"PERMANENT" TECHNOLOGICAL UNEMPLOYMENT

"Demand for Commodities Is Not Demand for Labor"

By Hans P. Neisser

I. Introduction

The theory of technological unemployment is a stepchild of economic science. The facts seem to stand in such blatant contradiction to orthodox doctrine, according to which no "permanent" technological unemployment is possible, that most American textbooks prefer not to mention the problem itself. This attitude is of recent times. The analysis to which Ricardo subjected the displacement of labor by the machine in the last edition of the Principles had stimulated a lively discussion among the later classical economists, who, as we shall see instantaneously, followed two different lines of thought. With the rise of neoclassical equilibrium analysis, the discussion died down, at least in Anglo-Saxon literature¹ and only recently the oldest argument against technological unemployment, originally developed by McCulloch, was revised in a little more sophisticated form by two American economists, P. H. Douglas and A. Director in The Problem of Unemployment (New York, 1931). We can, therefore, distinguish three approaches:²

1. The "Law of Markets" approach, formulated at first by McCulloch in Principles of Political Economy (first edition, 1825) Part I, chapter VII, and, as pointed out above, revised by Douglas and Director, applies Say's Law of Markets to the Labor Market. As there cannot be a general over-production of commodities produced, so there cannot be a general over-supply of labor. We shall analyze this argument in the first section of this paper, with some supplementary remarks in Section V.

2. McCulloch's argument was not taken up by the other classical authors, because it is at variance with the classical theory of the demand for labor. As John Stuart Mill stated it most pointedly: "Demand for commodities is not demand for labor" (Principles, vol. I, p. 5, para. 9). The maintenance of the demand for commodities according to Say's

¹ Pigou's and Hicks's discussion of labor saving and capital saving inventions was not developed with a view to the unemployment problem. See below, Section V.

² The history of the doctrine in question has been written, in a scholarly fashion, by Alexander Gourvitch, Survey of Economic Theory on Technological Change and Employment (Work Projects Administration, National Research Project, Report No. G-6, Philadelphia, 1940). The present approach differs in many respects from Mr. Gourvitch's one.
Law, therefore, does not militate against an over-supply of labor. It is the volume of circulating capital, interpreted as wage fund, that governs the demand for labor. Following Ricardo's lead, the theory of "compensation" of technological displacement of laborers was worked out. In contrast to the Law of Markets approach, which does not allow any exceptions to the denial of "permanent" technological unemployment, the Wage Fund School maintains the occurrence of compensation only as the general rule, exceptions from which are deemed possible though unlikely. In Section III,\(^8\) we shall consider this argument.

3. The neo-classical equilibrium approach differs from the preceding ones by denying the possibility of technological unemployment only as to a state of long-run general equilibrium proper, in which complete adjustment of all the variables of the economic system is attained (size of firm, input, output, prices of goods produced, prices of productive services, interest rate). The difference of the neo-classical approach from the Law of Markets approach is concealed by the use of the terms "temporary" and "permanent" by the latter school. By "permanent," Douglas and Director do not refer to the state of long-run equilibrium proper. This is clear from their definition of "temporary" technological unemployment (op. cit., pp. 113 ff.), which refers only to such obstacles to the reabsorption of laborers as: slow working of competitive mechanism, slow transfer of expenditure from one good to the other, or of workers from one industry to the other. A state of affairs in which these obstacles are overcome (as we shall assume throughout the present paper) still might be in a merely "short-run equilibrium" in the neo-classical sense, which is based on the assumption that all equipment is "given" as to quality and quantity, while long-run equilibrium proper in the neo-classical sense requires, among other things, the adjustment of the size of the firm and of the quality of equipment in such a way that average costs equal price for all firms. Indeed, if the Law of Markets is valid at all, it must be applicable to periods of any length, provided only the period is long enough to overcome the temporary obstacles; and similar considerations apply, as we shall see, to the wage-fund argument.

There is a further important difference between the scope of the neo-classical argument and the two preceding ones. Their concepts of unemployment differ. The older theories use something like the popular concept: a man is called unemployed if he cannot find employment at the prevailing wage rate. If "permanent" technological unemployment in this sense is impossible, then, indeed, technological progress would confer only benefits to the working class, as maintained by the two classical schools. On the other hand, the neo-classical approach only

\(^8\) Section II deals with the concept of a labor-saving device.
maintains that, in the long run, a man can always find employment at the long-run equilibrium wage rate, which may differ considerable from the prevailing rate. A man who refuses to work at this equilibrium rate might be called unemployed by the classical school, but would not be called unemployed by the neo-classical economists; it is in this sense only that neo-classicism denies the possibility of "permanent" unemployment.

While there is little merit in the two classical approaches, the neo-classical one stands on much firmer ground, on account of its lesser scope. However, even the neo-classical approach is far from giving the unambiguous answer its adherents ascribe to it. This will be shown in Section IV. On the other hand, while the unqualified denial of "permanent" technological unemployment in traditional theory is not justified, preliminary empirical investigations (which cannot be presented in the present paper) have convinced the present writer that popular opinion vastly exaggerates the amount of unemployment which properly could be called "technological." The relative small size of technological unemployment in history is attributable, partly, to the independent forces increasing employment, which briefly will be discussed in the last section. In no case would it be permissible to use simply the current unemployment statistics as a verification or a repudiation of the theories which affirm or deny the existence of technological progress that creates unemployment. Hitherto the discussion has been marred by a confusion of historical and theoretical statements. We read, e.g.: "As a matter of fact, however, the increased output, consequent upon the introduction of machinery, gave rise to an increased demand for products; and the increased products, due to the cheaper machine process, stimulated the accumulation of capital and resulted in the building and operation of numerous new plants which reabsorbed the labor supply. Thus machinery in the end has not displaced labor but instead has increased the marginal product of labor and thus increased real wages." We may interpret this as a historical statement concerning the period since the Industrial Revolution till the crisis of 1929; during this period, factors making for more employment are supposed to have outweighed the factors of displacement; and this historical statement is, of course, confirmed by the inspection of census figures. On the other hand, these statistics are quite inappropriate to the theoretical question whether technological progress contributes to unemployment. What would one think of an argument against the law of gravity based on the undeniable truth that only a very small number of people habitually fall against the center of the earth with an acceleration of 33 feet per second? And yet, the reference to unanalyzed observation is not worse than the reference

to unanalyzed historical facts. In order to obtain a reliable answer to our question, it is necessary to keep constant the other factors as far as they are truly independent, i.e., not exclusively or almost exclusively governed by the volume of technological unemployment itself.

II. The Law of Markets Approach

The compensation argument of the Law of Markets School runs as follows: Purchasing power is, by itself, indestructible; if technological progress in industry A reduces the amount of labor necessary to produce a given volume of output in this industry, the price of the goods will decline in proportion to the decline in average costs, at least under conditions of full competition; now either the sales volume can be increased correspondingly to the price fall (demand elasticity = 1), then the workers displaced will be reabsorbed by the industry A itself, which now produces more; or the sales volume increases by less (demand elasticity < 1), then the consumer will be able to increase his outlay for the products of other industries B, C . . . , which, therefore, would reabsorb the workers displaced in industry A. And in the case of a demand elasticity larger than unity it would be industry A which attracts additional labor. Thus, the initial displacement of workers in industry A is compensated by an increased demand for labor either in that industry, or elsewhere. In other words, with a given volume of consumers' outlay and with a given output, a definite amount of employment is associated; demand for commodities is demand for labor.

It is difficult to obtain a clear idea of the price theory which underlies this argument. The starting point of the Douglas-Director analysis obviously is a state of long-run equilibrium in which not only marginal costs but also average costs equal price; and the analysis ends by looking at another state of equilibrium, reached after the technological progress has materialized, because the authors assume that at the end of the process competitive prices will again equal average costs. The question naturally arises: In what way is the reabsorption of displaced workers in industries B, C . . . carried through? (For the sake of simplicity, attention will be focused in the present section on the case of a demand elasticity smaller than unity.) In the “short run,” i.e., with equipment given as to quantity and quality and with a given wage level, there is no reason to assume that an upward shift of demand in industries B, C, etc., would spend its force exclusively on output. On the contrary, as the basic equation of monetary theory is usually interpreted,

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5 The second condition is not strictly Marshallian and could be dropped in other applications of the short-run concept. As pointed out by F. H. Knight (Risk, Uncertainty and Profit, pp. 142-44, footnote), Marshall neglected to correlate clearly the theories of commodity prices and factor remunerations for the different phases because he was concerned chiefly with partial equilibrium analysis.
an increase in the flow of purchasing power may raise *prices* rather than *output*. And although this statement refers to the *total* flow in the economic system and to the price level, it may be true also for an individual industry; for the entrepreneur cannot possibly ascertain the source of rising demand; whether it is generated, on the one hand, by gold production, credit expansion, dishoarding, etc., *i.e.*, factors that govern the flow of purchasing power in general, or, on the other hand, by a re-distribution of the *existing* flow. We admit, however, that this application of the “equation of exchange” is not permissible in the problem before us; because even in the short run the physical volume of output is not a given magnitude (as assumed by the older forms of the quantity theory) but is indicated by positively sloped supply curves. Only in the limiting case (“full” utilization of resources) will demand intersect the supply curve in the *vertically* sloped segment of the latter; but there is no case in which the effect of the expanding demand would be wholly concentrated on output, as the theory of compensation implies. Even under imperfect competition, where the competitive supply curve has to be discarded, the cases are rare in which expanding demand will not raise the price.

As long as the equipment in industries B, C, etc., has not undergone fundamental changes as to quality and quantity, they are not able to reabsorb completely the workers displaced in industry A. This adjustment of the given stock of equipment is not discussed at all in this context by the Law of Markets School; and, indeed, the adjustment could not be secured by the operation of the Law of Markets alone. The adjustment can be achieved in various ways: (1) by a change in the size of the firm, other firms changing commensurately in the opposite direction; (2) by a change in the wage level, caused by the technological unemployment; (3) by a change of the “quality” of equipment; (4) by a change in the total quantity of equipment in the economic system. Of these methods, number (1) could not, in principle, raise employment *in toto*, because an increase in the size of one firm, under stationary conditions, involves a reduction in the size of another firm, from which capital is transferred to the first one; nevertheless, the implications of this re-distribution of capital deserve comments; we shall return presently to them. It is mainly the action of mechanisms (2)-(4), not the “indestructibility of purchasing power,” through which displaced workers may be reabsorbed. However, as shall be pointed out in later sections, the effectiveness of these mechanisms has theoretical and practical limits which militate against the hard and fast theoretical proposition that no permanent technological unemployment is possible.

The neglect of the mechanisms numbers (2) and (3) by the Law of Markets School can be explained, partly, by their second assumption
that not only consumers' outlay and output, but also output and employment are rigidly associated. In other words, an output of, say, $1,000 in industry A is supposed to be associated with the same amount of employment as an output of $1,000 in any other industry (B, C, etc.), materializing during the same period. The significance of this assumption for the Law of Markets approach is obvious; for let us suppose, for the sake of the argument, that $1,000, transferred from outlay for A to outlay for B would spend their effect exclusively on output and not at all on price in B; still it would not follow that the workers displaced in A would be completely absorbed in B, unless the crucial assumption we are discussing now is correct. However, since labor and capital cooperate in different proportions in different industries, $1,000 output will contain different amounts of wage costs and labor in different industries. The assumption is therefore untenable.

It should be noticed that the assumption discussed in the preceding paragraph does not become tenable if, instead of individual industries, "integrated" industries (including the so-called "higher stages" of production, where raw materials and machinery are produced) or the economy as a whole are considered. It is sometimes asserted that differences in the capital-labor ratio of a lower stage are of no significance for the economic system, because capital expenses will be "ultimately" resolved into labor expenses; thus, if in a lower stage of production the capital expense assumes a relatively large share of total expenses, labor expenses are supposed to take a correspondingly larger share on the "higher" stages. But, first of all, the resolution is not one of all capital expenses but only of the replacement allowance (for equipment and material) and it is not a resolution into wages alone but into all factor remunerations. The reader may consider the following pattern which symbolizes the circulation in two integrated industries differing as to the share of labor expenses in total expenses. In both cases, total expenses on the lowest stage are $1,000. Under the simplifying assumptions that (a) rent, cost-taxes and profits are zero, (b) that the period of turnover of capital is the same in both cases on all stages, the circulation can be represented, in each case, by three columns representing, from left to right, (1) interest, (2) the other capital expenses (to be distributed on the next stage), and (3) wages; the ratio is, on every stage, in the first case $1 \div 1 \div 2$, in the second case $1 \div 1 \div 6$.

In other words, the net output of an economic system may consist,

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6 Since the highest stages are common to all industries the assumption of a constant share of wages in total expenses on all stages of an "integrated" industry is incompatible with the existence of different ratios for different industries on the lowest stage. This does not invalidate the argument. A more realistic example can be found in my paper "Öffentliche Kapitalanlagen in ihrer Wirkung auf den Beschäftigungsgrad" in Economic Essays in Honour of Gustav Cassel, London, 1933, p. 464.
e.g., of $66\frac{2}{3}$ per cent wages and $33\frac{1}{3}$ per cent profit, interest and rent, or of $86$ per cent wages and $14$ per cent profit, interest and rent; in the latter case, obviously, employment would be larger, provided we compare systems with the same output and wage level.

**Circulation of Expenses in Integrated Industries**

<table>
<thead>
<tr>
<th>Stage</th>
<th>First Case</th>
<th>Second Case</th>
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<tbody>
<tr>
<td>First Stage</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Second Stage</td>
<td>62.5</td>
<td>62.5</td>
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<tr>
<td>Third Stage</td>
<td>15.6</td>
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<tr>
<td>Sum</td>
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<td>333</td>
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For the problem of technological unemployment, however, the correction by which we had to qualify the “resolution” theorem, may seem to be less important. We are still in the short-run phase of the problem, *i.e.*, we ask whether absorption of the released labor is possible with a stock of equipment of given quantity and quality; then only those costs which enter into short-run supply price will matter, *i.e.*, *marginal* costs; in their determination interest plays a very small rôle, the bulk of interest being a fixed charge. There is, however, another aspect of the “resolution” process, which further *invalidates the rigid association* between output and employment, supposed by the Law of Markets School. In an industry B with a relatively small share of labor expenses per $1,000$ of output, the total amount of *capital expenses* naturally would be larger than in industry A; and this result holds true also for “integrated” industries. But will the capital expenses be currently expended? We may here disregard the question where, in case of a transfer of consumers’ outlay from industry A to B, the money would come from to pay out the larger volume of total expenses, which as the example shows may develop in B as compared with A; for the problem is not purely monetary. Are we entitled to assume that the increased replacement allowances in industry B will be used currently for reinvestment and likewise, in case of an imperfect supply elasticity in B, that the ensuing profit increment in B will be spent and invested in its entirety and not hoarded? Obviously *if* some hoarding took place, then the “higher stages” would not benefit in full from the capital expenses (and profits) in the lowest stage, and the reabsorption of workers would meet a further obstacle.

The following alternatives seem to offer themselves as answer:

1. The chances for an increase in current investment and replacement in B are good if the capacity of the industry as a whole is so well
utilized that aggregate profits are above zero or at least not negative. But then the range over which the supply elasticity in B is still considerably above zero, would be rather small, and the transfer of purchasing power from A to B would spend its force largely on prices.

2. A large amount of unused capacity in the bulk of competitive industries, i.e., a wide range of elastic supply, is indicative of latent deflationary tendencies. If, therefore, the displacement occurs in an industry where the share of labor expenses is relatively large, the ensuing price fall, indeed, might bring about a rise in output in the lowest stage of B, C, . . . without a considerable price rise; but the absorption of labor in integrated B, C, . . . would not run parallel to the increase in output.

3. There remains the alternative of widespread "monopoly," under the reign of which unused capacity would not be indicative of latent deflationary tendencies. However, a stage of widespread monopoly certainly is not conducive to increasing the stock of equipment by investment.7

III. A Tentative Definition of Technological Unemployment

We have already obtained some results,8 though we have still a long way to go. The Law of Markets does not secure the reabsorption of workers; there is no rigid association between purchasing power and quantity of output nor between output and employment. In the latter conclusion the key to the understanding of technological unemployment is to be found: according to different stages of the arts, a given volume of capital tends to combine with different amounts of labor; the

7The Douglas-Director discussion of technological unemployment under "monopoly" conditions is not less objectionable than their discussion of the case of competition. Admitting that consumers of A would transfer less purchasing power from industry A to B, C, etc., under monopoly in A than under competition, they insist that the difference is made up from the increased monopolistic profits in A. This amounts to assuming that monopolistic profits can be spent in the same spending period in which they are taken in; in other words, monopoly is considered to secure an automatic increase in the flow of purchasing power per time unit or, what is the same thing, in the velocity of circulation. A detailed discussion of this unfounded assumption is not necessary because it is not essential to the basic argument of the Law of Markets School; moreover, although the transition from competition to monopoly certainly would reduce output and employment, no reason is visible why, under monopoly, the relative displacement of workers by technological progress would be larger in per cent of the employed than under competition.

8The results of Section I were obtained on the level of a "partial equilibrium" analysis. Most recently, Professor O. Lange has made the attempt, to work out, under the same assumptions (given equipment, given wage level) a short-run general equilibrium level in form of a system of equations, which would permit to ascertain the repercussions in industry A originating in the induced changes in another industry. The report on Professor Lange's paper (in "Cowles Commission for Research in Economics; Report of Sixth Annual Conference, 1940," pp. 68-71) is too brief to allow any judgment whether, on the basis of his model, results of wider scope than worked out above could be obtained.
labor-saving type of technological progress simply raises the amount of capital per worker. The phrase "tends to combine" points to the fact that the trend of technology may be nullified by forces of adjustment (mentioned above, p. 54), the discussion of which will be the topic of the last sections of this paper, but these forces do not entitle us to deny the existence of the technological trend itself.

From this viewpoint, a labor-saving device is a method of production which permits production of the same output with less labor than before, either with the same or an increased amount of capital. This definition provides also an answer to the naïve question whether the displaced laborers would not be reabsorbed in the production of the labor-saving device itself. As matter of principle, no increase in the physical volume of capital is necessarily involved in the technological progress; the improved device may not cost more than the unimproved one, and might be financed from depreciation funds; and even if, in a given case the capital embodied in the new device would exceed that embodied in the old one, reabsorption of all displaced laborers is impossible, since otherwise the unit costs of output would not be smaller than before, and no incentive to introduce the new device would exist.

On the other hand, our definition of labor-saving devices has obvious defects. The criterion "capital divided by labor," both measured in terms of prevailing prices, is defined for a firm of given size, measured in terms of current output; output and size of the firm, however, may vary, and for different volumes of output, the ratio in question may be different. (We shall take up this question in Section V.)

IV. The "Wage Fund" as Maintaining Employment

For the short-run analysis offered in the preceding sections, the increase of demand in industries B, C, etc., is the causal factor that brings about a short-run price rise and increase in output. The market price would rise at once under a stimulus of increased demand, above the short-run price, and it would be the response of entrepreneurs to the higher market price that would bring about the short-run increase in output and would lower the market price to the new short-run level. Consequently, in the analysis of short-run price and output, economic theory needs not bother about the question of where the entrepreneur procures the additional working capital: it is the degree by which working capital is provided that governs marginal output in the short run, and not the quantity of output that governs the volume of working capital needed. Whether the entrepreneur utilizes the temporary extra profits, from the rise in market price, or borrows funds to build up the marginal quantity of working capital, is irrelevant; in any case, the

*The corresponding definition of capital-saving devices is obvious.
supply price of the additional funds enters the marginal cost function, the shape of which governs the increase in output for any given upward shift in demand in the industries B, C, etc.

Thus, there would not be any reason to treat specifically the procurement of working capital within the framework of our analysis, if it were not for the central position into which classical economists have placed it in discussing technological unemployment: it is in circulating capital and not in the demand for commodities that, in their opinion, the demand for labor resides. Technological progress therefore could not affect the demand for labor but by impairing the stock of circulating capital. This classical proposition needs some comments.

The circulating capital or working capital is considered by classical economists as a stock of wage goods or "wage fund," supporting laborers during the "period of gestation," i.e., till the goods they are just processing have sufficiently "matured" to be consumed. To this construction, it has been objected that workers do not live on a stock of goods, accumulated in advance for the whole period of gestation but largely on a current flow of goods, emanating continually during the period, provided production is sufficiently synchronized. For our present purposes this point is of minor importance, the more so since the continuous coming forth of the flow is conditioned by the perpetual existence of a stock, not of finished wage goods, but of "goods in process." Ricardo based the possibility of technological unemployment or entrepreneurial inclinations to reduce, in the interest of higher profit, the wage fund by converting "circulating" capital into fixed capital. His successors, for a considerable time, identified the question whether technological progress has proved beneficial or not to labor, with the other whether the wage rate would be adversely affected in the course of progress. To answer in the negative, they were satisfied with proving that, at least in the vast majority of cases, the wage fund would not be reduced by technological progress. The theory of employment itself was only indirectly touched upon. It cannot be doubted, however, that, in classical opinion, the mere fact that the "wage fund" was maintained, sufficed to secure also re-employment of the displaced workers.

The wage-fund theory of employment can serve as an illustration of Marshall's dictum that many an older economist "did not seem to have a sufficient responsibility . . . for keeping the number of his equations

10 David Ricardo, Principles of Political Economy and Taxation, chap. 31.
12 The only systematic presentation of the issue from this angle known to the present writer is: H. Mannstädte, Die Kapitalistische Anwendung der Maschinerie (1905). As "theory of compensation," the argument appears in many German textbooks. Cf. e.g., Ad. Weber, Allgemeine Volkswirtschaftslehre (1928), p. 169.
equal to the number of his variables, . . .” (Letter to Colson, printed in *Econometrica*, Vol. I, 1933, p. 221). Evidently, in order to determine, on the basis of the wage fund the number of employed, one has to know the wage rate in terms of wage goods. On the other hand, in classical teachings, the wage rate itself is governed by the wage fund; it is obtained by dividing the wage fund by the number of employed: one equation, two unknowns! With the concept of a given stock of wage goods, it is consistent to conclude either that the laborers displaced in A are re-employed and the wage level remains the same, or that they are not re-employed, thus consuming less, while the real wage level of the still employed rises. The latter alternative, surprising as it seems at the first glance, is by no means improbable; we have only to remember that what is fixed contractually between employer and worker is not the real wage but the money wage rate; if the wage bill declines because of technological unemployment in some industry, the given stock of wage goods can be sold only at lower prices, as it usually happens at the beginning of a depression. If this alternative is accepted, it is tempting to deduce from this starting point a theory of depression; for, certainly, the producers of wage goods (whose costs have not yet declined!) would respond to lower prices with a short-run reduction of output; thus a chain of cumulative shrinkages could be supposed to be generated. However, this line of reasoning would imply the acceptance of a fundamental but faulty premise of the wage-fund approach, namely, that wage goods are rigidly separated from other consumer goods. There is not only a stock of wage goods in process, from which the continuous flow of wage goods emanates, but also stocks of “profit goods” in process, “rent goods” in process, etc., from which the flow of real income to the other classes is continually generated. Now even in the short run some transfer from the flow of wage goods to the other flows is possible; if the decline in the wage bill happened to be associated with a rise in profits, the wage fund would decline and the “profit fund” would rise. It follows that the classical equation: Wage Fund = Wage Rate (per period of gestation) times Employment, has three unknowns. And such a rise of profits, parallel to the decline in the wage bill in A because of displacement of labor, is by no means restricted to cases of imperfect competition, as Douglas and Director, arguing in terms of average costs, supposed; whether, under perfect competition, profits or losses are created in the short run by the introduction of the new technical methods depends inter alia on the way in which the shape of the marginal cost curve is affected by the technological progress.

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13 Senior was not without misgivings in this respect. The ratio of wage goods produced to profit goods produced is, in his theory, governed by the profit rate (*op. cit.*, p. 174); the logical circle is complete.
It is not surprising that the analysis of the wage-fund theory of employment, on the whole, gave negative results. For this approach, as embodied in the equation above, is purely algebraic and does not indicate the causal mechanism, neither the motives of entrepreneurs nor the technical possibilities of re-employment. The classical theory had recognized that production is conditioned by the co-operation of fixed capital, circulating capital and labor, the ratio of capital to labor being governed by what later was called "the nature of industry," i.e., the state of the arts; if so, how could the mere preservation of circulating capital ensure re-employment? Ricardo did not bother much about this question, because his "long-run" equilibrium concept was different from the later, neo-classical one,\(^4\) denoting not equilibrium as worked out for a given quantity of factors available, but rather the terminating point of a process in which the rise or fall of the supply of labor and the changes in the current rate of capital accumulation adjusted both prices and factor remuneration to their "natural" level, and secured full employment of labor. The most logical conclusion (which was, indeed, drawn by Marx) would be to have current employment governed by the quantity of fixed capital available and the nature of the respective industry; then, technological progress that raises the amount of fixed capital necessary per worker would bring about displacement, to be compensated solely by further accumulation and investment of capital.

Later classical economists like Cairnes and Sidgwick,\(^5\) being aware of these logical consequences of the Ricardian approach, tried to save the optimistic results of McCulloch and Senior in part by pointing out that additional fixed capital could also be provided by converting into fixed capital the working capital set free by the displacement of laborers. The quantitative significance of this process clearly would be small. Some theoretical comments on this suggestion may also be permitted here, because they will definitely clarify the position of working capital in the process of displacement and reabsorption. The setting free of working capital refers to the industry A where the technological progress materializes, not to the industries producing wage goods; because if these would reduce output and working capital, they would create additional unemployment, which would require an additional process of absorption.

Now, the output in industry A is certainly larger after the introduction of the new methods than before; otherwise, the price would not fall. Consequently, the physical volume of working capital in A must be larger than before, except in the case that the period of gestation is


reduced by the technological progress, which would imply a capital-saving device rather than a labor-saving one. Still it would be possible that the value of the stock of working capital is smaller than before, despite the larger quantity, because goods are now produced by less labor per unit of output. But even if the value happened to shrink, this would not imply an abundance of working capital which could be converted into fixed capital. Entrepreneurs in A would pay out, during the period of gestation, a smaller amount of funds to factors of production than they had before; in the subsequent period, the effective demand for commodities and the net amount by which the demand for goods in B, C, etc., is augmented, would be correspondingly smaller. In these industries, the entrepreneurs would respond to a lesser degree than assumed in Section I, by expanding output and working capital in the short run: any mobilization of the abundant working capital in A would, therefore, at the best, raise the compensation of the technological unemployment to the level indicated in our former analysis and no additional absorption would ensue.

Clearly, if, in the process of technological progress the flow of purchasing power is maintained, as the Law of Markets School assumes, then the aggregate value of working capital in the economic system would not shrink; its wage component may decline, but, because of rising prices or of a higher ratio of capital to labor (in B, C, etc.), the other components, viz., profits and business payments, would rise.

V. Changes in the Wage Level and in the Quality of Equipment

Removing now, step by step, the strict conditions of the short run, we drop first the condition of an unchanged wage level. Technological unemployment could lower the wage level throughout the system. In the short run, where equipment is given as to quantity and quality, this would cause a downward shift of the marginal cost curve and would increase current output and capital, for any given state of demand. At the same time, a long-run process is started, adjusting the quality of equipment. Lowering the wage rate tends to bring about a combination of the given quantity of equipment with a larger amount of labor, implying the reabsorption of a certain number of displaced workers.

As pointed out in the beginning, this theory of compensation, being the offspring of modern equilibrium theory, has a greater theoretical validity than the two older approaches discussed in the preceding sections. Equally great is the difference between the scope of the compensation argument of the equilibrium school on the one hand and the two older approaches on the other hand. The Law of Markets School and the Wage Fund School tried, above all, to prove that the wage level would not be affected; the mechanism of absorption we are going to
discuss now does not support in any respect the older doctrines. Moreover, the practical significance of the equilibrium theory approach is small in the present era of relations between capital and labor, where wage rates have proved very inelastic in face of the pressure of unemployment.

We do not want, however, to dismiss the problem with such purely practical considerations. Too easily would it be argued that unemployment caused by technological process is not genuine, but would vanish in time if a sufficient wage reduction set into motion the mechanisms now under consideration. Theoretical comments on the neo-classical approach are the more in order, since the opinion seems to be commonly held (although never explicitly stated) that wage reductions, in order to be sufficient for reabsorption, need not be considerable, or would at least not reduce the worker's standard of living beyond a fair minimum.

As to the short-run effects of a wage reduction, our comments can be brief: (1) It is still an unsettled question of economic theory whether the assumption of an unchanged state of demand is compatible with the general decline in the wage level; (2) the degree of reabsorption of displaced workers, consequent to the reduction of wages, is, in the short run, theoretically not related, to the magnitude of displacement.16

More complicated is the theoretical analysis of the changes in the quality of equipment caused by a wage reduction. For it is precisely by these changes that, according to the neo-classical theory, a state of general long-run equilibrium is brought about; and in such a state, no unemployment in the theoretical sense could exist. A closer analysis of the mechanisms involved is necessary.

The term "change in the quality of equipment" covers two processes. The first is a consequence of the change in the price relations brought about by the decline in wage rates which sharply lowers the prices of all goods in the production of which relatively much labor and little capital is applied; consumers' demand will turn to these goods, and productive resources will be transferred to such "little capitalistic industries" (as they may be called from now), from highly capitalistic industries, increasing the amount of labor combined with an equipment of given quantity. The second process refers to the change in the methods of production within the specific industry; it is a process underlying the traditional marginal productivity analysis, where, with a given quantity of "capital," different quantities of labor are combined. Both

16 Further results may be reached by a short-run general equilibrium analysis of a system of simultaneous equations, with equipment but not the wage level being given. Such a system has been developed recently by J. R. Hicks in Value and Capital (1938). The present writer has not yet been able to make it fruitful for the particular problems of this paper.
mechanisms together are supposed, in modern theory, to bring about general equilibrium in the long run.

The limits of the first mechanism are fairly clear. Obviously it would not work if in all industries the factors of production would be combined in the same fixed ratio. As illustration, let us assume that three units of labor are always combined with two units of capital. If, then, an equal amount of labor and capital is available, plainly one-third of labor would be unemployed all the time. On the other hand, if there are "industries," like the "industry" of personal services, in which labor needs not the combination with capital to operate, then it is certain that at a zero wage rate all labor would be employed. If this unrealistic assumption is discarded, however, the picture changes: at a positive wage rate, the equilibrium price for any good produced must be above zero, and then the demand for the product of the little capitalistic industry may not prove sufficiently elastic.

This possibility is somewhat concealed by the mathematical form in which the equilibrium theory is stated. Equilibrium is characterized by a system of equations, in which prices and output of the different goods and the different productive services are the unknowns; since the number of equations can be shown to equal the number of unknowns, there always seems to exist a set of solutions indicating the prices of goods produced and of productive services at which the latter are utilized in full and no longer unemployed in the theoretical sense, whatever the volume of their supply. However, these solutions need not give positive values for prices and output (not even real ones!); and if not, then they are meaningless, and no equilibrium exists on the basis of the data. In the following illustration, we use the original Walras model reproduced, in simplified form, by Cassel in his Theory of Social Economy, Book I, in which the methods of production, stated as "coefficients of production," are taken as fixed, because we wish to isolate the effects of the first mechanism from the second one, viz., the marginal productivity mechanism. We assume

1. Two kinds of productive services with unknown prices \( z_1 \) and \( z_2 \)
2. Two kinds of produced commodities with unknown prices \( p_1 \) and \( p_2 \)
3. Demand elasticities equal to unity, depending only upon the price of the good in demand, i.e., consumers' outlay being constant.

We denote by

\( S_1, S_2 \) the unknown output of the good produced,
\( D_1, D_2 \) the demand for these goods as function of their price
\( R_1, R_2 \) the available supply of productive services (say, of labor and capital)

\( a_{1,1}, a_{1,2} \) the (known) amount of productive service 1 necessary to produce one unit of commodity 1 and 2, respectively,
a_{2,1}, a_{2,2} the corresponding amount of productive service 2. We arbitrarily put the constant outlay for commodity 1 equal to that for 2, each equal to 10, the a-coefficients equal to 1, 2, 6, 4, respectively, and \( R_1 = 1, R_2 = 10 \). We have the following equations:

**Price equals average costs:**
\[
a_{1,1}z_1 + a_{2,1}z_2 = 1z_1 + 6z_2 = p_1 \\
a_{1,2}z_1 + a_{2,2}z_2 = 2z_1 + 4z_2 = p_2
\]

**Supply equals demand:**
\[
S_1 = D_1 = 10/p_1 \\
S_2 = D_2 = 10/p_2
\]

**Full use of productive services:**
\[
R_1 = 1 = a_{1,1}S_1 + a_{1,2}S_2 = 10/p_1 + 20/p_2 \\
R_2 = 10 = a_{2,1}S_1 + a_{2,2}S_2 = 60/p_1 + 40/p_2
\]

**Solutions:** \( p_1 = 5; \ p_2 = -20; \ z_1 = -35/2; \ z_2 = 15/4 \)

As pointed out before, the negative prices for product 2 and productive service 1 are meaningless;\(^{17}\) there is no full employment of all factors of production, on the basis of the data.

No specific illustration can be given which would show that an equilibrium system of equations in which the coefficients of production are variable, need not possess meaningful solutions either. The lack of reliable empirical material prevents a precise determination of the limits of the second mechanism. However, general observation renders it very likely that such limits exist, and that we are not entitled to expect from the marginal productivity mechanism the absorption of displaced workers beyond a certain, probably narrow limit. The present writer hazards the guess that in industry proper, as contrasted to agriculture and mining, the marginal productivity is very inelastic over the range beyond the combination of capital and labor which was obtained after the World War. To realize this more clearly, we only have to visualize a modern industrial enterprise like a steel plant, fully utilized in the short run, and to ask in what way and to what degree the plant, without increasing the quantity of equipment, could employ more labor if the wage level were lower. Certainly, a number of minor changes in the quality of equipment are possible which would permit employing more labor (say, for cleaning purposes); furthermore, by the removal of some gadgets of minor importance, capital might be set free, which, if added together for all steel plants, allows the establishment of a new steel plant that would absorb labor. However, to the present writer, it seems very doubtful that the total increase in employment caused by such methods could be of larger order of magnitude than a small percentage of the original volume of employment.

\(^{17}\) The emergence of both, a negative price of the productive service and a negative price of the good produced, is accidental. We could construct cases in which a negative price of the service arises despite of all prices of goods being positive.
Marginal productivity theorists, however, sometimes envisage another type of technical change. The era in which the puddling process was replaced by the Bessemer converter and by the open hearth process (processes requiring a much higher amount of capital per worker than used before) was also the era of rising wage rates. Would not a sufficient lowering of wage rates revert the development and bring about the application of older processes requiring much less capital per worker? This argument overlooks that, even at a considerably lower wage rate, the puddling process may be less profitable than the open hearth process. In other words, the transition from one process to another is not correctly described by moving along a given marginal productivity curve for capital; a shift in the curves was caused by technological progress.

The detailed investigation of the elasticity of marginal productivity curves and the classification of industries according to this elasticity is one of the most important tasks of an empirically founded theory of employment. It must be repeated that it is pure guesswork to assume, as the present writer does, that highly capitalistic industries have a smaller elasticity than the little capitalistic industries, particularly agriculture and mining. However, there is also a theoretical argument showing that under the conditions of modern industry the marginal productivity mechanism needs not always secure general long-run equilibrium. If to the Walras equation system, described above, a new set of equations is added, indicating the choice of methods of production as contingent upon the prices of productive services, then some of the obstacles are removed that may prevent meaningful solutions to materialize for the price and output magnitudes. But, by such an introduction of variable coefficients of production, a new difficulty is added at the same time. The marginal productivity mechanism can be considered to solve, theoretically, the unemployment problem in the long run only if equilibrium can be obtained for any possible combination of capital and labor. But it is a well-known mathematical fact that this is the case only if economics of large scale are completely absent (or, to express it in a more sophisticated way, if the production function is homogeneous of the first degree); then, and only then, the sum of factor remunerations according to their marginal productivity would just equal the market value of output, creating neither profit nor loss to the entrepreneur, whatever the combination of labor and capital. If, on the other hand, economics of the large scale are present, general

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18 We cannot discuss here the complicated but most realistic case in which fixed and variable coefficients appear in the production of one and the same good. Neither can we analyze the peculiar instance of variability in which the ratio of productive services employed is always the same, however large the output of the firm, although the absolute amount of input per unit of output declines with rising output.
long-run equilibrium is still possible, but only for specific combinations of labor and capital. The implications of this theoretical proportion are not yet fully explored. One thing is certain, however; the marginal productivity mechanism, currently at work in absorbing labor if wage rates decline, may fail, by itself, to secure general long-run equilibrium, and to eliminate permanent unemployment in the neo-classical sense.

The present writer is quite far from denying that the two mechanisms discussed in the preceding paragraphs are significant in absorbing unemployment. However, in a stationary state, with equipment given as to quantity they will work only very slowly. Even if wage rates declined, it would take a long time before an entrepreneur starts moving the immobilized resources from one industry to another, and further time till the process is completed; likewise, a change in the methods of production under the influence of lower wage rates is slowly started and slowly executed. It is only in a progressive state that the two mechanisms obtain a greater weight by directing investment into channels in which the new equipment will employ more workers per unit than if the wage level has not declined. However, to the largest extent, it is the expansion of the economy itself, i.e., the changes in the quantity of equipment, that all the time has absorbed displaced labor. Before commenting on this process, however, we must take time out to revise the tentative definition of the labor-saving device given in Section II.

VI. A Working Concept of Labor-Saving Inventions. Demand Elasticities Equal to and Larger than Unity

The introduction of the marginal productivity concept permits us to formulate a less objectionable definition of the labor-saving device; at the same time we shall be enabled to ascertain how far the results of the first section, obtained for a demand elasticity smaller than unity in industry A, are applicable to demand elasticities equal to and larger than unity. We describe, in the usual fashion, the production process in industry A by a marginal productivity function, here for labor (product measured in terms of current prices); the area below the curve indicates the volume of output, produced by coöperation of a given volume of other factors (here "capital") and a varying amount of labor (OL); the wage rate is considered equal to the marginal product of labor ML.

The technological progress in question would be indicated by a shift in the function, which at least partly would be upwards, and must satisfy the condition that the current output can be produced now with a smaller amount of labor $OL_1$ (i.e., $OPML = OP_1M_1L_1$). Now if the progress is of the type indicated in Figure 1 (where the marginal productivity of labor is raised, for any amount of labor $< L$), then entrepreneurs will not be satisfied with producing the same output as before
but will plan from the outset an increased quantity of output and hire more labor than \( L_1 \), because both \( M_1 L_1 \) and \( M' L \) exceed the current wage rate. This adjustment of equipment in A differs from the adjustment, discussed for B, C, etc., in the preceding sections, because the latter would be induced by declining wages and executed along a given marginal productivity function, while the adjustment now under discussion is "spontaneous," i.e., brought about by the labor-saving device itself; obviously the entrepreneur, in applying the new devices would not have greater difficulties in planning an output \( OP_1 M' L \) than \( OP_1 M_1 L_1 \). In the present case, he plans new equipment; in the former case, he adjusts existing equipment.

The volume of output would, however, be governed also by the price change caused by the increase in output itself. The degree to which such price changes are foreseen by the entrepreneur and taken into account in planning the new equipment is naturally different under different forms of competition. Anyway, the volume of output and employment eventually emerging will be influenced by the elasticity of demand for the product. The following rules do not require detailed comments: (1) Output in A will be larger after the introduction of the new device than before (except for a completely inelastic demand); for otherwise the price would not fall and with an unchanged price the urge to hire more laborers at the old wage rate would be overwhelmingly strong. (2) Other things being equal, the larger the demand elasticity, the smaller the displacement of workers in A; with a sufficiently large demand elasticity the industry may even attract labor.
Increase in the labor force is impossible under the second type\textsuperscript{19} of technological progress depicted in Figure 2, where OP\textsubscript{1}M\textsubscript{1}L\textsubscript{1} again equals OPML, but where the new curve lies partly below the old one, to the left of L. Even under an infinitely elastic demand, it would be impossible to increase output to such an extent that no displacement occurs, unless, of course, the wage level declines. Since such a decline is usually not foreseen, the entrepreneurial plans would refer to employment OL' and leave some amount of workers to be absorbed in B, C, etc., either, in the short run, by better utilization, or, in the long run, by an adjustment of the equipment.

We find, therefore, three alternative definitions of labor-saving devices installed in an individual industry. The widest one would include inventions that (1) reduce the amount of labor necessary to produce the current volume of output, \textit{and} (2) cause, at the current wage level, a displacement of labor in the industry concerned, because of a small elasticity of \textit{either} the new marginal productivity curve \textit{or} of the demand for the goods produced; this definition would cover also type (1) above (Figure 1). A somewhat narrower definition would cover only such devices which, besides satisfying condition (1) above, cause a displacement because of the low elasticity of the marginal productivity function, \textit{regardless} of the demand elasticity; this definition corresponds to type (2) above. The narrowest definition would include only devices which also would cause a displacement if the \textit{current} wage rate is replaced by a \textit{minimum} rate, fixed from the viewpoint of social justice.

If the present writer's conjecture is correct that, in industry proper, the marginal productivity of labor (in the long-run sense) tends to become less and less elastic the more capital is employed per worker, then the difference between the second and the third definition would be small, because even a substantial reduction of wage rates in A would not increase employment to a considerable extent. On the other hand, the difference between the first and second definition is very likely of great practical importance. Many devices which would not prove labor-saving if the market price of the commodity remained unchanged will become so on account of a low demand elasticity. Labor-saving inventions according to the first definition are, therefore, frequent, and only the compensatory effects of changes in the quality and especially in the \textit{quantity} of equipment have prevented net technological unemployment from taking vast dimensions.

The present approach to a working definition of labor-saving inventions differs from the definition as elaborated, on the basis of Professor Pigou's work, by Professor Hicks.\textsuperscript{20} Hicks calls an invention labor-

\textsuperscript{19}We disregard here the further type in which, at the given wage level, it is most profitable to produce less than before.

\textsuperscript{20}J. R. Hicks, \textit{Theory of Wages} (1932), pp. 122 ff.
saving if the relation of the actual marginal productivity of labor to that of capital is lowered. He considers, therefore, the effect of the invention on the position of labor in the whole economy, assuming that the long-run adjustment of the quality of equipment is realized throughout, and that the ensuing changes in the price relations of commodities are insignificant; the question whether an invention creates unemployment, cannot arise, since all short-run unemployment is supposed to be re-absorbed. The exact relation of Hicks's definition to ours is complicated and cannot be discussed here for lack of space.

VII. Changes in the Quantity of Equipment

In actual fact, the reabsorption of displaced labor has been brought about, to by far the largest extent, by the accumulation and investment of capital; much more, indeed, than by the processes analyzed in the preceding sections. It never has been doubted by any theorist of rank that accumulation of capital in the form of fixed equipment raises the demand for labor; Marx especially,\(^{21}\) consistently expounding the paramount ideas of the Ricardian system, depicts the capitalistic process as a race between displacement of labor through technological progress and reabsorption of labor through accumulation. The same view has been expounded with great clarity by a modern "marginalist" economist, L. V. Birck.\(^{22}\) Quite naturally, this approach has not been considered satisfactory by the "harmonistic" economists of the Law of Markets School or Wage Fund School; displacement and accumulation are two largely independent factors, and it is impossible to predict the outcome of the race between the two on purely theoretical grounds. Marx believed, mainly on the basis of the experience of the twenties and thirties of the last century, that displacement more and more would outweigh accumulation, but the experience of the fifty years after the publication of the first volume of Kapital refuted his forecast. On the other hand, the experience of the last twenty years is less favorable, at least more controversial.

This side of the question need not be followed up in this paper. More important is a theoretical qualification. Without doubt the two contestants of the race are not entirely independent. A rise in aggregate income, generated by technological progress, would increase also the rate of accumulation (per time unit), and thus speed up the reabsorption of labor. However, the proposition that "permanent" technological unemployment is impossible does not find much encouragement in this

\(^{21}\) K. Marx, Kapital, vol. I, chap. 23. In popular literature (and sometimes even in scientific writings), capital accumulation and technological progress are frequently confused, and Marx is credited with an opinion opposite to that which he really held.

fact. First of all, the favorable effect on accumulation can only materialize if a "moving equilibrium" is preserved in the economy; if, contrariwise, displacement of labor (in the absence of compensatory investment) by reducing consumers' purchasing power ushers in a depression, the favorable effects on accumulation of displacement might not materialize. Even more important is another reflection: the amount of capital needed per worker according to the "nature of the industry" is a timeless magnitude, in the sense that, though changing over time, it exists at any moment. Accumulation of capital, on the other hand, is a magnitude that possesses the dimension of time: so much per week, for example. The two magnitudes cannot be directly compared; the correct way of relating them is: it would take, at the old rate of accumulation, so many years of one man's wages to accumulate enough capital to re-employ one man; and at the new, presumably higher rate, this many years. Now what is important in this context is that the same process that reduces the number of years, by speeding up the rate of accumulation, also increases this number by enhancing the amount of capital per worker. Thus, even under favorable conditions (continuous prosperity), the rate of labor absorption through accumulation remains rather unaffected by the technological progress, and still can be considered as a largely independent variable.

The conclusion is inevitable: there is no mechanism within the framework of rational economic analysis that, in any situation, would secure the full absorption of displaced workers and render "permanent" technological unemployment in any sense impossible. How long the unemployment will last can be answered only by "economic biology," which, in an all-embracing economic-sociological approach, tries to evaluate the strength of all forces working in the society.