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THE DETERMINATION OF THE RATIONAL WAGE RATE

By F. BING and J. PETERSEN

Translated from Danish* by T. L. Johnston

In our view the determination of the level of wages is undoubtedly the most important problem which economic science has to solve. To be sure, it is interesting to see the part which the division of labour plays in industry, to note the laws that determine the price of land, and so forth, but industry produces its output and the landed proprietor sells his property without seeking the advice of economists. The wages question, on the other hand, is important in quite a different way, owing to the ferment which is working in the whole mass of society at the present time.

How can we see whether the demands of the workers are justified, and whether the means are available to satisfy them, when we do not know whether the level of wages is something fortuitous or is regulated by some principle? How many mistakes become possible when a measure adopted for a particular purpose may in fact produce an effect the exact opposite of that intended? The workers strike, and the strike may possibly give them momentary gain, but later, and indeed too late, they find that they have paid a price out of all proportion to the benefit received. The Manchester School stands for complete freedom, but its followers are not aware of the significance of freedom for the wage rate. Protectionists clamour for tariffs, and the socialists make every conceivable demand, but none of them realize where their measures will lead. Indeed, nobody can know this as long as the laws which govern wages are completely misunderstood.

In our view, economists have caused great harm by their habit of pretending to know something about this question. They are very well aware of its importance; they realize that, without a solution to the wage problem as a basis, Political Economy is only of slight value, and they are reluctant to admit that they are ineffectual. In order to show how justified our judgement is we shall investigate the explanations put forward by the most recent and most respected authors.

John Stuart Mill (who on this point speaks for many writers) says that the wages of labour depend on the amount of capital and the number of workers. He concedes that fixed capital must be excluded, which means that the largest part of the capital of a country is deducted. However, even circulating capital

* "Bestemmelse af den rationelle Arbejdsløn samt nogle Bemærkninger om Økonomiens Methode", *Nationaløkonomisk Tidsskrift*, Vol. I, part 1 (1873), pp. 292-320.

F. Bing (1839-1912) was a president of the Royal (Danish) Life Assurance Institute, and Julius Petersen (1839-1910) a famous academic mathematician. They were close friends. Petersen was known as a brilliant solver of mathematical problems, whatever the subject-matter involved, though usually he lost interest in the issue once he had dealt with it. In this way his path crossed economics around 1872/73. Bing's interest in the subject was perhaps the more lasting.

comprises much more than should be considered in the present context. The fact that we have large stocks of coal, silk, wine, etc., is of no importance for the wage rate. In his introductory remarks Mill says, quite correctly, that the workers only obtain what he calls the wages fund, but this is simply a definition of a new word and not a theory. This is to say that what the workers obtain from capital is their wage, but we are not much the wiser for this. If this wages fund were to constitute a fairly constant part of capital, the proposition would mean something; for instance, it would then teach us that the wage rate must be doubled when capital is doubled; but we have seen no proposition advanced concerning such a relationship. In fact, of course, a proposition of this nature would be utterly false, for, as we shall show in what follows, it is quite possible for the wage rate to be reduced by half while capital is doubled, notwithstanding that the number of workers is unchanged.

The theory could be interpreted in another way. Imagine that a certain amount of circulating capital is available at the commencement of production. One can then determine what a worker will obtain during the period of production by dividing the circulating capital by the number of workers. This is indisputable; as it is still assumed that no raw materials are used, the whole of the circulating capital will be paid out in wages. It is a very good theory, but it teaches us absolutely nothing. The whole question is how much of the capital will be used as circulating, and how much will be made fixed. It may perhaps be protested that the circulating capital cannot be made fixed without being paid out as wages; this is very true, but only tells us that if events occur which must result in a large part of the previously circulating capital being made fixed, the worker is not affected by this immediately, but only when the change takes place.

It can be seen that this is in no sense a basis for an investigation. Nevertheless, in several writers of repute one finds a proposition which runs something like this. If one wishes to investigate whether some proposed way of helping the worker is of any value, one need only investigate whether the measures suggested operate to increase the capital of the country or to reduce the number of workers. If the measures fail to have either of these two effects, the proposal is no good. The authors follow this rule faithfully in their investigations. It is easy to see how worthless the results must be.

Since the wage rate depends on the rate of interest, the problem can also be solved if the latter can be determined, and the writers in question pretend to know this. Ricardo states that the rate of profit depends on the rate of wages, Mill that it depends on the cost of production. In reading their explanations, one sees that they are simply saying in a roundabout way that the capitalists obtain that part of the product which does not go to the workers; this is a fairly obvious truth when the rent of land is not considered.

While many writers are thus content with empty platitudes and erect a high building without foundations, there is one authority who has endeavoured to establish a firm basis. We refer to von Thünen. If his theory was correct then it

must, we shall argue, be a crazy theory, since we arrive at an entirely different result from him. It is first of all necessary, therefore, to criticize Thünen's theory. As we do not have his own work available, we have used the exposition given by Wolkoff,* who described the theory as epoch-making for economic science.

Thünen's Theory. Thünen assumes that the workers receive rather more than they consume, so that they are also small capitalists. He assumes that complete freedom and mobility of labour and capital prevail, and he also postulates that there is unoccupied land, which costs nothing.

This must at once cause suspicions about the theory. The fact that the workers can devote themselves to tilling the soil only matters in the sense that they can organize another business. With complete mobility, all the land which it is profitable to cultivate is occupied, and the only vacant land is that which cannot yield the prevailing wage rate and rent. Thus, if a worker with his capital wishes to till the soil he must become worse off, or at any rate he cannot become better off, than if he works for the manufacturer and lends him his capital.

Thünen now also assumes that the capital of the workers is not large enough for farming; however, some workers are employed by the manufacturers and lend their surplus to those who till the soil, receiving in exchange a share in the proceeds. In this case, he says, it is the workers themselves who set the wage rate; they will determine wages as well as the rate of interest in the way which is most advantageous to them. This position is reached, according to Thünen, when the workers' surplus yields them as much interest as possible.

Let us assume that these farmers fix a wage rate w and a rate of interest r . If each one of them uses an amount of capital equal to total wage payments over t years, the capital is tw and the interest on it is twr . The product will now consist of this interest together with the worker's wage. If we call the product P , then

$$P = w + wtr$$

It is therefore always necessary to set w and r so that they agree with this formula. If now the consumption of the worker is c , his surplus is $w - c$, and the interest on this is $(w - c)r$. The question now is what the values of w and r must be for the interest payment to reach a maximum. Mathematics shows us readily that this is the case when $w = \sqrt{cP}$. The rational wage rate is therefore, following von Thünen, the geometric mean¹ of the worker's consumption and his product.

What we cannot understand is how it is possible to believe the correctness of a formula which states that a worker has a very easy and agreeable way of increasing his wage rate as much as he wishes, simply by increasing his consumption. In fact, Thünen has smuggled into his analysis the additional point that c

* Mathieu Wolkoff (or Volkov)—a Russian economist who after his retirement in 1854 lived in Paris—was a great admirer of von Thünen. He published an abridged version of Thünen's main work (*Der isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie*) in Russian and also translated part of the book into French. He also defended Thünen's theories against attacks made by other writers.—Ed.

¹ About midway between consumption and product.

is necessary consumption, but the above argument shows that we are only concerned with his actual consumption, regardless of necessity. The error in Thünen's theory is that he assumes that the workers can divide their product into wage and interest as they choose. True, if the worker only operates with his own capital, he can naturally call the product whatever he wishes, but he cannot expect others to follow suit. And if he employs the capital of other workers he must pay them the prevailing rate of interest, which in turn must mean that his wage is less than the normal. Thünen has introduced a rather arbitrary condition, confusing what he considers to be best for the workers with what they can enforce. He has seen that he only has one equation for determining the two unknowns r and w , and that he therefore needs another condition, but he has not seen where it is to be found.

Having thus shown how the matter stands we would like to observe, before proceeding to develop our theory, that we must assume a state of affairs in which the changes that occur are regular, since naturally we cannot discover laws where there are none. Take, for instance, a situation where the number of workers is such that none of them is dispensable. In these circumstances the wage rate would be determined solely by our need for the services of the workers and our ability to pay. The rate of interest could fall to zero, and it might even be necessary to pay the workers to induce them to preserve our capital. We therefore assume, in conformity with actual conditions, that we can always substitute fixed capital, for example, machinery, for some of the workers. If the wage rate becomes too high, we introduce threshing machines, ploughs, and so on.

Every logical science must begin with abstractions. Concrete circumstances are generally so complicated that we can only obtain some clarification by first confining ourselves to the most fundamental among the forces at work. When we understand the laws governing these forces, we can proceed to the less important factors, and so on. When we know the effects of each individual force taken in isolation, we can find the total result simply by addition. This fundamental mathematical principle can, with a little caution, be employed in most other sciences.

In the first place it is therefore necessary for us to define the idealized society we wish to investigate. We shall express our definitions in precise axioms so that, by making the appropriate deductions, we can give our exposition a logical form which will facilitate the discussion of the subject. As will be seen, our assumptions are the same as those generally employed; they correspond so closely with actual conditions that the results we arrive at cannot be considered purely theoretical, but must provide reliable guides to the solution of many practical problems.

Before we discuss the propositions themselves, we shall first develop the conception on which they are founded. As we have stated above, the basic factor is that these are workers who compete with machines, though we do not consider that all workers and all machines are in competition. There are machines so

good that there is no question of the workers being able to compete with them; they have long since acquired a monopoly of performing certain specific services. On the other hand, there are workers for whom machinery cannot be substituted; we cannot have a steamship operating on its own, however good the equipment, and we have no apparatus that can lay our meal before us at table without the co-operation of human beings. At the same time, there are always many machines which can be substituted for labour, and vice versa. It is this fact which provides the basis for a solution to the problem, for the law which is valid over the whole range of labour and machinery inputs is found at the point of transition. At this point the cost of using machinery must be the same as that of employing labour, for otherwise the cheaper input will be preferred, given that one has a choice. The point of transition must be that at which it is just worth using the worst type of equipment, i.e., that machine which in relation to its price displaces the smallest number of workers, for when the machine at the margin of transition can barely compete with the workers, every better machine must have an absolute advantage over labour. The interest earned on the worst type of machinery must be that which prevails in the economy generally; for if other types of machinery were more profitable, no one would be willing to use the worst kind. The manufacturers working with better equipment must therefore reduce the prices of their goods until profits are uniform. Likewise, every worker must be satisfied with the wage obtained by those who compete with machinery and who would otherwise undercut the better paid.

We will now outline a model which shows clearly how we think the adjustment takes place. We imagine a group of people who own one capital good (wheat) and who intend to establish a colony in an uninhabited place. Before their departure they go to a manufacturer who sells every type of equipment and spend their whole capital on machinery, since they themselves are just sufficient in number to look after the machines. The type of machinery they will choose depends on their needs and desires and on the amount of their capital; the larger their capital, the more desires they can have satisfied. It is reasonable to suppose that, when they purchase a lot of machines, they are more likely to have some poor machines than if they were only purchasing a few. They then divide the machines among themselves. They are indifferent about the manner of allocation, since they agree to exchange the products produced by each machine during a given time at the same price, so that there is no advantage in having a good rather than a bad machine; in fact many of the machines cannot even be termed good or bad, for they cannot be replaced by human labour and therefore are not valued by comparing them with labour.

They now journey to the colony, after stipulating that they can send the machines back and re-purchase their wheat if they so wish. In the colony, however, they find a number of workers, attracted there by rumours of the group's arrival, who no longer have the means to return. The colonists cannot, however, engage the workers, since all their capital is tied up in machines.

There is only one way out, say the capitalists. This machine cost us 1000 bushels of wheat, and yields us 30 bushels of wheat a year; we can trade it back and give you the wheat, provided that at the end of the year you pay us back 1030 bushels of wheat. This might, for example, be done by ten men; they each obtain 100 bushels in wages, and the capitalists earn interest at 3 per cent. But suppose there are more than ten workers. The most inferior machine is now one costing 1000 bushels and yielding 40 bushels of wheat annually. The workers have no choice but to displace this machine as well, and, since they must deliver 10 more bushels of wheat, each of them must give up one bushel of his wage. But competition from these workers means that the previous ten workers must now also be content with the smaller wage and give the capitalists 4 per cent. And so the process continues, until every worker has obtained employment, the wage rate falling steadily and the rate of interest rising steadily as better and better machines are displaced.

To avoid misunderstanding, we should add that it is only for the sake of simplicity that we have let the second machine produce wheat; it may yield another product, but of the same value. The point is simply that when the second product is produced by the workers it costs them the same amount of effort as the production of 40 bushels of wheat. They produce this product and wheat for their wage the following year.

The wage rate we have determined is the highest the workers can obtain; however, if there is competition between the capitalists, it is also the lowest. For if the wage rate were lower there would be machines for which labour could with advantage be substituted, and the owners of these machines would be willing to outbid one another in order to obtain workers.

Thus the wage rate is determined by competition between labour and the least efficient equipment available; what these machines are depends on the demands of consumers, capital and the state of knowledge. An increase in capital would lead to an increase in the number of machines, but an increase in wages would occur only if some of the new machinery could be displaced by labour more easily than the equipment used hitherto.

After this short summary of our theory we shall proceed to express it in precise form.

Axioms defining the idealized society we are considering:

1. The workers are all equally capable in all jobs.
2. Capital and labour are completely mobile and always move to where they can earn most.
3. Capital can immediately be transformed from circulating to fixed capital, as the owner thinks fit. (This assumption simply means that we do not wish to consider the transitional period during which the change takes place.)
4. All production is assumed to begin from scratch and to take one year.

The whole wage is paid at the beginning of the year.

Propositions derived from our assumptions:

1. Every worker receives the same wage.

If this were not the case, those paid less would undercut those paid more. The wage of a worker, paid in advance for one year, is denoted by w , and the number of workers by n .

2. The rate of interest is the same for all capital.

If this were not the case, all capital would seek the most profitable employment. The rate of interest, i.e., the annual interest on a capital sum of 1 is denoted by r ; the interest on an amount of capital K is therefore Kr .²

3. Determination of the value of a product Q , produced in one year by m workers with a fixed capital K .

The capitalist has paid out a total wage bill mw , which with interest will amount at the end of the year to $mw(1+r)$. In addition, the interest on his fixed capital is Kr . The product must just pay for the whole, thus

$$Q = Kr + mw(1+r)$$

A product P produced by one worker without fixed capital in one year thus has the value

$$P = w(1+r)$$

We shall take this product as our standard. If fixed capital K can be produced by q workers without fixed capital in one year, it has the value qP , and again we obtain the value of the product Q :

$$Q = (qr + m)P$$

4. Interest on fixed capital equipment with which labour competes. The annual interest on an amount of fixed capital K valued qP is qPr . If this equipment is substituted for m workers it yields a product mP . At the point of transition the use of fixed capital instead of labour must not lead to a profit or to a loss. This means that

$$qPr = mP$$

and

$$r = \frac{m}{q}$$

The rate of interest therefore depends solely on the worst machine which is in use. What machinery is being utilized in turn depends on the amount of fixed capital, on the demands of consumers, and on the various kinds of machinery which are available. Machinery which is better than the worst equipment in use has already displaced labour; the interest earned on these machines is brought down to that obtained from the least efficient equipment by a fall in the value of the output produced. This value can be deduced from the formulae developed above, once r has been determined. The number of workers displaced by machinery is obtained by deducting from the labour force which corresponds

² Fixed capital which is old may well yield a lower rate of interest, in relation to the original value of the equipment, than the prevailing rate, but this means that a capital loss has been incurred. If the rate of interest is 4 per cent and a machine that previously cost 1000 *kroner* yields 2 per cent, the machine is now worth only 500 *kroner*.

to the gross product the number of men needed for maintaining the machinery perpetually in the same running order. When the rate of interest is known, the wage rate is expressed by

$$w = \frac{P}{1+r}$$

5. The dependence of the wage rate on capital.

If we denote amounts of capital which successively become fixed by $A, B, C \dots M$, where M signifies the worst machine in use, and if K is the total capital available, we have

$$K = A + B + C + \dots M + nw$$

This equation simply states that the total capital consists of fixed and circulating capital, the latter (which is divided equally among the n workers as wages) being nw . To find $A, B, C \dots$ we must know how far the demands of consumers have changed and what new inventions have been made during the period the whole capital has been invested. This, however, is of no interest; what matters is the way in which newly created capital is allocated when we start from a given situation. We shall therefore let K stand for only that part of capital which is not already irrevocably fixed, and assume that the rate of interest in the given situation is R .

New capital need not bring about a fall in the rate of interest. If the desires of the consumers are such that it is not necessary to resort to poorer machines than previously new capital can be allocated among the same uses as before, and the rate of interest and the wage rate remain unchanged, together with the value of the products. In this case the whole of the additional capital becomes fixed and there is no reason why wage rates should rise. However, we can generally assume that the growth of capital creates new desires, and that among these are some whose satisfaction requires the introduction of machinery which is inferior to that previously used. These machines now begin to pay their way, for to satisfy the newly created demands by the use of labour only would necessarily imply an increase of the wage rate. (The growth of capital would lead to a rise of the total wage payment, and the number of workers is assumed not to change.) The additional capital will therefore be divided between fixed and circulating, and the question then becomes how this division is made. Since we do not know the law which governs the decline in the rate of interest (i.e., the law relating to the variations in efficiency as between different types of machinery), we now assume that the additions to capital are so small in relation to the total capital in existence that, as more capital is successively put into fixed form, the rate of interest can be regarded as declining steadily. We shall then assume that the rate of interest falls by a certain very small amount α for each additional amount of capital P (the unit of value) that is made fixed. For the rate of interest to fall from R to r , capital amounting to $\frac{R-r}{\alpha}$ must thus become fixed.

If in equilibrium the rate of interest is r and if K is the total capital to be divided into fixed capital and wages, we have

$$K = \frac{R-r}{\alpha} P + nw$$

and

$$P = w(1+r),$$

two equations with two unknowns, r and w .

We shall not pause to solve the simple quadratic equation which follows from these two equations, but content ourselves with a rough determination of the proportions in which a small addition to capital is divided between the workers and fixed capital.

We start from an equilibrium position³ with a rate of interest r and a wage w . If we then have a small addition to capital, k , we obtain a new equilibrium where the rate of interest has fallen to r_1 and the wage has risen to w_1 —

$$k = \frac{r_1}{\alpha} P + nw_1$$

The workers therefore receive nw_1 and the owners of fixed capital $\frac{r_1}{\alpha} P$, and the relation between the two kinds of incomes is

$$\frac{nw_1}{\frac{r_1}{\alpha} P}$$

However, in the new situation

$$P = w(1+r)$$

becomes

$$P = (w + w_1)(1+r-r_1)$$

If we discard the very small quantity $w_1 r_1$, we obtain from this

$$r_1 = \frac{w_1(1+r)}{w} = \frac{w_1(1+r)^2}{P}$$

When the last expression is substituted for r_1 in the equation showing the relation of wages to interest, this will read

$$\frac{n}{(1+r)^2} = \frac{n}{\alpha}$$

As $(1+r)^2$ is only slightly greater than 1, we can write,

$$\frac{\text{labour's share}}{\text{fixed capital's share}} = \left(\frac{1}{\alpha}\right)$$

³ By this we mean a situation in which the forces at work hold one another in balance, with the result that no change would occur as long as no new force—for instance, an increase in capital or in the number of workers, an invention etc.—came into operation.

The formula shows, as we also saw above, that if α is zero, the workers obtain nothing. If, on the other hand, we make the assumption (which is certainly on the high side) that an addition to fixed capital of 20,000 P (about 6 million *kroner*) would make the rate of interest fall by one per cent, we obtain

$$\alpha = \frac{0.01P}{20,000P} = \frac{1}{2,000,000}$$

If we further assume, for the sake of argument, that there are 100,000 workers, the ratio becomes $\frac{1}{20}$. This means that on these assumptions (which are certainly very much more favourable to them than actual conditions) the workers would each obtain only $\frac{1}{21}$ of any addition to capital.

What we have determined here is the nominal wage rate, expressed as P . However, it is more important to determine the real wage, i.e., the necessities which the workers can obtain with their wage. These are very varied in character, and the workers consume now more of one kind, now more of another. We obtain a good approximation of labour's position, however, if we enquire how many agricultural products the workers can obtain. If Q now stands for the product of a farm cultivated by m workers with capital qP , we find

$$Q = (qr + m)P = (qr + m)w(1 + r),$$

and

$$w = \frac{Q}{(1 + r)(qr + m)}$$

Since we have not allocated any of the product to rent, the land we are considering must lie on the margin of cultivation and thus be of no value. We see that the real wage rate rises in the same proportion as Q . If an invention is made, which enables us to obtain from the least fertile land and with the same inputs twice the gross output produced so far, and if this invention does not alter the relative efficiency of the machinery we use, the real wage will double. In actual fact wages would no doubt rise still further. The effect of the invention is that far more agricultural products are produced than can be consumed, and a great deal of land would therefore be abandoned. In consequence the margin of cultivation would rise, so that Q would increase greatly. We must remember that we are discussing an isolated country. When the surplus products can be sent abroad, the workers derive no benefit from the invention, for now it simply operates to increase rent and thereby to enrich the landowner. However, we are not yet ready to conclude our examination of the isolated community.

Inventions which result in some capital becoming fixed generally reduce the nominal wage rate. If this capital were taken entirely from wages, the wage rate would fall and the least efficient machines could now with advantage be displaced by workers. Additions to fixed capital therefore consist partly of capital which was already fixed, and only the remainder is capital which so far was circulating. (This is on the assumption that fixed capital can change its

form without loss.) Since, as we have seen, an increase in capital only benefits the worker to a very small extent, a reduction in capital can only harm him slightly. If, however, fixed capital cannot be transformed, poor machines will continue to be used until they are worn out, and new ones will simply not be purchased. There will therefore be a transitional period; during this time the workers are worse off than they would have been if the invention had been made before the worst machines were acquired. Inventions therefore reduce the nominal wage; however, as we have seen, the real wage will rise if the inventions increase the yield in the production of workers' necessities. Inventions which affect the production of other goods, however, only tend to harm wage earners.

We have said that every worker obtains the same wage. This is not realistic, and we must therefore show how our formulae have to be modified to be used in practice. Because of his skill or other qualities, one man contributes more than another to increasing the production of an enterprise, and he therefore receives a higher wage. The foreman receives more than the ordinary worker, and the manager more than the foreman. If observation shows that there is a definite relationship between the wage received by persons in different positions, we can still make use of our formulae by merely counting a man who obtains twice as much as an ordinary worker as two workers, and so on.

The matter is different if we can assume that the premium over the ordinary wage which a skilled worker may obtain is simply the interest (at the prevailing rate) on the capital used in training him, in other words, if the capital employed for these purposes is subject to competitive forces. Each man is then counted in the formulae as only one worker, but the capital used in his training must be included in fixed capital. However, this interpretation is of hardly any significance. Economics is not much concerned with the past. The profit yielded by a machine is not determined by what it has cost, but by what it would cost now, and in the same manner a worker's wage is not determined by the cost of his training, but by what he can perform. It all depends on the capital which at the moment is on the margin between fixed and circulating. Immovable fixed capital such as roads, harbours, railways, buildings, permanent equipment, etc., does not differ fundamentally from the natural qualities of land, and the interest it yields is in many respects similar to the rent of land. When we have spoken so far of the worst machine, we therefore mean the worst which we would now be willing to take into use.

Let us now reduce the element of abstraction and come closer to reality by assuming that labour is immobile, though capital is still assumed to be mobile. Imagine that the workers consist of two groups. To begin with, all the men enjoy similar conditions, with the result that they would be unwilling to move from one group to another even if they could. Assume that in this initial situation the rate of interest is R and the wage rate w . This wage, which is measured in terms of the product, has the same value in both places, i.e., a worker in the first group can exchange his product for that of a worker in the second group.

What happens if several workers are now added to one of the groups? We will be understood more easily if we state the problem without using algebraic formulae.

The new workers must displace some machines, and this makes the rate of interest rise. Business is therefore profitable for the capitalists, and new capital is attracted from the other group. Production therefore rises in the first group and falls in the second group and, since this change in production does not originate in a change in demand, it must lead to a change in the value of the products; so the products of the first group of workers become cheaper, while those of the second become dearer. The rate of interest on capital used by the first group will therefore fall again, and interest on capital used by the second group will rise, until the equilibrium position—where the interest rate is the same everywhere—is restored. The consequence of an increase in the number of workers in the first group is therefore this: labour's share of the product declines, because the rate of interest rises, and in addition the share which the workers obtain carries a lower value.

If the workers in the first group can produce their own fixed capital their position is made worse, for the reduction of wages will make fixed capital cheaper than it was before, and the cheaper machines in turn force down wages. If it is possible to continue using the same kind of machinery without resorting to inferior equipment, equilibrium can only be restored if the additional workers die off; since capital declines in value at the same rate as the product, the rate of interest cannot fall, and there will be a steady increase in capital accompanied by a steady reduction in the value of the products. Those who have previously used capital in the business suffer a loss of assets because the value of the capital declines, but the reduced asset value continues to yield the high rate of interest, and this constantly attracts new capital. Theoretically, equilibrium can only be reached when the wage rate and the value of capital have fallen to zero. In practice, there are naturally other forces at work which alter the position, but the principle developed here still indicates the main tendency.

Let us repeat that in order to avoid misunderstanding we have departed from a precise exposition. As is usual in economics, we have therefore not got much further than to discover the problems that ought to be tackled and to obtain a rough idea of the direction in which we are moving; a proper solution, however, has not as yet been developed. We have seen that capital is transferred from one business to another, that the wage rate falls, that the rate of interest rises, etc., but the question is how much capital is transferred, by how much does the wage rate decline, and so on. These are perfectly precise problems whose solution presents only practical difficulties. It is easy enough to discover how the calculation should be made; and in view of the calculations which astronomers and actuaries make, the time which the calculations would occupy should not be regarded as an obstacle.

Although we have not attempted to derive social programmes from our results, we cannot refrain from drawing attention to the discrepancy between

the general clamour for greater provision of education and capital as the sovereign remedy for the workers and our analysis above, which showed that it was precisely the growth of capital and the education of workers which, in the case considered, worsened their position.

For the present we shall not discuss various other investigations which we have been pursuing, since they cannot be presented in reasonably popular form. Moreover, we regard what we have done so far only as a very imperfect start, indicating method rather than yielding final results. We would, on the other hand, like to make some general comments. It will be readily evident from some of our statements that, in our view, economics is at present at such a low level that it does not deserve the name of a science. An economics textbook conveys much the same impression as a popular presentation of the natural sciences, but with the difference that there is always solid reasoning and knowledge behind the latter, but nothing behind the former. Problems can be seen to exist, but they are tackled sporadically and hardly any have been solved. We believe that the explanation for the poor progress made by economics must be sought in the fact that the method adopted has not been a strictly scientific one. This in turn may possibly be due to the need to present economics in such a way that it is intelligible to a generally educated person. Economics has in fact become a kind of common property; anyone feels he is entitled to contribute. It does not often occur to anyone other than an astronomer to calculate the path of a comet, but anyone who can read a newspaper thinks he can participate in discussions about the effect of free trade on wages, for example, though we can assure him that the second question is a much more complicated one than the first.

Economics is a discipline dealing with magnitudes; therefore it naturally belongs to the mathematical sciences. Its task is to determine what conditions have to be fulfilled for the economic situation in a society to be in equilibrium and what changes will be brought about by given disturbances. What will wages, interest, rent, prices, etc., be under such-and-such conditions, and how will these magnitudes vary when the conditions change? That is the general problem of economics, and it is a purely static problem. To be sure, there is also a dynamic problem (the investigation of the way in which the movements take place), but this is probably as yet far too difficult for us to tackle.

Please note that our attack on economics does not extend to statistics. Statistics is simply observation, it does not reason, or in any event ought not to reason. In economics the problem is frequently that of the observer being unable to detect numerous small changes, which elude the statistician and which can only be discovered by logic. The statistician's task is to pursue investigations into society in order to provide the economist with the material to work on, just as economics in turn must serve as the foundation for social science. Pure reasoning cannot tell us the fertility and situation of the soil, human propensities, the inventions which are made, the amount of capital, the number of workers, and so on. The economist asks the statistician for information on these points, and,

as we understand the matter, the statistician answers every query with a figure. What we have called α is an example of such a figure. Gradually, as more capital becomes fixed, the number of workers displaced as a result changes. In terms of geometry this variation can be depicted by a curved line, and this is what the statistician should really determine; however, we have limited ourselves, no doubt appropriately, to investigating only such small changes that the part of the line which concerns us can be regarded as straight: all one then needs is the figure indicating the slope of the line.

Another example is the problem of the distribution of corn production among different countries. This depends on the increase in production that results from every new investment of capital. The economist must know this increment in order to solve the problem, but the answer depends on the natural qualities of the country and can therefore only be discovered by observation.

Take yet another example. The consumption of a good depends on the price, but the law which governs the extent to which consumption varies with price can only be determined by the statistician. Likewise, only the statistician can establish how far an increase in production gives rise to greater division of labour and thus to lower production costs. When the relevant magnitudes have been discovered, it is for the economist to determine the most advantageous scale of production, the appropriate amount of capital and all the other relevant magnitudes. All these are quite explicit problems, and are easily solved.

In brief, what we are stressing is this: there is a sharp distinction between what can only be discovered by observation and what can then be deduced by logic. As regards logical deduction, it is necessary to insist that a partial solution of a problem is no solution. Just as statistics must always work with an eye to economics, so must economics continually remember that it is the servant of social science, that it sets out its propositions so that with their help one can decide whether a particular change is beneficial to society or not. But the well-being of society is the sum of various quantities. Now every schoolboy knows that the accuracy with which one can determine the sum of several quantities is no greater than that with which the least accurate of the quantities is determined. If I wish to assess a man's estate and I know accurately every debit and credit except one, about which I know nothing, then in reality I am utterly ignorant about his fortune. The same is true of economics. To assess the importance of free trade, for example, it is necessary to understand its influence on prices, on the rate of interest, on wages, and so on. As soon as a single one of these points is not known, the problem is quite insoluble. This is not to say that accurate information must be available of all the magnitudes involved; an approximately correct result is also of value if the limits of possible error are given.

Postscript. It will be appreciated that we have been a little hesitant about throwing down the gauntlet to the whole of respectable and official economics, for economic studies have merely been a side-line for us, and even then only

for a short time. After our paper was written we were greatly encouraged to get hold of a book by Jevons, the Professor of Economics at Manchester, in which he discusses the system and method of economics in a way rather similar to our own. Our knowledge of the literature is not extensive, and there are therefore perhaps some other works that we should have mentioned; we believed that, having read half a dozen of the latest and most reputable books, we could be certain that no theory of importance has escaped us.