CHAPTER I

SUMMARY

Origin and Scope of Survey

In type the problems raised by advancing mechanization are common to the more than a century and a half since the beginning of the Industrial Revolution although in degree they may have been accentuated by the events of recent years. Our survey had its origin in the hectic years of the post-War decade as an inquiry into the extent to which the effects of immigration restriction upon the supply of labor were likely to be offset by an increasing use of labor-saving machinery. Then conditions changed so that the center of interest shifted from the possibility of a labor shortage, caused by immigration restriction, to an apparent threat of a surplus of labor, arising from improvements in efficiency, and the emphasis in our study was shifted to the characteristics, conditions and effects of progressive mechanization. Since it is to the post-War period that we must look for much of the evidence available to illustrate the nature and effects of mechanization, let us first sketch in broad outline certain significant events and tendencies of that in many ways remarkable decade the better to define our problem and its setting.

The decade opened at the peak of the post-War boom, but before the first year had closed the slump to the depression of 1921 had begun. War conditions had provided an effective check on emigration from Europe to the United States, and in the immigration acts of 1921 and 1924 this check was con-

tinued by legislative restriction.[1] As industry began to recover and approach the 1923 peak of activity, questions began to arise concerning a possible or actual shortage of labor. Some urged that the bars on immigration should be lowered Others voiced the opinion that labor-saving machinery and other improvements in efficiency would fill the gap. But, as the decade wore on, doubts began to be voiced whether the machine was not doing its work too well, for there appeared to be a substantial volume of unemployment even though industry was relatively active. The term 'technological unemployment' became current. Then, with the close of the decade, a prolonged depression set in. If some of the evils

[1] The extent of the slump in immigration may be readily indicated by comparing the net immigration (immigrants less emigrants) in three periods. (1) the pre-War seven-year period ending June 30, 1914; (2) the War and early post-War seven-year period ending June 30, 1921; (3) the first eight years of the quota restriction period, ending June 30, 1929. Net immigration in the first period was 4,646,000, in the second, 1,254,000, and in the third, 2,314,000.

If we compute 'deficits' by finding the excess over the actual net immigration of that net immigration which would have occurred if the annual average net immigration of the pre-War period had continued in the War and post-War years, we reach some interesting estimates. The deficit for the seven years of the War and early post-War period was 3,392,000, and for the quota period, 2,996,000.

The decline in immigration was heaviest from the sources of the so-called 'new' immigration, that is, the countries of eastern and southern Europe. The deficit from this section of Europe was 3,410,000 in the eight-year quota period.

The 'deficit' in the net immigration of the unskilled was 1,565,000 in the War and early post-War period, and 1,451,000 in the quota restriction years. To reach this estimate we have counted as unskilled all those listed as having an occupation and not classified by the Bureau of Immigration as 'professional', 'skilled', 'merchants and dealers', 'agents', 'servants', 'farmers', or as in various other 'miscellaneous' occupations, totalling only 6,067 in the year ending June 30, 1929.

The corresponding deficits for all occupations are over 2,500,000 for the War and early post-War period, and over 2,200,000 for the first eight years of quota restriction.

attendant on changing mechanization had been unduly minimized in earlier years, now the pendulum swung back and there came a sharp emphasis upon, if not an exaggeration of, the actual and potential adverse effects of the machine. It was noted that the decade had brought marked increases in productivity in leading industries. F. C. Mills estimates an increase in output per wage earner in manufacturing from 1919 to 1929 of 43 per cent, or 3.8 per cent per year, compared with 1.7 per cent per year for the decade and a half, 1899–1914.[2] David Weintraub estimates the increase in output per man-hour in manufacturing, 1920–29, to have been 48 per cent (Ref. 23). For the same period, we estimate a 28 per cent gain in productivity per man-hour in the operation of steam railways in the United States and, in terms of annual output per 300-day worker, of 20 per cent in bituminous coal mining, 74 per cent in the mining of copper ore, and 82 per cent in iron ore. Productivity in anthracite coal, on the other hand, declined about 5 per cent.[3]

[2] In 60 individual industries for which the change in productivity per wage earner was computed by Mills the average annual rates of change from 1923 to 1929 increased in 56 industries, the maximum of 8.8 per cent being in the production of other than gas-house coke, and declined in 4 industries, the maximum decline of 3.6 per cent being in the organ industry. *Economic Tendencies in the United States* (National Bureau of Economic Research, 1932), pp. 290–7.

[3] The estimate for railroads follows the procedure used by W. H. Dunlap in an article in the *Monthly Labor Review*, March 1927, pp. 471–8. The 'traffic units' used in estimating the combined output of the freight and passenger departments were computed by adding to the total revenue ton-miles of freight each year the passenger mileage multiplied by 3. The productivity estimates for mining are computed from output data published by the U. S. Geological Survey in the annual issues of *Mineral Resources of the United States*, and from data on employment, in terms of equivalent 300-day workers, in bulletins issued by the U. S. Bureau of Mines on *Metal-Mine Accidents in the United States* and *Coal-Mine Fatalities in the United States*. Both underground and surface workers are included.

Doubtless substantial gains have been made in other industries for which data are not so readily available.

To appraise the causes of observed unemployment is a task rendered difficult by the fact that it is hard to distinguish between the labor-saving consequences of increased productivity and declines in employment that arise from changes in marketing conditions (see Ch. X). A further complicating factor is that, until checked by the depression, there had been tremendous migration from rural to urban areas, involving, among other shifts of population, a northward movement of the negro. Some have attributed these movements in part to marked increases in the mechanization of farm operations.[4]

It is in this setting that the inquiry upon which we are now reporting took shape. In 1923, at the request of the National Research Council, the National Bureau of Economic Research inaugurated a study of the relation between immigration and the supply of labor. It directed its attention first to the interrelation between cyclical and seasonal fluctuations in immigration and business conditions. A report on this subject, *Migration and Business Cycles,* was issued as volume 9 of the National Bureau publications. Later, in cooperation with the Social Science Research Council, the National Bureau continued, under the former's auspices, the study of the relation between immigration and labor supply. Attention was next directed to the possible relation between an increased use of labor-saving machinery and any shortage of labor that might derive from a continued restriction of immigration. We have noted that this question arose during the consideration of the quota acts. Fears were expressed by some that restriction might be disadvantageous to the interests of American industry. It was pointed out that a large

[4] See Ch. IV, section on Agriculture.

proportion of those workers who are engaged in the rough, dirty and unpleasant tasks, the tasks requiring on the whole a relatively small degree of skill but much physical strength and endurance, were of foreign birth. Furthermore, to those raising this issue no general willingness on the part of the native born to engage in such rough manual work was apparent. "How then," was the query, "are we going to get our rough work done? If we bar a substantial portion of the class of laborers from whom our unskilled laborers have been recruited in the past, who will dig the ditches, mine the coal? Can we narrow the sources of our labor supply and expect to achieve the development of our productive enterprises that is considered desirable?"

One suggestion made when this issue arose was that in the absence of large accretions by immigration to the ranks of those able and willing to do the rough and dirty work of industry, we should find not that the progress of industry would be seriously handicapped but that the use of labor-saving equipment, which has always been a marked characteristic of American industry, would be stimulated still further and hence the effects of immigration restriction would be offset, at least in large degree, by increased use of mechanical devices to do the kind of work for the performance of which we have in the past relied upon the brawn and willingness of recently immigrated workers.

Our survey was initiated as an inquiry into the problem just stated. We set out to examine the nature of the occupations and industries in which immigrants engaged and the tendencies towards and possibilities of mechanization in them. But, as indicated above, during the years in which the inquiry has been in progress, the question of the restriction of immigration has passed from the center of the stage. On the other hand, attention has been focused in increasing degree upon the nature and effects of progressive mechaniza-

tion. Consequently, though the form which the early stages of this inquiry took was determined to a large extent by its potential bearing upon the immigration problem, the attempt to relate the analysis to the question of immigration restriction as such has been abandoned; it has seemed advisable rather to study the characteristics, conditions and effects of changing mechanization. To this end we endeavor to set forth as clearly as we can the degree of mechanization in the leading industries, and the nature of the changes taking place as reported to our field investigators or ascertained from other sources of information; and then to formulate at least tentative hypotheses as to the conditions that determine the rapidity of mechanization, and the effects of increasing mechanization, especially upon the number and type of workers required for the production of goods and services.

Methods and Materials

Our problem is many-sided and our methods of attack upon it have been diverse. We have tried so to conduct our inquiry that it would suffer neither from an exaggeration of spectacular but unrepresentative developments nor from a failure to give due recognition to significant changes. We have utilized whatever pertinent material we could find in the published reports of the federal and several state governments and also in various books, pamphlets, articles in periodicals and unpublished material prepared by many individuals. For a large part of our information we have relied upon data gathered by field representatives in inspections and interviews with executives in several hundred factories and construction operations.[5]

[5] Aside from cotton and furniture mills in the South, lumber mills in the Northwest, paper mills in Wisconsin, and highway construction operations in the Middle West, the majority of the plants inspected were in

Our study and inspections commenced in the autumn of 1924 and were conducted actively in the summer of 1925. Further inspections, especially of machine industries, and inquiries into the proportion which workers engaged in materials handling constitute of the total force in factories as a whole and in the several departments, were made in 1926. Also, supplementary studies of changes in productivity and accompanying changes in equipment were made in the closing years of the decade in lumber, cement, beet sugar, and to a lesser extent in other industries. The collection of information by mail and the examination of published data have been continued through all these years. As a result, our information does not all apply to exactly the same period, and much of it is not fully up-to-date. However, we trust this defect is more than compensated for by the more inclusive nature of our information and the better perspective that the passage of time has made possible.

The tentative conclusions based upon the field surveys have been verified and checked as far as practicable by correspondence and interviews with persons familiar with the technical problems of the several industries and by reference to the published descriptive and statistical material of more recent years.

To some of the industries chosen for special study we sent representatives to observe operations and interview executives. Most of the work of this type was done in foundries, brick yards, steel, cotton and paper mills, highway construction, and the excavating phase of building construction though a limited number of inspections were made in several other industries.

the New England, Middle Atlantic and East North Central states. Further details concerning the geographical location of the plants inspected are given in Ch. III and IV.

BASES OF SELECTION OF INDUSTRIES

In selecting the industries to which special attention should be given, we aimed at a diversity sufficient to furnish examples of the more important conditions affecting the degree and rapidity of mechanization. We sought examples of both expanding and declining industries; of highly mechanized and of predominantly manual operations; of light and heavy manufacturing; of markedly seasonal industries and of those more continuous in operation; of industries with well-standardized products and of those with diversified products and production in limited quantities; of industries in which mechanization has proceeded leisurely and of those in which it has been rapid and perhaps with revolutionary effects. Furthermore, the peculiarities of certain industries suggest their obvious suitability for special study.

Common brick, for example, was chosen because the relative simplicity of the processes facilitated study, the proportion of unskilled labor is high, the volume of handling work large. Incidentally, it affords an example of an old industry catering chiefly to local markets but scarcely holding its own against severe commodity competition. The foundry is an essential part of the business of producing machines; it involves much heavy and arduous work in the handling of materials and, while using much relatively unskilled labor, also affords examples of the encroachment of machine operations upon skilled handicrafts. The steel industry, likewise, is closely allied to the machine-producing industries and employs a large number of workers, many of them of immigrant origin. And, for our purpose it had the advantage that one of our staff had previously given special study to it and upon certain phases of the industry an unusual abundance of published materials is available. Cotton goods affords an example of an industry that has long been

highly mechanized; its processes are reasonably comparable though the product is varied, and it is geographically concentrated in two major competing areas, the one utilizing in large part female workers of foreign stock of the first or second generation, the other, which has been growing more rapidly, relying almost entirely upon native white workers. Pulp and paper manufacture affords an example of an industry highly mechanized on the processing side, operating customarily on a 24-hour basis and, incidentally, concentrated in this country largely in regions where we were studying other industries. Stevedoring and the handling of retail coal were selected as illustrative of industries that perform almost exclusively handling rather than processing operations. Highway construction affords an illustration of a rapidly growing industry, using a large proportion of unskilled labor and operating under highly seasonal conditions, frequently with considerable urge to the speedy completion of the job.

Further diversity in type is added by the industries for which our own inspections do not constitute the major source of information. For example, bituminous coal mining is of large interest because although overdeveloped and overmanned, it is nevertheless becoming more and more mechanized. As to agriculture, conditions in the post-War period caused large numbers to leave the farm, and thus to swell the ranks of the industrial workers, at the same time that more power machinery was being used in both farm and factory. The mechanization of household tasks illustrates the invasion of the machine into the personal service field. Glass affords an example of a relatively recent transition from handicraft to machine methods, and the pertinent published material available is quite abundant. In the sound movie we have an example, in its effects on the employment of

TABLE 1

SCOPE OF SURVEY AND SOURCES OF INFORMATION, BY INDUSTRIES [1]

INDUSTRY	TOTAL PLANTS IN SURVEYS	PLANTS INCLUDED IN MECHANIZATION SURVEY		PLANTS IN OUTPUT-PER-HOUR SURVEY	CHIEF SOURCES OF INFORMATION [2]
		FIELD	MAIL		
All industries	1,301	710	320	271	
Allied to machine-producing industry					
Steel works and rolling mills	9	9	...	...	Published statistics; special studies [2]
Foundries	89	83	6	...	Mechanization field survey
Machine shops	4	4	...	...	Mechanization field survey
Machine manufacturers	56	52	4[3]	...	Field survey; machine producers
Other manufacturing					
Brick, tile and pottery	112	65	20	27	Field survey; output-per-hour survey
Textiles	117	80	37	...	Field survey; textile machinery manufacturers
Paper and pulp	45	35	10	...	Field survey
Furniture	42	28	14	...	Field survey
Garments	20	20	...	...	Field survey
Cement	104	6	...	98	Output-per-hour survey
Lumber	42	...	3	39	Output-per-hour survey
Glass	8	4	4	...	Special studies; technical journals
Beet sugar	90	...	...	90	Output-per-hour survey
Miscellaneous [4]	227	100	111	16	Field survey; mail; technical journals and special studies

Construction					
Roads and pavements	122	66	56[5]	...	Field survey; mail
Building, excavation and structures	120	102	18	...	Field survey; special studies
Handling industries					
Stevedoring	46	22	24	...	Field survey; special studies
Retail coal	38	28	10	...	Field survey
Mining	5	5	...	...	Government statistics; special studies
Other industries [6]	5	1	3	1	See footnotes

[1] For further explanation of the surveys briefly designated in Table 1 as 'Mechanization field survey,' (or, for short, 'Field survey') and 'Output-per-hour' survey see text of Ch. I. Workers in the 1,030 establishments covered by the mechanization survey numbered about 310,000.

[2] 'Technical journals': information obtained from examination of articles in magazines devoted to particular industries or to the manufacturing, construction and engineering industries in general. This type of information has been used sparingly.

'Special studies': monographic reports listed in Appendix D.

[3] Exclusive of machine-producing establishments that furnished annual sales data but not other information.

[4] 'Miscellaneous' manufacturing comprises a few plants each in many industries, including: food products 52; iron and steel products (other than those listed elsewhere in the table) 26; lumber products 3; leather and its products 21; rubber products 7; printing and miscellaneous paper products 8; chemicals and allied products 12; lime 3; brass and other non-ferrous metal products 32; tobacco manufactures 10; passenger automobiles and motor trucks 20.

[5] Includes reports from 31 state highway engineers on mechanization developments in their states.

[6] 'Other industries' includes three hotels, a power laundry and a municipal water works. Also, in Ch. III and IV various industries are discussed that were not included in our field survey and are not listed in this table—agriculture, domestic service and numerous other manufacturing and non-manufacturing industries. The sources of information concerning these industries are indicated at appropriate points in the text.

musicians, of the revolutionary type of mechanization that is sometimes alleged to be typical of the entire process.

In Table 1 we have summarized by industries the scope of our factory inspections and indicated the extent to which information obtained from other sources has been utilized. Some further explanatory details appear in the table footnotes.

INFORMATION SOUGHT IN FACTORY INSPECTIONS

In the industries to which we devoted most detailed attention in the field phase of our survey, the general plan of procedure was to determine the successive major processing stages or departments in the industry, and to ascertain for them the proportion of labor force involved, the type of equipment used, the modifications in equipment that had been made since 1920 and their effect on the size of the crew required.[6] We did not attempt to trace the subsequent employment experience of any workers displaced. The scope and form of the questions evolved somewhat as the survey progressed and also varied considerably from industry to industry. Typically they concerned the following points: How many workers are employed in each major process? How many are machine operators or machine helpers and how many hand workers? And, as a clue to the proportion of unskilled workers, how many are receiving the customary rate for common labor? What labor-saving changes have been made since 1920? With what effect?

For a limited number of plants in a few industries we obtained a statement of all major items of equipment, when they were installed and what they replaced, even if they were not specifically identified as labor saving.

[6] In some instances we obtained information for earlier years, but most of the figures are dated 'since 1920'.

In several industries we gave special attention to the equipment, the workers and the volume of work involved in the handling of materials, recognizing that in many industries a transition from manual to mechanical means of handling has played an important role in recent labor-saving developments (see Ch. V).

In the summers of 1927, 1928 and 1929 our field representatives obtained data concerning changes in output per hour, and the accompanying changes in method and equipment, for a substantial proportion of the plants engaged in the manufacture of Portland cement, Douglas fir lumber and beet sugar, and for a few plants in several other industries, notably clay products and wheat flour. These studies have contributed to this report in numerous respects, though the results are not published here in detail.

For the machine-producing industries, we sought information concerning the type of labor used, the conditions that further or retard sales, and the volume of sales from year to year. Some machine plants were included in the inspections made in 1925, and in 1926 the writer visited another group to obtain data concerning the characteristics of the machine-producing industry. Also, in the subsequent years correspondence has been carried on with some hundreds of machine-producers on various phases of our problem. From about a hundred producers we have obtained their annual sales volume.

SUPPLEMENTARY SOURCES OF INFORMATION

On selected points we have sought information by mail from a group of machine users in a wide variety of industries, endeavoring in this way to fill some of the gaps left by our necessarily limited selection of industries for field study. For example, reports by mail from between 150 and 200

factory executives stated the nature and effect of the most important labor-saving change made in their respective plants since 1920. Also, inquiries concerning labor-saving changes were directed to the state officials in charge of highway construction.

Finally, we analyzed numerous articles in various technical journals, as a supplementary method of assuring ourselves that we had not overlooked significant movements in mechanization. Such material taken alone is likely, we believe, to be colored by the successful efforts of the more progressive firms; but it has been useful in guiding us in our research and illuminating the information obtained in other ways.

The principal sources of information other than our own survey are cited at the points used.[7] We are heavily indebted to the contributions made by the Bureau of Labor Statistics in its productivity studies of merchant blast furnaces, stevedoring, the dial telephone, printer telegraph, cigar machine and other industries. The treatise by William Haber, *Industrial Relations in the Building Industry,* has been relied upon for information to supplement our limited sample of building operations. The studies made by Dr. Elizabeth Baker in the commercial printing industry are especially noteworthy for the comprehensiveness of treatment. In coal mining the report of the Coal Commission, the *Coal Mine Mechanization Year Book* of the American Mining Congress, the statistics compiled by the Geological Survey, and various private studies such as those of Southward, Hamilton and Goodrich, have been our chief sources of information. Special studies by the Department of Agriculture and its statistics of annual sales of farm equipment have contributed largely to

[7] See also Bibliography, Appendix D.

the data on mechanization in agriculture. Similar sources of information could be cited for the other industries.

Summary of Findings

It is not our purpose to essay the formidable task of appraising the relative merits of machine and handicraft civilizations and the cumulated changes wrought in our economic, social, political, moral and artistic life in the course of the long evolution from completely handicraft industries. We are here concerned only with the more limited task of appraising the nature and significance of current changes in the degree of mechanization.

These short-time aspects are of major importance. A return to a pre-machine civilization may be impossible; but it is not impossible to reach such an understanding of current changes that we may in some degree control the manner and rapidity with which they take place.

Now the most important single question about current changes in mechanization is, how fast do they occur? If the rate is unduly checked, industry does not progress. While a moderate rate of change may be relatively painless, it is obvious that an extremely rapid tempo may result in major social maladjustments. Moreover, if the rapidity of increase is overemphasized, exaggerated fears of the deleterious effects may be aroused. On the other hand, if the probability of substantial change is greatly underestimated, we are likely to neglect due precautions to minimize the individual and social disadvantages incident to mechanical progress.

Hence, we shall marshal our evidence so as to throw light upon the rate of mechanization that has prevailed in the relatively recent past and to make possible inferences as to the rate that may be expected to prevail, given substantially similar conditions in the future. The writer interprets the

evidence presented in the following chapters on the nature, causes and effects of changing mechanization as leading clearly to a 'middle-of-the-road' conclusion concerning the rate at which mechanization may be expected to proceed.

To particularize:

1. A continuing increase in mechanization at at least a moderate pace may be expected. For even in modern industry there is abundant scope and ever-present incentive for further mechanization.

First, there are still many operations not yet thoroughly mechanized, if mechanized at all.[8] The extent of mechanization varies markedly not only between industries but also between the several processes in an industry (see Table 30). Thus, fabrication processes are more highly mechanized than handling operations.[9]

Again, at any given time few of the labor-saving devices in commercial use are universally installed throughout the industries or processes for which they are adapted (*cf.* Ch. VII and Appendix B); and the competition of the more modernized establishments affords a more or less constant incentive to further installations. Even in depression periods, although the purchases of new equipment decline sharply (see Ch. VIII), there is a strong incentive to increase productivity through a more effective organization of the equipment already in place. Likewise, the development of new techniques and equipment is never completely at a standstill.

2. No more likely than a near cessation of mechanical

[8] In the aggregate of factory and construction operations inspected by us, hand workers constituted 44 per cent of the total, the ratio ranging from as low as 12 per cent for cotton goods manufacturing to about 70 per cent for ferrous foundries and about 80 per cent in some non-manufacturing industries (Table 29).

[9] In a group of 45 brick plants inspected, handling was by power methods for less than half of the total distance materials were transported (Table 10).

progress is the danger of an uncontrollably rapid mechanization. The phenomenon of increasing mechanization is too complex, too varied, too pervasive, to justify the assumption of a radical change in rate unless conditions are exceptionally favorable. These the near future does not promise. The executive in whose hands lies the decision for or against increased mechanization must weigh not only the technical difficulties to be overcome but also considerations of increased overhead expense, the availability of an adequate market for an increased output, the cost of scrapping the existing equipment, and the difficulties of financing new equipment, the possible opposition of his workers, and sometimes adverse public opinion and even restrictive legislation.

The many-sided nature of changing mechanization will be apparent to the readers of Chapters III, IV and V. Alike in manufacturing and non-manufacturing industries we find numerous examples of labor saving through increased mechanization in a wide variety of forms. Here the gains are through completely new technique or equipment; elsewhere merely through higher speeds or larger and more powerful machine units (Ch. VI). Mechanization in building construction has advanced through changes in materials and consequently in the essential erection processes. In coal mining, on the other hand, the work to be done has retained its general character and the process has been merely one of applying machinery to the kind of task formerly done with hand tools. Many economic changes have indirectly contributed to the growth of mechanization, notably (a) the elimination of inefficient plants and regional shifts to high-productivity areas; (b) in certain industries, a decline in the number of establishments and an increase in their average size, although this movement has not been marked in the decade of the 'twenties for manufacturing as a whole; (c) in many industries, an evident tendency to increase the capacity of indi-

vidual machine units (Table 23); (d) marked gains in the degree to which the manufacturing industries are electrified. It is estimated that the degree of electrification was 44–49 per cent in 1919 and 69–74 per cent in 1929 (Table 24).

The improbability of a sudden change in the rate of mechanization is enhanced by the fact that numerous changes of a minor sort, in some industries at least, outweigh in importance the more spectacular innovations (Ch. X). Examination of the records of labor saving obtained by us in interviews and inspections of industrial and construction operations reveals a preponderance of changes with small reductions in the number of workers required. In half of the instances the number of men saved per plant was under 10, even when allowance was made for increased output of the crew. Evidence supporting the thesis of the relatively high importance of numerous small changes is afforded by other studies of mechanization and changing productivity.

That the several stabilizing factors above mentioned do in fact retard the rate of introduction is evident from a consideration of the typical life histories of machines (Ch. VIII). Most machines require several years to pass through the period of experimentation and trial, several more to reach widespread adoption, after which they continue to increase in use more slowly for several additional years. A sample of 23 machine series, for periods ranging from 11 to 39 years, yields the following estimates of the typical duration of periods in their life histories: commercial trial, 3 to 11 years; rapid increase in use, 4 to 11 years; slackened increase (with a customary annual gain of less than 10 per cent), 3 to 6 years; decline of undefined length. Processes and types of equipment suffer declines for long periods before they pass completely out of use. They linger on in small plants and for special uses long after they have been replaced

by new processes or equipment in the major part of the industry.[10]

It does not appear probable that in the near future conditions will be exceptionally favorable for rapid mechanization. There is on the industrial horizon no clear evidence of that rapid expansion in industries and an easy capital fund market which are particularly favorable to rapid changes in technique. Furthermore, the experience of the closing years of the 'twenties and the subsequent depression period have focused attention as perhaps never before upon the unfavorable aspects of increasing productivity, and it is possible that measures will be designed to check unduly rapid mechanization. Already some measures restrictive of the use and expansion of machine equipment have been written into the codes under the National Industrial Recovery Act, and there have been various proposals for a dismissal wage and taxes on machinery designed to retard excessively rapid and disruptive changes in equipment or technique.

3. Changes in the rate of mechanization, although limited, are not negligible. The record of experience and a consideration of the factors limiting mechanization have led us to the conclusion that the rate of change in mechanization is relatively stable; but this means, not that there are no significant differences or changes in the rate of mechanization, but rather that they are within limits that are to a reasonable degree predictable.

That the rate of mechanization is variable, and in fact, reached a somewhat unusual speed in the 'twenties, is reason-

[10] See *Economic Reconstruction,* report of the Columbia University Commission on Economic Reconstruction (Columbia University Press, 1934). Replies to questionnaires addressed to prominent engineers and business executives indicate a possible improvement of 75 per cent in physical output if existing equipment and management were brought up to the level of the most efficient.

ably clear, despite the lack of precision in the available measures of mechanization and productivity (Ch. VI). With high wages, restricted immigration, relatively low prices for capital goods and an abundant and easy capital market (Ch. IX), the conditions for rapid mechanization were unusually favorable in that decade. At the peak for manufacturing (which was in the biennium 1923–25) the rate of increase in mechanization, as measured by horsepower per wage earner, reached 6.4 per cent.[11] For the decade 1919–29 as a whole it would appear that agriculture, mining and steam railroads show even greater gains than manufacturing in the ratio of horsepower to wage earners.

4. Even within the limited range of fluctuations in the rate of mechanization, there are, as indicated by the experience of the 'twenties, some ill effects requiring thoughtful consideration, but again, the rate and extent of such maladjustments are not beyond reasonable possibility of prediction and control, or at least the effects can be foreseen and ameliorated.

First, the progress of mechanization brings, especially when rapid, a substantial amount of skill displacement and technological unemployment which, even in the case of changes representing a net gain to society as a whole, may bring serious losses to individual workers, particularly to the older and highly skilled.

Finally, while advancing mechanization probably tends to lessen seasonal fluctuations in industry, there is reason to suspect that it may aggravate cyclical fluctuations through intensifying competition, enlarging the function of capital

[11] The rate of increase in aggregate horsepower in manufacturing was on the whole less in the post-War period than in the War and pre-War years; but horsepower per wage earner experienced a more rapid rate of increase in the post-War period, the maximum being reached in the 1923–25 biennium.

goods in the economic system, and (to the degree that it raises the general level of real income) increasing the share of expenditures in those lines, such as durable consumer goods, the effective demand for which is characterized by sharp reductions when a recession sets in. In brief, to the extent that mechanization contributes to the unpredictability and the variability of economic processes, it may likewise contribute to an aggravation of the severity of cyclical fluctuations.

Limitations of Findings

We are here concerned primarily with labor-saving changes that take the form of increased mechanization. It is beyond the scope of the present inquiry to attempt a detailed description and appraisal of the non-mechanical efficiency devices, though at various points in the text incidental attention has been given to this important phase of industrial change.[12]

Nor have we attempted to describe in detail the industrial processes in which labor-saving improvements have taken place or their technical character. At first we contemplated the inclusion of separate chapters for each of several selected industries, with descriptions of processes, equipment and changes; but it has seemed advisable to restrict ourselves to brief summaries for the several industries.[13] These are given in Chapters III, IV and V, together with bibliographical references which will aid the reader if he wishes further details. Although we have written for the layman rather than the

[12] *Cf.* the recently published article by W. G. Roylance, Significance of Nonmechanical Factors in Labor Productivity and Displacement, *Monthly Labor Review,* November 1933, pp. 1028–38.

[13] A typed copy of the more detailed draft of the description of processes, equipment and changes in the selected industries is on file in the office of the National Bureau of Economic Research.

technician, we have sought to give a substantially accurate picture of the technical aspects, and to lessen the chances of error we have submitted the more detailed description of changes, in a number of the industries to which special attention was given, for the criticism of persons familiar with the technique and problems of the industry in question. We have not endeavored to state the relative pecuniary costs of particular hand and machine methods, nor to indicate to the factory executive what mechanical devices will be economical for his use.

Paralleling the seasonal, cyclical and technological unemployment of workers is an analogous set of phenomena pertaining to seasonal and cyclical idleness of plant and equipment, and the technological obsolescence of equipment as new competing techniques arise. The entrance into an industry of competitors equipped with new devices and techniques lowers the earning power and encourages the scrapping of out-moded equipment. The job uncertainty that arises for the worker from technological change finds a counterpart in earning power uncertainty for the capital invested in equipment threatened with obsolescence. How can we obtain significant measures of effective capacity, in order to have a sound basis for measuring idleness of equipment? How can we measure the rate of obsolescence and appraise its effects on the nature and profits of industrial operations? Here is a research problem affording a real challenge to the analyst of mechanized industry, and requiring, for thorough consideration, the application of careful accounting and statistical technique and a fund of data not now available. We have not attempted to deal with the problems of equipment unemployment and obsolescence, other than in an incidental way, but they should be recognized as important aspects of mechanization.

Furthermore, this report does not attempt to forecast the

precise nature and effects of anticipated mechanical changes. Obviously, it is impossible to foretell with any approach to precision what developments will take place in the use of mechanical power even within the next few years. Improvements in the use of mechanical equipment and the expansion of scientific knowledge upon which such appliances in large part depend must be recognized as unpredictable in detail. Applied technique, and the science upon which it rests, is in a constant state of flux. Some developments can be anticipated with relative certainty; others are entirely unpredictable.

Finally, as previously noted, this study of mechanization is not designed as a broad comparison of the nature, merits and demerits of a machine civilization in general with more primitive forms of social and industrial organization. It is rather a study of the more immediate differences that arise from the types of change that may be expected from year to year and decade to decade as industry evolves from the stage of development now reached.

Despite the large unpredictable element in the future development of mechanical appliances, we entertain the hope that the reader who scans these chapters and weighs the evidence presented concerning the conditions that affect mechanization will be in a better position to judge for himself concerning the probable limits to the changes to be anticipated in the reasonably near future. The economies of labor-saving machinery pertain to an important phase of our economic life and a phase that has by no means been fully explored. We hope for this study that it may better somewhat our understanding of the conditions which have aided or hindered in the past and which may be expected in the future to continue to affect the development and use of power as a substitute for human labor, or perhaps more accurately, as a complement to human labor, in the production of goods

and services. Even in the many respects in which this study is based upon scanty materials (and the conclusions are necessarily tentative), we hope it will help to point out what further studies are needed. There is much to be done.