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Power and Efficiency

Efficiency of Labor

Reuben W. Hecht and Eugene G. McKibben

TODAY a farmer with mechanical and electrical power, modern machines, improved seeds, fertilizers, and pesticides, convenient buildings, and improved breeding stock and feed turns out almost four times as much product each hour of work as a farmer did each hour in the years just before the First World War.

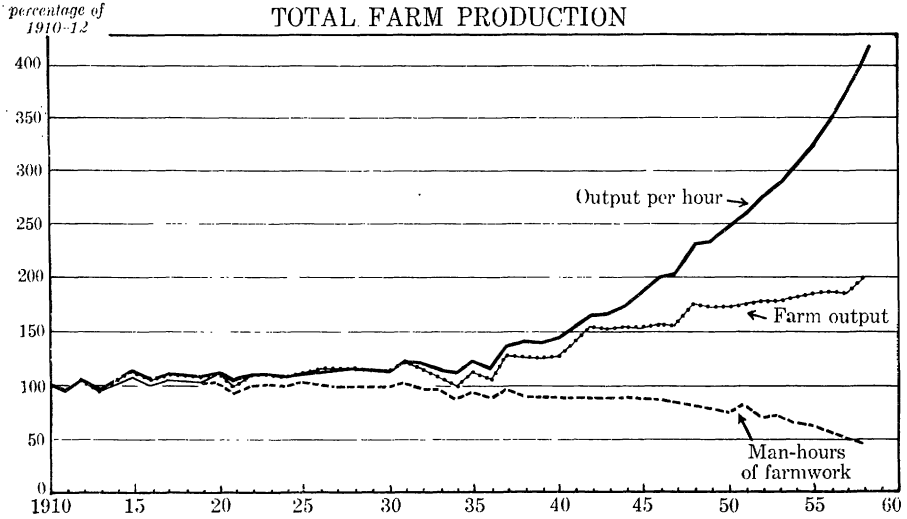
Advances in efficiency of farm labor have resulted directly from fewer hours of farmwork and from greater farm production. Many related and interrelated forces, including engineering and biological developments and economic and social changes, have been behind these basic causes.

During the half century since 1910, farm output per man-hour has risen at an average rate of almost 3 percent a year. This gain has not come about gradually.

For the first decade after 1910, farm output per man-hour rose less than 1 percent a year. The increase was due to the expansion in farm output as the labor used on farms also rose.

The two decades between the First and Second World Wars were characterized by a start of a persistent downward trend in the number of workers on farms. Lack of an effective demand for farm products and other factors held the annual gain in farm output to a modest 1 percent a year, but the gain had a greater influence on raising farm labor efficiency an average of 1.6 percent a year than the reduction in the amount of labor used on farms had.

EFFICIENCY IN USE OF FARM LABOR
TOTAL FARM PRODUCTION



The annual increase in farm production and its contribution to the greater labor efficiency that came during the Second World War was without precedent in the history of American agriculture and has not been equaled since. By a fortunate conjuncture of circumstances, farm output rose 3.3 percent annually and was largely responsible for raising production per man-hour to record levels. Efficiency of farm labor rose at the annual rate of 4.8 percent from 1940 to 1945.

The advances in mechanization and the changes that accompanied it have meant an acceleration in the reduction in the man-hours of farmwork since the war. The number of man-hours dropped at an annual rate of 4 percent from 1945 to 1950. Since 1950 the reduction on a percentage basis has been even greater—4.2 percent a year. Expressed in hours of farmwork, the drop in the 5 years following the war amounted to almost 750 million man-hours a year. During the next decade the annual reduction was about 500 million hours a year.

The postwar drop in farm labor input is shown also in the number of workers on farms. There were 10 million on farms at the end of the war. Primarily because of the return of workers from war industries and the Armed Forces, farm employment rose for a couple of years, but after 1947 numbers again turned downward.

In the first 5 years after the war, the reduction was only 15 thousand workers a year, compared with an annual drop of about 200 thousand from 1940 to 1945. Farm employment averaged only about 7.4 million workers in 1959: The annual reduction since 1950 has been almost 20 times as fast as during the first 5 postwar years.

On the other side of the labor efficiency ratio—the production side—additions to farm output after the war continued to contribute significantly to the steep upward climb in labor productivity.

Its effect was less than during the wartime period for two basic reasons, one absolute and the other relative: The annual increase in farm production was less than during the war; the accelerated reduction in labor used on farms lowered the relative effect of additions to farm output.

In line with the great strides made in adding tractors and other forms of

mechanical power to farms after the war, work animals disappeared rapidly. From 1945 to 1950, the drop in work animals was responsible for additions to cropland for raising products for human use, amounting to 2.6 million acres a year. The horse-and-mule-release of cropland had equaled 2.2 million acres annually during the war and has averaged 1.5 million acres yearly since 1950.

As only about 3 million head of horses and mules were left on farms and ranches at the beginning of 1960, this source of additional output is about exhausted. However, this aspect of farm mechanization was the prime source of greater farm output for the first half decade after the war. Since 1950, greater crop and livestock production resulting from higher yields has been chiefly responsible for additions to farm production.

While greater farm production helped, the reduction in labor used on farms was the chief cause of the steep upward climb in labor efficiency after the war. It rose at the annual rate of 5.2 percent for the first half decade and 6.5 percent a year since 1950.

MANY adjustments in organization and management of farms and related industries developed concurrently with the advance in farm technology and labor efficiency. Indeed, they were part of it.

We have said that the farm mechanization phase of the technological progress in farming both lowered the amount of labor used on farms and raised the amount of farm products available for human use. That is true, but it is an oversimplification of the complex and interrelated changes that have been part of the technological revolution in agriculture.

An all-inclusive discussion of labor efficiency in farming would include consideration of most of the forces behind growth in the total economy. The more general of these include human desires; stable government and institutions; public and private research for new and adaptable products and techniques; education, particularly regarding adoption of the innovations; and a favorable economic climate.

Economic forces express themselves through prices and incomes. Many price relationships and changes in the relationships have profoundly affected advances in technology.

An example is the cost of farm labor and the cost of the items that can be substituted for labor. Much of this kind of substitution has taken place, particularly the replacement of work animals by mechanical power.

To simplify the comparison, we assume that wage rates paid to hired workers reflect the cost of operator's time and that of unpaid labor of his family. (This assumption fails to recognize remuneration for management functions performed by farm operators. On the other hand, they and family workers do many jobs that add little to farm income.)

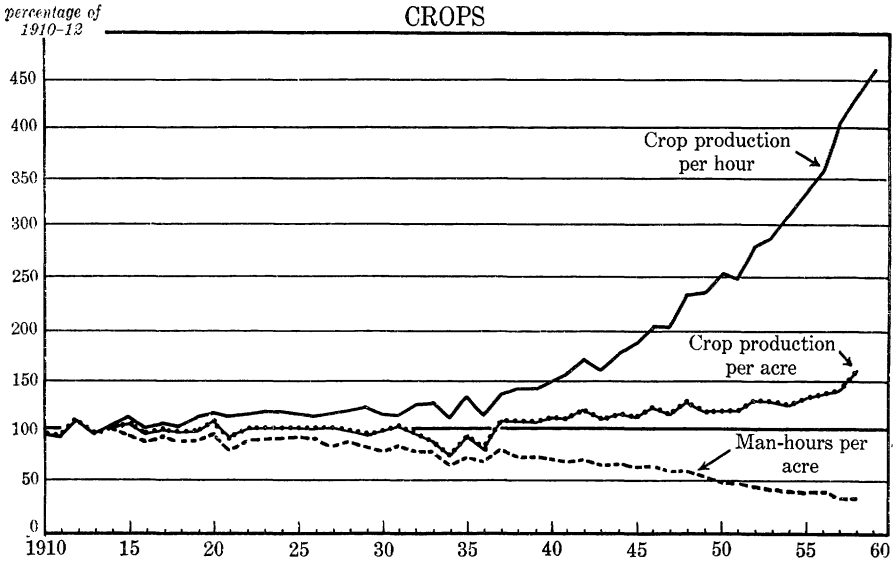
Farm wage rates were more than 200 percent higher in 1958 than in 1925–1929. During those 30 years, the average prices paid for tractors, trucks, and automobiles rose 190 percent; farm machinery, 130 percent; and fuel, tires, and other motor supplies about 30 percent. A comparison with 1935–1939 would show even greater disparity in the rates of increase.

We could cite other illustrations of the relationship of prices that favor the adoption of technology, such as the prices paid for fertilizer and improved seed, whose cost generally has been considerably less than the value of their additions to production.

THE INCREASE in size and specialization of farms has been one of the most significant changes in farm structure and organization that have come with the adoption of technology.

About a billion acres have consistently constituted the land base in farming, but the number of farms has dropped from about 6.5 million at the time of the First World War to fewer

EFFICIENCY IN USE OF FARM LABOR



than 4 million in 1960. Each year the fewer remaining farms, on the average, add land to their operations. More than two-fifths of the transfers of farmland are for the purpose of enlarging farms. They were one-fifth of the purchases in 1950.

One might expect that by this time wheat farmers, who were among the first to mechanize, would have pretty well adjusted their operating units to the new machines and methods. A larger proportion of the current transfers of farmland, however, is for farm enlargement in the wheat farming areas than in other parts of the country: Even in the more mechanized areas, innovations are being adopted that save even more labor, and effects of them are being translated into larger farms.

The number of acres is not a reliable measure of size in all farming situations, of course. A poultry farm may have few acres but be a large unit in terms of total investment or in number of birds or eggs produced. Here a major part of the investment is in buildings and equipment that induce large flocks and raise production per hour of labor.

Modern equipment and machines are so expensive in many instances that it is advantageous to the farmer to develop larger farms and enterprises to make full use of the new resources and to hold down unit costs.

Under older systems of farming, a farmer could add acres or animals without increasing proportionally the labor he used. With modern equipment, tools, and methods, the increase in labor needed is even less, relative to the added acres and animals.

The degree of specialization on farms may be indicated by the number of enterprises (such as milk cows or corn) each has. Of 20 major enterprises, the average farm had 5.4 in 1940 and 4.7 in 1954.

Specialization has occurred in both the general and the unusual farm enterprises. The number of farms dropped about 10 percent between 1950 and 1954, but the number of farms with chickens and those having milk cows each fell 19 percent. The number of farmers growing snap beans dropped

35 percent, and the number producing tomatoes, 30 percent. In each instance, the average size of the enterprise was greater in 1954.

Besides raising overall efficiency in farming, specialization has had other effects on farm labor.

One of the disadvantages of specialization is that work may not be provided for all seasons and periods of the year if there are only a few enterprises.

That is particularly significant on farms with a relatively fixed labor force, such as many family farms.

According to the census, workers on farms put in about 5 fewer hours per week in 1959 than they did in 1949. Or on a daily basis—around September 1, 1959—farm operators averaged 9.8 hours of work a day. Hired workers averaged 8.9 hours. Comparable lengths of workdays 10 years earlier were 11.1 and 9.5 hours, respectively.

Specialization, then, has been translated into fewer hours per farmworker as well as into greater production per worker and per hour of work.

We do not mean to stress specialization unduly or to imply the absence of other influences. Many forces have induced changes in input and productivity of labor.

THE INDEX of labor efficiency is the ratio of total agricultural output to the input of labor in farm production. The index thus reflects the net effect of all forces that influence either farm production or farm labor.

Myriad influences underlie changes in the two basic indexes of total agricultural output and labor used in farm production. They are themselves interrelated.

For example: Labor used on farms has trended downward for nearly four decades, and the descent would have been greater were it not for the upward trend in farm production.

In terms of a specific crop, in 1950–1954 it took an average of 69 man-hours to grow and harvest an acre of sugar beets yielding 15.5 tons. The average for the following 4 years was 53 hours per acre, or more than a fifth less, and the drop would have been greater if the yield had not increased. The average yield in 1955–1958 was 17 tons. The combined effect of fewer hours and more tons per acre, including the almost innumerable forces back of these changes, was to raise production of sugar beets per man-hour by more than 40 percent in 5 years.

To understand the meaning of production per hour we have to understand the underlying measures of labor input and production.

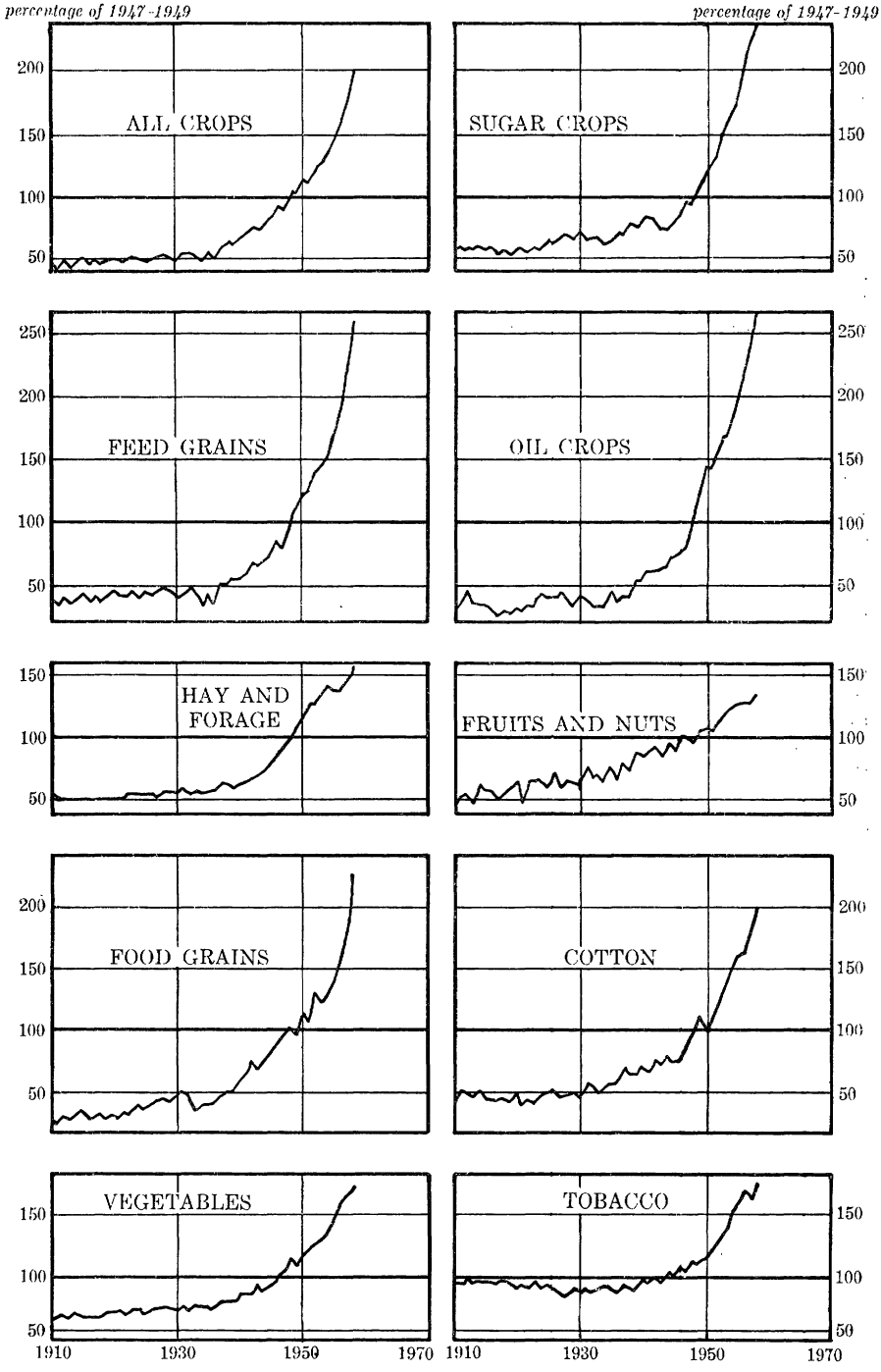
The annual series of total man-hours of farmwork are "built up" by individual farm enterprises by applying regional average man-hours per acre of crops and per head or unit of production of livestock to the official estimates of acres and numbers prepared by the Crop Reporting Board of the Agricultural Marketing Service. Time for farm maintenance or general overhead work is estimated separately and added to the direct labor for crops and livestock in arriving at man-hours of all farmwork.

For an individual farm commodity or enterprise, production per man-hour may be expressed in bushels, pounds, tons, or any commonly used measure. Groups of farm commodities or total products, however, because of their diversity, cannot be added directly and must be converted to addable units. Average prices for farm products for a period of years serves this purpose.

Average prices for 1947–1949 are used for the years since 1939.

Total farm output measures the annual volume of farm production available for eventual human use. The output computations are made in such a way that crops fed to livestock, for example, are not double counted, or as part of both crop and livestock production. Eggs used for hatching also illustrate an item that is deducted to avoid double counting. Production of horses and mules and the hay and grain fed to them are likewise excluded from farm output.

PRODUCTION PER MAN-HOUR



It would not be correct to attribute all the changes in efficiency to farm labor. We should not interpret the indexes as an allocation to labor of all the advances in farming efficiency. Labor is the most important single input in agricultural production, however, and changes in the ratio of production to labor provide a useful measure of changes in efficiency of farm production.

Changes in production per man-hour of labor must be interpreted in the light of changes in mechanization, yields of crops and livestock, and other technological forces that operate on labor input and farm production.

The ideal measure of efficiency would include all production inputs in the denominator of the ratio.

Solomon Fabricant, of New York University, said this regarding productivity ratios:

"As a general rule . . . it is better not to limit productivity indexes that purport to measure change in efficiency to a comparison of output with a single resource. The broader the coverage of resources, generally, the better is the productivity measure. The best measure is one that compares output with the combined use of all resources.

"Information on all resources is not available, however. Until rather recently, economists interested in measuring the rate of increase in national productivity had to make shift with labor input alone—first, in terms of number of workers, then in terms of man-hours. This is still true for most individual industries, narrowly defined even on a historical basis, and for both individual industries and the economy as a whole on a current basis."

His statement about individual industries certainly applies to farm enterprises. It applies at all levels of aggregation or from national data to those for an individual farm.

For a comprehensive measurement of overall efficiency in agriculture, information on the amount of each production resource going to each enterprise would be necessary. Improvement of efficiency in farming results from more efficient production of corn, wheat, beef, or another enterprise. Without total input data for each enterprise, we can learn relatively little of the how and why of total farm efficiency. Capital inputs particularly are difficult to define and to obtain, but we have a wealth of data on the amount of labor used for the individual farm enterprises.

Annual series since 1930 of farm production per man-hour of labor and of production per unit of total input are available for about 17 types of commercial family-operated farms.

Glen T. Barton and Ralph A. Loomis, of the Department of Agriculture, presented an analysis of the trends in these two series in a paper published in the Journal of Farm Economics for December 1957.

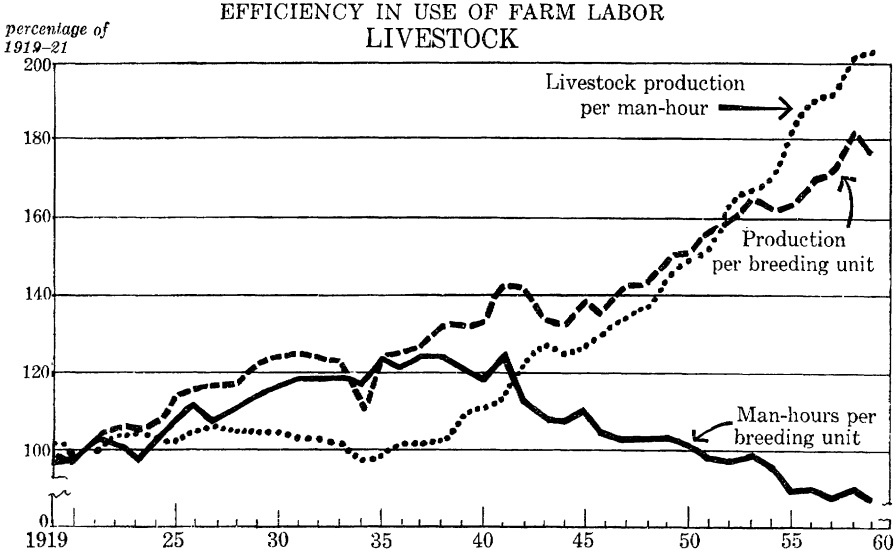
They found that the percentage increase in production per man-hour is much larger, but that a close association exists between changes in it and in production per unit of total input. Put another way: A given percentage increase in production per unit of inputs is associated with a much larger percentage increase in production per man-hour.

They stated further: "The high correlation between changes in production per man-hour and in production per unit of input is not surprising when viewed against the background of technological progress in agriculture. The bulk of the innovations adopted in farm production have been of a direct, or indirect, labor-saving nature."

While it has limitations, production per man-hour is reasonably reliable for general purposes as an indicator of total efficiency.

IT IS UNREALISTIC in some respects to view farming as a thing apart. When our Nation was young, that could be done because agriculture was largely self-contained. The draft animals, feed, tools, building materials, implements, manure, the family's food and clothing, material for the farmhouse and furni-

EFFICIENCY IN USE OF FARM LABOR
LIVESTOCK



ture, and the fuel were all mostly produced on the farm.

Not so today. Now farmers sell most of what they produce and buy what they need on the farm and in the home. There has been a dispersion of jobs or functions from farms to nonfarm business firms.

The modern farmer retains primarily the function of a producer of crops and livestock. This is a different kind of specialization than we discussed previously. The average farmer specializes on fewer enterprises and he also performs fewer functions.

The evolution from self-sufficiency to commercialization of farming may best be portrayed by changes in the distribution of the population and labor force. At the beginning of the 19th century nearly everybody lived in rural areas, and 80 of every 100 persons in the labor force were engaged in farming. Now only 12 percent of the people live on farms, and of each 100 in the total working force, only 9 are farmworkers.

ENTIRELY NEW industries and service institutions have had their beginning and growth in the increasing tendency of farmers to utilize production supplies originating off the farm.

Complementing this development has been the creation of still another group of business entities with the functions of handling, storing, processing, and distributing food, fiber, and other products from the farm to the consumer. Thus we have three groups of related industries with interrelated functions. Altogether they embrace essentially the functions that the term agriculture denoted 150 years ago.

Their dimensions are large. Consumers in 1954 bought food and fiber worth about 93 billion dollars, or roughly 40 percent of the total consumer expenditures for all products and services.

The total assets of the three segments equaled approximately 220 billion dollars, which was almost three-fifths of the total assets of manufacturing, wholesale, and retail corporations and agriculture.

About 24 million persons, or about two-fifths of the total working force of 64.5 million, engaged in the activities pertaining to agriculture—about 6 million were employed by farm-supplies industries, about 8 million were

engaged in farming, and 10 million were in the processing-distribution industries.

The significant point is this: The workers in the farm-supplies industries by taking over functions formerly done by farmworkers have contributed heavily to the advance in farm output per hour of farm labor.

Before going into the extent of this contribution, we should indicate that the processing-distribution workers also do a few functions that were done by farmworkers, but most of their tasks were taken over from housewives.

The processing-distribution workers, that is to say, chiefly perform additional services or processes rather than the functions that farmworkers once did. Processing-distribution workers should be excluded, therefore, in a comparison between farm production or output as it leaves the farmer's gate and the workers who contribute to it.

If we add farm-supplies workers to the farm labor force, however, and compare the sum with farm output, we get a measure of the efficiency of all labor—direct and indirect, farm and nonfarm—that contributes to farm output.

This concept attempts to answer in aggregate a question of which the following illustrates a part of the broader inquiry:

Does using a tractor on a farm still save labor even though we include the miners who dug the iron ore and coal from the earth, the smelter workers who converted these raw materials into steel, the manufacturing workers who fabricated the steel into tractors, and all the other nonfarm workers who assisted in producing and distributing the tractor, the fuel, and the other supplies that it requires?

We cannot give an exact measurement because we lack precise and full data. Some jobs, for example, have been transferred to nonfarm workers and have later been transferred back to farmworkers: Farmworkers once hauled nearly all farm products to a local market. When motortrucks were introduced, many were purchased by commercial truckers, who did a lot of hauling for farmers. When farm trucks became more common, many farmers tended to do their own hauling rather than to hire nonfarm truckers. The exact division of the hauling job between these kinds of workers at a given point in time is unknown.

Estimates by men in the Department of Agriculture indicate that 5 million persons worked in the farm-supplies industries in 1947 and 6 million in 1954. Industrial workers put in about 40 hours a week during this period. Farm-supplies workers therefore spent 10 billion to 11 billion hours in producing goods and services purchased and used by farmers in 1947–1954. At the same time, work on farms took 17 billion to 13 billion hours, or from half to two-thirds of the total.

Similar estimates were made for a few years near the end of the First World War, near the beginning of the Second World War, and for a current period. They help us compare changes in efficiency of farm labor and of total labor for two periods—between the wars, when farmers increased their purchases of supplies from the nonfarm sectors of the economy by about a fourth; and from the beginning of the Second World War to 1958. During the latter period, the quantity of farm supplies, as measured in 1947–1949 average prices, rose from about 7.8 billion dollars to 14.4 billion.

Farm output per hour of farm labor rose by about 40 percent during the interwar period. When the time of the farm-supplies workers is included, the increase is less—about 30 percent. Since the beginning of the Second World War, the gain in farm labor productivity has been a little more than 150 percent. The inclusion of farm-supplies workers reduces it to about 50 percent.

Thus, when farm supplies are converted to labor and added to the farm labor force, the gain in efficiency is not so great as when only farm labor is considered. The increase is still sizable—

more than 80 percent from the end of the First World War to 1958.

The technological revolution has not been limited to agriculture. It has occurred in industrial plants, also; it has meant a gain in productivity of those workers as well as a substantial contribution to the increase in efficiency of workers on farms.

THIS IDEA of laborsaving or gain in efficiency of all labor resulting from the adoption of technology is clearer when it is put in terms of a few important farm machines such as cornpickers, cottonpickers, and milking machines.

First, let us assume that in the late 1950's the average cost of labor going into the production, handling, and delivery of these machines is 2 dollars an hour. Second, let us assume that the total labor represented by one of these machines as received on the job is something less than the delivered cost divided by the average wage. The difference, of course, consists of items—such as natural resources and profit—that do not represent labor.

TWO-ROW mounted cornpickers cost 2,000 to 2,400 dollars delivered to the farm. The farm-supplies labor represented is about 1,100 hours. The use of such a picker may reduce harvest labor requirements by 5 man-hours per acre and can harvest 80 or more acres in a season. This means a total reduction of more than 400 man-hours annually.

Thus, under usual conditions, only a few years would be required for the reduction in farm labor to equal the nonfarm labor required to produce and deliver the machine. A cornpicker, of course, requires a tractor, fuel, and other supplies produced by nonfarm workers. But here, also, a net saving in labor occurs compared with the farm labor required to raise, feed, and work the animals required under older methods of harvesting corn.

One-row, tractor-mounted cottonpickers cost 4,000 dollars to 8,000 dollars. The off-farm labor used to produce, handle, and deliver such machines may be 2,000 to 4,000 man-hours. Such a picker under normal use will reduce the man-hours needed for cottonpicking from 40 to 50 per acre on 40 to 80 acres. This would be a reduction of farm labor of 1,600 to 4,000 man-hours a year. Again, only a few years would be required to balance reduced man-hours of farm labor against the man-hours of industrial labor required to deliver such a cottonpicker to the user.

A four-unit milking machine costs about 1,000 dollars. The off-farm labor represented must be something less than 500 man-hours. Such a machine will handle 40 or more cows, with an annual reduction of about 30 man-hours per cow compared to hand milking. Thus, the annual reduction of the dairy labor will be 1,200 hours or more. Thus, in many cases, less than a year's use will be sufficient for the reduction in man-hours of dairy labor to balance the man-hours of industrial labor required to make the milking machine available.

These examples constitute further evidence that the increase in time of farm-supplies workers is more than offset by the reduction in time of farm-workers resulting from their use.

EFFICIENCY in farming results from more efficient production of corn, cotton, milk, and other farm products.

How have the different farm enterprises fared in this respect?

How do crops compare with livestock?

If there are differences, what have been the significant causes?

American farmers in 1956–1958 raised more than three times more total crops per hour of labor than they did in 1910–1912. (The 3-year averages are used to add stability.) During the same period, livestock production per hour nearly doubled, and labor efficiency in total farm production rose 2.8 times.

The increase in productivity of the labor spent on crops has been far from uniform among crops and sections and

for different parts of the last half century.

There has also been considerable variation during different parts of the period in the relative influence of the two basic factors behind the phenomenal increase in crop production per hour. These causal factors are higher yields per acre, which were largely the result of fertilizer, variety, hybrids, pesticides, weather, and other biological factors, and fewer man-hours per acre, which resulted primarily from mechanization—that is, more effective power sources, machines, and methods.

Man-hours per acre and yield are interrelated. To illustrate: If a greater quantity of fertilizer is applied to a crop and results in a greater yield, additional time is needed to obtain and to apply the fertilizer and to harvest and market the higher yield. The relation between yield and time for harvest depends on the extent of mechanization. Additional yield of a highly mechanized crop adds little to the time for harvesting but for crops that are gathered by hand the increase in harvesttime is almost proportional to the added produce.

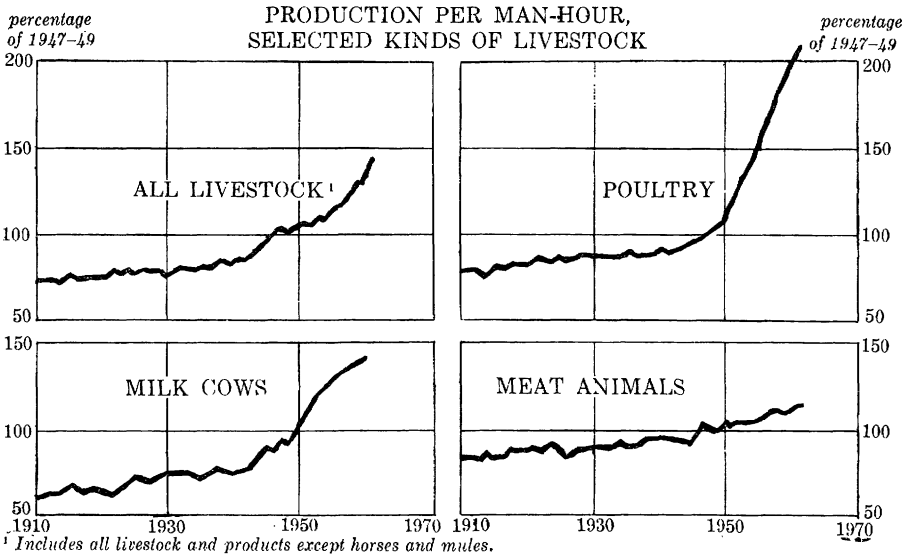
For the half century beginning in 1910, wide adoption of mechanized and laborsaving methods of producing, harvesting, and marketing crops resulted in a drop in man-hours per acre of crops at the rate of 2.2 percent per year. Mechanization was the prime cause of greater labor efficiency in producing crops. The increase of 0.8 percent per year in yields also contributed, however, and the combination of the two resulted in the substantial rise—3.1 percent annually—of crop labor productivity. Of the gain in crop efficiency, 72 percent resulted from fewer hours per acre. The remaining 28 percent was associated with higher yields.

Between 1910 and 1920, there was a relatively small but still important increase in the labor efficiency of crop production. Crop production per acre dropped slightly. That had a negative effect on labor efficiency. But changes in equipment and methods, the beginning of the trend toward mechanization, was enough to offset the influence of lower yields and to raise the efficiency of crop labor at the rate of 1 percent annually. There was a trend toward the use of larger teams. Tractors were coming into use, particularly in the western wheat areas. The use of the combine was expanding.

During the depression years of the interwar period, the labor efficiency of crop production continued to improve at the slightly greater rate of about 1.5 percent annually. It was partly the result of moderately higher yields per acre, but a developing mechanization was the dominant factor. It was responsible for about two-thirds of the gain during these two decades. The tractor, particularly the general-purpose tractor with pneumatic tires, was widely accepted in these years. The combine harvester-thresher had almost entirely replaced the binder and threshing machine. Extensive use was made of cornpickers. The adoption of field forage harvesters and field pick-up hay balers was expanding.

During the war years of 1940–1945, the increased demand and prices for crop products resulted in an almost explosive combination of biological and engineering developments, which had been incubating during the depression years. The result was an annual increase of crop production per man-hour of nearly 5 percent. Biological developments in crops, soils, and entomology appear to have made contributions about equal to those of mechanization during this period. The use of hybrid seed corn and heavier applications of fertilizer became almost universal. Laborsaving harvesting machines were generally used, except where wartime limitations on steel for their manufacture prevented.

During the period 1945–1950, labor efficiency continued to increase and at the still higher rate of about 5.3 percent per year. Slight increases in yield per acre occurred during this period,



[1] *Includes all livestock and products except horses and mules.*

but the major contribution to increased production per man-hour resulted from fewer man-hours per acre, which dropped an average of about 5 percent per year. The Korean situation helped maintain farm prices but did not seriously restrict the production of farm machines. Thus, mechanization developed at the highest rate so far attained and accounted for 97 percent of the gain in productivity of crop labor.

Mechanization, as reflected in man-hours per acre, continued at the slightly lower rate of about 4.6 percent per year from 1950 to 1958 and was the most important factor contributing to rapid increase in labor efficiency.

During this period, though, there was also the highest rate of increase of average yield per acre so far attained—nearly 3 percent annually. An important factor was acreage allotments for wheat, cotton, and a few other crops. With the allotments there was strong incentive to use the best agronomic practices on the best acres.

The combination of this rapidly increasing yield per acre and the reduced labor per acre caused by the continuing rapid development of mechanization resulted in a startling 7.4 percent average annual increase in crop production per man-hour. About two-thirds of this phenomenal gain resulted from advances in mechanization and the other third from greater yields.

The biggest gains in labor efficiency have been for the feed and food grains and oil crops, among them corn, wheat, and soybeans, which are among the most completely and effectively mechanized. Farmers in 1956–1958 produced more than six times as much oil crops, six and two-thirds times as much food grains, and almost six times as much feed grains per man-hour as in 1910–1912.

Even greater gains in efficiency were made in the major producing area of each crop.

For sugar crops, mainly sugar beets, the gain in labor productivity for the past 5 decades has been nearly 300 percent, somewhat less than for crop production as a whole. Production of sugar crops per hour from 1950 to 1957, however, rose more rapidly than for any other group of crops except feed grains. Much progress has been made in mechanizing production of sugar beets, which took about 95 hours per

acre during the war but only 53 hours in 1955–1958. Also contributing was a significant increase in yield from 12.7 tons to 17 tons an acre.

For cotton, the gain in labor efficiency also has been just under 300 percent. Picking cotton was about one-third mechanized in 1958. Even less progress has been made in mechanizing chopping and hoeing—the most time-consuming preharvest operation.

Production of hay and forage is well mechanized, but the gain in productivity during 1910–1958 was only about three-fifths that of all crop production. That is because baling, one of the modern methods, does not save a great deal of labor as compared with older methods, most notably in the West, where stacking was formerly the prevalent method. Chopping with a field forage harvester, the most laborsaving modern method, has not increased significantly. In fact, the percentage of the hay crop that was chopped has dropped slightly. Advances in the mechanization of tillage and seeding operations have had less effect on the labor for forage production because many acres of forage crops produce for several years with one seedbed preparation and seeding.

The gain in labor efficiency for vegetable production has also been equally low—170 percent—although for certain vegetables as green peas and spinach for canning and freezing production has been completely mechanized.

The mechanization of fruit and nut production has made still less progress. In many fruit and vegetable crops, particularly those produced for the fresh market, the increase in productivity has been low. That is true also of certain special crops.

Tobacco, for example, is an important commercial crop but still requires nearly two-thirds as many man-hours per unit of production as it did in 1910. Because the manual harvesting of this crop has a high labor requirement, the large increase in yield, more than 60 percent, that has occurred since 1910 has tended to counteract the savings per acre resulting from progress in the mechanization of other operations. In fact, production per man-hour has increased less during this period than the yield per acre, with the result that the man-hours per acre required in 1958 were somewhat higher than in 1910.

WHAT ARE the possibilities to improve farm labor efficiency further for crop production by mechanization?

The complete or partial mechanization of harvesting fruit and vegetables is the most challenging. Another important possibility is the completion of the mechanization of the harvesting and handling of difficult crops, such as for cotton and certain fruit and vegetables, where a good start has already been made. Promising starts have been made on the mechanization of the harvesting of such very difficult crops as tobacco, tomatoes, cucumbers, cherries, and blueberries.

Complete mechanization of weed control in all crops offers a good possibility of further improving the work efficiency of crop production. Peak labor demands for manual weed control and harvesting required almost 1.5 million seasonal workers at the peak in 1958.

We can expect that machines will become reliable—that is, less subject to breakdowns and other interruptions. That could improve greatly the work efficiency of crop production.

More effective machines for planting and applying fertilizers and pesticides might increase work efficiency by reducing the labor cost of replanting and by increasing the yield per acre.

The development of more reliable and effective machines and the more extensive adoption of land forming and stone removal will open the way for the use of wider machines at higher operating speeds. That will tend to contribute proportionately to improved work efficiency.

The possibilities of eliminating operations, such as some of the seedbed and cultivating operations in favor of so-

called minimum tillage, or combining operations, such as was done with the combine harvester-thresher, are intriguing but quite unpredictable.

FOR LIVESTOCK production, farm labor efficiency about doubled from 1910–1912 to 1956–1958. It rose at the rate of 1.5 percent a year. That would appear to be good progress when considered by itself, but it is only about one-third of the increase for crop production. It seems to have been the result of more effective application of engineering to crop production, because for the four decades following 1920 the gains from animal science, as reflected in production per breeding unit equaled or surpassed those from plant and soil science.

Production per breeding unit is essentially an average of milk per cow, eggs per hen, and so on. The gain in production per breeding unit was about three-fourths, while the gain in crop production per acre was slightly less than one-half. On the other hand, the reduction in man-hours per breeding unit was less than 10 percent, while the reduction in man-hours per acre of crops was 60 percent.

This gain in production per breeding unit has been continuous throughout the period at a fairly uniform rate. Some acceleration began about 1945, but the gain from 1950 to 1956–1958 was slower. Up to 1937 or so there was little gain in efficiency of labor spent on livestock; the man-hours per breeding unit just about kept pace with the production per breeding unit. The production per man-hour therefore remained virtually unchanged.

Livestock production per man-hour has risen at the rate of 3.7 percent a year since 1950.

The war years were the only period during which the reduction in man-hours per breeding unit was more effective than higher livestock yields in enhancing livestock labor efficiency. Hours per cow, sow, and hen dropped at the rate of 2.4 percent a year and was responsible for more than 90 percent of the gain in labor productivity. There was a great urge to save labor and despite critical shortages of steel and rubber, the number of farms having milking machines more than doubled during 1940–1945. Almost half the farms were receiving central-station electric service in 1945, compared to about a fourth in 1940. Many of the machines and installations that save chore labor depend on electricity.

Declines in man-hours per breeding unit have continued to be a significant factor in greater labor efficiency since the war. They have come through engineering developments, such as more effective buildings and farmstead arrangement; mechanized methods of handling water, feed, bedding and manure; and so on.

Livestock yields also have gone up since the war, however. The average milk cow on farms produced 6,438 pounds of milk in 1959 but only 4,787 pounds in 1945. Rate of lay was in excess of 200 eggs per hen in 1958 and 152 in 1945. Besides, a growing number of the eggs were hatched into broilers; that increases production per hen on farms. These developments were more effective than the reduction in labor in the greater production per man-hour. Since 1950, however, the two basic causes have been about equally responsible for increased livestock labor efficiency.

The dairy and poultry enterprises are the large users of labor in livestock production. The large gains in labor efficiency have been in them.

For meat animals, the gain in labor efficiency was only about a third from 1910 to 1958. This has been a slow but rather constant development throughout the period; it has accelerated somewhat since 1950.

On the other hand, the gain in labor efficiency for dairy production has been over 100 percent. The gain for poultry has been still greater—about 170 percent.

The labor efficiency gains for the egg production phase of poultry is about the same as for dairy, but the produc-

tion of poultry meat products has been outstanding. Turkeys and broilers have reached commercial status as a farm enterprise since 1940. Turkey production per man-hour has increased nearly 350 percent since 1910, and broiler production per man-hour about 400 percent since 1935.

It is impossible to say exactly what will happen in the way of continued improvement of the labor efficiency of livestock production. It seems certain that for some time the trend will continue to concentrate much of the livestock production in what might be considered livestock factories rather than as secondary or even primary enterprises on general farms. That would mean greater efficiency of the labor spent on livestock.

Development and Application

R. L. Green and N. L. LeRay

PEOPLE develop and apply technology in agriculture in a way that reminds us of a slow-motion game of leapfrog, in which the time between advancing leaps is months or years or decades.

Geography fixes somewhat the intervals between jumps because of the stages of producing, processing, and marketing crops. In a broader way, the influences of people's moral codes, labor practices, and ways of life limit their initiative in developing and adapting new techniques.

The acceptance of new ideas, a complicated process, involves a series of thoughts and actions that often extend over considerable periods of time. An example: The average timespan between the time an Iowa farmer learns about hybrid seed corn and the time he accepts it for continued use is 7 years.

George M. Beal and Joe M. Bohlen, of Iowa State University, said the stages in learning about new ideas and adopting them are awareness, interest, evaluation, trial, and adoption.

They classified people on the basis of the sequence in which they adopt or reject new practices as innovators, the first to adopt new ideas; early adopters, those who are among the first to use approved practices in a community, but not the first to try new ideas; the early majority, the ones who must be sure an idea will work before they adopt it; the majority, most of the people in a community who adopt proved methods; and those who do not adopt a new practice even after it has been adopted by most neighbors.

Age, education, social-economic status, and activities in progressive organizations are among the factors that influence the sequence. The more education a farmer has, the greater the likelihood that he will adopt new ideas. Younger farmers are more favorable toward new ideas than older ones. Farmers who belong to farm organizations and cooperatives often are early adopters of new practices.

The differences that make for uneven development and application of technological advances for a commodity include:

Variations in the topography, soils, and climate in areas of production.

Variations in the cultural requirements of crops.

Variations of different production stages in susceptibility to technological advance.

Variations between adapted varieties throughout the area of production.

Variations in the economic feasibility of technological change within the area of production. Feasibility is often determined by ultimate form of a commodity for consumption and the availability and cost of labor.

Variations in the culture of people working with a commodity.

Variations in the prior combina-