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National Productivity and Its Long-term Projection

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National Productivity and Its Long-term Projection

This paper is concerned with the problems of projecting national productivity over the long term, by which is meant several decades. National productivity here refers to the ratio of real gross private national product, in terms of the U. S. Department of Commerce concept, to man-hours worked in the private economy. Projections of productivity, employment and average hours, are the basic variables involved in obtaining a first approximation of total real gross private product in the target year, in terms of base-year prices.

Successful projection involves first of all a clear concept of the variable under consideration, and the chief factors which determine its movement. Since real gross national product per unit of factor input, in aggregate and by industry, differs in important respects from most other productivity measures, considerable space will be devoted to clarifying the concept. The main factors which affect the movements of this type of productivity measure will be discussed theoretically.

As Dr. Kuznets pointed out in his introductory paper, projection involves, among other things, a knowledge of persistent patterns of behavior in past periods. Accordingly, another section of this paper describes calculations of secular trends in national productivity over several past decades. Productivity trends in the farm and nonfarm sectors of the private economy are measured separately in order to illustrate the industry approach to productivity analysis.

The discussion of projections of productivity is largely related to technique. The types of adjustment which would have to be made in extrapolations of past productivity trends in order to obtain a projection that is articulated with the relevant details of the economic projection as a whole are developed.

Finally, the areas are indicated in which further data, analysis and theory are needed to advance our knowledge of productivity and thus our ability to project.

I. The productivity concept in a gross national product framework, in aggregate and by industry

There are many distinct members of the family of productivity concepts and measures. The real product per man-hour, in aggregate or by industrial origin, used in connection with over-all economic projections, differs in a number of important respects from other types of productivity measures. Understanding of the distinctive features of productivity measurement in a real product framework, to be brought out in the following discussion, is essential to its use for analysis or projection.

A. The real product dividend - a net output concept

Gross national product according to the Department of Commerce concept measures the market value of the Nation's economic output of final goods and services. To arrive at constant dollar ("real") estimates, the detailed current dollar expenditure figures are, in general, divided by appropriate indexes of market prices. In effect, the outputs of the various types of final goods and services are weighted by base period market prices.[1/]

Gross national product, in current and in constant dollars, is "gross" in that no deduction is made for business and institutional consumption of capital goods. It is net, however, in the important sense that all other intermediate products, such as raw materials, semi-finished goods, or components--other than those entering the change in inventories--are excluded.

This factor may quite significantly affect the movement of real product relative to the volume of gross output, and the productivity measures derived therefrom. For example, economies in the use of intermediate products, given the same gross output

1/ Significant features of gross national product, deflated by the tentative methods developed in the U. S. Department of Commerce, are discussed in the article by George Jaszi and John W. Kendrick, "Estimates of Gross National Product in Current and Constant Dollars, 1929-49," Survey of Current Business, January 1951.

in two periods, are reflected in an increase in real product. Input factors remaining constant in relation to outputs, an increase in productivity would result due both to the increase in real product and the decrease in man-hour inputs as man-hours engaged in intermediate production are reduced. Composite physical production series based on gross output would not only show no increase under these circumstances, but, if they covered the entire economy, would decline due to the smaller volume of output of intermediate products. A composite productivity series, based on gross output dividends would show no change, abstracting from the effect of interindustry shifts.

The gross national product by individual industries of origin, while gross of capital consumption, is likewise net of intermediate products consumed. Estimated from the product side, gross industrial product is, broadly speaking, measured by the value of gross output (and inventory changes) less the value of intermediate products consumed in the production process. If intraindustry sales are included in the value of gross output, then an equivalent amount, representing intraindustry purchases, would be included in the deduction for value of intermediate products consumed. If, however, value of gross output is defined and measured net of intra-industry sales, then the value of intermediate products represents purchases from other industries. In either case, the industrial product estimate is the same, and is additive to the gross national product estimates for other industries.

Gross industrial product, as a value-added type concept, is equivalent to the sum of income accruing to the factors of production, plus indirect business taxes and capital consumption allowances. For deflation purposes, however, the product data are essential. Real industrial product is obtained as the difference between the value of gross output, adjusted for price changes by detailed product groupings, and the value of intermediate products consumed, deflated likewise.

Thus, the real product of an industry will move differently from the physical volume of gross output if the ratio of real purchases of intermediate products to the real value of gross output varies. Most productivity measures are based on gross output, and therefore do not allow for changing proportions of intermediate products consumed. Yet this factor is definitely relevant to productivity measurement.

These points, with reference to individual industries and the economy as a whole, are illustrated in the hypothetical model shown in Table 1. For the sake of simplicity, the model relates to an economy composed of two industries, A and B.

In industry A, due to the increasing proportion of intermediate products consumed, the national product rises less than the value of gross output. In industry B, the reverse is true. Due to the greater importance of industry B in the economy as a whole, the over-all proportion of intermediate products consumed declines and the total national product rises more than the value of the total gross output.

These examples are hypothetical, but not necessarily unrealistic. The real gross farm product in the United States has behaved like industry A, according to estimates discussed later. This behavior may be typical of extractive industries generally, once diminishing returns prevail. The extractive industries, however, currently account for a minor proportion of gross national product.

The hypothetical data for industry B may typify manufacturing industries as a whole, for example, although good data over time concerning intermediate products consumed would be required for verification. Certainly the increasing degree of processing, and scientific industrial controls which have helped to economize the utilization of raw materials, have tended to reduce the proportion of intermediate products consumed.2/

2/ Mr. V. R. Berlinguette of the Dominion Bureau of Statistics of Canada, in a paper presented to the September 1950 meeting of the Econometric Society, "Limitations on Measurements of Physical Production," reviews the few scattered attempts to measure the volume of net industrial output, and presents statistics relating to Canadian industry. On the basis of a study of 21 industries representing close to 25 percent of the total net value of manufacturing production for the period 1935-47, he concludes: "On balance, the index based on net output was significantly higher than that based on gross production, indicating that the degree of processing per unit of output had increased over the period covered." Cf. Summary of paper in Econometrica, Vol. 19, No. 1, January 1951, pp. 71-72.

Table 1.—The National Product of an Hypothetical Economy

(Monetary units of constant value)

	Time periods I	Time periods II	Percent change
Industry A			
Value of gross output			
Final products	100	100	
Intermediate products	50	100	
Total	150	200	+33
Value of intermediate products consumed	50	80	+60
National product of industry A	100	120	+20
Industry B			
Value of gross output			
Final products	200	620	
Intermediate products	50	80	
Total	250	700	+180
Value of intermediate products consumed	50	100	+100
National product of industry B	200	600	+200
Total economy			
Value of gross output	400	900	+125
Intermediate products consumed	100	180	+80
Total national product	300	720	+140

This tendency may prevail in the economy as a whole. The net versus gross comparison for any individual minor industry would depend on the industrial classification scheme followed. The scheme would have to be consistent for the period studied, if the tendency towards increasing specialization were not to be reflected as an increase in the intermediate product ratio for any one industry.

In any case, it is apparent that gross output data may be misleading in an economic sense. Consumption of intermediate products represents an important real cost of production, and for most purposes of economic analysis allowance should be made for changes in this variable relative to changes in gross output. This is especially true as regards productivity measurement, since efficiency in the use of materials is usually a relevant aspect of the problem. And allowance for changing ratios of intermediate products consumed is better made in the dividend of the productivity equation, reserving the divisor for use as a measure of factor input.

B. The factor input divisor - the real cost of productivive services

The physical volume of production is a function of the quantity and quality (or "efficiency") of the factors of production employed. The basic factors are customarily defined as: land in the broad sense of natural resources; capital - plant and equipment and working stocks; and human labor. These factors represent stocks, or social and economic capital, and the employment or input in production of the factors represent flows of productive services, or "real costs."

The physical volume of input of the factors must be defined and measured carefully to avoid counting changes in efficiency as changes in physical volume. If changes in efficiency of each of the factors could be measured separately, and were counted as changes in volume, then there would be no change in productivity defined as the composite effect of changed efficiency of the factors. But for various purposes it is important to obtain a measure of productivity, so in this connection the divisor of the productivity equation is conceived of and measured net of the changes in efficiency of the factors in production of goods and services.

For each factor, the physical unit input or real cost can be measured as the physical volume of the stock in productive employment times the base period rate of remuneration, or cost, of the factor. The total of this constant dollar flow of services from all factors would provide a measure of the composite physical volume of factor input.

It would seem logical to move the base period cost of the factor by input for each industry separately. If relative prices or costs of factors, as well as of final products, in the base period are accepted as a yardstick of relative physical volumes, then shifts of factors to industries with higher than average unit cost should be reflected as increases in the volume of input.

Most productivity measurements have related output to labor input only in terms of man-hours. This has been partly a matter of expediency, and partly due to the greater interest attaching to production in terms of persons or man-hours employed, due possibly to the close relationship of this concept to the ideas of real income and standards of living. In this paper too, discussion and measurement are centered around the idea of man-hour productivity. However, it is clear that the real volume of input of the other factors relative to labor input influences the movement of the productivity quotient, as well as the efficiency of all the factors.

In order to make more explicit the assumptions involved in using a man-hour productivity measure, Table 2 has been set up, carrying the data of Table 1 a step farther to show the relation of the input measures to each other, and to the real gross products in the component industries and in the hypothetical economy as a whole. The figures in parentheses are the series by which the base period factor costs were moved - except for the total, in which case they are the unweighted sum of the data by industries. For the sake of simplicity, the returns to land and capital have been lumped as "property cost."

Table 2.—Real Factor Input, by Type, Relative to Real Product in an Hypothetical Economy

(Monetary units of constant value, and man-hours)

	Time periods I	Time periods II	Percent change
Industry A			
National product	100	120	+20
Factor cost	100	106	+6
Labor cost	70	70	0
(Man-hours worked)	(100)	(100)	
Property cost	30	36	+20
(Real value utilized)	(500)	(600)	
Industry B			
National product	200	600	+200
Factor cost	200	480	+140
Labor cost	120	240	+100
(Man-hours worked)	(100)	(200)	
Property cost	80	240	+200
(Real value utilized)	(1,000)	(3,000)	
Total economy			
National product	300	720	+140
Factor cost	300	586	+95
Labor cost	190	310	+63
(Man-hours worked)	(200)	(300)	+50
Property cost	110	276	+151
(Real value utilized)	(1,500)	(3,600)	+140

Before discussing the relationship of the various measures of factor input, a few words should be said concerning the conceptual and statistical problems involved in measuring actual total real factor input in the U. S. economy.

In the first place, in order to obtain an equivalence between factor cost and gross product in the base period, real product would have to be revalued in terms of factor prices, which would mean deducting indirect business taxes from the Commerce data, and also adjusting for subsidies and statistical discrepancy, and revaluing depreciation allowances in terms of current prices.[3/]

Labor cost in the base period should be inclusive. That is, the labor compensation element in entrepreneurial income should be segregated and included with the wages, salaries and supplements of all types of employees.

Base period labor cost (by industry) would be moved by man-hour data. Although some productivity measures relate to average employment only, the average hours worked measures the rate of utilization of employed workers, and is a closer approximation to labor input.

All types of labor should be included in the man-hours data - and are, in the data presented later: entrepreneurs (business and professional) and family workers, management and other administrative workers, and production workers, direct and indirect. Productivity measures related to only certain types of labor are influenced by the movement of the ratio of uncovered labor to the type of labor included in the divisor.

The property cost shown in the table consists of the rents and royalties of land, and of the return on capital. There would be difficult problems involved in obtaining a segregation in the base period. Some capital is leased, so the data on "rents"

3/ This procedure raises difficult statistical problems, especially when carried through on an industry basis. The general discussion in this paper of real product at factor prices, and total real factor cost, is purely theoretical.

include part of the return on capital as well as the rents of land. On the other hand, the data on corporate profits and entrepreneurial income would include rent (imputed) on land owned by the business. The income accruing to capital would include not only the profit element of entrepreneurial income and corporate profits, but also net interest and capital consumption allowances (in the real gross product approach.)

The real input of land would be computed as the base period ratios of rent to the total value of land employed in the various industries moved by the quantities of land, the latter possibly adjusted by a use-intensity ratio.

The real cost of capital (net of depreciation allowances) could be computed as the base period return on the net value of capital (buildings, equipment and inventories) moved by the constant dollar net value of capital employed, times a factor representing the degree of capacity utilization. Depreciation allowances would have to be revalued in terms of base period prices. Needless to say, estimating the constant dollar value of capital assets and depreciation charges would present difficult statistical problems, particularly as regards the appropriate depreciation rates to apply to the various types of plant and equipment.

In the example, it will be noted that total man-hours show a smaller increase than real labor cost. This would always be true insofar as there is a relative shift of labor towards higher-pay industries. Man-hours are interchangeable with real labor cost only on the assumption that there has been no shift in the industrial composition of man-hours employed.

Total real factor cost shows a greater increase than labor cost. This would always be so whenever the ratio of the total real value of property per man-hour was increasing, which has probably been true generally of progressive economies. Thus, aggregate productivity would show a smaller secular rate of increase than labor productivity alone.

In my opinion, it would be desirable if productivity measurement and projection could be done in terms of total factor input, so that explicit allowance could be made for property input. Since we have not reached the point statistically, where this is feasible, labor productivity projections should be made at least with awareness of the property factor. Projections of past rates of increase imply not only that technical advance will keep up with past trends, but also that the ratios of real property input to labor will continue to increase at past rates. If this assumption is not consistent with other aspects of the economic projection, the productivity projection should be modified accordingly.

C. The productivity quotient - joint efficiency of the factors of production

"Productivity" is not an independently observable variable, but is a meaningful abstraction. Mathematically, it is the quotient of output and factor input, however defined. The precision with which it can be measured depends on the quality of the underlying data. Economically, the content, or meaning, of productivity change depends on the definition of the concept.

Defined as real product per unit of factor input (whether total real factor cost, real labor cost, or man-hours) composite productivity changes reflect changes in the joint efficiency of the factors, due both to technical and economic forces - as well as the influence of the real volume of input of uncovered factors if only part of factor input is used.

Technical forces relate to the changes in output of specific types of goods and services relative to factor input. These forces stem from increases in knowledge concerning production, and their application to productive procedures and instruments through technology. This type of "pure" productivity measure for broad segments of the economy is usually approximated by combining productivity series by a system of constant weights.

Aggregate real product per unit of factor input is also influenced by the effect of variable input weights applied (implicitly) to productivity movements of individual industries. This influence may be termed economic, since it stems from shifts in relative demand for products and the factors among the various industries. By taking separate account of this influence, productivity analysis and projection can be more precise.

1. Economic efficiency

Real product per unit of factor input changes not only as productivity in the component industries change, but also as the weights used to combine the real products per unit of factor input in the various industries change.

These weights are, implicitly, the relative real factor costs in the various industries in any given year. This factor may be termed economic, since it stems from the relative demand for the productive factors by industry which, in turn, depends on the relative demand for final goods and services. Final demand shifts as tastes change, and in response to changes in relative prices which reflect changes in relative costs. In a sense, relative changes in productivity itself are a partial cause of the industrial composition of factor input, since they influence the relative costs of the factors in the various industries.

In the case of real product per unit of aggregate factor input, a shifting composition of aggregate factor input by industry affects the movement of productivity only insofar as productivity movements by industry differ. If, on net balance, factor input shifts towards industries whose productivity rises more rapidly than the average, the rise in aggregate productivity will be greater than that indicated by application of base-period weights to the component industrial productivity series.

In the case of real product per unit of labor input (real cost or man-hours) aggregate productivity is affected not only by differential productivity movement by industry, but also by the different levels of real product per unit of labor input in the various industries. If, on net balance, labor input shifts towards industries with higher levels of real product per unit of labor input than the average, total real product per unit of labor input will rise, apart from any changes in labor productivity in the various industries. This effect will be reenforced, of course, if the industries with higher than average real products per unit of labor input are also those in which productivity is rising more rapidly than the average.

From an aggregate economic viewpoint, the influence of the shift of resources among industries should be reflected as productivity changes. A shift of resources towards industries in which the real product per unit of factor cost is higher than average represents a real gain to the community, since the utility in terms of base-period relative values, created by the factors in their new employment is greater than in the old. Thus the factors are more "efficient" in an economic sense.

The effects of variable factor cost weights may be seen in Table 3, which spells out the productivity implications of the second table.

It was seen in Table 2 that industry B has a higher value added per unit of labor input than industry A, and also shows a greater increase in productivity. The higher real product is due to a higher ratio of real property to labor, and to higher rates of return to both property and labor.

However, in the case of real product per unit of total factor input, since productivity in both industries is unity in the base period, aggregate productivity is influenced only by the shift of input towards the more rapidly rising productivity series.

In the case of labor productivity, the shift of labor towards the industry with the higher level of productivity also influences the aggregate productivity. Since the differential in levels of productivity is greater in the case of man-hour productivity than for productivity based on real labor cost, the shift of relative man-hours between industries causes a greater increase in aggregate productivity on this basis than the shift in real labor cost causes on that basis.

It should not be thought that the increases in productivity on a man-hour basis are any less real because they show a larger influence of the shifting distribution of man-hours among industries. The meaning and movement of any productivity measure is relative to its definition. Man-hour productivity is certainly a legitimate

Table 3.—Productivity Measures in an Hypothetical Economy Using Different Input Measures and Different Weighting Systems

(Monetary units of constant value)

	Time periods I	Time periods II	Percent change
Industry A			
National product per unit of:			
Total factor cost	1.00	1.13	+13
Labor cost	1.43	1.71	+20
Man-hours	1.00	1.20	+20
Industry B			
National product per unit of:			
Total factor cost	1.00	1.25	+25
Labor cost	1.67	2.50	+50
Man-hours	2.00	3.00	+50
Total economy (variable input weights)			
National product per unit of:			
Total factor cost	1.00	1.23	+23
Labor cost	1.58	2.32	+47
Man-hours	1.50	2.40	+60
Total economy (constant input weights)			
National product per unit of:			
Total factor cost	1.00	1.21	+21
Labor cost	1.58	2.21	+40
Man-hours	1.50	2.10	+40
Effect on aggregate productivity of variable input weights			
National product per unit of:			
Total factor cost			+2
Labor cost			+5
Man-hours			+14

concept, and can be used as a projection tool. It is merely based on an incomplete measure of factor input, and one that probably rises less rapidly than total real factor cost. The influence of this fact must be consciously considered in using the tool.

2. Technical efficiency

Most conventional composite productivity measures attempt to isolate changes in technical efficiency by using constant weights to combine individual industrial productivity index numbers. Insofar as the relative weights are of the value-added type, corresponding to the relative gross products originating in the various industries, these composite index numbers correspond to the productivity measures using constant weights based on relative factor input shown in Table 3.

The economic factor is not entirely eliminated from such constant weighted indexes, however, since intraindustry shifts of the factors among products with differing productivity levels and/or changes affect the movement of productivity in the individual industry. "Pure" productivity change based on technical factors alone could be measured only in terms of individual products. But it is true that a composite productivity index for the economy as a whole using constant weights for the component industrial productivity series comes closer to the concept of pure technical productivity than one using variable weights.

The causes of the changes in productivity from the technical angle lie in the fundamental activities which result in changes in efficiency, or output capacity of a given quantity of any one of the factors in combination with the other factors.

It is impossible to segregate the changes in efficiency attributable to any one factor, although, obviously, changes in joint productivity can be related to, or measured in terms of, any one factor. This is due to the fact that changes in efficiency of one factor usually require and are accompanied by a progressive adaptation of the other factors to the changed shape of the services rendered by the factor initiating the change in production technology. For example, new machinery requires retraining of workers and possibly a reorganization of plant lay-out, work-flows, and the like.

The fundamental activities producing improved efficiency of the factors relate to improvements in technology, and the rate of incorporation of technical innovations into the body of the factors employed. Technological innovations, in turn rest on advances in human knowledge, which in systematized form, may be called scientific progress. Advances in knowledge result from research, whether formalized as a distinct function or not. These advances are frequently directed towards, or may be adapted to, improvements in concrete procedures or instruments of production, resulting in technical innovations, or "inventions."

Research and development work relates not only to improving productive plant and equipment. It is also devoted to raising the level of physical and mental health and efficiency of human beings in their productive activity, and in the rest of their lives, which also bears importantly on work efficiency. Much of the investment in personal efficiency is made by individuals themselves, as for education.

Research and development activity is also devoted to the problems of land and resource use to increase the productivity of land with a given input of the other factors. It is also devoted to problems of materials use, improvement, and substitution, which, as we have seen, affects real product per unit of factor input through the dividend of the equation.

A measure of real research and development outlays should show a high degree of correlation with changes in technical productivity. No attempt is made here to tackle the difficult problem of precise definition and measurement of the volume of research and development activity. However, as such activity increasingly becomes a distinct, organized function in business firms, the possibility of such measurement becomes greater.

Indeed, this type of intangible work, which represents current expenditures devoted (directly or indirectly) to the object of increasing productive efficiency in the future, might well be classified as "investment" in the national accounts, instead of being charged to current expense as is done in the case of the business economy.

If such a procedure were eventually adopted, the gross business product would be higher by the amount of expenditures for research and development; profits would be higher by a like amount. Factor income could be redistributed to show "research and development" as a distinct industry. Government and personal purchases falling in the "intangible investment" category could also be segregated, but since these expenditures are already counted as final product, no adjustment of the totals would be called for.

The rate of adoption of new developments also affects productivity. This would be hard to measure in respect to personnel procedures, plant lay-out, organization of work flows, and the like. It is a more tangible factor in the case of plant and equipment, in which the average age of the capital would be an index of the rate of incorporation of new devices into the body of productive capital. Likewise, changes in the average education and training and health per worker are susceptible to rough measurement. The spread of improved methods of land management and resource use in general is likewise relevant, but probably difficult to measure.

In any case, not only technological innovations affect the quality of the factors, but also the rate at which these innovations are incorporated into the body of the various factors, and the changes in their organization in relation to each other.

Even this brief review of some of the dynamic factors which cause changes in productivity shows the difficulty of attempting a quantitative measure of the fundamental forces behind the changing efficiency of the factors.

What can be done is to relate productivity measures to time, and (after abstracting from the effect of changing weights) consider the average annual rate of increase in productivity the net effect and measure of the combined influence of the various dynamic factors behind factor efficiency.

Projection of a past rate of growth in productivity would be based on the implicit assumption that intangible investment per unit of factor input, and the rate of incorporation of new technique into productive capacity, would proceed at past rates.

II. Past trends in national productivity

Long-term projection is basically a matter of extrapolating past trends as modified by introducing the effects of anticipated or assumed abnormal changes in relevant factors. This section describes the calculation of past productivity trends in the private economy which could serve as a basis for projections.

The gross government product, measured by compensation of general government employees, is excluded from the analysis of productivity trends. This was done since in the constant dollar series this item, by major types of general government employee compensation, was moved by employment or man-hours. No allowance was made for productivity changes, since for large areas of government activity, such as the defense establishment, there is no objective method for computing productivity. Therefore, if this approach is used, projection of real government product for a target year would hinge directly on the assumptions as to employment and hours in the major categories of general government, and no productivity projection would be involved.

The real gross product and man-hours data entering the productivity computations are shown in Table 4, and described in an Appendix which is available upon request.

The estimates of gross private product in constant (1939) dollars from 1929 to 1950 are those published by the U. S. Department of Commerce. They were extrapolated from 1929 to 1909 by the author based on data for the major segments from various sources. The aggregates are solely his responsibility. The real gross farm product estimates are likewise unofficial ones, calculated largely from Bureau of Agricultural Economics data on the value of farm production, and intermediate products consumed, deflated by

Table 4.—Gross National Product in Constant (1939) Dollars, Man-hours Employed, and Real Product per Man-hour By Major Sectors of the U. S. Economy, 1909-50

Year	(1) Gross national product (billions of 1939 dollars)	(2)	(3)	(4) Man-hours employed (billions)	(5)	(6)	(7) Real product per man-hour (1939 dollars)	(8)	(9)
	Private	Farm	Private nonfarm	Private	Farm	Private nonfarm	Private	Farm	Private nonfarm
			(1)-(2)	(5)+(6)			(1)÷(4)	(2)÷(5)	(3)÷(6)
1909	45.3	5.1	40.2	89.7	25.2	64.5	.505	.202	.623
1910	46.2	5.3	40.9	91.5	25.1	66.4	.505	.213	.616
1911	47.8	5.6	42.2	90.0	24.9	65.2	.531	.225	.647
1912	49.6	5.6	44.0	92.3	24.8	67.4	.537	.227	.652
1913	51.6	5.6	46.0	92.4	24.8	67.6	.558	.226	.680
1914	50.3	5.9	44.4	89.9	24.8	65.2	.559	.238	.682
1915	49.8	6.3	43.5	90.2	24.7	65.5	.552	.255	.664
1916	55.6	5.8	49.8	96.1	24.8	71.3	.579	.233	.699
1917	58.2	5.6	52.6	101.8	24.3	77.4	.572	.232	.679
1918	63.4	5.6	57.8	103.1	23.8	79.3	.615	.233	.729
1919	60.4	5.3	55.1	94.9	23.4	71.6	.636	.228	.770
1920	55.7	5.2	50.5	93.8	23.8	70.0	.594	.219	.721
1921	51.9	4.9	47.0	82.7	21.9	60.8	.628	.225	.773
1922	58.5	5.7	52.8	89.8	22.7	67.1	.652	.249	.787
1923	65.8	5.7	60.1	97.0	22.9	74.2	.678	.250	.810
1924	65.4	5.5	59.9	94.5	23.1	71.4	.692	.239	.839
1925	71.3	5.5	65.8	98.8	23.6	75.2	.721	.235	.875
1926	74.4	5.9	68.5	102.6	23.7	78.9	.725	.250	.869
1927	75.4	5.8	69.6	102.4	22.8	79.7	.736	.255	.874
1928	76.3	5.9	70.4	103.7	23.2	80.5	.736	.256	.874
1929	81.5	5.9	75.6	107.5	23.0	84.5	.758	.257	.895
1930	73.5	5.6	67.9	100.1	22.8	77.3	.734	.246	.879
1931	67.7	6.5	61.2	91.2	23.4	67.9	.742	.279	.904
1932	57.4	6.2	51.2	81.2	22.5	58.6	.707	.274	.877
1933	56.5	6.2	50.3	80.5	22.5	58.0	.702	.276	.869
1934	62.0	5.1	56.9	81.9	20.0	61.9	.757	.254	.922
1935	67.6	5.9	61.7	86.4	20.9	65.5	.783	.283	.943
1936	76.4	5.3	71.1	92.7	20.2	72.4	.824	.262	.982
1937	80.9	6.4	74.5	98.7	21.9	76.8	.820	.291	.972
1938	76.4	6.6	69.8	90.4	20.5	69.9	.845	.320	1.000
1939	83.7	6.6	77.1	95.2	20.6	74.6	.879	.321	1.034
1940	92.1	6.4	85.7	99.5	20.5	79.0	.926	.313	1.082
1941	106.2	7.0	99.2	108.5	20.2	88.4	.978	.345	1.122
1942	116.5	7.5	109.0	117.0	21.1	95.9	.996	.354	1.136
1943	125.3	7.0	118.3	121.1	20.9	100.2	1.035	.335	1.180
1944	133.0	7.0	126.0	120.3	20.8	99.5	1.105	.339	1.265
1945	129.7	6.6	123.1	114.8	20.0	94.9	1.130	.333	1.297
1946	125.6	6.8	118.8	117.5	19.8	97.7	1.069	.343	1.215
1947	128.8	6.4	122.4	121.8	19.5	102.4	1.056	.330	1.195
1948	133.2	6.8	126.4	123.4	19.5	103.8	1.080	.349	1.217
1949	132.0	6.8	125.2	119.0	19.4	99.6	1.109	.349	1.257
1950p	142.5	6.6	135.9	120.9	18.3	102.5	1.179	.360	1.322

appropriate prices received and prices paid index numbers on a 1939 base.

The private nonfarm employment estimates from 1929 to 1950 are based on Department of Commerce estimates, and include proprietors as well as full- and part-time employees. Numbers of unpaid nonfarm family workers were added. This series was extrapolated back to 1909 by Bureau of Labor Statistics and National Industrial Conference Board data. The employment estimates, by major industries, were multiplied by estimates of average hours worked per week, raised to an annual level, derived from various sources, mainly the Bureau of Labor Statistics. Average hours worked in industries for which data are unavailable (especially in the earlier periods) were assumed to move as the average for the covered industries. Man-hours worked on farms are Bureau of Agricultural Economics estimates, 1917-50, extrapolated back by an employment series from the same source.

More intensive reworking of the past data would be desirable, especially for the period prior to 1929. Better estimates would probably not yield significantly different results on an over-all basis, however, particularly as regards the trend calculations.

A. Productivity trends in the private economy as a whole

Chart 1 shows the net regression on time of productivity in the private economy, fitted to data for the years 1909-41. A second independent variable, the ratio of civilian employment to civilian labor force, was employed in the equation, and held constant at 96.5 percent in the calculation of the "net trend."

Due to the various violent disturbances associated with depression, war, and postwar readjustment, which have affected the American economy from 1929 to date, it did not appear wise to fit a simple trend line to the entire period.

The war and postwar periods involved forces which affected estimated productivity to such an extent that the period since 1941 was omitted altogether. The lack of comparability of munitions with nonmunitions, rationing, quality deterioration, and other disturbances render the meaning of real product during World War II dubious.

Even using a conservative relative valuation for munitions, real private product per man-hour in the later war years swings well above the computed net trend line.

In the first postwar years, on the other hand, productivity falls well below the trend. Apart from continuation of some of the wartime disturbances, this is to be expected in the light of restrictions on new gross private domestic investment in peacetime industries during the war. They resulted in a postwar capacity which was older than the prewar average, and the industrial distribution of which was imbalanced in relation to postwar demands.

It was to be expected that heavy postwar expenditures for new plant and equipment would gradually raise productivity to the prewar trend line, and by 1950 this appears to have taken place.

As the 1940's fade into history, that period could probably be included in productivity trend calculations without distorting the results appreciably. But coming at the end of the historical period now under consideration, it was felt that the long-term trend would be distorted to some extent by inclusion of the years 1942-49.

The problem of the 1930's is a different one. By 1933, productivity had fallen well below the trend line, and whereas the discrepancy was subsequently made up gradually, it was not until 1941 that productivity was almost back in line with the historical trend.

The depression movement must have been associated with inefficiently low rates of utilization of capacity and low levels of new investment and consequent aging of the stock of capital per worker, to mention the most important. The introduction of a variable describing the cyclical factor was indicated if use was to be made of the 1929-41 data in calculating the trend. For this variable, the ratio of civilian employment to the civilian labor force was used. The employment ratio not only takes account of fluctuations in the rate of capacity utilization, but approximates the cyclical factor generally as it affects the movement of various causative factors bearing on productivity.

When the employment ratio is held constant, the average annual rate of growth of real private gross product per man-hour implied by the regression equation is 2.1 percent. The net trend line shown in Chart 1 is computed on the basis of holding the employment ratio constant at 96.5 percent, taken to approximate a full employment level.

Other types of curves would, of course, yield somewhat different results. It does appear that a constant rate of growth is implied by the data for the period covered. Possibly data for earlier decades would give a different impression. Real product comparisons become increasingly tenuous, however, the longer the period, especially when there are radical shifts in product composition.

It is interesting to note the trend line has almost exactly the same slope as is obtained by using the period 1909-29 only, and without a third variable. The average annual growth implied is also almost the same as is computed from the real private product data for 1929, 1941, and 1950, all years of relatively high employment, and relatively free from unusual disturbances.

If, however, the coefficients for the same variables employed in the formula are computed for the period 1929-41 only, the implied average annual rate of productivity growth is somewhat higher - almost 2.2 percent. The longer-term picture is probably a better guide to the future, however, despite the poorer quality of the data in the early years.

B. Productivity trends in sectors of the private economy

It was pointed out in Part I that real gross private product per man-hour in the private economy is a composite of real gross product per man-hour in the various private industries, combined by variable man-hour weights. For projection purposes, insofar as productivity trends by industry differ, and the percentage distribution by industry of man-hours worked changes, it is desirable to handle various industries separately.

Practically no work has been done to develop historical productivity estimates by industry on a real gross product basis. This is partly due to insufficiency of data. Data being developed for interindustry relationship tabulations hold promise for the future, however.

Relatively complete data for the period since 1909 do already exist for the farm economy, and in connection with his work in the Office of Business Economics, the author has made estimates of real product and productivity in the farm sector, preliminary results of which can be presented here. This makes possible computations of real product and productivity in the private nonfarm sector. Presentation of these two sectors of the private economy separately will serve to illustrate the methodology involved in analyzing real product per man-hour by industry, and the effects on aggregate productivity of interindustry shifts of labor input.

1. Productivity trends in the farm economy

Farm productivity has been computed by a number of agencies. Generally, these computations are based on one variant or another of the physical volume of gross farm output. Such productivity computations, based on gross output, show a larger average annual rate of increase than the real gross farm product per man-hour series, shown in Table 4. This is due chiefly to the fact that in real gross farm product estimates, the real value of intermediate products consumed is subtracted from the real value of gross farm output. Gross farm product is "gross" only in the sense that it includes depreciation charges; otherwise, it is "net" in that it excludes purchases of intermediate products consumed in the production process.

The ratio of the real value of intermediate products consumed to the real value of gross farm output has increased significantly during the period 1909 to 1941, so real gross farm product has increased substantially less over the period than the various measures of the physical volume of gross farm output.

It should be noted that the real value of gross farm output used here differs somewhat in concept, and in movement, from the several physical volume series used in other farm productivity series. The series used in the real gross farm product estimates follows the Commerce concept, which includes in the value of gross output the following items: cash receipts from farm marketings and C.C.C. loans, the value of farm products consumed on farms where produced, the value of the net change in all farm inventories, and the gross rental value of farm homes.

But the most important factor distinguishing these estimates from the conventional ones remains the increasing ratio of the real value of intermediate products consumed to the real value of gross farm output. The relevant figures are shown for selected years in the following table.

(Billions of 1939 dollars)

	1910	1941	Percent change
Value of gross farm output	7.08	10.69	+51
Value of intermediate products consumed	1.75	3.73	+113
Gross farm product	5.33	6.96	+31

Thus the real gross farm product increased 31 percent from 1910 to 1941, contrasted with a 51 percent increase in the real value of gross farm output. This was due to the much greater relative increase in the real value of intermediate products consumed than in the real value of gross farm output, as reflected in an increasing ratio of the former to the latter from 25 to 35 percent over the period covered. By 1950, the ratio approached 45 percent, as real expenditures for operation of vehicles and machinery, for fertilizers, and so forth, continued to climb more rapidly than the volume of production.

These comparisons would be more clearly in line with the concepts outlined in Part I if the value of gross farm output were net of sales to other farmers, and the intermediate products represented exclusively purchases from other industries.

The inclusion of intraindustry sales (or purchases) in both places does not affect the gross product figure, and the movement of the "intermediate product" ratio should closely approximate the movement of a "purchases from other industries" ratio.

Most calculations of farm productivity have been on a "per worker" basis, due to the paucity of reliable average hours worked data for agriculture. However, in order to tie in with man-hour productivity data in the private nonfarm sector, and obtain man-hour productivity data for the private economy as a whole, a Bureau of Agricultural Economics' series on man-hours worked in agriculture was used with a small adjustment for the early years. This series was derived from intensive man-hour requirement studies for various time periods. When divided by farm employment data, the man-hour series implies only a small secular decline in average hours worked over the period, much less than is apparent in the private nonfarm sector. Thus, man-hour productivity computed using this series would not differ much from a per worker productivity calculation.

The man-hour productivity series obtained from dividing the real gross farm product by the man-hours data is shown on Chart 2. The employment ratio is not relevant to this computation, but it was used in order to make possible an exact reconciliation of the farm and nonfarm productivity trends with the trend in the private economy as a whole.

The net regression on time indicates an average annual increase of 1.2 percent in farm productivity. The coefficient of multiple correlation is not as high as for the regression equation fitted to private nonfarm productivity, due partly to the greater importance of noncontrollable influences in farming.

It will be noticed that most of the years in the 1940's are somewhat above the trend line. This may be due in part to unusually favorable weather conditions, but to some extent may represent real gains in productivity over and above the trend. The deviations above the trend in the 1940's are not as great, however, as in the productivity series based on gross output, since gross production gains were partly due to higher relative purchases from other industries, which are not reflected in this productivity computation.

2. Productivity trends in the private nonfarm economy

The real gross private nonfarm product shown in Table 4 is obtained by subtracting the real gross farm product from the total real gross private product. When divided by man-hours worked in the private nonfarm economy, the productivity series emerges which is shown in Chart 3.

As would be expected, the movements of real private nonfarm product per man-hour are similar to those of the productivity series for the private economy as a whole - since the real farm product has comprised less than 10 percent of the total real private product in the period as a whole.

The same variables employed in the private productivity equation were used to describe private nonfarm productivity over the same time period, 1909-41. Holding the employment ratio constant at 96.5 percent, the average annual rate of increase of the net regression on time is 1.9 percent. The difference between this growth factor and that for the private economy as a whole is due to the influence of farm productivity-- its rate of growth, a downward influence, and its level, an upward influence due to the shift of labor from the farm to the nonfarm economies--to be discussed in the next section.

It would be desirable if real product per man-hour could be computed for individual nonfarm industries. But the real product estimates necessary for such computations do not exist. The data being developed in studies of interindustry relationships give promise for the future. This approach rests on estimates of the value of the product inputs and outputs of each industry. For the years covered, the outputs, deflated by appropriate prices received indexes, less the inputs, deflated by the appropriate prices paid indexes, would yield estimates of real product in the various industries.

The interindustry chart being prepared for the year 1947 is the first one with a degree of accuracy requisite to good industrial gross product estimates. Possibly data from the charts for previous years could be utilized, at least for broad industrial groupings. However, the fewer the industries included, the less adequate could the deflation procedure be.

For 1947, and later years for which interindustry relationships will be estimated, a basis for real industrial gross product estimates exists which opens the door to adequate industrial productivity estimates for the future by the real product approach.

In the meanwhile, certain expedients might be adopted to obtain consistent real product per man-hour estimates by an industrial breakdown. This would involve using productivity estimates on a gross output basis, available for many industries over relatively long time periods in the studies of the National Bureau of Economic Research, the Bureau of Labor Statistics, and others.

If it is assumed that the ratios of the real value of intermediate products consumed to the real value of gross output in the industries concerned have not changed significantly over the period covered, then the available productivity series could be used to move a base-period gross product per man-hour in the various industries. The industrial gross product estimates for the base period could be approximated by appropriately adjusting the national income by industrial origin estimates, or estimated from interindustry data.

This procedure would, at best, however, be an expedient. The assumption of a constant intermediate product ratio is important, but dubious, as we have seen. Also, productivity data for large areas of the economy are not available - notably, for trade, service and finance. Thus, no check could be made by summating industrial real products and comparing with the over-all estimates.

It would be possible, however, to multiply real product per man-hour for the covered industries, derived by the procedure described above, by the corresponding man-hour data and obtain a total real product for the covered areas. By subtracting this total from total real private nonfarm product, the implied real product of the uncovered industries as a whole would be obtained. By dividing this residual real product by the residual man-hours, an approximation to productivity in the uncovered areas would emerge, and could be assessed for reasonableness.

If reasonable, the uncovered area could be projected as a whole, in conjunction with the productivity data in the covered area by industry. It is probable that, due to the generally higher rate of growth of productivity in the covered areas than that indicated for the private nonfarm economy as a whole, the average rate of productivity growth in the uncovered areas, chiefly trade, service and finance, must have been below the average rate. Much more work needs to be done in defining the concept and conducting measurement of productivity in these areas before intelligent projections can be made.

C. Effect on productivity of interindustry shifts

It was pointed out in Part I that composite real product per man-hour reflects changing proportions of labor input among industries, quite apart from changes in technical efficiency within the component industries.

The economic, or weighting, factor in productivity change is usually minor compared with technological factors, but it is significant enough to warrant special treatment in analysis of past trends, and trend projections.

1. The farm to nonfarm shift

Over the 1909-41 period covered by our trend analysis, the ratio of man-hours worked on farms to the total worked in the private economy declined from almost 30 percent in the early part of the period to about 20 percent in the latter part. Since real farm product per man-hour averages out at less than one-third of real private nonfarm product during the period, it is clear that the relative labor shift would have an upward influence on real private product per man-hour.

The influence of this shift can be measured by comparing real private product per man-hour with variable man-hour weights as computed in Part II-A, with a real private product per man-hour computed by weighting together real farm product per man-hour and real private nonfarm product per man-hour by constant (1939) man-hour weights. An index of the influence on productivity in the private economy of the farm to nonfarm shift is obtained by dividing the variable weighted series by the constant weighted series. This index is plotted in Chart 4.

The general upward trend during periods of relatively full employment is marked. During periods of depression the index moves down, since a reverse shift takes place in depressions, as the volume of farm output holds up well relative to nonfarm output as a whole.

When the net regression on time is computed from the index of the influence of the farm to nonfarm shift on productivity in the private economy, holding the civilian employment ratio constant, the average annual rate of increase is computed at .27 percent.

Without the influence of the farm to nonfarm shifts, productivity in the private economy as a whole (using constant, 1939, man-hour weights to combine farm and private nonfarm real products per man-hour) shows an average annual rate of increase of 1.84 percent. This is smaller than the 1.91 rate of growth of productivity in the private nonfarm economy, due to the fact that growth of productivity in the farm sector is less. But by adding the average rate of increase occasioned by the farm to nonfarm shift of .27 percent, a reconciliation with the over-all average annual rate of increase in the private economy as a whole of 2.11 percent is obtained.

It will be noticed that real private product per man-hour in 1950 is almost on the net trend line, while real private nonfarm product per man-hour is somewhat below.

This is due to the fact that both farm productivity, and the index of the effect of the farm to nonfarm shift, were somewhat above their trends.

2. Shifts among nonfarm industries

Since real product per man-hour estimates for the nonfarm industries are not at hand, it is not possible to compute precisely the effect on private nonfarm productivity of relative shifts of labor among the nonfarm industries.

A crude approximation to the effect of such shifts can be made on the basis of the Department of Commerce employment and national income data on a 60 private nonfarm industry break for the period 1929-49. This approximation involves the broad assumption that relative levels of national income by industry approximate relative levels of real gross product by industry, and that shifts in the proportions of persons engaged among industries approximate shifts in man-hours worked among industries.

Total persons engaged in the private nonfarm industries were distributed for all years by the base-period (1939) proportions, and the products of given year national income per person by industry and persons engaged so distributed by industry were summated. By dividing the calculated total into the actual total private nonfarm national income for the various years, an index was obtained which reflects the effects of a shifting distribution of labor input.

This index (1939=100) works out at 96.1 for 1929 and 100.9 for 1949. Contrary to what might be expected, excluding the war period, there appears to be an inverse correlation between the index and the employment ratio. During the war period, the index reached 104, reflecting the shifts to higher value-added industries.

The average annual rate of increase between 1929 and 1949 is approximately one-quarter of one percent. Inspection indicates that this result is close to what would be obtained by fitting a trend line mathematically to all the observations.

More refined analysis over a longer time period is clearly needed. A highly tentative conclusion is that relative shifts of labor input among private nonfarm industries have been in the direction of increasing the trend of productivity in the private economy. Such shifts in aggregate have apparently been not more important than the farm to nonfarm shift alone.

If this is true, then interindustry shifts of labor input in the private economy as a whole have accounted for not more than about one-fourth of the secular increase in real private gross product per man-hour.

III. Technique of productivity projection

The chief factors involved in productivity projections have already been implied in the discussion of productivity concepts and measurement. It remains to tie together the factors involved, and relate them to the economic projection as a whole.

A. Over-all projection - first approximation

Before the forecasters of consumption, investment, and government expenditure patterns go to work, they need first of all a general idea of the total dividend. A first approximation to real gross national product can be obtained by first multiplying the projection for the target year of total private man-hours by a projection of real gross private national product per man-hour. If real gross government product is treated according to the present Commerce concept, a projection of government employment and real gross product would have to be made separately in the first approximation.

If the first projection of private real product per man-hour is based on the past growth trend, several major assumptions are implicit:

(1) Continuation of past rates of change in the real volume of capital and land per worker, or man-hour, as in the past.

In the case of plant and equipment, the past average rate of replacement and addition would involve rising levels of real expenditures for new capital goods, although the future ratios to total gross product could not well be established without actually working out estimates of the total real volume of capital in the past.

The past secular trend of real plant and equipment expenditures represents an average over the business cycle. If the projection for the target year assumes a pathway between now and then under conditions of close to full employment, either the past average rate of new investment would be used, in which case a policy of stimulating other offsets to saving would be implied; or, if a rate of new investment consistent with past periods of high level employment were assumed, some policy of assuring this high rate would be implied. A program of investment incentives, such as accelerated depreciation allowances, might be the assumption. Under these conditions, in which a higher rate of new investment were assumed than prevailed on the average in the past, a corresponding upward adjustment in the projected rate of growth in productivity would be called for.

(2) A continuation of the same net effect on over-all private productivity of the shifting distribution of man-hours employed among industries would be assumed.

This assumption becomes increasingly untenable the longer the projection period. It should be checked against the distribution of final demand in the target year by industries. This check, however, would have to be done in a second approximation, since a first approximation to real product is needed before a product and industry break can be made.

(3) The same rate of increase in real intangible investment (research and development expenditures) per unit of real factor input as in the past would be assumed.

A fairly steady secular rate of growth in technical productivity seems to be among the more persistent features of a highly industrial economy. In the absence of specific assumptions or forecasts which would alter the tendency to devote increasing amounts of resources to research and development, extrapolation of past rates of aggregate growth seems reasonable.

Insofar as the assumptions for the target year, and the pathway to it, implied special policies accelerating (or retarding) intangible investment, the past rate of pure productivity increase would be modified accordingly. Since the correlation between intangible investment and pure productivity measures has not been quantified for past periods, any adjustments in the productivity projection would, of necessity, be subjectively based.

B. Productivity projections by industry - successive approximations

Projection of productivity by as fine an industry break as possible would aid in refining the economic projections for the target year. First of all, they would be of use in arriving at approximations of relative prices, which in conjunction with total real income and other relevant factors, would be needed to make a final product distribution of total real gross product in the target year.

This breakdown of real product could be translated into a chart of interindustry relationships, which, as we have seen, can be used to obtain real product estimates by industry.

Real product estimates by industry for the target year, in conjunction with industrial productivity projections to the target year, would yield estimates of man-hour requirements. The total man-hour requirements for the target year could then be compared with the projected man-hours available figure, and any surplus, or deficiency, used to adjust the total real product projection by successive approximations.

If the industry productivity projections were, in aggregate, consistent with the original over-all productivity projection translated into a constant weighted aggregate, the difference between the final approximation to real product and productivity in the target year, and the first approximation, would be due to a different set of relative factor input weights than those implied by the first approximation which assumed a continuation of past trends in relative factor input.

The projection of productivity by industry would have to take account of the same factors spelled out above in connection with the over-all projection. Additional complications would be present in industry productivity projection, however. For one thing, it is likely that the productivity function for many minor industry groups would be more complex than for broader aggregates, with differential rates of productivity change in various phases of industry development.

At this stage of our knowledge, it is unlikely that the aggregat of productivity projections for individual industries would be more accurate than an aggregate projection alone. For this reason the former should probably be tied into the latter on a constant-weighted basis. The specific adjustments for shifts in weights based on the product distribution in the target year should, however, result in a desirable refinement of the projection of aggregate national productivity. It would be dangerous to assume that the shifts of input factors among industries for a long future period would follow those in the past.

If the spelling out of real product by industry in the target year were accompanied by estimates of capital requirements by industry, a modification of the over-all investment assumption might be required. This would be indicated only insofar as shifts of labor input from lower to higher capital per unit of labor input industries deviated from past patterns.

If product prices in the target year were spelled out in some detail, it would be interesting to revalue the total gross national product in the take-off year by the prices of the target year. This would probably serve to reduce the indicated rate of increase in total real product and productivity, since the products for which demand increased relatively more rapidly would be those in which productivity probably increased relatively more rapidly, and relative prices declined. By using target year relative prices as the base for price deflation, less weight would be given to the more rapidly expanding outputs, and thus to the related industrial products and productivity measures.

This phenomenon is apparent in measurement of historical aggregate real product and productivity movements in general - the more recent the price base, the smaller the increase. This does not mean that productivity measurement is an illusion. It merely means that the essence of economics is the relativity of values - at one point in time and over time. The particular set of values chosen as weights in measurement of the real product dividend of productivity measures depends on one's point of view relative to the specific problem.

C. Areas for further productivity research

This brief analysis of the projection problem points up the need for much more information regarding productivity.

Although the concept of productivity has been clarified to some extent in this paper, more extended and precise theoretical thought is needed. This theory would be particularly fruitful if related to the practical problems of productivity measurement. The concept of industrial productivity on a real product basis, in particular, needs to be sharpened, especially in the noncommodity areas where the definition of output lacks precision.

On an over-all basis, much more work needs to be devoted to refining annual estimates of gross national product in constant dollars, especially prior to 1929. Available data on labor force, employment, and average hours worked per week, need to be reworked for earlier periods, and the best possible estimates made.

Annual estimates of the total real wealth of the country in terms of productive capital and land would be most helpful in attempting to obtain productivity measures related to total factor input. Although these estimates would be rough at best, if they were good enough to indicate general trends in real property relative to labor input, they would be instructive.

Finally, work on productivity by industries needs to be refined and extended. The field of real product per unit of total factor input estimates by industry is virgin territory. Not only estimates of real product for most industries are needed, but also estimates of man-hours and real property employed in various industries. Even gross output per man-hour measures have not yet been made for many industries. Annual estimates of total productive capacity, and percentages of capacity utilized, in terms of physical units, would also have considerable bearing on the productivity problem, especially in its cyclical aspects.

In many of these areas, it may be impossible to construct adequate historical productivity series. It is never too late, however, to commence gathering and processing data, which, as time passes, will add to our knowledge of this important area of economics. Future generations of economic analysts, forecasters and policymakers will find their task made more comprehensible by our initiative.

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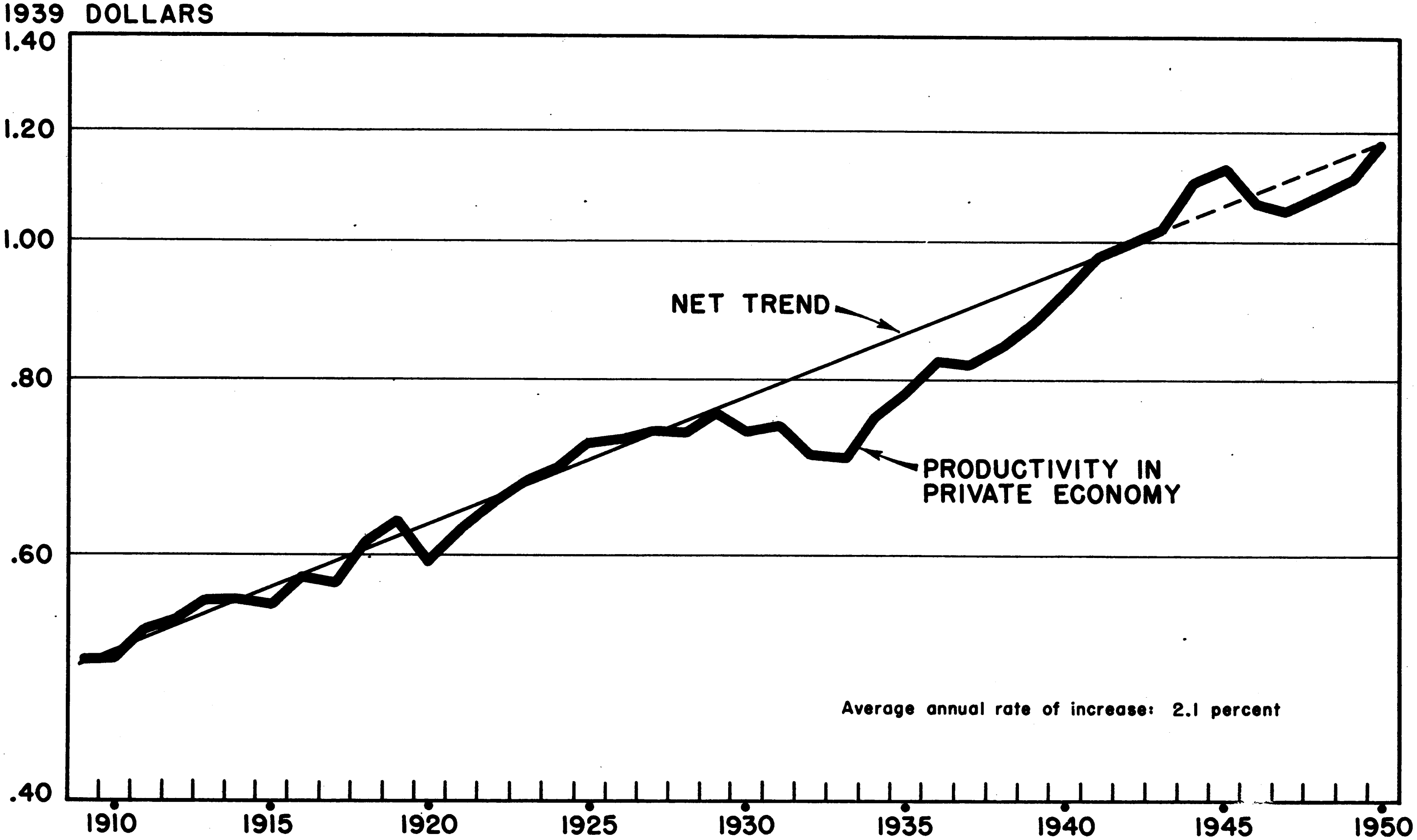
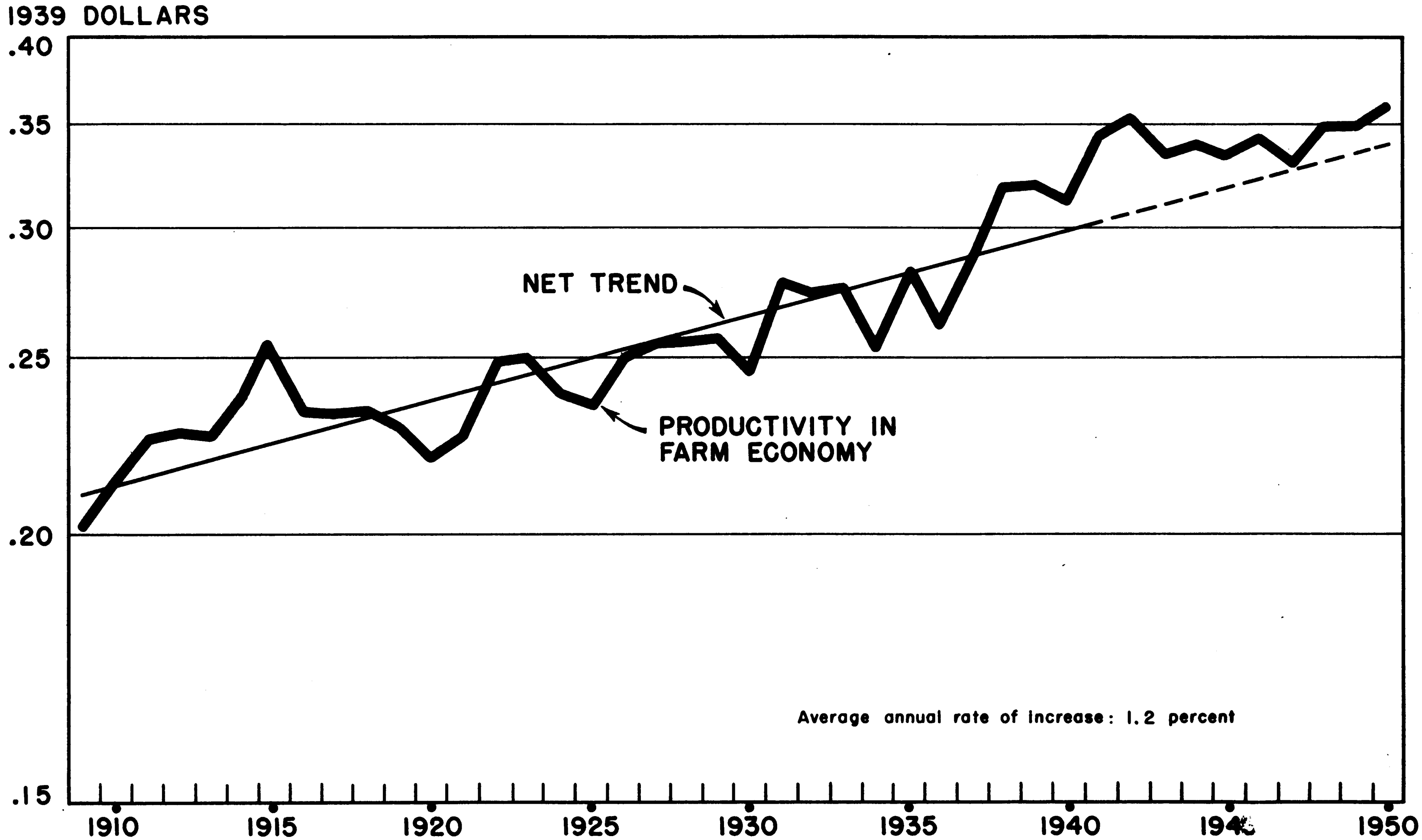
Washington, D.C.
April 19, 1951

Chart I. - REAL GROSS PRIVATE PRODUCT PER MAN-HOUR, 1909 - 1950 NET TREND, 1909 - 1941



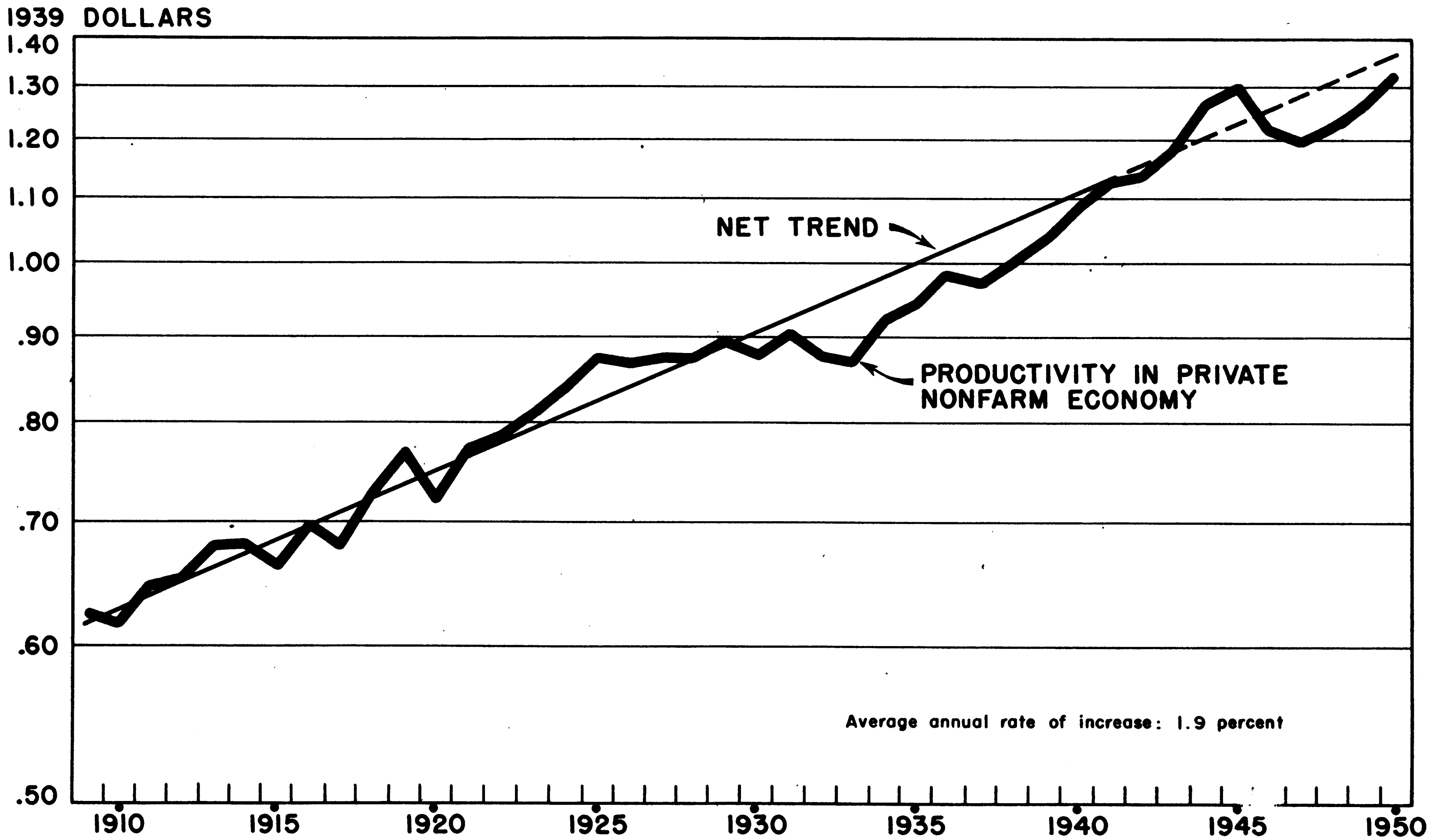
Log y (real gross private product per man-hour) = 1.59300 + .00263 X (ratio of civilian employment to civilian labor force) + .00907 t (straight-line time trend, year 1925 = 0)
Regression equation fitted to data for the years 1909-41; R = .989

Chart 2.- REAL GROSS FARM PRODUCT PER MAN-HOUR, 1909-1950
NET TREND, 1909-1941



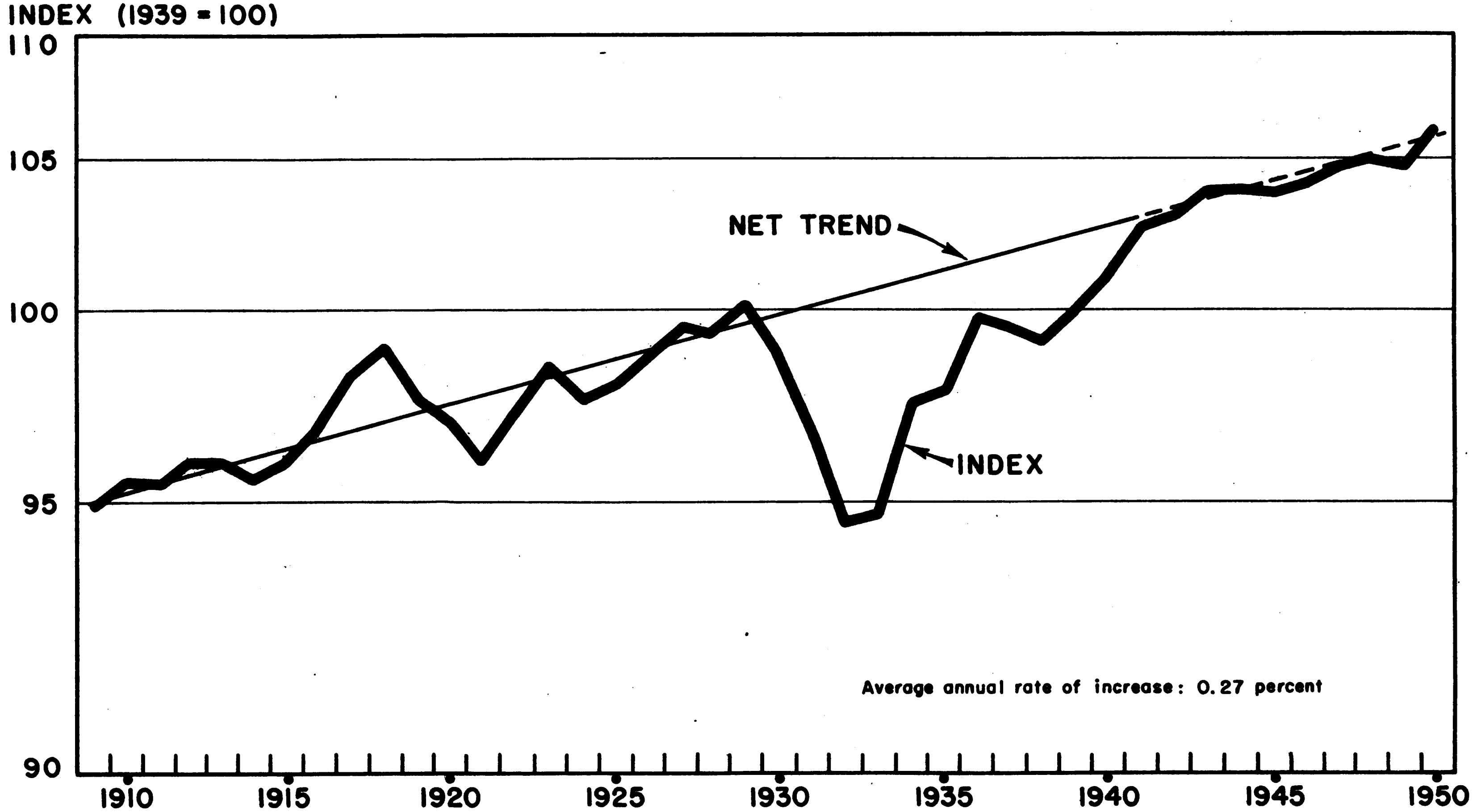
Log y (real gross farm product per man-hour) = 1.40160 + .00001 X (ratio of civilian employment to civilian labor force) + .00504 t (straight line time trend, 1925 = 0); R = .889

Chart 3.- REAL GROSS PRIVATE NONFARM PRODUCT PER MAN-HOUR, 1909-1950 NET TREND, 1909-1941



Log y (real gross private nonfarm product per man-hour) = 1.75597 + .00172 X (ratio of civilian employment to civilian labor force) +.00821 t (straight-line time trend, 1925 = 0); R = .985

Chart 4.- INDEX OF THE EFFECT ON PRODUCTIVITY IN THE PRIVATE ECONOMY OF THE RELATIVE SHIFT OF MAN-HOURS WORKED FROM THE FARM TO THE NONFARM SECTORS, 1909-1950
NET TREND, 1909-1941



Log y (index) = 1.89458 + .00105 X (ratio of civilian employment to civilian labor force) + .00112 t (straight-line time trend, 1925 = 0); R = .958