting for labor in the mechanical operations of farms. However, if the rate of capital substitution for labor is sufficiently rapid in the mechanical operations of farming, this substitution more than offsets biological innovations in increasing the demand for labor. Carried to sufficient levels, these trends then cause the labor force employed in agriculture to decline. Whether there is a concurrent decline in labor employment of the rural community surrounding agriculture depends upon the type of community and its relation to agriculture. Three types of communities and actions are relevant: (a) The community has an endowment of natural resources, transportation facilities or skilled and low cost personnel which causes nonfarm industries to emerge, absorb labor freed from agriculture and even to grow in employment. These industries generally relate to the endowment of transportation, labor facilities, or natural resources. With growing employment opportunities aside from agricultural recession, the community can grow in income generation and availability and quality of human services. (b) The community has no particularly favorable endowment of transportation and natural resources. However, because of the ingenuity and capital of an imaginative person, a unique industry of the "foot-loose and fancy free type" (it is not tied particularly to natural resource, transportation, and highly skilled labor) is developed and brings nonfarm employment and income generation to the community. This event is normally the function of "unique" and other capable characteristics of an individual person, rather than economic structures and natural resources. (c) The community has no endowment other than agriculture and it does not have individual leadership to provide the imagination and capital to develop successful "footloose and fancy free' enterprises. Its economic welfare then depends upon the viability and trends of agriculture.

If the capital-labor suflstitution process dominates the effects of biological innovations in generating labor demand, the rural community will have a declining work force. The demand for nonfarm goods and services of the rural community also may decline. Too, capital substitutes for labor (e.g., tractors) usually come in "lumps." These lumpy investments entail higher fixed costs and farms can be operated most efficiently if their sizes are increased to allow lower per unit costs. The result will be fewer and larger farms, a smaller farm population and labor force. The demand for both producer and consumer goods by agriculture may then decline.

Farm Size and Structure and the Rural Community

These complex interrelationships between the technology of agriculture, the type of the rural community and rural community development eventually must be faced in many regions and countries which are in an intermediate stage of economic development. To illustrate these possibilities we compare the estimated employment and income effect of three farm sizes and structures in American rural communities. Societies have the opportunity to augment or restrain these trends and structures depending upon the policies and institutions they formulate and implement. Hence, we believe the United States example, the only major aggregate analysis made, provides advice for other countries.

THE AMERICAN STUDY

American farm size has been going through a rapid structural transformation. This change is not yet complete and policy makers still have the opportunity to mold it depending on national goals, or the optimum mix of goals in a multi-goal objective function. If the market forces are allowed to dominate, the result is likely to be a small number of mammoth farms which cause deterioration of other rural community sectors, reduce the availability and quality of human services, and cause public services to have high unit costs (because of the reduced tax base). On the other hand, policies could be used which restrain farm size. The restraints might not be so severe that they result in a large number of subsistence and poverty farms. Compromise opportunities also exist. We review these several possibilities from an empirical study we have made since they have important implications for other countries in medium stages of development, or for regions of advanced development in developing countries.

What would be the effect on major economic groups, including rural nonfarm and other sectors closely linked with agriculture, if agriculture were composed of farms of different sizes? The impacts on farm commodity prices, the interregional distribution of production, net farm income of the agricultural sector, net farm income per commercial farm, number of farms, labor used on farms, income generated in the rural non-

farm and agribusiness sectors associated with agriculture, and consumer food costs are evaluated and presented at regional and national levels for a U.S. example.

Given the low price elasticities of demand for food commodities in the U.S. and the potential that lower rates of resource transformation on small farms would restrain supply, it is logical that with agriculture made up of small farms, net income to the farm sector would be higher and consumer food costs would be greater. A system of small farms might also generate greater employment and income in rural areas because it implies a greater number of farm families and larger quantity of inputs to produce a given output. For the same reasons, an industry of large farms implies opposite outcomes. Various studies indicate that commercial U.S. farm policies are oriented to large commercial farms and generally have brought gains to this group and to the general consumer sector at a relative sacrifice to hired farm labor, small farms, and the nonfarm rural community [4, 5].

While all facets of the relationships between farm-size structure and the welfare of different groups in the nation are not unraveled, the objective is to provide some initial estimates of trade-offs involved as a particular structure might prevail or be encouraged through public programs. Quantities such as these, placed against values which society attaches to various outcomes or variables relating to various economic groups, then could provide a basis for policy selection.

METHODOLOGY

The national linear programming model incorporated an interregional comparative advantage analysis, a transportation submodel, and an input-output submodel, and required fulfillment of consumer demands in 31 market or consuming regions. Due to space limitations, details of the model are not presented here. With adaptations for time trends in technology, price indices, and demand, the basic model is essentially that outlined in Heady and Skold [1]. A more detailed discussion of this updated model can be found in Heady and Sonka [2]. Commodity supplies are generated endogenously in each of 150 rural or agricultural areas, and land in each of these areas serves as an internal restraint on supply of crop commodities. The model minimized the cost of producing the crop commodities in the 150 agricultural areas and transporting them among the 31 consuming regions but required factor costs be covered for all commodities in each region. Supplies of crops included in the analysis are determined endogenously in the model while demands are estimated exogenously.

The study refers to the contiguous states of the U.S. and includes winter and spring wheat, all feed grains, soybeans, and cotton as endogenous commodities. It also includes all forages and livestock products as fixed bounds. Both the linear programming model and the secondary impact

variables used relate to various regional concepts. The 150 producing areas follow county boundaries and represent homogeneous areas of farm commodity production. Technical coefficients for each commodity by each farm size were computed separately for each of the 150 areas, and the model's objective function was optimized over these areas and the transportation network. Production patterns and resource use, computed for each rural area in the model solutions, are aggregated to consuming region levels in this report. Separate demand areas for winter and spring wheat, feed grains and oilmeals are defined by 31 consuming regions which follow state boundaries and encompass the continental United States. Cotton lint demand is determined on a national basis.

SECONDARY INCOME IMPACT

One goal of this study was estimation of the potential effects of farm size on income generated in agriculturally-related communities and industries. These off-farm impacts of agricultural production are important to a nation where a large part of the nation's population resides in rural areas and does not consist of farmers. But nonfarm people are closely related to the farming industry. Many work in industries which directly serve agriculture by supplying inputs to farmers, processing farm outputs, or supplying consumer goods and services. Other rural inhabitants work in nonagricultural industries which locate in agricultural communities and also have an interest in the future structure of farming. They consume many of the sam services that farm operators and their families use. For example, schools, and local governmental services which nonfarm industries and their employees demand and support also derive much of their support from farmers and the farming industry. Changes in the structure and viability of the farming industry, then, are reflected in the quality and quantity of services available in the community and affect all residents of rural America.

Hence, to measure secondary impacts, multipliers are used which relate output of each endogeneous crop to income generated in agriculturally-related communities and industries. These multipliers are based on regional input-output matrices of the agricultural and agriculturally-related sectors.[1] These income multipliers express the increase in the total income for each of the production regions and for the U.S. economy due to the production of an additional one dollar's worth of output in an individual farm sector of the model. (The sector of relevance is a specific farm commodity produced in a specific farm production region.) This increase in total income has three components: (a) the income received by producers from an additional one dollar's worth of farm output; (b) the

[1] The regional input-output matrices used in developing these multipliers were reported by Schluter [3].

income resulting from the increased activity of agribusiness firms (through increased sales of productive inputs to farmers and the additional sales of industries that process farm products); and (c) the income resulting from increased sales of consumer goods to farmers and workers in agribusiness industries and rural communities. Different technological coefficients or input mixes exist for each farm size and each producing area. Hence, the income multipliers were recalculated, using the same basic regional input-output model, to reflect the technology of each of the farm-size alternatives analyzed.

PARAMETERS ESTIMATED FOR FARM SIZES AND COMMODITIES

Production coefficients used in the Small Farm Alternative represent the technology of commerical farms with gross farm sales of less than $10,000. This grouping corresponds to farms in economic classes IV and V of the Bureau of Census. Commercial farms in this category had a U.S. average size of 232 acres in 1969. Such farms would be considered too small to provide an adequate farm family income with farming as the sole income source. Forty-one percent of the farm operators in this category were employed in off-farm work for more than 100 days in 1969.

The production coefficients for the Medium Size Alternative represent the structure of commercial farms in economic classes II and III of the Bureau of Census. Farms in these classes have gross farm sales of more than $10,000 but less than $39,999. The average farm in this grouping was 520 acres in size and had gross farm sales of $20,597 in 1969. Viability of farms in this category cannot be determined by the absolute level of their gross sales alone. The location and type of farming involved greatly affects the net income of particular farm operators in this category. In the analysis, differing productive coefficients are calculated according to the agricultural or rural area in which farms of the three alternatives are located.

Production data for the Large Farm Alternative characterize farms in economic class I, farms with gross sales greater than $40,000. For the U.S., these farms average 1,603 acres and $113,552 in gross sales in 1969. Farm operators in this group are highly commercial and could depend entirely on farming operations for family incomes.

In this study iterative procedures were used to equate total demand with total supply for the Medium Farm Alternative. These quantities were then held constant for the other farm-size alternatives. This procedure was used in order that the mix of goods purchased by consumers would be fixed among alternatives and consumer expenditures for food would be standardized by commodity mix. While accomplishing this goal, the procedure tends to underestimate slightly the total production for situations with larger farms.

Although a large amount of quantitative work and modeling went into the study and is itself interesting, emphasis in this paper is on the results under projected alternatives in farm size. While resource use, commodity supplies, prices, and related data were computed for 150 agricultural areas, the data were summarized into aggregates for the 10 production regions of the U.S. indicated in Table 1. The input-output matrices, upon which the income multipliers are based, were also computed for these 10 production regions. Input-output matrices and multipliers for each of the 150 production regions would have been preferable, but time and funds did not allow their derivation.

ECONOMIC IMPACTS

Using projected 1980 coefficients for each farm size, farm employment in most of the 10 production regions would be greater under small farms than under large farms (Tables 1 and 2). However, since the national allocation of production differs among farm-size alternatives and because different output and input mixes are implied by area for them, impacts on labor employment and capital use do vary among the 10 production regions. Regionally, labor and capital usage generally follows the pattern exhibited at the national level. Hours of labor required and the value of capital expenditures are generally highest under the Small Farm Alternative and lowest under the Large Farm Alternative. Exceptions are in the Appalachian and Southeast regions which devote more land to crops (especially to cotton in the latter region) under the Large Farm Alternative than under the other two size alternatives. In the Pacific region where cotton production is reduced under the Large Farm Alternative, labor and capital usage

TABLE 1. HOURS OF LABOR REQUIRED FOR ENDOGENOUS CROPS UNDER THE SIZE ALTERNATIVES FOR THE U. S. AND 10 FARM PRODUCTION REGIONS

(Thousand hours)

Region	1980 estimated labor requirements		
	Small Farm Alternative	Medium Size Alternative	Large Farm Alternative
United States	1,517,108	1,199,232	1,093,121
Northeast	35,928	34,574	31,009
Corn Belt	576,629	436,054	410,565
Lake States	161,683	135,928	125,432
Appalachian	39,478	19,826	39,822
Southeast	19,733	13,736	21,288
Delta States	73,219	44,404	35,146
Southern Plains	237,552	207,896	208,869
Northern Plains	224,258	188,536	144,077
Mountain	77,830	62,991	58,051
Pacific	70,798	55,285	18,862

TABLE 2. VALUE OF PURCHASED INPUTS FOR ENDOGENOUS CROPS UNDER THE SIZE ALTERNATIVES FOR THE U.S. AND 10 FARM PRODUCTION REGIONS

(Thousand dollars)

Region	1980 estimated value of inputs purchased		
	Small Farm Alternative	Medium Size Alternative	Large Farm Alternative
United States	11,962,065	10,588,937	9,277,901
Northeast	364,037	377,336	270,654
Corn Belt	4,473,875	4,044,743	3,672,911
Lake States	1,180,215	1,002,105	870,239
Appalachian	364,197	268,949	316,946
Southeast	316,985	254,665	323,794
Delta States	581,593	482,232	386,249
Southern Plains	1,518,603	1,334,751	1,167,331
Northern Plains	2,025,595	1,847,191	1,515,351
Mountain	555,706	536,343	482,821
Pacific	581,259	480,622	271,605

are less under this alternative than under other farm sizes. Hours of labor required by the Large Farm Alternative are 66 percent less and capital expenditures are 43 percent less than under the Medium Size Alternative.

The national capital-labor ratio would also vary among size alternatives. The Small Farm Alternative, the most labor intensive of the three, uses 39 percent more labor but only 29 percent more capital than the Large Farm Alternative (Table 2). The national capital requirement under the Medium Farm Alternative is 11 percent lower than under the Small Size Alternative and thus indicates somewhat greater capital intensity than for the latter situation. These data indicate that farm size has important implications for economic opportunity of nonfarm sectors in rural communities.

PRICES AND INCOME

The model used generated farm prices under each farm-size alternative. Table 3 presents these national indices. Prices are considerably lower under the Large Farm Alternative than under the Medium Size Alternative. Under the Small Farm Alternative, farm prices are considerably higher than under the other two alternatives. Lower prices are generated under the situations with large farms because their lower production costs give rise to lower supply prices. In general, then, price is expected to decrease as farm size is increased under the inelastic demands of the United States.

The highest net returns occur under the Small Farm Alternative because of its higher farm product prices (Table 4). Net returns under this alternative are $9.4 billion higher than under the Large Farm Alternative which has the lowest return of the three alternatives.

TABLE 3. U.S. FARM PRICES FOR THE SIZE ALTERNATIVES WITH 1970 PRICES FOR COMPARISON

Crop	Unit	1980 estimated price indices*		
		Small Farm Alternative	Medium Size Alternative	Large Farm Alternative
Wheat	dol./bu.	100	84	76
Feed grains				
Corn equivalent	dol./bu.	100	86	74
Soybeans	dol./bu.	100	86	70
Cotton	cents/lb.	100	88	79

* All prices for 1980 are measured in 1970 dollars and do not include inflation to 1980 [6].

TABLE 4. U.S. TOTAL NET FARM INCOME, NET FARM INCOME PER COMMERCIAL FARM, AND RELATED DATA UNDER THE SIZE ALTERNATIVES, WITH ACTUAL 1970 VALUES FOR COMPARISON

	1980 estimated values[a]		
	Small Farm Alternative	Medium Size Alternative	Large Farm Alternative
	Million dollars[b]		
Cash receipts from farm marketing	67,946	57,867	50,429
Production expenses	48,014	43,583	39,865
Net receipts from farm marketing	19,932	14,284	10,564
Non-money income and inventory change[c]	3,632	3,632	3,632
Net returns from farming	23,564	17,916	14,196
Income from government sources[d]	0	0	0
Total net farm income	23,564	17,916	14,196
Number of commercial farms (thousands)[e]	5,585	1,652	1,001
Net farm income per commercial farm (dollars)	4,219	10,845	14,182

[a] Source: [5].

[b] All dollar values are measured in 1970 dollars with no adjustment for inflation to 1980.

[c] Includes the value of home consumption and the rental value of farm dwellings.

[d] Includes ACP, Great Plains Conservation, Sugar Act, and Wool Act payments as well as payments under the Wheat, Feed Grains, and Cotton programs.

[e] Source: [6].

For each farm-size alternative, Table 4 also includes the estimated number of commercial farms (those with gross sales over $2,500) in 1980. The Medium Farm Alternative requires $278,000 fewer commercial farms than existed in 1970. The 5.6 million commercial farms of the Small Farm Alternative are considerably more than under the other alternatives.

Net income per commercial farm under the Large Farm Alternative is $14,182 in 1970 dollars which is $5,924 higher than the 1970 average

per farm real net income. This relatively high net income per farm occurs under the Large Farm Alternative even though net income for the farming industry as a whole is lowest under this alternative. The average size under this alternative, 1,140 acres, is much greater than under the other alternatives, and induces higher per farm net income through lower unit costs, fewer farms, and greater sales per farm. Only slightly over a million commercial farms would be required under this alternative, 929,000 fewer than in 1970. Hence, greater net income per farm is attained at the expense of net income to the total farm sector. Or conversely, for the Small Farm Alternative, greater net income for the total farm industry comes at the expense of net income per farm which is estimated to be $4,219 (1970 dollars) under this alternative.

SECONDARY OR OFF-FARM INCOME GENERATION

This section indicates how income generated in rural communities and agriculturally-related industries, as well as in agriculture, is affected by each farm-size alternative. The amount of income generated outside of agriculture is affected by both (a) the acreages of crops and levels of production and (b) the level of farm income associated with each of the alternatives considered. Secondary income generated under each alternative has been expressed as an index value to allow a direct comparison among the farm-size alternatives.

Nationally, the income index value estimated under the Small Farm Alternative is considerably higher than under the Medium Farm Alternative (Table 5). This difference is due to the increased value of output and greater input requirements associated with the former alternative. Due to lower farm prices, fewer farms, and less labor under the Large Farm Alternative, the national nonfarm income index value is 14.1 percent lower under this alternative than under the Medium Farm Alternative and 27.3 percent lower than under the Small Farm Alternative. Index values in the Northeast, Corn Belt, Lake States, Northern Plains, and Mountain regions decrease by nearly the same amount as the national figure under the Large Farm Alternative. These regions have nearly the same number of acres in production under the Large Farm Alternative as under the Medium Farm Alternative, but the lower prices and reduced labor and capital inputs act to depress the amount of off-farm income generated in these regions.

Reduced off-farm income characterizes the economic and social difficulties which prevail in typical rural communities as the agricultural structure moves from small farms to larger farms and other employment opportunities are not available. While large farms can produce with lower costs and can supply markets at lower prices, they use fewer total farm inputs including labor. Thus, fewer service firms can exist. The smaller

TABLE 5. INDICES COMPARING OFF-FARM INCOME GENERATED IN THE U.S. AND 10 FARM PRODUCTION REGIONS UNDER THE SIZE ALTERNATIVES

Region	1980 estimated index values		
	Small Farm Alternative	Medium Size Alternative	Large Farm Alternative
United States	100	85	73
Northeast	100	98	86
Corn Belt	100	84	72
Lake States	100	83	71
Appalachian	100	89	100
Southeast	100	80	121
Delta States	100	76	64
Southern Plains	100	87	83
Northern Plains	100	86	69
Mountain	100	83	78
Pacific	100	90	36

farm work force also would result in fewer purchases of consumer goods and services from local merchants. As Table 5 shows, these elements of nonfarm income and employment generation are generally larger under the Small Farm Alternative and generally lower under the Large Farm Alternative. With production concentrating in regions of greatest advantage under the structure of the programming model, the largest difference in nonfarm income estimated for 1980 is for the Pacific region. Here, nonfarm income generated under the Large Farm Alternative is 64.0 percent less than under the Small Farm Alternative.

CONCLUSIONS

An attempt was made in this study to link a changing agricultural structure to economic groups vitally affected by these changes. Because of the economies of larger-scale farming operations, net farm income and consumer food expenditures are estimated to decline as the size of individual farming operation expands. But at the same time, a reduction in farm input usage, especially labor, and in the number of farming operations needed can reduce economic opportunities in rural communitiesdnat needed can reduce economic opportunities in rural communities, at particular stages of development. Of course, decline of economic opportunity is only one factor in the total process of rural community decline. Such elements as higher costs for public services and the breakdown of social institutions must also be considered when evaluating reductions in economic opportunities in rural areas.

The estimates presented in this paper illustrate trade-offs implicit in public policy questions regarding rural areas. For example, although consumer food costs and economic activity in rural areas may at first glance

seem to be unrelated, the results of this study indicate that efforts to reduce the former by capturing economies of scale in farm production may also contribute to a reduction in the latter. Therefore, policies to expand farm size so as to reduce food costs implicitly require subsidization of urban consumers by rural townsfolk. This is not to say that every policy must only have positive benefits before it should be adopted. It does, however, underscore the need for policy analysis which attempts to discover the complete impacts of proposed policies.

Of course, estimation of complete impacts of public policy is not a simple task. This difficulty is also implied, although by omission, in the analysis presented in this paper. Even though dealing with a number of variables, that analysis does not begin to evaluate the many other complex social variables affected by the issue of farm-size expansion.

The inferences of this study apply mainly to the U.S. There are, however, other developed nations facing the same trade-offs in farm structure and rural community welfare. Some advanced farming areas in developing countries are facing a similar situation. Of course, the net national impact depends on the rate of economic growth and the mobility of rural people to urban growth centers. Some of these regions are near urban centers where migrants from farms can obtain employment. In contrast, typical U.S. rural communities are in geographically and thinly populated areas.

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