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SOME THOUGHTS ON THE DISTRIBUTION OF EARNINGS[1]

By A. D. ROY

I

AN attempt has been made elsewhere[2] to show that the output of any individual working by hand is the resultant of a large number of random influences. As a first approximation these influences can be assumed to operate independently, i.e. they are not significantly associated with one another. The rather vague term 'influence' is intended to refer to such factors as health, strength, skill, and so on. The suggestion was made that it is more fruitful to define such factors so that, taken singly, they exercise the same proportionate effect on the output of otherwise similarly situated individuals rather than the same absolute effect. In other words, it is more reasonable to say that a given loss of health will depress a worker's output by, say, 10 per cent., other things being equal, than by, say, 10 units.

If this viewpoint is acceptable, then it necessarily follows that the distribution of individual output will tend to be such that the logarithms of output in a given period have a 'normal' frequency distribution, provided that certain very general conditions are fulfilled. At least, this would be the form of the distribution of individual output if the whole working population were producing the same goods by hand, or if, considering a single occupation, each member of the working population had the same chance of being employed in this occupation. In practice this is very unlikely to happen since those persons engaged in a particular occupation tend to be selected in a purposive manner from the working population as a whole.

The purpose of this article is to discuss one possible and fairly simple method of selection and to investigate, as far as possible, its effect on the distribution of output (and of earnings) and on productivity in the various occupations of a community.

In part, too, this article is intended to combat the view, which appears to be implicitly held by many, that the distribution of incomes is an arbitrary one that has developed by the process of historical accident. Such a distribution ought then to be modified, so the argument runs, and such a change cannot but be for the better. Such a contention may well be partly true so far as property incomes are concerned, but at best it seems

[1] My thanks are due to Dr. A. R. Prest, Fellow of Christ's College, and to Mr. C. F. Carter, Fellow of Emmanuel College, for reading this article in typescript and for their valuable comments. Naturally the responsibility for the views expressed and for all errors is entirely my own.

[2] See 'The Distribution of Earnings and of Individual Output' (*Economic Journal*, September 1950).

to be a dangerous half-truth if it is applied to earned incomes as well. It will be shown here, albeit with many simplifying assumptions, that whatever the rates of remuneration which either rational choice or irrational prejudice allocate to the units of output in different occupations, such scales of relative rewards exercise no more than a superficial distorting effect upon a basic pattern. This underlying pattern is independent of the subjective feelings of consumers and of entrepreneurs and is determined by objective facts. It depends, in other words, upon the varying relative effectiveness of human abilities when faced with different kinds of productive problems and can be altered only by changes in the techniques of production in the various activities in which the human race engages. Manipulations of scales of payment may result only in the near extinction of certain occupations in the long run.

In order to establish these conclusions, many assumptions must be made to simplify the argument, which must necessarily be conducted in terms of a remote and abstract world. Later, when the points of substance have been underlined, an attempt will be made to bring the discussion nearer to life as it really is or, perhaps more accurately, as it seems to be.

It is to the first of these tasks that the intellectual effort must now be applied.

II

To begin with, let a very simple community be considered in which a member of the working population has the choice of only two occupations: hunting, and fishing, for example. Every such individual is quite free to move from hunting to fishing as and when he chooses. No autocrat headman has decided that those men whose names begin with letters A to L shall be hunters willynilly and the remainder fishermen. In this simple and idyllic existence even Nature herself has taken on an unwonted simplicity. The hunters, try as they will, can only snare rabbits of identical weight and succulence, while the fishermen's trout invariably weigh $1\frac{1}{2}$ lb. each.

The council of elders in the village in their savage ignorance have not yet discovered any device that improves upon the free operation of the price mechanism.[1] Demand and supply tend to establish prices for a standard rabbit and for a trout in terms of the local currency of cowrie shells. If every adult male fished for a year the distribution of the logarithms of output of fish would be normal. Similarly, if they all hunted for a year the distribution of rabbits caught by individuals would have the same form. There is, of course, no reason to suppose that the shape of

[1] Capital equipment is renewed and new investment in fishing-tackle and snares takes place on days specially set aside for this purpose. Investment is the responsibility of the community as a whole and not of individuals.

these two distributions will be the same. The rabbits are plentiful and stupid and even the less skilled man can ensnare a fair number in a year's hunting while the exercise of a quite appreciable degree of skill does not enable the better hunters to catch many more. The trout, on the other hand, are particularly wily and fight hard, so that many men would undoubtedly starve if they had to eat only what they themselves caught; but nevertheless the real fisherman can obtain very big catches in a year's fishing, although such catches are pretty rare occurrences.

The distribution of hunters' output may thus be said to be much more 'concentrated'[1] than the distribution of fishermen's output. Nor is this all, for it is possible that a considerable degree of association may exist between individual performances as hunters and as fishermen. There may be a marked positive association so that the best hunters and fishermen are, generally speaking, the same people, or the association may be negative so that the best hunters generally make the worst fishermen and conversely.

When there exists no tendency for the numbers of hunters and of fishermen to change at the ruling prices for fish and rabbit, it must be the case that no individual can improve his position by changing his occupation. Among these simple-minded people the net advantages of an occupation are represented solely by the annual earnings in cowrie shells. Every man, too, has a fairly good idea of what his annual output is likely to be in both occupations. In the long run, then, the proportion of the total number of adult males in each occupation will be equal to the chance that the annual earnings of any male, chosen at random, will be higher in that occupation than in the other.

First, let the occupation in which the distribution of output is the less concentrated be considered, that is, the business of fishing. Whatever the relative prices of fish and rabbit, the distribution of output resulting from the selective process outlined above will be of the same general form. Those men who are the very best fishermen will all spend their time fishing and, as progressively lower outputs of fish are considered, the proportion of men who fish rather than hunt will decrease steadily until virtually none of the potentially worst fishermen of all find it worth their while to fish.

In the other occupation of hunting, matters are not quite so simple, for this is, in a sense, an inferior occupation because the potential individual performances are much more concentrated. It is possible to distinguish three possible eventualities. If the association between output of fish and output of rabbit is, in general, either positive but sufficiently small, or negative, the distribution of output of rabbit, after the selective process has operated, will be of the same general form as the distribution of output

[1] The 'concentration' is inversely proportional to the dispersion of the logarithms of individual output.

of fish, i.e., most of the potentially good hunters will hunt and virtually none of the potentially bad hunters will do so.

If, however, there exists a substantial positive association between hunting and fishing performance, while at the same time potential rabbit output is significantly more concentrated than potential fish output, it will not be possible to get both many good hunters and many good fishermen. In fact, since hunting performance is more concentrated, those people who take up hunting will include a very large proportion of the worst hunters and very few of the better ones. This, then, is what makes hunting the 'inferior' occupation, since the requirements of fishermen must necessarily be satisfied primarily from amongst those people who are potentially both the better fishermen and the better hunters while the hunting profession must be content with what is left over.

It may be, however, that there is a certain positive association between hunting and fishing prowess and that the concentrations of individual performance in both occupations stand in such a relation to one another that the same proportion of all grades of hunters find it worth while to adopt this occupation exclusively. Such a situation is clearly a limiting one, intermediate between the two discussed previously. In this case and in this case only will it be true that the distribution of individual output of rabbits is actually, as well as potentially, normal in the logarithms of output.

It is instructive to consider the implications, as far as productivity in the two occupations is concerned, of the sudden increase in the popularity of trout relative to rabbit in the community's diet. The price of trout relative to the price of rabbit will rise and it will become advantageous for certain men to give up hunting and take up fishing instead. If the association between individual rabbit output and trout output is negative, zero, or sufficiently small and positive, those men who now become fishermen will on the average have lower outputs of fish than those who were fishermen before the demand for fish increased. Productivity in the sense of average output per head in the fish industry will thus fall. But these same men will be those whose output in the rabbit industry is on the average lower than that of the men who find it worth while to remain hunters, even though the price of rabbit in terms of trout has fallen. Productivity in the meat trade will thus rise.

If the association between outputs in the two occupations is positive but not sufficiently small, productivity among the fishermen will still fall, but now the men moving from hunting to fishing will be those whose hunting output is on the average higher than that of the hunters left behind. Productivity in terms of rabbits per hunter-year will thus fall. Hence the attempt to satisfy the increased demand for trout has resulted in a fall in productivity in both occupations.

In the limiting case when the association between outputs has a certain positive value, the average output per head in rabbits of hunters turning over to fishing will be the same as the average output per head of those who remain hunters and in this case, while productivity will of course fall in fishing, hunting productivity will remain unchanged.

The reader should have no difficulty in adapting the reasoning to the situation arising if the community's preferences changed in favour of rabbit.

III

The cases discussed so far have been perfectly general ones, but in order to obtain a further insight into the working of this simple model, further consideration must be given to two special cases.

Suppose now that villager Ay Bee is the star fisherman of the community and also the best hunter. The 'average' man Ell Emm is ranked fifty-seventh, say, in order of merit both as a fisherman and as a hunter, while poor old Wy Zed is the most incompetent villager in both occupations. In general, any villager's position at the end of the season would be the same if the entire community decided to devote themselves to hunting or fishing exclusively. It still remains true, however, that individual catches of trout tend to be much more differentiated than individual bags of rabbits.

When the supply and demand for fish and meat have been equated at the current price, it will be found that all the fishermen have outputs greater than or equal to a certain minimum level determined by the relative prices of rabbits and trout, and that all hunters have outputs less than or equal to a certain maximum value, similarly determined. Furthermore, the minimum earnings of fishermen and the maximum earnings of hunters will be equal. The distribution of the logarithms of earnings for the whole community will be a sort of composite normal distribution, with a relatively high dispersion in the upper section of the range and a lower one in the bottom section.

Suppose now that, for some reason such as changes in the habits of both rabbits and trout or alterations in hunting and fishing technique, the individual performance as hunter and fisherman tend to have the same pattern so far as the concentration is concerned. The more similar such patterns become, the greater will be the movement of men from one occupation to another induced by a given small change in the relative prices of fish and meat. Finally, if the patterns become identical there are only three possible positions of equilibrium. For if the ratio of the price of fish to the price of rabbit is greater than a certain value, everyone will opt for fishing, while if the ratio is less than this the whole of the labour force will take up hunting. When the price ratio is exactly equal to this limiting

value, every man will find that he can earn the same number of cowrie shells whichever occupation he takes up and he will therefore be indifferent as to the one he enters. It seems reasonable that the possibility of mental breakdown on a large scale ought to be ruled out, and that it may be assumed that under these conditions half of the adult males will start to fish and half to hunt.

This example serves to illustrate the fact that when the association between outputs in the two occupations is high, the differing rates of payment per fish and per rabbit will not be an efficient selective device unless the patterns of output in the two occupations are substantially different.

The other special case arises when the qualities required of a fisherman and a hunter are such that Ay Bee, the best fisherman, finds himself the worst hunter, while Ell Emm, who ranks fifty-seventh from the top as a fisherman, now ranks fifty-seventh from the bottom as a hunter. Wy Zed has recovered most of his self-esteem because, although he is still an impossible fellow to trust with rod and line, he now has no equal with the snare or the ferret. In general, the ranking of each individual would be exactly reversed if the whole village gave up fishing in favour of hunting, or vice versa.

Now it will be found that every fisherman catches at least a certain minimum of fish while every hunter bags at least a certain amount of rabbits, once the prices and the consequential distribution of the labour force have equilibrated supply and demand. Everyone will earn at least a given minimum of cowries, and these minimum earnings will be the same for both fishing and hunting. The distribution of earnings can be obtained by considering that arising in the previous case discussed and then folding over the lower section of the distribution with the smaller dispersion and superimposing it upon that part with the greater dispersion.

In this situation it does not matter whether the patterns of hunting and fishing performance become the same or not, for the method of selection will not be faced with a problem that it cannot resolve.

In the first instance, it was true that all fishermen had higher earnings than any hunters and consequently fishermen might be expected to acquire a superior social status. In the second case, no such broad generalization could be made, but nevertheless there is reason to believe that even in this case fishing would be the right thing for nice people to do. For if a high enough level of earnings is chosen, the level being dependent on the prices of both fish and meat, it will always be found that, among the men with earnings greater than this, fishermen predominate. In this particular sense, then, it is true to say that fishing is the 'better paid' or 'superior' occupation. Although this result has been mentioned in the discussion of two special cases, yet in fact it has a far more general application. For,

whatever the degree of association between individual hunting and fishing performance, and whatever the relation between the prices of fish and rabbit, it will always be possible to find a level of earnings above which there are more fishermen than hunters, provided that, of course, individual performances are more concentrated in hunting than in fishing. An attempt to raise the status of hunting by offering increased prices for rabbits only increases the level of earnings above which fishermen are in a majority.

IV

So far the discussion has been confined to a very simple sort of community, but it appears worth while to see what will happen in a more sophisticated township. The inhabitants have now found that, once they have eaten their fill, there are a great variety of pursuits that can be employed to while away the time. The intelligentsia are well aware of the undesirability of encouraging monopolistic competition by product differentiation and it has been ordained that any manufactured article must conform precisely to certain approved specifications. Nevertheless, a great many different kinds of goods are demanded by the community in widely varying quantities.

The passage of time and the concomitant progress have not altered the essential character of this happy people; they still tend to take up the occupation which offers the greatest reward. The existence of many alternative occupations makes the results of the selective process rather more varied, but even now certain broad generalizations can be stated.

Fishing still remains the most respected profession although it is closely rivalled by the writing of scientific papers of uniform quality, exactly 6,000 words long. The catching of rabbits occupies an intermediate position in the hierarchy, while the choppers of wood and the fillers of standard size water-buckets are, respectively, the least but one and the least esteemed of occupations. In other words, fishing performance is still the least concentrated while the drawing of water is the most concentrated in the sense used earlier in this article. Everybody in the community is capable of producing some output in every occupation, although in some lines of activity there are many men whose potential output is not far removed from zero.

Whatever the prices established by supply and demand and whatever the degree of association between individual potential performance in each pair of occupations, fishing will always attract most of the good fishermen and virtually none of the bad ones. If each association is less than or equal to zero or is positive but sufficiently small, given the varying degrees of concentration of performance in different activities, every occupation will attract a high proportion of the better men and the proportion will steadily

fall as less and less able men, in so far as this particular occupation is concerned, are considered. If these conditions are not satisfied, it will be found that the men who are forced by circumstances to devote their lives to providing the water-supply will include a very high proportion of those who are very inefficient water-carriers and this proportion will fall steadily as the potentially more efficient water-carriers are considered. In the other intermediate occupations the proportion of workers of different levels of competence will not increase or decrease steadily with competence as is the case with fishing and watering respectively, but over some ranges of potential output the proportion will rise and over others it will fall. The general effect will be that for the higher forms of activity the distribution of output of those who take up this occupation will approximate to the distribution of output of fish, while for the more lowly sorts of occupation, the distribution of output will tend to be like that of the output of buckets of water.

As in the two-occupation community, there exists a limiting situation in which the water-drawing profession will attract a constant proportion of workers at every level of efficiency in this activity.

If conditions are such that it is possible to disentangle the best workers in each occupation while at the same time leaving sufficient competent men for the other activities, an increase in the demand for the product of any kind of industry will clearly cause productivity in that occupation to fall and in all others to rise. If such an unravelling process cannot be effectively carried out, the result of such an increase in demand on the particular industry concerned will obviously vary, but the effect on productivity in other activities can be stated more definitely. Productivity in fishing will clearly rise, in science it will probably rise, but nothing can be said about hunting. In the firewood industry productivity will probably fall, while amongst water-carriers it will certainly fall.

A further clarification of thought will probably ensue, if two special limiting situations are discussed in a little more detail. First, let it now be supposed that Ay Bee, the great-grandson of the earlier villager of the same name, is the undisputed *victor ludorum*, for he excels in the catching of fish and the writing of theses and can fill more buckets of water in a year, if he is put to it, than anyone else. In short, he can do everything better than anyone else. Everyone has the same ranking in each occupation and poor Wy Zed is as clumsy with buckets of water, and everything else, as his great-grandfather was with a fishing-rod. Then the highest earnings will be obtained by the fishermen and next highest by the writers of theses, while the lowest earnings will be received by the water-carriers. Furthermore, the least earnings of the fishermen will be equal to the greatest earnings of the academics, and so on. For certain levels of prices

it may not be worth while for anyone at all to enter some occupations, but, with this reservation, whatever the relative prices, the incomes earned in a particular activity will be greater than any earned in occupations in which the performance of individuals is more concentrated and less than any earned where individual performances are less concentrated. Thus, any attempt to reduce the earnings in a particular occupation relative to the others simply serves to reduce the numbers of workers in this line and those that remain occupy the same position in the hierarchy of earnings as before.

Under the circumstances described, the distribution of earnings in the whole community is such that the logarithms of earnings are distributed normally with different dispersions over different sections of the range. At the top end of the range the dispersion is at its greatest and it diminishes by finite steps as movement is made from the top to the bottom of the range.[1]

The other situation worth examining is that existing when there are two groups of occupations within each of which the ranking by individual output is the same in every occupation but such that for any pair of occupations taken from different groups the ranking is exactly reversed. Young Ay Bee is champion fisherman, hunter, and log-chopper, but he is the worst performer at the writing of scientific papers and water-carrying. Wy Zed excels at the two last-named activities but is the most incompetent at the three first named. When the demand and supply for the various products are in equilibrium, it will certainly be true that the worst fisherman earns the same as the best hunter and the worst hunter the same as the best log-chopper. Similarly the sparsest output of scientific effusions will earn more than the greatest output of buckets of water. It can also be stated quite definitely that if a high enough level of earnings is chosen, there will be more fishermen with incomes greater than this than scientists; while if a low enough level of earnings is selected, there will be more water-carrying incomes below this level than log-chopping ones. Nothing further can be said about the intermediate occupations, and this rather odd case provides a 'partial' exception to the rule stated in the last paragraph of section III.

If any two or more occupations, for which individual performances are positively associated, are such that these performances have the same degree of concentration, it will be possible to find prices of the products of these activities that induce equal numbers of workers to take up employment in each of these occupations. But if the prices are slightly disturbed

[1] Such a distribution if plotted on logarithmic probability paper would not appear as a straight line but as a series of straight-line segments convex downwards towards the right-hand bottom corner of the sheet.

from this relationship the total labour force in these two or more occupations will move into just one of the activities. This is just another example of the necessity for the differences in concentration of individual performances, if the method of selection is to work properly when associations are high and positive.

V

The argument has now reached the point where it seems advisable to try to remove some of the simplifying assumptions on which it has rested so far. As progress takes place, or rather as the community becomes industrialized, which may or may not be the same thing, each worker will not be rewarded by the price which a unit of his product fetches in the market, instead he will be paid a wage by his employer. Where this reward is related simply and directly to his output the analysis clearly needs no modification. If a worker's reward is not in the short run connected with the output he produces in a given period, it does not follow that it is not so connected in the long run. For it is an accepted fact that every time-wage must be related to the expected output of a worker. Thus, the previous analysis, while not seeming to be immediately applicable to real conditions, may be fairly considered to deal with the fundamentals of the situation rather than with superficial appearances. This sort of approach must also be valid when dealing with wage systems of the bonus type, which are based partly on time and partly upon output.

What will happen as techniques are improved and as handicraft gives way to machine operation? The answer to this question depends upon the effect of such innovations upon the concentration of individual performances. It is a characteristic of machine operation that only part of the time of each cycle of operation varies with operators' differences in skill and aptitude. Machines are run at constant speeds and the machine time for any operation is thus fixed. This means that the outputs of individuals working with machines are likely to be more concentrated than those of people working with their hands at jobs requiring similar skill. It may be, of course, that machine working requires human qualities which were not needed when the job was done by hand and in this case the change-over might cause the concentration of individual performances to be lessened. In general, however, it may be expected that the advent of machines will increase concentration and hence, other things being equal, an occupation will move to a lower position in the hierarchy of activities. If a sufficiently high level of earnings is chosen, fewer workers in the occupation with earnings higher than this level will be found than was the case before the introduction of the machines.

More generally, innovations may be considered to be of three kinds.

There are those which raise the output of all individuals in the same proportion, those which raise the output of the better workers in a greater proportion than the output of the worse workers, and lastly those which raise the output of the worse workers proportionately more than that of better ones. Whatever the effect of such innovations upon the price of the product and the consequential change in the rate of remuneration of the workers, the first sort of innovation will, other things being equal, leave the status of the occupation, as determined by the highest incomes, unchanged. The second type of innovation will raise the position of this activity relative to other activities, while the third kind, paradoxically, will diminish the status of the occupation despite the fact that the productivity of the least efficient has been brought up towards that of the best workers.

Is this result so paradoxical after all? If 'anybody can do it', there is no reason to esteem or pay very much for its performance. If only a few persons are sufficiently gifted to reach a moderate level of competence, any sort of demand for their services is likely to result in some at least reaping high rewards. At the moment there is much talk of the evils of levelling downwards and of the desirability of trying to level upwards. If there is anything in the argument put forward here, the process of levelling inevitably operates downwards, in so far as any profession is judged by the highest incomes which its practitioners may earn.

It should be apparent that the analysis attempted in this article bears some sort of affinity to the theory of comparative advantages. A situation has been examined in which individuals' comparative advantages in various activities differ widely. The advantages are of such a nature, due to the hypothesis that output is likely to be distributed normally in its logarithms, that variations in flat rates of reward per unit of output are never sufficient to destroy them entirely, although the number of people who can exploit them may be progressively diminished.

VI

In the discussion of the primitive community, the assumption of perfect occupational mobility was made. For a more advanced society, such an assumption leads to an air of artificiality. In the short run, at all events, workers will not switch jobs just because their earnings are likely to be increased but, if they are rational, they will consider the costs incurred by such a change and the differences in the 'net advantages' of alternative occupations. If, however, the longer run is considered, a worker who is just entering the labour force will incur no such costs, provided always that he can find employment in the occupation of his choice near his own home.

The application of the foregoing analysis must therefore be limited to the long run.

To deal with the problem of costs of geographical movement necessarily incurred by a person entering an occupation and with the difficulty caused by worker's preferences for certain jobs even when no differences in earnings exist, use must be made of the concepts of the 'average cost of movement' in terms of the output of the particular occupation and of the 'average net advantage', also reckoned in terms of output. If, then, any worker's most profitable activity is to be found, his earnings in any occupation must be calculated by considering his 'notional output' multiplied by the appropriate piece-rate, where his 'notional output' is equal to his actual output less the 'average cost of movement' and plus the 'average net advantage'.

This kind of modification is obviously a very tiresome one and it must be hoped that, in general, the corrections necessary are sufficiently small to be neglected. It does not seem likely that they will be of sufficient importance seriously to modify the conclusions of this argument based upon the more simple assumptions. Nevertheless no deduction based upon the properties of this naïve model ought to be applied to the real world, without bearing in mind at least some of the assumptions that ought in principle to be removed.

VII

The results of the previous analysis will now be briefly summarized. It has been shown, granted the truth of the particular assumptions made, that the distribution of earnings depends on certain 'real' factors, i.e. the character of the distributions of various kinds of human skill and the state of technique existing in different occupations. The desires of the individuals in the community for various sorts of goods are naturally of great importance too, but they are only able to exert their influence within the framework determined by skill and technique.

It must be emphasized that the conclusions reached are dependent upon the particular kind of distribution of individual output assumed at the start of the discussion. They would not necessarily be true if other types of distribution were considered. The choice of the particular form of distribution is not, however, an arbitrary one but has a reasonably plausible empirical basis.

In an analysis like this there is little chance of stumbling upon new or startling truths. Nevertheless, a fairly detailed examination of this sort seems worth while if only it serves to illuminate familiar and commonplace phenomena from rather different angles.

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