THE SCIENTIFIC REVOLUTION AND ITS IMPACT ON MODERN ECONOMICS*

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INTRODUCTION

The main thesis of this paper is that a new revolution has occurred in the economy of the civilized world, a revolution to be called the scientific revolution. This revolution occured mainly in America around the end of the last century. It superannuated, therefore, the old industrial revolution which had its origin in England during the latter part of the previous century and then spread to America in the decade or two following the War of 1812. The impact of the new revolution on modern economics has caused changes no less significant than those produced by the former revolution, some of which will be pointed out in the latter part of this paper after the nature and characteristics of the new era have been indicated.

There is no longer anything revolutionary about industrialization in America. Industrialization in this country has been continuous, coming mainly as a sequel to the political revolution and as a part of the process of a new country becoming weaned from the economy of the old world, the process of a land caught in a primitive stage of development coming rapidly abreast of the most advanced civilization of the period. By the time of the Civil War, America had begun to develop a civilization that gave it substantial independence from the rest of the world. By 1900, the western frontier was closed and the census revealed that the majority of the population no longer made its living by agriculture. During most of the present century, the growth of employment in manufacturing, as a percentage of total employment, has not kept pace with the growth in commerce and trade, and both have lagged behind employment in government and professional services—the loser throughout the period being agriculture. Not only commercialization and socialization, but other movements such as urbanization, mechanization, consolidation, and greater capitalization are the aspects of the evolution of a growing economy and concomitants of industrialization, in some cases its causes and in others its consequences.

Of paramount significance during these developments was the practical application of science. Science and its handmaiden, technology, constituted the dynamic and the upsetting force behind the new revolution, the force that made the period one of revolution instead of evolution. Science was applied not only in the field of the natural sciences and in industry, but also in agriculture, en-

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gineering, medicine, marketing, management and other fields, and in all with revolutionary results. The significance of science did not lie, therefore, in its subject matter alone, but also in its purpose and its methodology. Science is creative in purpose and fact-finding in methodology; it analyses, classifies and summarizes facts in order to draw conclusions; and it attempts to test its conclusions with previously established facts and with new facts as they may be discovered. For these reasons the term "scientific" seems to be a better choice of a name for the new revolution than "technological," "new industrial" or other terms that have been suggested.

The period which first felt the impact of science was, roughly, one beginning a little before 1880 and extending to the outbreak of World War I in Europe, a period including the roaring eighties, the gay nineties and the beginning of the present century. It should be pointed out, however, that no period in history is self contained, nor are the contributions and characteristics of a previous period erased by a succeeding revolution. Those that have survival power merely lose their dynamic influence and become commonplace though still important from the point of view of quantity of usage. For the same reason the main developments of the scientific revolution did not come to an abrupt halt at the end of the period; they merely lost their revolutionary character. Since the creative force of science, a force that is not exhausted by its use, constituted the dynamic element in the new era, there is ample justification for inferring that the scientific revolution marked the beginning of what has been called our "permanent revolution." It was in this period that the pattern for the present economy was forged and many of our most successful modern institutions were established.

To prove that this period should be singled out as a period of revolution, rather than a mere span of time in economic evolution, we need but to refer to history for analogies and precedents, and to see how historians have defined and distinguished previous stages of development and other so-called revolutions. Although any segmentation of history into eras or stages is arbitrary, historians do seem to have agreed that there were periods that may be marked as revolutions, each having its peculiar characteristics and its dates of beginning and end. Although a review of previous revolutions is essential as a background for an understanding of the new era and as a guide in selecting the forces and factors which constitutes its main characteristics, it need not be attempted here. The division of economic evolution into stages such as the hunting and fishing, the pastoral, the agricultural, the handicraft, and so on, are already well known. Also familiar to all students of economics are the so-called revolutions, such as the renaissance, the commercial revolution, the mechanical revolution and others descriptive of some aspect of economic evolution. Adding a new revolution to this list is a presumptuous as well as a precarious undertaking; but doing now what future historians will some day do for us should not only keep history up to date but help better to understand our own age and our modern economy.

Before proceeding with a description of the new era it should be pointed out that a single example or a first event of an important development occurring

in an unfavorable environment or ahead of its time may be of little or no significance. For example, Hero made a steam engine about 300 B.C. in Constantinople, and da Vinci designed an aeroplane nearly 500 years ago. Moreover, the Greeks seemed to have thought out much of what had to be rediscovered centuries later and, as is said, they usually had a name for it, but they never perfected a system for linking together the various components necessary for the implementation of their ideas. They failed to develop an economy that could provide them with a surplus of capital and the means of protection against outside marauders. They spurned industry and commerce in favor of the finer arts, a practice, incidentally, which some of our scholars would have us imitate today.

The industrial revolution was the result of a concatenation of events occurring during a short period of time. It is perhaps best remembered by the year 1776, a date that marks the beginning of American democracy and the publication of *The Wealth of Nations*. Moreover, it came only eight years after the invention of the steam engine by James Watt, a friend of Adam Smith, and only one year after the several textile inventions were brought together in one machine, a feat accomplished by Richard Arkwright, sometimes called the Henry Ford of his day. Before the end of the century, Edmund Cartwright had patented his power loom, and Henry Maudsley had made a lathe which formed the basis for the machine tool industry. So numerous were the inventions of this kind that the period is often referred to as the mechanical revolution. The period is also known for other significant contributions to our present economy, for example, the factory system, wage labor, city slums, the limited liability corporation, and the beginning of experimental science. These developments, and many others that might be mentioned, are characteristics of the industrial revolution, characteristics that should not be confused with those of the later scientific revolution.

In order to summarize the characteristics that distinguish the scientific revolution, the achievements of the period may be grouped according to what appears to be the most significant areas of development. Accordingly, the revolution may be described by examining briefly the following factors: (1) technological developments, especially those in materials and in the sources and forms of energy, (2) systems of operation, including the systems of manufacturing, marketing management, (3) institutional changes important in creating and perpetuating the revolution, and (4) economic theory and the new schools of economic thought.

TECHNOLOGICAL DEVELOPMENTS

A. Materials. The materials with which a civilization fashions the tools used in its productive processes have been usually included among the factors by which a stage or a revolution is known and distinguished. The scientific revolution has been characterized accordingly as the age of steel. Steel had been in use for several centuries, but it had never been produced cheap enough for everyday purposes until the Bessemer and the open-hearth furnaces were perfected about

the time of our Civil War. Likewise, wood, one of man's oldest materials, had defied all attempts at substitution until plastics were developed by Hyatt a little later. The first alloy steels, which permitted the cutting of ordinary steel as such steel cuts iron and as iron cuts wood, were not perfected until near the end of the century. Copper, another old and useful metal, was not produced on a large scale until after 1880; electrolytic aluminum and carborundum were produced in 1891; and cement was made by the efficient rotary kiln around 1895—to mention only a few of the most basic materials.

Other materials that have proved to be of revolutionary importance to the present economy were also first produced during this period: the numerous products of coal tar distillation became available after 1882, sulphate paper in 1884, and nitric acid by the cyanimid process in 1895. By the end of the century the age of industrial chemistry had begun. America became independent of Britain in the production of inorganic chemicals after 1890, although its independence of Germany in organic chemicals did not come until after World War I. The revolution in chemicals, it may be noted, still shows little indication of reaching a stage of diminishing growth; research budgets in chemistry are the largest in American industry and still growing. The situation is much the same in other branches of science. For example, it is estimated that one half of the products sold in a drug store did not exist ten years ago, and that ninety per cent of prescriptions are now written for medications that did not exist fifteen years ago. These materials and many others upon which the present civilization is dependent were largely unknown to the industrial revolution. Synthetic chemistry no longer attempts to duplicate nature, but to make materials that nature cannot duplicate.

B. Energy. Energy, or power as it is more popularly called, has always been regarded as a vital factor in man's progress. In fact, one of the best indexes of the standard of living of any country is the amount of energy per capita it uses. Each new source and each new form releases human energy for other pursuits and opens up new fields of application that often herald a new age. The internal combustion engine perfected by Otto in 1876 was a development of this kind. It was followed by the invention of the automobile by Benz in 1885, a newer type of engine by Diesel in 1895, and the aeroplane by the Wright Brothers in 1903, all of which taken together have indeed revolutionized transportation. In the field of stationary power, the development of the water and the steam turbines during the last decade of the nineteenth century was of no less significance in permitting greater efficiency to be gained from old sources. Now that a new source, atomic energy, and a new type of engine, the jet engine, are on the way, a still newer revolution is predicted.

A new form of energy is of as much practical importance as a new source, for it makes possible what was previously impossible. The phenomenon of electricity, for example, was known to the Greeks who gave it its name; and Sir William Gilbert, physician to Queen Elizabeth I, because of his early experiments, has been called the father of electricity. Many others since his day made valuable contributions to the subject, but even so, the industrial revolution had

only mechanical and thermal energy to do its work. It was apparently not until Edison invented his incandescent lamp in 1880 and installed his "jumbo" generator in 1882 that this form of energy became of practical importance in the economy of the country. The invention of wireless by Marconi in 1898 and other inventions by DeForest and Fessenden during the next fifteen years started another series of developments that produced the new field of electronics, the field that gives us hope of getting some day our mechanical brain. Other forms of energy, magnetic, chemical, and radiant, were put to greater use mainly during this period.

SYSTEMS OF OPERATION

A. Mass Production. No factor or characteristic of our economy has received more comment and sometimes admiration than our system of manufacture, generally known as mass production. Although this system contains the specialization of labor of the gild system, the functional separation of marketing and manufacturing of the domestic system, and the powered machines of the factory system, it contains other features found in none of these. Eli Whitney is usually regarded as the father of mass production because of his early application of the principle of interchangeable parts. Eli, however, did not have the other essentials of the system known as mass production today. He could not standardize parts with sufficient accuracy for mechanical feeding and fitting; he had not yet made automatic special purpose machines; he did not know how to use powered conveyors and moving assembly lines; and he did not have the benefit of time and motion study to help him simplify tasks and schedule production. These several elements of the system were developed and perfected separately, for the most part, during the latter half of the nineteenth century. They do not seem to have been integrated into one complete system for large scale production, however, until soon after Walter Flanders, an expert on work simplification, became production engineer for the Ford Motor Company in 1908. Thereafter the new system soon proved its superiority and spread rapidly throughout American industry.

Mass production, it might be mentioned, usually implies large-scale production, although size is only a relative characteristic. The mass-production plant does have to be large enough to make its product, to use specialized machines and equipment of the most efficient size, and to obtain the optimum degree of specialization of labor and management. Such a plant, furthermore, due to usual high overhead costs, requires continuous operation and sufficient volume of purchases, services, and sales to permit bulk handling and trading. It is usually built for a definite capacity and it operates efficiently and economically only within narrow output limits. A plant larger than necessary, due to the cost and inconvenience of transportation of materials and communication of workers, is at a relative disadvantage. The trend in recent years has been toward decentralization and diversification, which usually mean smaller-scale production, but production nevertheless.

B. Mass Marketing. Mass production leads naturally to another development

of the scientific revolution that is sometimes overlooked—mass marketing. The industrial revolution never advanced in the distribution of its products much beyond the methods developed by the preceeding commercial revolution. Peddlers and hucksters were still common in this country at the end of the last century. Probably one of the first new developments in merchandising in this country was the old trading post, an institution regarded by many as the prototype of the modern department store. Several early merchants have been designated as the father of the department store idea, but it was not until considerably after the Civil War that John Wanamaker developed the idea into its modern form. The first unit of the Great Atlantic and Pacific Tea Company was established as early as 1859, though the chain store idea did not spread until several decades later. These contributions and many others suggested by such names as F. W. Woolworth, A. T. Stewart, Sears and Roebuck, R. H. Macy, Marshall Field, Montgomery Ward, John H. Patterson, P. T. Barnum, William Wrigley, and others who were leaders in various aspects of mass merchandising during the decades that followed. In 1870 there were only 7,000 drummers on the road; in 1900 there were 93,000. The national magazine and mass advertising began in the eighties and grew phenomenally until the end of the period of the revolution.

Marketing, having once become large scale, created the opportunity and the incentive for the study of ways and methods of further improving the process. Many of the policies and methods in use today were tested and proved successful during the period, such as the one-price policy, the use of prizes, the acceptance of returned merchandise, free delivery, cash and carry, the money-back guarantee, installment selling, the rudiments of market analysis, and many others. An early example of the modern discount store, for instance, was the cut-rate drug store which appeared in the eighties. Developments such as these when combined into an integrated system have been characterized as scientific merchandising and constituted what has been called the mercantile revolution. Mass production is dependent, of course, on mass distribution to create a "mass" demand and maintain a continuous market for its standardized output. It forces upon marketing and merchandising the burden of servicing and adjusting to individual consumer's needs. If distribution costs too much, as many say it does, it is largely because it enables production to cost relatively so little. Neither good bargains nor better mouse traps in today's economy sell themselves.

C. Scientific Management. In addition to the revolutions occurring in other factors of the economy, a revolution occurred also in management itself, the factor which organizes, directs, and controls the other factors of production. In previous eras management was seldom separate from entrepreneurship and ownership and therefore was usually sheltered from objective or critical investigation. By now, however, enterprises had become too large, too complex, and too diverse in ownership for personal direction and control, and there was no body of recorded experience to call upon for help. The gild system had left many fine examples of workmanship and methods of operation which had been passed along from one generation of workers to the next as the great tradition. The type of management that followed has been characterized, accordingly, as tradi-

tional management—a name, incidentally, that is descriptive of some types of management found today. The industrial revolution initiated many changes in management methods: double entry bookkeeping was adapted to factory accounting; some aspects of the line-staff organization, so successfully used by the Prussian army, were beginning to be employed; the personnel activities of Robert Owen gained considerable popularity during the first half of the nineteenth century; and, finally, much study and emphasis was devoted to procedures and systems, an emphasis that has led to the management that resulted being characterized as systematic management.

A new type of management had its beginning in 1895 when F. W. Taylor read his first paper before a group of professional engineers. His first book, *Shop Management*, published in 1903, described a type of management to be later named scientific management. This book propounded, among other things, the principle of high wages and low labor costs, a statement that seemed, at the time, nothing more than a witty paradox. Taylor, in testifying before a congressional committee, stated that the acceptance of this principle by both capital and labor would require nothing less than a mental revolution and that this mental revolution was, after all, the main objective of his work. In less than a decade Henry Ford was applying the principle and at the same time accumulating one of the largest fortunes in history. Scientific management was an attempt for the first time to apply scientific knowledge and the scientific methodology to the study of human effort and business activity. It soon incorporated the contribution of any field of scientific investigation that seemed to offer a solution to some of its problems. Among these were cost accounting, which was developed as a complete system in America by Henry Metcalf in 1885; psychological testing, fatigue study, and the principles of learning, after the field of psychology shifted its base from the philosophical to the scientific; and the application of mathematical statistics to business problems, after the work of Karl Pearson—both about the same time.

Even with such a solid basis for continued progress, however, scientific management met resistance from several sources. The labor unions claimed that it robbed the worker of his skill, making it the knowledge of management, and that it tended to dilute labor and cause technological unemployment. As a result, Congress in 1912 prohibited the use of the stop watch in making time studies in all government operations, a prohibition which was not removed until after World War II. Furthermore, scientific management fell into disrepute with businessmen because of its frequent misapplication by some of its early practitioners, the efficiency experts. The sudden increase in demand for management personnel engendered by the production phase of World War I made it necessary to recruit and promote many who were poorly prepared for their responsibilities. These new managers had learned a few of the techniques of scientific management without a knowledge of the painstaking research of Gilbreth, Gantt and other associates of Taylor, and they tried to imitate Harrington Emerson, the great exponent of the efficiency movement, without Emerson's experience. As a consequence, the Society of Industrial Engineers, an organization of the better trained of the experts, gave up its identity not to be re-estab-

lished until after World War II. During the intervening years, managers became more critical of their techniques and more cautious in installing them in the face of strong union opposition, but piecemeal and under one name or another the principles of scientific management have prevailed to constitute one of the most significant contributions of the scientific revolution.

D. The Integration of Science and Industry. The best test of the contribution of management in general to the success of the revolution is found, not only in the improvement of its own methods, but since it is the factor that controls other factors, in the total system it creates for adopting and using the results of scientific research in industry. Science itself was largely an importation from Europe; what American management contributed was an effective method for its application in a free enterprise economy. This method may be described in six steps.

The first step is market analysis, or, the use of various statistical tools to find out what people want, how much they will buy, and how much they are willing to pay for it. The second step is library and field research to find out from published information and statistical surveys what has been done and what developments may be expected in the near future, especially those of possible competitors. The third step is protection, a step which is carried out by the acquisition of patents, copyrights, options, leases, trademarks, etc., or merely by secrecy. The information and the rights thus protected may then be capitalized, pledged for a loan, and depreciated as other business assets. They constitute a new factor of production in our economy more important in many cases than land or natural resources. The fourth step is applied research carried out in laboratories, shops, offices, stores, or in the field. It differs from pure research in that the applied researcher knows what he is looking for and what to anticipate, knowledge that has made him a productive and profitable worker in a business economy. The fifth step is commonly called the pilot plant stage. Here all laboratory quantities are translated into production quantities, costs are computed, and results are tested in small quantities for both utility and customer acceptance. The final step is, of course, the construction of a complete plant or operation designed specifically for the purpose.

By means of this methodology the creation and development of new products and services became an orderly and profitable business, and research became a major functional department in many companies, frequently with a vice president in charge. More recently companies have been formed for the purpose of conducting research as their sole product, a type of company of which Edison's laboratory was an early example. Now, it is being proposed that the Bureau of the Census recognize research as a separate new industry. In America, therefore, science and industry came together, apparently with profit to all parties; while in Europe, for example, no later than last summer, it was announced as news that science and industry are "beginning to get together."

INSTITUTIONAL CHANGES

The foregoing constitute, therefore, what seem to be the basic factors characterizing the scientific revolution in America. However, revolutions and stages

of development are not complete without their institutional factors. These factors, though often more permissive than causative, are no less a part of the change and usually necessary for the ultimate success and permanence of the revolution. Among such factors, the changes in education and in economic administration seem to be of such importance as to have themselves created nothing less than an institutional revolution.

A. Education. In the past, education has usually been associated in our thinking with literature, culture, the arts, and the proper enjoyment of life; less often has it been considered as one of the generative factors in material progress and the production of wealth. In the fields of the sciences and business administration changes took place that were not only revolutionary within themselves but contributed substantially to creating the environment for the occurrence and rapid spread of the scientific revolution throughout all phases of the economy.

Science has been a subject of study and speculation for many centuries, as may be indicated by mentioning such names as Aristotle, Bacon, Galileo, Descartes, Newton, Dalton and others. It does not seem to have been a subject for professional study, however, until the eighteenth century when it came into the program for the degree of doctor of philosophy in Germany. The professional doctor's degree, it may be noted, dates back nearly nine hundred years to the University of Bologna which awarded the degree of doctor of medicine. Thereafter degrees were given in law, divinity, literature and other fields. The peculiar feature of the Ph.D. was the requirement that the doctor's thesis make an original contribution to knowledge, thus something more than the usual examination and exhortation on what was already known. This requirement led students to search all fields of knowledge for thesis material, especially those fields not already pre-empted by other degrees. By the middle of the nineteenth century the new degree had proved its worth. Thereafter the annual tide of American students going abroad for advanced study turned to the German universities now famous for their great scholars and their popular seminars for group study.

In 1874, the degree was established at The Johns Hopkins University, and before the end of the century Andrew Carnegie is supposed to have hired the first Ph.D. in industry, a metallurgist. Thereafter, American universities turned rapidly to the new type of degree, and their graduates in the sciences began the gold rush to industry. In the applied sciences, particularly in agriculture, engineering and medicine, the revolution was even more pronounced. Among significant developments were: Federal aid to colleges of agriculture and the mechanical arts after 1862 and to agricultural experiment stations in 1887, the founding of the several engineering societies and their corresponding degrees mainly during the latter half of the century, and the contributions of John D. Rockefeller to medical education around the beginning of the next. Furthermore, during this period the education of the masses through at least the high school grades became the great American goal. After these developments the educational institutions of the country could both create new knowledge and train scientists and technicians in its use. They could thus perpetuate the process of both creation and application.

College education in business, however, has been from the beginning an

American development. Even now, in Europe and among those who follow Plato and the classic tradition, it is considered somewhat less respectable than other fields of study. The first proposal to establish a school or department to teach business in college was made, apparently, by Robert E. Lee while he was president of what is now Washington and Lee University. Lee died, however, before his proposal could be put into effect. In 1881, a businessman by the name of Wharton gave the University of Pennsylvania funds for such a purpose, and accordingly, a school of commerce, accounts and finance was soon established. The idea does not seem to have been contagious for more than a decade, but by the turn of the century the movement began which has given schools of business the largest enrollment of any of the professional schools, with the possible exception of education.

The curricula of these schools drew heavily upon economics and accounting, but other fields, particularly law, statistics, psychology and English, were searched for useful materials to study and teach. Accounting rose rapidly to the status of a learned profession after the passage of the law for the certification of public accountants by the State of New York in 1896. The new fields of marketing and management were explored but were developed rather late to have played a part in producing the revolution; marketing was studied extensively only in a few schools in large urban centers, and management was left mainly to the schools of engineering. As a result, these two subjects even today are still in the process of catching up, especially in the South.

The main contributions of the schools of business to the progress of the revolution were, first, the analytical study and the publication of business policies, practices and so-called trade secrets, and second, the training of a professional personnel capable of managing the large and complex business organizations needed for the new economy. Their contribution has had its greatest effect, however, since the period under study. Now that graduate study, and since World War II the research program for the Ph.D. in business administration, have been undertaken by the schools of business, there is little reason for fearing that any new scientific development could fail to be made useful because of a failure in administration or that any undertaking could become so large that it could not be efficiently organized and managed.

B. Economic Administration. Most of the institutional changes occurring during the period of the scientific revolution are well known and have been evaluated by economists. A few may be called to mind, however, because of their total effect in creating what has been spoken of both as an institutional revolution and as the beginning a new economic system. One of these of great political, as well as economic, importance was the rise of bureaucracy as a form of government supplementing democracy. Bureaucracy, in spite of its bad name, has proved to be an effective agency for the administration of economic affairs. Good examples are the various Federal boards or commissions, the most noted being, perhaps, the Interstate Commerce Commission created in 1887, or the Department of Commerce and Labor—a department composed of bureaus—created in 1903. Note should also be taken of the growth and importance of corporations, trusteeships, holding companies, and other forms of business combination; also

of organizations for collective action both political and economic, for example, farmer's and consumer's cooperatives and labor unions established for the purpose of collective bargaining—especially after the founding of the American Federation of Labor in 1884; and finally, of trade, professional and institutional associations formed for the purpose of regulating and standardizing the activities of their members.

From these examples, and many others that might be given, it is apparent that American society was getting organized. It was creating instituitons both for the collective control of the economic factors essential to its progress and for the collective regulation of its various specialized functions. Although these two purposes were often mixed, even in the same group, they should not be confused. Collective control was an attempt to gain monopolistic advantage by eliminating competition; collective regulation was an attempt to eliminate chaos by establishing institutions through which competition could be practiced and thus preserved.

The first of these, collective control, appeared the more obvious and was the first to receive political attention. The Sherman Anti-Trust Act of 1890 recognized what was taking place and marked an attempt to prevent the monopolization of the American economy. This act and others for the same purpose were generally regarded by the public as punitive measures to curb big business and to discipline businessmen—the so called robber barons, and by the latter as an infringement of their natural rights. By the economists, however, they were more correctly appraised as measures to counteract control, whether individual or collective, to keep competition free, and to make laissez-faire work. It was now evident that the propensity to monopolize, to conspire, to restrain, and to control were no less inherent in a democratic society or economy than the propensity to consume, to succeed, to possess, or to give—propensities that are the proper concern of a society and its government. The efforts to maintain a competitive system by thus outlawing monopoly were often misdirected, poorly executed, or almost abandoned as in the twenties when mergers and rugged individualism were in fashion and again in the thirties when the substitution of combination and control was sought as a way out of the depression. On the whole, however, they were constructive and probably sufficient for the purpose; the rule of reason proved to be, in spite of its faults, a good rule. These efforts did serve, it now appears, to curb monopoly and to protect both the producer and the consumer against the worst abuses of competition without destroying the initiative and the productivity of the system.

Collective regulation, the second purpose of this institutional revolution, though less obvious, was perhaps the more important of the two. What most of the new organizations of both businessmen and others were trying to do was to bring some kind of order into their respective businesses, trades, or callings by establishing rules of the game and a means for their enforcement. They were trying, in other words, to regularize and to regulate themselves for their own good and protection. Evidence of these objectives may be seen in their codes of ethics; their institutional advertising and other devices for promoting their common welfare; their various agencies for the standardization of sizes, nomen-

clature, and trade practices; their associations and institutes for exchanging information and for approving, certifying, and accrediting what was to them acceptable; and finally their willingness to accept the decisions of referees, umpires, and czars. Society was becoming more close-knit and its citizens were thus exercising their right of free assembly for the correction of some of their mutual grievances. The need for positive regulation was eventually recognized by Congress in the passage of the public utility acts, the Clayton Act, the Federal Trade Commission Act and others designed for their implementation and improvement. Congress in these acts, apparently realizing that to preserve competition it must preserve competitors, began to do what business was trying to do for itself. It recognized the inability of the competitive system to operate orderly and effectively and of its participants to compete profitably yet honorably without approved practices and a code of law enforced by an agency competent for the purpose.

C. The Economic System. What these two institutional changes meant, judged from the prospective of the present, was the beginning of a new economic system. This system may be described as regulated competition to distinguish it from the old laissez-faire system and its free competition. Regulated competition, though probably borrowing from previous systems, was unlike the just-price system of the canonists, the gild system, or mercantilism, nor was it akin to any of the forms of socialism popular in economic theory. It evolved mainly after the closing of the western frontier, the raising of the tariffs, the increase in industrialization, the spread of knowledge and education, and the growing power of the Federal Government.

In the new economy improved transportation and communication brought people of the same interests together; news traveled with the speed of light; statistics, directories and manuals were published; and competitors were rated and evaluated as to their current strength and their potential capacity to compete. In such an economy, or more realistically, a game, a contender no longer plays the whole field blindly, or plays without himself being watched and studied. Even though competitors are numerous, they can often be classified and reduced statistically to calculated risks and mathematical probabilities. Under such conditions the laws of perfect competition no longer apply; the group of competitors is now a society—actually an oligopoly—which soon develops its leaders, its outcasts, and its regular members, and before long, its Dorothy Dix, its Hoyle, its Robert's Rules of Order, and finally a new lex mercatoria which in a democracy eventually becomes the law of the land. The development of this new system came in answer to the changes and the needs of the period, and constitutes one of the major factors characterizing the scientific revolution. The success of the system, in spite of its many deficiencies, has no doubt been America's chief buttress against socialism, communism and economic dictatorship.

ECONOMIC THEORY

Finally, as previously indicated, a new economic revolution is not complete without a new school of economic thought that attempts to interpret and ra-

tionalize its causes, its purposes, and its main developments. Whether the scientific revolution produced such a school may be questioned. The school of thought dominant throughout most of the period was, of course, the neo-classical school headed at this time by Alfred Marshall. The theory of this school was to some extent new, but hardly new enough. Marshall was an Englishman and wrote good English economics; neither he nor his followers seem to have recognized that what was taking place in America was anything more than a continuation of the old industrial revolution. The refinements of the marginalists helped clarify old theory but brought it no nearer to reality. Even Marshall was later disappointed that economists generally preferred to quote his principles rather than emulate the example of his *Industry and Trade.*

The really new economics of the period was, of course, institutional economics, a school originating largely in the works of Thorstein Veblen. He and his followers were generally keen analysts of the economy, outspoken critics of the classical school, and great debunkers of business and businessmen. They seem to have derived so much satisfaction from criticism and debunking, however, that they never got around to developing a constructive or consistent body of thought. Their students became labor economists, utility economists, agricultural economists and so on, or they strayed from the field to become lawyers, political scientists and sociologists. In so doing, nevertheless, they did make a real contribution, not to economic theory as such, but to the new economic system by helping to free it of some of the ideological restraints of the old school and to guide its various activities during the period of the institutional revolution then in progress.

John R. Commons, the most noted and, no doubt, the most constructive of the group, likewise, did not try to develop a theory for the school that would serve as a focal point for its ideas or a rationalization of its activities, except, of course, the main theory that economic society is the product of its institutions. However, the idea of regulated competition seems to be implicit in his writings and his work, even though not always advocated with sufficient clarity and emphasis to distinguish it from certain forms of socialism, laborism, the welfare state, or a controlled economy later adopted as new-dealism. The idea of regulated competition is better deduced by summarizing what the institutionalists were doing and writing, each in his own field, and determining the pattern of their work and their objectives. That pattern seems to have been, in effect, regulated competition.

The economists of both schools were fully aware of the changes taking place in the economy and took an active part in protesting many of the dis-economics and abuses of the day, especially those of the twenties. They rallied in full force to protest the Smoot-Hawley Tariff (the so-called scientific tariff), a tariff that came just over a hundred years after the Tariff of Abominations, but they were thoroughly rebuffed. They made their services available and were taken in almost wholesale by the New Deal, and in the eyes of the public almost as thoroughly discredited. Commons, in his *Institutional Economics,* published in 1934, helped to reconcile institutional and neo-classical doctrine, but it was hardly adequate as a complete economic theory, and it came too late. The in-

stitutionalists had already gone off in all directions and the neo-classicists had found another Englishman with a new English economics.

The new economics of John Maynard Keynes did much to arrest the development of the economics of a regulated economy by substituting in its stead the economics of a controlled economy. Although Keynes contributed a most useful semantics and a much needed methodology, his economics was developed for a matured economy and a theory which seemed to point toward perpetual inflation or socialism. His economics was kinetic but it was not dynamic. Taking physical productivity for granted or as relatively fixed, he and his school concerned themselves mainly with a better distribution of values. They often failed to distinguish between a distributive share of wealth, such as wages, and the productivity or contribution of a factor of production, such as labor. For example, they did not seem to recognize that a high wage does not mean that labor produced it, but only that it got it. Regulated competition was from the beginning much concerned with a better distribution of wealth but not at the expense of a smaller or even a consant production of wealth. The American economists of both schools had witnessed the enormous productivity of modern manufacturing and marketing, the efficiency of scientific management, the initiative and incentive of the competitive system; and they recognized them as forces that should not be sacrificed in the new system. Being fully aware of both the acquisitiveness of society and the ineffectiveness of politics, they were gradually and cautiously evolving, it now appears, both the regulatory institutions and the economic policy for a new school of economic thought.

Such then completes the outline of the developments which taken together produced what seems to have been a new economic revolution as great and as distinct as any of the revolutions that have existed heretofore. Although the revolution is still too recent for a proper assessment of all its implications and its impact upon modern economics, yet time is fleeting and teachers of economics may be losing ground should they be caught teaching an economics of the past or using ideologies and analytical tools that do not fit. After the great depression many economists lost hope in competition—even regulated competition—as a way of economic life, but the idea was not abandoned. The whole economy got out of balance during the twenties and remained ineffective until called upon to arm for a great war. Regulated competition and its theory learned much from this experience, but there is much yet to be learned and unlearned before it can become a complete system and a theory ready for the history books.

MODERN ECONOMICS

The changes produced by the scientific revolution have raised many problems for modern economics. Although time does not permit solutions here, it is possible to suggest at least one area where further study might prove helpful in making the subject of economics more useful to those who are still attempting to apply its established principles. Many such workers often feel the need for an economics that does not ignore so many exceptions to its theory, or clash so often with the findings of its applied branches. The most basic need of such an

economics is for a body of concepts and terms that denote and connote economic phenomena that exist today, rather than similar phenomena that existed in previous eras when such terms were first used in economic literature. Words and concepts having grown old and obsolete should be re-defined or else retired from use. In the space remaining, therefore, three such concepts may be selected for re-examination; namely, competition, cost, and the corporation.

Competition, though practically legislated out of existence in agriculture, labor, and other limited fields of activity, in the field of business and possibly athletics is still our national policy and the ideological goal of most economists. Economists, however, by interpreting competition too narrowly in their zeal to stamp out every vestige of monopoly and thus to make competition too pure and too perfect, have probably done the cause of competition more harm than good. In describing monopolistic competition, for example, they have often given the impression that since monopolistic competition is analogous to monopoly it is a form of monopoly instead of a form of competition, as its name denotes.The downward sloping supply curve, it may be pointed out, is typical of all heavily capitalized companies and industries; the demand curve is largely the product of effective advertising; and price is often administered with long-run objectives or potential competition in view. Such mis-allocation of resources as may be shown by static cost and demand curves may be highly problematical, therefore, and more than counterbalanced by the economies of mass production and mass marketing.

The term "brand competition" is more descriptive of this form of competition, generally, for it is no longer commodities but brands that compete. Even with consumer research, the average consumer cannot calculate the relative values of all the specifications, services, and conveniences of most of the products of industry. He no longer buys under the law of caveat emptor, but under the policy of money-back guarantee. What he buys today includes the reputation of the maker or distributor, and the satisfaction that he is in style and keeping up with the Joneses. Even in the case of an oligopoly, competition is often sufficient for adequate consumer choice. The psychologists have found that the average consumer cannot ordinarily distinguish accurately for the purpose of evaluation between more than about five or six choices, and more often less. It is the same principle that applies in selecting winners among contestants and in rating or grading examination papers. Neither is price leadership nor following similar price policies proof of monopoly and conspiracy more than of rivalry and orderly competition in a society where every one is known and under the scrutiny of every one else. In today's economy, monopolistic competition is, no doubt, less wasteful than perfect competition, the only kind feasible in many cases, and probably the best kind of competition there is.

Cost, another troublesome concept, is often spoken of as a known and accurately determined amount, although any cost except out of pocket expense is largely arbitrary, depending upon the methodology employed in its computation. The high capitalization of modern firms has magnified the importance of all fixed expenses connected therewith, and under the new labor laws and collective

bargaining contracts much of the cost of labor is becoming an overhead cost. As is well known, there are many methods for the valuation of fixed assets and inventories, for the calculation of depreciation and amortization, and for the adjustment of values due to fluctuations in the purchasing power of money. Increasing diversification and integration have magnified also the importance of methods of allocating joint costs and of inter-plant pricing. Moreover, the failure to include a return on equity capital as interest has always distorted cost, as well as both interest and profits as defined by economists. As a consequence of these difficulties, many accountants no longer regard fixed expenses, especially those incurred in connection with sunk capital, as an item of short-run cost of production; for after all, costs do not have to be distributed evenly over short-run periods or total units of output. They may be recovered quickly, gradually, or not at all, depending upon company policy or expediency, or upon the permission of authorities regulating taxes and accelerated depreciation. Unit cost, therefore, is a term that may be used safely only by the cost accountant who understands the calculation; managers usually avoid its use in analyzing operations by drawing their company supply and demand curves as break-even charts or other diagrams expressed in terms of total costs. Some of this confusion was started by Ricardo when he introduced the language of finance and business into the literature of economics. It now awaits another Keynes who can supply a new semantics and a more logical and discriminating terminology.

Another concept that may need overhauling is that of the large, diversely owned corporation and its function in modern society. Today, the corporation is about the only example left of the old concept of an economic man. The consumer, according to the market analysts, is the victim of mass advertising, fads, prizes, and high pressure salesmanship; the laborer, only a little better, is captivated by propaganda and union loyalty; the farmer, like the teacher, is the follower of a way of life; and the businessman is now best known only as a Hollywood caricature. The only example of the real *homo economicus* still in existence is the modern business corporation.

As an institution, the corporation has largely taken over the function of entrepreneurship in the present economy. As such, it is society's main supplier of goods and services, its chief employer of labor, saver and lender of money, owner of capital, collector of taxes, and is rapidly becoming its chief giver of gifts. The corporation is generally a long-run enterprise, preferring status and security in many cases to short-run profits. It has usually a published history, a professional reputation, and a public conscience guided and guarded by a corps of experts in public relations. Its actions are no longer determined entirely by the interplay of economic forces, but are more often the result of careful planning with the aid of such mathematical devices as linear programming, operations research, the theory of games, and military strategy, all subject to review by the overriding judgment of the "Corporate Mind." It is, no doubt, the most efficient form of organization for group action directed toward the accomplishment of a specific economic objective that society has yet evolved.

Even in government operations, some of the most effective units are those organized and administered as corporations.

The corporation is of particular importance to teachers of economics, for one of their main functions in modern society, whether realized or not, is training future corporation executives. The individual in today's economy is too small a unit to compete successfully as an entrepreneur. The corporation, on the other hand, provides an instrumentality through which he may enter business by becoming a member of a group, giving it his loyalty, sharing its success, and thus existing as a part of the corporate personality. By this means the business or technical school graduate can practice his special field of training and devote himself to a professional career which offers not only remuneration, opportunity, and security in fair degree but also a respectable way of life. These graduates thus no longer study and enter business with the expectation of starting a new business enterprise, getting rich, or even becoming a corporate director or president. Since there are eight times as many vice presidents as presidents, however, they may expect to become before retirement at sixty-five at least a vice president. What they need from the economist, therefore, is an economics that can be translated into the language and methodology of accounting, statistics and management, and an economics usable in solving some of the problems of the corporate firm. This training they must eventually get, either from economists or from some other profession even more competent to supply the service.

CONCLUSION

In taking modern economics to task for some of the foregoing deficiencies, it must be remembered that the science of economics was not developed as a branch of business administration. Although the word *economics* is derived from a Greek term meaning household management, or home economics in today's terminology, the study of economics developed mainly as a branch of social and political philosophy. It still has its original function to fulfill by serving society in general as one of the social sciences, a function that it cannot afford to abandon. Economics becomes embroiled in the problems of business administration because it purports to analyze, explain and criticize business practices and policies. It cannot escape, therefore, the responsibility for accuracy and reality in its interpretations, no matter who may compose its clientele. At one time schools of business administration relied on economics to provide a common background and a connecting link for the several business disciplines, but in recent years economics has been reduced to merely one of the seven separate and often noncommunicating fields. As a result, economists are left with only the functions of teaching sophomores their "Principles" and providing graduate students one of their required hurdles similar to the language requirement—a requirement which, it may be noted, is being gradually discontinued.

As a subject of study among the social sciences, economics often lacks popularity because it is considered too hard, too dull, or too dismal. As a subject in

business administration, however, it yields credit for these "honors" to accounting and business statistics, but only to face other criticisms almost as bad. In this field its teachers are said frequently to waste time in offering assumptions as a substitute for a knowledge of the facts, in defending conclusions that contain an obvious bias, in labelling business management as a mere technique when it is no longer mere, and sometimes, though not often, in basing their concepts and their precepts on the wrong revolution.