Farm mechanization research: assessing the consequences

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Monies expended on mechanization research can yield significantly high net returns to society, despite evidence of large adjustment costs.

Hand-harvesting red onions near Fresno (June 1978)

Indirect and delayed impacts of technological change in agriculture have become increasingly important concerns in American agriculture. From a historical perspective, the mechanization of agriculture is nearly complete, in terms of the number of people left to work on farms. Some of the negative impacts of technological change are unintended results of viewing the effects of mechanization research too narrowly. Consideration of indirect effects involves value judgments and factual uncertainties: there can be few "correct" solutions to the problems that emerge.

If properly conducted, preassessment of farm mechanization research can enhance the contributions of new mechanical devices to societal objectives of improved efficiency and equity. Possible adverse results of displaced farmworkers, concentration of market power, and other socioeconomic consequences might be prepared for or avoided.

While the method of preassessment proposed here will have some appeal to research directors who are charged with ranking projects, it should be viewed as a partial response to accurately gauging the "worth" of mechanization research. This method also offers a somewhat better understanding of the kinds of questions that must be answered to assess university research on farm mechanization.

Three steps are involved in preassessing the consequences of mechanization research: (1) determining what to measure, (2) collecting appropriate data, and (3) measuring the pertinent factors and relating them to potential impacts.

What to measure

For the most part, technological change in agriculture has not been neutral in its effects on the demand for resources. Rather, most innovations have altered resource productivities in such a way as to provide incentives to change the resource-mix employed. Hence, we face an immediate problem in determining what to measure and the extent to which we consider interdependent effects. In general, the range of impact assessment should take into consideration: the direct and indirect effects; losers and gainers; and the time period covering the effective life of the innovation.

Most farm machinery impacts include a complementary package of effective practices, including such inputs as new seed, fertilizer technology, new cultural techniques of farming, and changes in the timing of operations. Typically, however, improvements in technology also increase the productivity of capital and alter the technological rates of substitution of capital for manpower, reducing the amount of capital that is necessary to replace a unit of manpower at particular levels of output. Other innovations make it possible to reduce the amount of manpower in relation to land needed to produce specified levels of output.

In addition, certain effects of the introduction of farm mechanization do not impose a cost or confer a benefit within the immediate realm of the innovation itself. Such indirect effects have a noticeable impact on the factors directly associated with the new technology, however, and should be included in the analysis. Direct effects of mechanization are usually evident from the change in yields, input requirements, and the net returns to the adopters. Indirect effects result from the interactions caused by direct effects and related factors, such as the farmer's output and the price consumers pay for the item produced.

All direct and indirect costs and returns associated with mechanization research should be divided according to who gains and who loses. Direct gainers from efficiency-increasing mechanization are most likely to be early innovators and some input manufacturers, including their additional laborers. Direct and indirect gains pass through the growers to middlemen and to the consumers as the per unit cost of output declines.

Individuals who serve dual roles in

society as both input suppliers and output consumers (such as farmworkers) experience both short-run losses and long-run gains. On the other hand, direct losers are most likely to be displaced agricultural laborers and late adopters and those input producing industries and their labor force that may be made obsolete by the switch to new technology. Indirect losers are as difficult to determine as indirect gainers, but might be found in communities that lose income as the result of labor displacement and unemployment.

To analyze the impacts of public mechanization research additional information is needed on the likelihood of the innovation becoming commercially available in specific future years, the rate and pattern of possible adoption, and the rate at which substitute technology might be developed and introduced.

Collecting appropriate data

In general, three classes of data are necessary: First, data to measure the amount of work time, and income of pertinent workers employed in the impacted areas, are needed to determine the socio-economic characteristics of the workers potentially affected, and their chances for reemployment. Second, data to measure the costs of both research and development and extension efforts to determine the magnitude of the public's investment. Third, data to determine the potential returns (or cost savings) to society from the adoption of the innovation—and data to assess the current costs of employing traditional technology.

To cover the issue of who among workers bears the greatest burden of adjustment costs alone, one would need to have detailed data to answer the following questions:

• What jobs are done before the mechanization (*i.e.*, a categorization of the different activities done by farmworkers)?
• What jobs will be eliminated—and what are the characteristics (age/race/sex) and the income of the workers dependent upon the "extinct" jobs?
• What new tasks will be created by the technology, who will land these jobs, and at what pay?
• What jobs will be available for the displaced workers? What will be their new income?
• What assistance will be given to aid in the transition and what costs will be assumed by the displaced workers?

These questions could shed light on displaced farmworkers' potential ease or difficulty in finding other farm or nonfarm employment—and explain why persons who are less skilled and older may have a more difficult time finding new jobs than those who are younger and more skilled. While some jobs are lost, new jobs might be found, indicating, perhaps, a reduction in labor's costs of adjustment. New harvesting machines will no doubt reduce the need for seasonal hand pickers in affected areas. However, new jobs may open for shed workers (including sorters, cullers, and packers), machine operators, mechanics, and allied workers with food processors and packinghouses.

The allocation of new jobs will more than likely be less than needed under the traditional harvest techniques, however. Existing programs, such as unemployment insurance, job referral services, and welfare programs, could help displaced farmworkers in the transition and lessen the costs of the adjustment process.

Measuring social returns

The third important step in assessing mechanization research is to quantify direct and indirect costs and returns accruing to the innovation and to set the framework for their evaluation. Available methods for measuring the potential effects from mechanization research involve either the traditional methods used by economists or the general method of "technology assessment."

Assessing the consequences is approached here by combining the economist's approach with the general approach of technology assessment, and offers a practical result which can be used to rank various types of research projects. The suggested method attempts to answer three related questions: (1) What would be the future situation of prices, quantities, costs, and returns for society as a whole if no innovation were created and diffused? (2) What would be the future situation in terms of losers and gainers over time if an innovation were diffused? (3) Would society be better off under the conditions "found" under (1) or (2) *i.e.*, which of the two future situations yields the "best" social rate of return?

With this framework of analysis, three estimates are generally made: a measure of the gross social return (GSR), a measure of the gross social rate of return (GSRR), and a measure of the net social rate of return (NSRR) to society.

The gross social return is an estimate of the cost reduction in output over time resulting from the adoption of new technology within the agricultural sector. Stated another way, it is an estimate of the cumulated differences of the costs of production associated with the old technology less the costs of production associated with the new technology times the percentage of machines adopted on farms during the relevant time period.

Gross social returns are estimated by: first, calculating the total "discounted" costs of production using the "old" technology; second, calculating the "discounted" cumulated costs of production using the "new" technology, taking into consideration its expected rate of adoption; and third, subtracting the results of step one from the results of step two to yield a gross "net" return. Thus, the gross social returns measure captures most direct benefits and costs associated with the expected rate of diffusion of the innovation in agriculture.

The flow of annual gross social returns is then related to the flow of annual research and development expenditures (R + D) to compute the gross social rate of return to society:

$$\text{GSSR} = \frac{\text{Total Annualized Value of GSR X 100.}}{\text{R + D}}$$

Here, the GSRR captures most direct costs and returns associated with both the R + D investments and the expected rate of adoption of the innovation.

To measure external costs to society (*e.g.*, the wage loss to displaced workers), it is necessary to subtract the costs of adjustment from the gross social returns.

$$\text{NSRR} = \frac{\text{GSR} - \text{Cost of Displaced Workers X 100.}}{\text{R + D costs}}$$

The net social rate of return accounts for the goals of improving efficiency and also the goal of maintaining full employment.

Tomato studies

In a study of tomatoes using the method of measurement adopted here, Schmitz and Seckler (1970) assumed a "low-cost" saving of $5.41 per ton resulting from the diffusion of a new tomato harvester from 1965 to 1972 in California, and estimated a gross social rate of return of $9.29 per dollar of research and development investment. The total "annual" discounted value of GSR was $42,608,018, while the R + D costs were close to one-tenth as much, or $4,585,320:

$$\text{GSRR} = \frac{\$42{,}608{,}018}{\$\ 4{,}585{,}320}(100) = 929\%$$

Subsequent research by Friedland and Barton (1976) on "tomato technology" in California indicated that consideration of indirect social costs would tend to reduce the gross social rate of return of the Schmitz and Seckler study. Friedland and Barton cite for example: (1) a drop in the labor force from approximately 50,000 tomato harvest workers in 1962 to an estimated 18,000 in 1972; and (2) an increased specialization and concentration of tomato production on large scale farms and a decline in the number of tomato growers from approximately 4,000 in 1962 to 597 in 1973 while tomato production rose from 3.2 million tons in 1962 to nearly 6 million in 1974.

Although these social costs might be considered relatively high, considering all things (such as the ability of labor to adjust to new jobs), it is doubtful that the net social rate of return to tomato technology would approach zero.

Lettuce harvesting

The study by Johnson and Zahara (1976) considered the gross social rate of return of a new lettuce harvest machine (and system) at an adoption rate of 5 percent between 1980 and 1985 and 25 percent between 1985 and 2025 and estimated a gross social rate of return of $22.80 per dollar of R + D expenditure:

$$\text{GSRR} = \frac{\$39{,}250{,}000}{\$\ 1{,}720{,}000}(100) = 2280\%.$$

Johnson and Zahara also note that the mechanization impact on labor will be to eliminate the hand-cutting jobs, although certain new jobs will be created. The overall job reduction is estimated at 1.56 percent of the current work force at a 5 percent adoption rate, and at 7.8 percent at the 25 percent rate of adoption. Net wage reduction at a 5 percent adoption rate is estimated to be $.79 million, and $3.95 million at a 25 percent adoption rate. Despite these projections, Johnson and Zahara do not believe the adjustment costs for the specific workers in question will be high, since they consider lettuce hand cutters to be "elite" agricultural workers with good reemployment possibilities (1976: 381).

The foregoing examples provide insights into how to assess mechanization research. The measures derived from the concepts of social rates of return give an orderly and "objective" means for ranking projects. Appropriate data are a function of the time frame of analysis and the questions posed regarding direct and indirect costs, losers, and gainers. In the two studies just discussed, it has been shown that monies expended on mechanization research can yield significantly high net returns to society, despite the evidence of large adjustment costs.

Although measures of GSR, GSRR, and NSRR provide decision-makers with criteria to rank projects, other factors should also be considered in the assessment. For instance, most calculations unrealistically assume that each dollar gives the same satisfaction (or same sacrifice) irrespective of who gains (or who loses). It could be the case that low income farmworkers gain more satisfaction from an additional dollar of income earned and incur greater sacrifice from an additional dollar of income lost, than high income employers. Hence, the adjustment costs of labor displacement might be appropriately (and justly) weighted higher than the foregoing estimations suggest.

We should also note that projects with high net social rates of return can obfuscate large labor displacement effects, while projects with relatively low rates of social return can have minimal labor impacts. The high positive returns to mechanization research primarily indicate that a substantial income is saved from innovation—enough to compensate the losers and still leave society better off than before. However, the presence of savings does not assure that benefits would accrue to displaced workers, nor that compensation would actually occur.

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