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NONFARM INPUTS AS A SOURCE OF AGRICULTURAL PRODUCTIVITY*

Farm output depends not only upon the quantity and quality of agricultural resources (labor and durable capital, including land) used in the production process, but also upon the quantity and quality of nonfarm inputs, such as fertilizer (*3*, p. 395). It follows that the level of farm productivity is dependent on the extent to which nonfarm inputs are employed in agriculture. John W. Kendrick's recent volume, *Productivity Trends in the United States* (*5*), provides an excellent example of the need for a greater appreciation of this relatively simple, but important, idea.

Although Barton, Cooper, and Loomis of the United States Department of Agriculture have developed estimates of the ratio of gross farm outputs to gross farm inputs over time (*1, 7*), Kendrick's work represents the most comprehensive effort to date to specify annual changes in the ratio of *net* farm outputs to *net* farm inputs in agriculture.[1] This approach does provide estimates of the savings of agricultural resources over time, but Kendrick also implies that his measure of agricultural productivity (he calls it *total* factor productivity) is not affected by shifts in the production of intermediate goods from the farm to nonfarm sectors of the economy. This paper seeks to show that such an interpretation is unwarranted and that its acceptance is likely to lead us to overlook, or underestimate, the important role that nonfarm inputs have played in raising the efficiency of agricultural resources. Kendrick's preëminent concern with the measurement of over-all productivity in the United States would absolve his estimates of any failure to apportion accurately the gains among industries, were it not that the very process by which his estimates are built up makes it inevitable that they will be used for precisely this purpose. Moreover, Kendrick does not ask for absolution, but implies that his method does permit accurate attribution of net productivity trends to resources within the various industries, including agriculture.

Nonfarm inputs are defined as those intermediate products purchased annually by farmers from nonfarm sources, for example, gasoline, fertilizer, and processed feed and seed. Items of durable capital, such as tractors and other machinery, are considered as *net farm inputs,* along with farm labor and real estate.

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[1] Ruttan (*10*) and Stout (*11*) have also estimated changes in the ratio of outputs to inputs, both measured net of current operating expenditures. Their published measures refer only to selected years or periods since 1910, whereas Kendrick provides annual series which begin with 1889.

The measurement of agricultural productivity is complicated as the production of intermediate goods is transferred from the farm to nonfarm sectors of the economy. In more general terms, it can be said that as the range of intermediate goods produced and consumed by a given industry changes, the task of measuring productivity within that industry becomes more difficult. This is true for at least two reasons. First, the boundaries between industries are arbitrary and changing. For example, in earlier years farmers used resources to produce feed for horses and mules; today they purchase from nonfarm firms most of their energy requirements in the form of motor fuels. This would not provide an insurmountable obstacle were it not for the second difficulty, a lack of sufficiently detailed data. Information is not presently available to enable one to sort through inputs and outputs and rearrange them so as to obtain a more accurate description of productivity within a given sector. To continue the example, one cannot subdivide the inputs of the petroleum industry sufficiently to isolate that portion of labor and capital devoted to the production of intermediate agricultural goods.

Kendrick faces these difficulties and says that they disappear "in productivity measures for the economy as a whole" (*5*, p. 29). However, he goes further to suggest that the "problem is overcome in principle if industry output is conceived of as real value added or product originating." He reasons that "If the production of a particular intermediate product is shifted to a different industry, the real value added in the given industry is reduced by the extent of the additional real purchases. Since factor input would be correspondingly reduced, industry productivity would not appear to increase merely as a result of a shift in the scope of industry activity" (*5*, p. 29). Accordingly, Kendrick's estimates are based on a value added concept of output and an index of inputs that excludes purchased intermediate goods. The implication is that such a measure of productivity indicates the extent of technical change within agriculture and that any gain in net farm output can be attributed solely to the increased efficiency of agricultural resources. In fact this is how estimates based on Kendrick's method have been utilized.[2]

I suggest that the transfer of the production of intermediate goods from a given industry to other industries can and most likely will affect the productivity of the given industry.[3] Hence, an investigation into the causes of agricultural productivity changes which fails to consider properly the role of nonfarm produced intermediate goods may be expected to neglect factors of great significance.

Consider, for example, the situation which probably existed in the early part of the present century. Farmers were aware of the response of crops to plant nutrients, but because of the relatively high price of fertilizer they purchased relatively small amounts of these products. Instead they devoted resources to producing their own plant nutrients in the form of legumes and manure. Be-

[2] See Mackenzie (*8*, p. 42): "In this paper an index of net output per unit of factor input will be used as an indicator of technological change within agriculture. This presumes . . . that a rise in net output comes about as a result of internal productive efficiencies."

[3] This possibility, especially as it pertains to measures of output per unit of labor, has been suggested by Robinson in his discussion (*9*, p. 1578) and by Kuznets (*6*, pp. 63–64). Kendrick himself seemed to recognize the effect of change in nonfarm inputs on his measure of productivity, for in a preliminary report of his findings (*4*, p. 1557) he says ". . . relative purchases of intermediate products have risen because efficiency and net income could be increased thereby." Unfortunately, this earlier statement does not appear to have influenced his more recent work.

tween the two World Wars, technical changes occurred so that the chemical industry was able to produce nitrogen more cheaply. The result was a decline in the relative price of fertilizer (2, pp. 594–95). Farmers then found it profitable to use more commercial fertilizer. The effect of this upon net farm productivity can be analyzed by considering two special cases.

Case I. Suppose gross farm output remains constant. Fewer net farm inputs would be required, but since nonfarm inputs increase, net farm output would be reduced. However, farmers would have no incentive to substitute nonfarm for net farm inputs unless the reduction in net farm inputs were proportionately greater than the reduction in net farm output. Therefore, net farm productivity would be expected to rise.

Case II. Suppose net farm inputs remain constant. Using more nonfarm inputs, a larger gross farm output could be produced. But farmers would not purchase the extra inputs unless net farm output was expected to rise; hence, net farm productivity would be expected to increase in this situation also.[4]

Note that in this illustration, it is possible to speak of an increase in net farm productivity that results not from technical change in the farm sector, but from technical change in the nonfarm economy. (See Griliches, 2, p. 604.)

Empirical evidence lends support to the proposition that changes in nonfarm inputs affect net farm productivity. For example, the figures of Table I indicate that the period of greatest apparent increase in net farm productivity (1937 to

TABLE 1.—NONFARM INPUTS, NET FARM INPUTS, AND NET FARM PRODUCTIVITY, SELECTED YEARS, 1869–1957

Year	Nonfarm inputs[a] (1929 = 100)	Net farm inputs[b] (1929 = 100)	Ratio of index of nonfarm inputs to index of net farm inputs	Net farm productivity[c] (1929 = 100)
1869	15.0	47.5	31.6	68.8
1879	24.8	63.9	38.8	79.5
1889	34.0	75.8	44.9	83.9
1899	46.3	85.7	54.0	93.1
1910	56.5	94.8	59.6	92.5
1919	76.5	102.0	75.0	88.4
1929	100.0	100.0	100.0	100.0
1937	104.1	95.6	108.9	106.6
1948	207.5	83.5	248.5	142.8
1957	271.4	65.6	413.7	198.0

[a] An index based on Intermediate Products Consumed (in constant 1929 dollars), John W. Kendrick, *Productivity Trends in the United States*, p. 347.
[b] *Ibid.*, pp. 362–65.
[c] *Ibid.*

[4] The changes in gross farm output (GFO), net farm output (NFO), net farm input (NFI), and net farm productivity (NFO/NFI) can be summarized symbolically for these two situations as follows:

Case I:
$\Delta GFO = 0$
$\Delta NFO < 0$
$\Delta NFI < 0$
$-(\Delta NFI/NFI) > -(\Delta NFO/NFO)$
$\Delta (NFO/NFI) > 0$

Case II:
$\Delta GFO > 0$
$\Delta NFO > 0$
$\Delta NFI = 0$
$\Delta (NFO/NFI) > 0$

1957) coincides with the period in which the ratio of the index of nonfarm inputs to the index of net farm inputs was rising most rapidly. This growing relative importance of nonfarm inputs would seem to suggest that at least a portion of the increase in net farm productivity is attributable to increases in nonfarm inputs. Or in other words, changes in net farm productivity have come about not only because of technical change within agriculture, narrowly defined, but also because of technical change in the nonfarm sectors of the economy.

Correlations between individual nonfarm inputs and net farm productivity seem to support this reasoning. For example, relating the Department of Agriculture's index of total plant nutrients used (*12*, p. 24) to Kendrick's index of productivity (*5*, pp. 362–65) for the period from 1910 to 1957 gives a simple coefficient of correlation of 0.970. The coefficient between the index of feed, seed, and livestock purchases from nonfarm sources (*12*, p. 46) and Kendrick's farm productivity index for the same period is 0.933. It would be incorrect to attribute the changes in productivity primarily to these inputs solely as a result of these calculations. However, they do suggest that there is a strong relationship between these factors, and they lend support to the contention that nonfarm inputs do affect net farm productivity.

It should be recognized that the argument that nonfarm inputs influence agricultural productivity does not rely entirely on the substitution of nonfarm for net farm inputs. For example, new products, which farmers have never produced themselves (e.g., pesticides), may also be expected to raise net farm productivity, and yet one gets the impression from Kendrick's discussion that no changes in intermediate products affect his measure of "total factor productivity."

CONCLUSION

My main point is that intermediate products (at least the labor and capital devoted to producing them) are just as much an integral part of the production function of agriculture as are the labor and capital located on the farm. Estimates of the ratio of net farm outputs to net farm inputs, while measuring the agricultural resources saved over time, do not necessarily indicate the extent of technical change within the narrowly defined agricultural sphere of the economy. Such a ratio is in fact subject to somewhat the same limitation as other partial productivity ratios (e.g., output per unit of labor): it does not indicate changes in overall productive efficiency, because it is affected by changes in the composition of inputs, i.e., factor substitutions.

So long as nonfarm inputs are relatively small, their impact on farm productivity is also probably small. But once they become as large as they have in recent years, accounting for about 36 per cent of the value of gross farm output (*5*, p. 347), then the effect that they do have is likely to become more important.

Today agricultural output is produced not only by farmers working with machines on farm land; it is also produced by nonfarm labor and equipment which turns out fertilizer and gasoline, as well as better seed varieties and feed mixtures. And to consider the ratio of net farm outputs to net farm input as a measure of agricultural efficiency may be to overlook significant factors in productivity improvement.

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