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# THE RESEARCH PROGRAM OF THE NATIONAL RESEARCH PROJECT



WORKS PROGRESS ADMINISTRATION  
NATIONAL RESEARCH PROJECT



**WORKS PROGRESS ADMINISTRATION**

**HARRY L. HOPKINS**  
Administrator

**CORRINGTON GILL**  
Assistant Administrator

**NATIONAL RESEARCH PROJECT**

on

**Reemployment Opportunities and Recent Changes  
in Industrial Techniques**

**DAVID WEINTRAUB**  
Director

**IRVING KAPLAN**  
Associate Director

**THE W.P.A. NATIONAL RESEARCH PROJECT  
ON REEMPLOYMENT OPPORTUNITIES AND RECENT CHANGES  
IN INDUSTRIAL TECHNIQUES**

Under the authority granted by the President in the Executive Order which created the Works Progress Administration, Administrator *Harry L. Hopkins* authorized the establishment of a research program for the purpose of collecting and analyzing data bearing on problems of employment, unemployment, and relief. Accordingly, the National Research Program was established in October 1935 under the supervision of *Corrington Gill*, Assistant Administrator of the WPA, who appointed the directors of the individual studies or projects.

The Project on Reemployment Opportunities and Recent Changes in Industrial Techniques was organized in December 1935 to inquire, with the cooperation of industry, labor, and governmental and private agencies, into the extent of recent changes in industrial techniques and to evaluate the effects of these changes on the volume of employment and unemployment. *David Weintraub* and *Irving Kaplan*, members of the research staff of the Division of Research, Statistics, and Finance of the WPA, were appointed, respectively, Director and Associate Director of the Project. The task set for them was to assemble and organize the existing data which bear on the problem and to augment these data by field surveys and analyses.

To this end, many governmental agencies which are the collectors and repositories of pertinent information were invited to cooperate. The cooperating agencies of the United States Government include the Department of Agriculture, the Bureau of Mines of the Department of the Interior, the Bureau of Labor Statistics of the Department of Labor, the Railroad Retirement Board, the Social Security Board, the Bureau of Internal Revenue of the Treasury Department, the Department of Commerce, the Federal Trade Commission, and the Tariff Commission.

Also cooperating are the following private agencies: the Industrial Research Department of the University of Pennsylvania, the National Bureau of Economic Research, Inc., the Employment Stabilization Research Institute of the University of Minnesota, and the Agricultural Economics Departments in the Agricultural Experiment Stations of California, Illinois, Iowa, and New York.

The undertaking called for a many-sided approach. Surveys have been made of a number of industries - manufacturing, mining, agriculture, and railroad transportation - covering not only machinery, equipment, and motive power, but also raw materials and the labor involved in their production. In manufacturing alone, more than 700 individual plants have been surveyed.

These studies measure changes in production, employment, and output per man, and then dig deeper in an effort to determine the causes and effects of the changes. Interest centers in their effects on total employment opportunities and on particular occupations in an industry itself and in related industries which supply it with machinery, equipment, motive power, and raw materials.

To help complete the picture, a series of studies has been organized which, instead of dealing with the net changes in individual industries, focuses on individual wage earners as they are affected by industrial changes. To this end, employment histories of more than 20,000 workers have been collected. Against a background of the history of the enterprises and of the working population in the industrial labor market chosen for inquiry, they will show the frequency and duration of unemployment periods; the number of times workers have changed occupation, employer, and industry; the relationship of age and industrial experience to occupational mobility; the sources of the labor supply in new and expanding industries; and the geographic mobility of labor in relation to the migration, expansion, or decline of industries.



**THE RESEARCH PROGRAM OF THE NATIONAL RESEARCH PROJECT**

by

Irving Kaplan

Paper prepared for the Meeting of the  
Washington Statistical Society Chapter of the  
American Statistical Association  
Washington, D. C.                      June 10, 1937

*Philadelphia, Pennsylvania*  
*August 1937*



## PREFACE

On June 10th, 1937, the Washington Statistical Society, a chapter of the American Statistical Association, held a meeting under the auspices of the Works Progress Administration. The subject of discussion was "The Research Program of the National Research Project on Reemployment Opportunities and Recent Changes in Industrial Techniques." The meeting was arranged by the Works Progress Administration to acquaint members of the technical and research staffs of the Federal agencies cooperating in the National Research Project with the Project's research program. Because of widespread interest in the subject, it was decided to hold the meeting jointly with the Washington Statistical Society. Approximately 500 persons attended the meeting, which was held in the auditorium of the Department of Commerce Building.

In planning this program, arrangements were made to mail to members of the Washington Statistical Society the statement on "The Research Program of the National Research Project" prepared by Irving Kaplan, Associate Director of the Project, describing the scope and perspective of the research program.

The program for the evening included the following discussions:

"The Place of Individual Plant Histories in Surveys of Changing Productivity" by Harry Jerome, University of Wisconsin

"Changing Labor Requirements in Agriculture as Illustrated by Data Covering One Agricultural Product" by John A. Hopkins, Iowa State College

"Technical Progress and Productivity in Mining" by O. E. Kiessling

"Employment and Productivity in the Railroad Industry" by Morris L. Jacobson

"The Coal Loading Machine and Its Effect on Employment in One West Virginia Coal Field" by Tom Tippet

"Recent Trends in the Philadelphia Labor Market" by Gladys L. Palmer

A summary of the evening's program is scheduled to appear in the Chapter Notes of the September issue of the quarterly *Journal of the American Statistical Association*.

David Weintraub

Irving Kaplan

Philadelphia,

August 3, 1937.



## THE RESEARCH PROGRAM OF THE NATIONAL RESEARCH PROJECT

The general problem indicated by the Project's title, Reemployment Opportunities and Recent Changes in Industrial Techniques, has often been approached in terms of a special problem of "technological unemployment" or of "displacement of labor" by machine techniques. These terms, by their emphasis, have tended to take the analysis of problems of unemployment out of its proper economic context, as if technological development were self-generating and its effect on employment a mechanical consequence.

"Technological unemployment" and "labor displacement" as general concepts, if they are to have analytical validity, must be distinguished from designated observable facts. To take a simple case - a particular installation of a coal-loading machine - we may, perhaps, agree that the separation from their jobs of a given number of hand-loaders can be observed while other hand-loaders are retained for mechanical loading. Shall we now agree, on the basis of the designated facts, that the jobs terminated represent "labor displaced by machines" and that the men laid off are "technologically unemployed"? What if the mine had only the alternative of mechanizing or shutting down? If this alternative rested on competition from another coal mine, more favorably situated without mechanical loading, but less favorably situated for the introduction of mechanical loaders, there may have been indirect displacement of employees of the competing mine. What if the alternative rests on competition from another fuel? Obviously economic considerations overwhelm the significance of the observable facts.

Suppose now we alter the situation somewhat by assuming that the mine had been shut down and that mechanical loading was introduced to reopen the mine. The economic considerations involved are the same as under the alternative of "mechanize or shut down." But the new working force differs from the old in certain respects, and the absence of immediacy in the association of machine introduction and lay-offs makes it impossible to designate the individuals affected. Suppose again that, upon introduction of the loading machine, the mine increases its production schedule, but that some time subsequently there follows curtailment of production and personnel or shut-down. Here again are the two ques-

## 2 PROGRAM OF THE NATIONAL RESEARCH PROJECT

tions: Was there a reduction in the amount of employment afforded? and, if there was a reduction, who were the technologically displaced?

Finally, assume a designated case of technological displacement and its subjects labelled. There are nine of them. Two men are retained by the same plant, but one of them takes the place of a third person, who is laid off; one obtains employment with a new enterprise, one with an old enterprise, one opens up a grocery store, one peddles shoelaces, one becomes sick, one goes on a vacation, and one is looking for a job. The last one, we may agree, retains his original label and is one of the technologically unemployed, but there are seven questions to answer before the inventory can be completed.

Few who walk the streets in search of work can be labelled for the source of their unemployment. The isolation of "technologically unemployed" or "displaced" workers from the unemployed and employed is no more feasible than the isolation of a special problem of "technological unemployment" or "displacement of labor" from problems of unemployment in their social and economic context. Therefore, an analytical approach undertaking to segregate a special problem, rather than to place it in its proper context, would artificially limit its scope and magnitude, perhaps to the point of extinction, or, alternately, pose an artificial problem juxtaposing the utilization of mechanical against human labor power.

The problem of technological unemployment is often regarded as one of machines versus men. In the light of the foregoing considerations, the problem must rather be approached in a comprehensive economic context.

### THE APPROACH

In their most general terms, the problems of our Project refer to the relationship between changes in industrial techniques, or in methods of production, and changes in the volume and incidence of production, employment, and unemployment. Our basic approach has been to analyze given questions within a context of historical economic relationships.

Industrial history and the operation of economic relationships cannot, however, be covered by conveniently given discrete categories. Our efforts have been and are being directed to testing

the value and adequacy of analytical concepts and techniques, to the end that problems may be defined and distinguished and that fairly conclusive results may be obtained in the several spheres of inquiry. The time allowed the Project may militate against the comprehensiveness of the results, but the very magnitude of the Project afforded an opportunity to initiate work characterized by varied and related approaches to common problems.

Technological changes are, of course, introduced into the economy in order to obtain useful products with less expenditure of effort than is otherwise required. An historical description of the mechanical or engineering types of industrial techniques and the rates at which they have been or are being introduced and adapted to specific uses would serve to define the technological threshold at which we stand and, in a measure, the prospects in store. To serve these analytical ends, however, the history of technology must embrace not only the development of industrial techniques considered as mechanical or engineering changes, but also the economics of their application and the conditions affecting their introduction.

The practical applications of principles of science and engineering run a course in history which at times cuts across so many industries or production methods that it transforms the productive processes in society as a whole and the world we live in. The historic role of the application of steam power has its more recent and perhaps only apparently lesser counterpart in the application of electric power and its inherent uses for economy and precision of control and for automatic operation. The latter may be challenged by developments in the uses of chemicals for control of processing and products, the development of uses for new and substitute materials, and the development of new and substitute products. Of recent and current importance is the introduction of material-handling and transporting equipment of various types into a large number of industries. Supplementing the generic types of development in the application of principles of science and engineering are developments in their application to the specific processing requirements of individual industries.

When a new or changed production technique is applied to the production of products not otherwise considered worth the effort required, it may, in an economic sense, be said to have created new products. When the technique brings within reach new uses or additional users for given products, it does, in an

economic sense, expand production of these products. A classified inventory of principles of science and engineering and the history of their industrial application will not, however, explain either the development of the principles or their applications in industry, or their effect on production and employment. The very use and development of production techniques, as well as the effect of their use on production and employment, take place within a sphere of economic relationships which is controlling and selective according to the principles on the basis of which the economy operates.

#### THE PROBLEM

The given problem, How do changes in industrial techniques affect employment opportunities? can thus be answered only by reference to the conditions of the economy and the factors or forces which underlie the course of its development. Within this context the basic question for analysis is, Given the calculable effect on labor requirements per unit of output, how does the change affect total output?

This primary question can, of course, be stated with reference to the development and prospects of the economy as a whole, or with reference to particular, defined sectors of the economy, or designated industries, or products. These alternatives with respect to the scope of economic activities to which the question may be referred are not, however, mutually exclusive for analytical purposes.

For the appraisal of employment prospects in particular industries, an evaluation of the trend and prospects of the economy as a whole is indispensable. Indeed, the trend and production prospects of "the economy as a whole determine, in greater or lesser degree, the volume of production of each industry. Changes or trends in production and employment must thus be evaluated not only on the basis of the conditions of the industry and the economics of its operation, but also on the basis of the industry's relation to or place in the economy and the relevant conditions of the economy in which it has its place. Production and employment prospects of the economy as a whole are similarly conditioned by the capacity and trends of development of its components. For the given conditions at any time, the related functioning of all activities in the economy may be said to set

the limits of total economic activity within which the prospects of each industry or production unit is confined.

For the economy as a whole, technological changes may be said to reduce employment permanently or for long duration only when the economic developments are such that the reduction in labor requirements attendant upon increased use of capital equipment exceeds the labor requirements created by expanding total production. When the effect of expanding total output fails to outstrip reduced labor requirements by the margin given by additions to the labor supply, whether these additions arise from population changes or from social and economic changes affecting the number of persons seeking employment as a source of livelihood, unemployment increases. It is only with reference to technological change, viewed in the light of these economic developments, that permanent and temporary unemployment can be properly distinguished.

By distinguishing these adverse relationships according to whether they arise out of particular conditions in an industry or in the economy, or out of the conditions of development of the industry or the economy, local, temporary, cyclical, and permanent unemployment may be distinguished. Analysis of the economics of the relationship between production and employment changes for individual products or industries may therefore serve the dual purpose of measuring the incidence of employment and unemployment and evaluating the character of the problem it presents.<sup>1</sup>

In considering the effects of technological changes in the light of the fundamental question juxtaposing changes in unit labor requirements, on the one hand, and changes in the volume of production, on the other, the criteria of major interest are, first, the effect on production cost, primarily as this effect arises through reduction of labor requirements and labor time represented by materials consumed in the process affected, and second, the effect on expansion of production capacity. These two effects are not exclusive categories of types of changes in industrial techniques, but are usually associated, as when capacity increases as a result of the increased rate of oper-

<sup>1</sup>The insecurity of employment is at all times of deep concern to those who depend upon jobs for their livelihood - whether economic conditions present unemployment prospects of long or short duration, and whether economic conditions limit the incidence of unemployment to selected, "sick" industries or locations or spread the incidence throughout the country. The frequency and duration of unemployment according to the conditions out of which they arise and the characteristics of individuals affected are subjects of the Project's labor-market studies, which are described on pp. 13 ff.

ation of a given machine, which thereby also reduces the unit labor requirements, or when larger units of given equipment yield greater economy in fuel requirements, as in the case of boilers.

Changes in the industrial techniques or processes do not only take the form of introduction of physical equipment. In fact, the introduction of a new or changed process frequently gives rise to engineering problems of lay-out and ordering of work and is usually associated with managerial changes. We have therefore regarded the concept "industrial techniques" as comprising both physical capital equipment and the organization of its use.

The analysis of types of technological change and of the rates of their introduction under conditions of expanding, stable, or declining output - or prosperity, depression, or stability of the economy or a given industry - requires the direction of attention to distinguishing changes in techniques according to the relative amount of labor required for the production of the capital equipment as compared with the reduction in labor requirements incident to its use. Defined statistical categories for a distribution of the types of change would be the ratio of the change in labor requirements to capital costs or to labor time represented by the capital costs. The analysis of the rates of introduction in time requires a distinction between demand for replacement and for growth. Such analysis is directed to an explanation of the production trend, and fluctuations therein, of the capital-goods-producing industries. Not only do these industries assume a role of ever-increasing importance in the trend of total production and employment as industry develops, but in recent years they have attracted singular attention because of the low level to which their activities dropped and the long lag in their recovery. This experience of the capital-goods industries is characteristic of their behavior in prior depressions. To the extent to which technological developments contribute to the continually growing role of these capital- and other durable-goods industries, they thus also have an important bearing on problems concerning the security of employment and the incidence of unemployment.

Again, the inevitable association of changes in machinery with rearrangements of the process of production means that changes in total labor requirements are not properly measured by a comparison of performance records for two machines. The measure of labor requirements and its changes must therefore be arrived

at for the production process as a unit, rather than by discrete steps in the processing by given machines.

Furthermore, the structure or organization of producing units - industries or plants - is not likely to be uniform at any time and is not likely to remain constant over a period of time. One automobile manufacturer purchases carburetors and other engine parts, another manufactures all engine parts and purchases body forms, and both have changed the scope of the processing in their own plants, and in particular plants from time to time. Moreover, changes in the volume of output of an industry are conditioned by the costs of materials and parts purchased as well as by the manufacturing costs in the given industry for its final products. The adequate measurement of changes in labor requirements must therefore be predicated on the designation of products and on the whole of the vertical structure of processing required for the output of the product.

#### STUDIES OF CHANGES IN PRODUCTIVITY AND IN TECHNOLOGY

The larger share of the Project's efforts is centered around studies of productivity changes in an extensive number of industries - in agriculture, extraction, manufacture, and transportation. Reports in preparation will cover rather extensively labor requirements for the domestic output of the Nation's raw materials.

In a series of studies undertaken in collaboration with the Department of Agriculture, we have provided for measurements of changes in agricultural production, farm population and employment for the country as a whole and for crop areas, the relation of their trends to changes in agricultural techniques, and for measurements of the trend in labor requirements for the principal agricultural products in relation to farm practices.

In cooperation with the Bureau of Mines, the Project has undertaken a survey of the major extractive industries. These studies are based primarily on data reported to the Bureau from year to year, supplemented by data gathered during the past year, on installations or sales of mechanical equipment and on conditions of mining. The study for each of the extractive industries is designed to yield statistical series on output, employment, and productivity. The coal studies will be most complete because the

Bureau has production and employment data for a long series of years and has called for specific information on mechanization during the whole of the post-war period.

The availability of resources and the physical conditions given for their recovery afford the natural setting to which the techniques of exploitation of mineral products must be adapted. As the utilization of known resources proceeds, particularly in the extraction of raw materials which have been basic to the industrial development over a long period of time, the conditions of mining change so as to impose increased obstacles in two respects, the increasing physical difficulties of extraction, and the declining proportions of recoverable metal or mineral content in the material extracted. For the purpose of interpreting the related measures of employment, productivity, and production, analytical interest therefore centers in changes of the character of reserves and the physical conditions of mining, in the adaptation of types of technological change, and in the rate and extent of their introduction. At least for the coal industry, which accounts for an overwhelming proportion of the activities in the extractive industries, market prospects are fairly well defined, and the foregoing type of analysis may therefore contribute substantially to an adequate appraisal of employment prospects.

In the case of manufacturing industries, nature imposes no such limitations as in extraction. Availability of material resources of requisite volume and types and labor supply of requisite volume and skills or adaptability, and the nature of human needs and wants, do, of course, impose maxima. The occasion for our social-economic problems, is, however, the inability to satisfy needs; there has been no want of raw materials; and the social problems of unemployment could hardly exist if the labor supply were the factor determining the volume of production.

The factors explaining the effects of changes in productivity on the volume of output are thus economic relationships, rather than physical or mechanical in character. We have, therefore, regarded productivity studies in manufacturing industries not merely as contributions to studies of the incidence of changes in labor requirements by industries, but also as case studies for the analysis of economic factors affecting the relationship between production, productivity, and employment changes, according to the economic characteristics and conditions of each industry selected and its function or role in the economy.

Reports on productivity in the boot and shoe and the leather-tanning industries, in the cotton and rayon textile and the cotton-garments industries, and in the cigar and cigarette industries are being prepared in cooperation with the Bureau of Labor Statistics.

On the basis of a cooperative arrangement with the National Bureau of Economic Research, which was responsible for surveys undertaken in these industries some years ago, the National Research Project is preparing reports on the brick, cement, lumber, flour, and beet-sugar industries.

All of these studies provide for the compilation and analysis of series on production, productivity, pay rolls and employment, the latter two by departments and by direct and indirect use of labor. In the case of industries in which the distribution of occupations within departments is significant, data on changes in employment by occupations have also been obtained.

The plans for the completion and extension of the studies initiated by the National Bureau of Economic Research were prepared with a view to as comprehensive an economic analysis as feasible, without imposing undue burdens on cooperating companies.

Total value and unit prices, in addition to physical quantity of output for the products of each plant, were obtained in order to aid the solution of the problem of comparable products and to investigate the relationship between productivity and price changes.

In order to complete the accounting of major production costs and to be able to account for the labor requirements in current manufacturing costs, the value as well as physical quantities of materials and fuels consumed were obtained. Brick and cement plants characteristically extract their own raw materials, and this process was covered by departmentalization of these industries. To obtain data on the labor requirements for the production of logs consumed in the lumber saw-mills and planing mills surveyed, a special survey of logging camps was undertaken. For the purpose of converting raw materials used in the flour and beet-sugar industries, the studies of the Project's agricultural section on labor requirements in the production of wheat and sugar beets will be drawn upon. The Bureau of Mines data on productivity in the coal-mining industry and the data on labor requirements in railroad transportation, from our study with the Railroad Retirement Board, are being used to add to the description of trends in

## 10 PROGRAM OF THE NATIONAL RESEARCH PROJECT

labor requirements for the vertical structure of processing required for the manufacture of the final products.

Data were also obtained on the capital investment in plant and equipment, on the distribution of production costs as they arise out of labor, materials, and capital employed, on the types and costs of major changes in physical equipment and measures of its relative performance (capacity, rate of operation, and power or fuel requirements), and on the labor employed for the equipment displaced and the new equipment. The data on the growth of capital investment and on changes in the distribution of costs may throw light on the behavior of prices in selected industries as they have a bearing on the distribution of the benefits of technological progress. The data on capital investment and equipment changes are designed for an analysis of labor embodied in plant and equipment, and in specific changes in equipment, in relation to changes in labor requirements for the processing of the products in the plants surveyed, and for an analysis of the types of technological change.

These surveys have been supplemented by a survey of the machine-building industry. The data obtained include production series, series on employment and raw materials and fuels used, and costs of materials and fuels, designed to be used for estimating labor time embodied in the dollars invested in equipment used by the industries of interest; data on the quantity of labor time embodied in specific machines of interest for comparison with the change in labor requirements incident to their use; and data on year-by-year sales of classes of equipment and individual machines, with descriptions of their engineering characteristics, for an analysis of the technology of the industries using the machines, the types of technological change, and the rates of their introduction. The bearing of this analysis on two problems may here be distinguished; first, the trend in types of technological development and the rate at which and the economic conditions under which these developments bring about substitution of capital for labor employed in industry; and second, the rate or time sequence of demand for production and employment in the capital-goods-producing industries, under given economic conditions.<sup>2</sup>

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<sup>2</sup>The study of productivity and technology of railroad transportation is described under the labor market section on page 15.

The major instrument of technological change is capital equipment. The economic effect of increased use of capital equipment may be traced in several directions. Most direct is its bearing on the proportions of direct and indirect labor requirements, particularly operating and maintenance labor, and its effect on the occupational incidence and the tenure in employment, on the one hand, and on the relationship between productivity and the proportions of capacity utilized on the other. The latter is a subject of analysis in the productivity studies described. A further effect of increased use of capital equipment, already observed, is the increasing importance of the capital-goods-producing industry in the economy and the increasing dependence of the stability of employment on the sustained activities or growth of these industries.

Increased use of capital equipment is, however, dependent upon the flow of funds for capital investment, and the flow of such funds is dependent on their availability and on the return of income for the funds. Moreover, with increased use of capital equipment, the return demanded for the flow of investment funds alters the distribution of production costs between capital and labor charges. It may thereby alter the distribution of income available for consumer and capital goods, even creating, on the one hand, a pressure of funds available for investment, and, on the other, inadequacy of consumer funds.

These considerations underlie issues in which problems of distribution of purchasing power are set off against price and wage safeguards of a profitable basis for the operation of industry. They thus relate to the trends in and the condition and prospects of the economy as a whole. To the intensive analytical approach to selected industries, the Project has, therefore, added a more extensive approach to the organization of available statistical data.

To the statistical section of the Project has been assigned the task of organizing and analyzing the data for a summary of economic trends. Special assignments cover measures or indicators of the growth of capital, measures of changes in the total labor supply and in employment, and an analysis of trends in the composition of production and income, according to producers' and consumers' durable and nondurable goods, and according to extractive, manufacturing, distributive, and service functions. In view of the post-war growth of employment in distributive and serv-

## 12      PROGRAM OF THE NATIONAL RESEARCH PROJECT

ice functions, special interest attaches to these activities in the analysis of developments in the composition of economic activities.

In addition to the foregoing analyses, comparable series on production, employment, and productivity changes during the post-war period are being prepared for approximately forty industries. These series add to the extensiveness of coverage of the incidence of changes in labor requirements in relation to changes in output and employment by industries. They also provide a base for the construction of productivity indexes, designed to reflect, more adequately than otherwise available, changes in relative labor requirements for the output of the composite of products of a group of industries or all industries. This is important for the analysis of relationships in trends of production, employment, and productivity in all industries and in different types of industries, classified according to their economic function or characteristics.

The construction of adequate measures of changing productivity, for many industries, has been a considerable statistical task because available measures of production were originally compiled for other purposes. Changes in the labor requirements per unit of output of a group of plants or a group of industries arise out of the operation of two factors: changes in the labor requirements per unit of output of the different products and changes in the relative volume of output of the different products. The latter is the subject for inquiry into the changing composition of the aggregate of production. The changes in the labor requirements per unit of output of the different products is the subject of measurement by a productivity index, which must be designed to answer these alternative questions: What relative volume of labor time is required at different times to produce a given volume of a given composite of products? or, what different volumes of a given composite of products can be produced at different times with a given expenditure of labor time? To answer these questions, a production index used to obtain a productivity index for a composite of products must be constructed by weighting the several products included in the composite according to the total labor time which was actually required to produce the several components of the total.

## LABOR MARKET STUDIES

There remain for consideration the labor-market studies of the Project. These are concerned with questions most directly pertinent to the purposes and problems of a relief administration. The problems are designated by the relationship between the size and the changes in the size and composition of the labor supply, on the one hand, and the changes in the volume and composition of labor required for economic activities, on the other - the relationship of a population to available jobs and of jobs to a population available for work. Whether, under recent, current, or any given conditions of development, the economic prospects foreshadow unemployment of relatively permanent or temporary duration, interest attaches to the magnitude of unemployment, the frequency and duration of its occurrence, the relationship of these frequencies and durations to durations of employment, and the distribution of these relationships among the population. The relationship of technological changes to these questions, it has already been indicated, presents a problem of analysis to explain the direction and character of the influence of changes in techniques, rather than a problem of isolating "technologically unemployed."

There is thus, first, the problem of ascertaining what is the magnitude and the industrial and occupational composition of the given population according to employment status at a given time or according to employment and unemployment experience over a period of time. These are measures of incidence of employment and unemployment. Then there is the question: How have technological changes conditioned the magnitude of employment and unemployment and the selective characteristics of the population by which their employment status or work experience may be distinguished?

The answer to this question requires the measurement of the incidence of employment and unemployment and their respective durations, according to the time and economic conditions of their occurrence, their geographic location, industrial and occupational impact, and other economic characteristics. In the light of their current relationship to industrial and occupational requirements, the age and sex factors should also be accorded consideration in this context. These measures of incidence are related to the conditions out of which the problems arise and are, therefore, perti-

nent to the explanation of the problems and to evaluating their prospective magnitude and duration.

An additional question, of particular interest to a relief administration, can now be added: What are the needs of the unemployed population, and what practical alternatives are there for taking care of these needs? Family composition and relationships, age, sex, and other attributes of individuals and their experiences have their primary reference to this question.

A review of characteristic ways in which the introduction of technological changes affect the relationship of people to jobs may serve to emphasize our analytic approach to measures of incidence of employment and unemployment.

In the course of the development of our industrial society, for example, smaller and smaller proportions of the working population have been providing the food and agricultural materials required by the growth of urban population and industry. In fact, in more recent times, statistics on farm population show a trend characterized by a decline in absolute numbers. The conditions for such a trend are the development and application of technology in agricultural pursuits. The problems in labor-market analyses attach interest to the type and economic conditions of the population which is drawn into the industrial labor market from the farm, the rate at which and the conditions under which they become accessions to labor markets, the industries and occupations to which they become attached, and the tenure and conditions of their work.

In the early days of the industrial revolution, a typical technological change was represented by a complete change in the production process caused by a substitution of machine for hand techniques, which directly displaced large numbers of hand workers immediately, though larger numbers may subsequently have been absorbed even in the same industry. Today, examples of complete changes in process are relatively rare, though a few may be cited, such as those in the glass industry and the cigar-making industry. Technological changes have come to be continuous, particularly in the mass-production industries, which have originated or developed on the basis of a fairly high degree of mechanization.

Technological change is ordinarily introduced to expand the market or to maintain the market against competing plants or products. In any event, the immediate occasion for the introduction of improved capital equipment is the continuation or

expansion of output. It is the backward plant or industry which is forced to reduce production and employment or shut down, and renovation often takes place as a condition for resumption of production. At the time of a change in techniques, under these conditions, the personnel is frequently retained for expansion in the same department or elsewhere, though changes in employment may be subsequently effectuated when production declines.

A consideration of the foregoing conditions for technological change reveals the fact that technological changes have their impact primarily on the trend or changes in the volume and duration of employment and unemployment, according to the industries and occupations affected. It follows that the appraisal of the representative character or the significance of trends or changes in volume, frequency, and duration of employment and unemployment must be made according to the economic and industrial conditions which given measures reflect.

Since both the direct and the indirect effects of technological changes on labor requirements have an immediate bearing on the industrial and occupational composition of these labor requirements, the incidence of technological change in the labor market may be best approached on the basis of studies by industries or of situations defined on the basis of selected industries. The plan of research for the railroad industry, undertaken in cooperation with the Railroad Retirement Board, may be described briefly to illustrate the ordering of analytical problems for a given industry in the general scheme of the Project.

On the basis of available data a statistical study is being made covering changes in employment, earnings, and productivity of railroad labor for the country as a whole, for defined regions, and for such departmental and occupational groupings as are uniformly distinguishable over a period of time. To explain the changes recorded in the several statistical series and the relationships observed, a number of studies of the history of technological and economic changes have been made including mechanical and managerial changes on the railroads, the changing character of the traffic haul, the development of the capital structure and of the financial control of the railroads, the effects of technological changes on specific occupational groups, and the adaptations which labor has undertaken to technological changes. This analysis may be regarded as comparable in scope and purpose to the studies of changes in productivity and technology outlined for the manufacturing industries.

## 16      PROGRAM OF THE NATIONAL RESEARCH PROJECT

The analysis of changes in railroad labor requirements and in railroad technology may also be regarded as providing the historical background for interpretation of the patterns of work experience on the railroads which have been tabulated on the basis of the personnel records for the employees of thirteen Class I railroads. These personnel records cover some 400,000 railroad workers, representing the whole of the working force on each of the given railroads during three pay roll periods, one each in 1924, in 1929, and in 1933. The information recorded for each individual includes age, year of entry into the service of the railroad, the dating and the occupational designation for each period of work with the railroad, and the date and reason for each interruption of work. For a sample of these workers the annual earnings are also recorded. The analysis of these records for the period 1924 through 1933 covers changes in labor force, trend of earnings, and patterns of frequency and duration of periods without work on the railroad, by those selective characteristics most important in railroad employment - age, length of service, and occupation. To supplement these analyses of employment experience with the railroads, a field survey has been made covering the work and unemployment experience during periods of interruption of railroad service or after separation from it, for a sample of the railroad workers.

The most fruitful conditions for such analyses of the labor markets of the other industries selected for productivity studies would apparently require an expansion of the field studies to cover the characteristics of the labor supply at the plant locations, the sources, tenure, work experience, and earnings of the plants' working force, and the characteristics and experiences of the persons separating from the plants. These data could then be analyzed in direct relation to the analysis provided for in the given productivity study, the personnel policies of the plants and the industry, the alternate employment opportunities afforded by other economic activities at the plant locations, and the organization, resources, and modes of adjustment of the population of interest. To assemble the requisite data on work experience from personnel or pay roll records, where available, would, however, impose an additional burden on the cooperating plant greater than the requirements of our productivity studies alone (not to speak of the added expenditures required of the Project). Practical rather than analytical necessity thus dictated recourse to other means.

Accordingly, the labor-market surveys of the Project were outlined on the basis of a survey of the historical background of the changes in industrial activity, the changes in the working population, and such local factors as may be related to the situation selected for study. The record of work experience and unemployment in each study was obtained by means of a work-history schedule which was filled out for a sample of workers. The labor-market studies of the Project are necessarily limited to selected examples of diverse industrial situations. The sampling procedure was, of course, in each case dependent upon the given situation. Where the industrial situation selected was a predominant characteristic of the locality, usually in smaller communities or one-industry towns, an employment and unemployment census, on a sample basis, was taken to describe the occupational and employment status of the population. The work-history samples were designed to be representative of the industry, occupation, or plant on the basis of which the selected situation was defined.

Some of the industrial situations selected for survey represent examples of striking technological changes. Thus, in the case of the Scotts Run coal mines in West Virginia, mechanization of loading immediately preceded and continued throughout the time during which the field survey was made. The study of cigar workers at Manchester, New Hampshire, covers the former cigar workers of the plant which employed a large complement of male workers who were all supplanted by a much smaller force of women when the plant was mechanized. The study in Millville, New Jersey, covers present and former glass workers in a plant that has been mechanized, and also the employees of the textile mill which, with the reduction of employment in glass making, has assumed increasing importance in the community and has absorbed a number of former glass workers.

In most other instances selections were made to represent given situations in an industry which is the subject of a Project survey of productivity and technology. Brazil and Clay County, Indiana, for example, are dependent on the clay-products industry, and many of its clay-products plants have been sampled for the brick productivity survey. The shut down Amoskeag mills at Manchester were once the major textile-producing mills in the country. It is the only situation, in addition to railroads, for which extensive plant and personnel records were available. The personnel records, covering tenure, accessions, and separations, were employed to cover a cross section of the working force since

1911. The records on earnings and working experience with the plant were sampled to cover the working force at the time of the final shut-down, the separations during the period of curtailment at the bottom of the depression, the accessions and separations during the period immediately preceding the depression, and the accessions immediately following the resumption of work after the 1922 strike shut-down. For as many individuals within these samples as could be located, a field survey utilizing the work-history schedules was undertaken in order to ascertain the work experience of the sample during periods of separation from Amoskeag and the extent of unemployment. Because of the difficulty in locating an adequate number of the former Amoskeag workers, who had migrated, a study of labor mobility was undertaken at Manchester. Since, with the decline in textiles, shoe manufacturing has been assuming increasing importance in Manchester, a field survey of the work history of Manchester shoe workers was also made.

The geographic mobility of labor and of certain industries at least and the shifting of workers from one industry or occupation to another are important subjects for study in relation to our measure of employment and unemployment. These factors, however, create obvious difficulties in sampling the whole of the working force attached to a plant, an occupation, or an industry in a given locality during a period of time. The sampling was, therefore, selective according to the important characteristics of the situation selected for study and the facilities available. The sampling for Amoskeag is a case in point. To illustrate again, in the studies of Lancaster, Pennsylvania, the four largest plants, each representing a different industry in a growing town, were selected for study. Lancaster industry draws its labor supply from a commuting population as well as from persons leaving neighboring farms. The samples were therefore apportioned among Lancaster residents and nonresidents. For the studies of other situations, where plants have shut down, the sampling of present residents was supplemented by work histories for a group who had removed to neighboring localities. Where records were available, samples were drawn to cover the working force attached to the selected situation at different periods of time.

Tabulations of these work histories are directed to an analysis by years or by predepression and postdepression periods of the duration of employment in the industry or occupation selected as the basis of the study, and in other industries or occupations, the duration of unemployment and the shifts in jobs, employers,

industries, and occupations. In addition to the surveys already mentioned the following situations in given localities are covered:

Textile, metal, and radio workers in Philadelphia; the bituminous coal miners in Logan County, West Virginia; the lumber-mill workers in Poplarville, Mississippi; skilled metal workers in Minneapolis; silk-textile workers in Paterson, New Jersey; cotton-textile and furniture workers in High Point, North Carolina; textile and other workers in Easthampton, Massachusetts; silk and other textile workers, paper workers, and metal workers in Holyoke, Massachusetts. The sample of former employees of the Worthington Pump now in Holyoke, was supplemented by the enumeration of the Worthington Pump employees who were transferred to the company's plant in Harrison, New Jersey, and for comparison, there was added a sample of Worthington Pump employees in Harrison in the same occupational groups as the individuals transferred from Holyoke.









