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Appendices

Appendix A

On the Measurement of the Physical Output of Public Utilities

Physical output might at first sight be considered a fairly simple notion; nevertheless it is a notion capable of a number of different interpretations, some of which must be distinguished briefly. Take for example the contrast between gross and net output. Not only is there some doubt as to just what deductions separate gross output from net, but in addition common usage employs the terms differently in relation to a single enterprise and to the economy as a whole.

CONCEPTS

Naturally for a single enterprise *gross* output comprises the entire product, without any deductions whatever. In such a case the entire output of the firm is treated as originating within the enterprise, irrespective of any input which the firm may obtain from elsewhere. *Net* output on the other hand is what remains after appropriate deductions are made. The comprehensiveness of these deductions varies with the purpose in hand. Thus we may subtract materials and fuel purchased elsewhere, and even the firm's consumption of its own capital. The intention is always to segregate the portion of its gross output that in some sense originates within the firm in question: the remainder — the firm's input — originates in other enterprises. In its strictest sense, therefore, net output includes only the contribution of the factors — natural resources, labor, and capital — peculiar to the enterprise in question. Conceptually it is identical with the real income originating within the enterprise. In this strict sense input, regarded as the difference between gross and net output, comprises not merely a firm's purchased materials, but everything necessary to maintain its capital intact. Conceptual and statistical difficulties connected with the maintenance of capital may lead us to prefer a rather less

strict, i.e., less comprehensive, definition of input, and an associated definition of net output in which only some of the appropriate deductions from gross output are made. Indeed the actual business of performing deductions of this kind is difficult enough, for in order to conform with our concepts it has to be performed in real rather than in money terms. But a discussion of concepts must precede any discussion of the measurement of their contents.

So much for the output of the individual enterprise. The physical output of the community as a whole also may be considered in either aspect, gross or net. The *gross* output of the community, not further qualified in common usage, remains a rather vague notion. It may mean simply the sum of the gross outputs of all the enterprises in the system. In that case it includes an amount of duplication which depends upon the business structure of the economy considered. Usually, however, gross output for the community means something narrower and less arbitrary than this. It means the sum of the *net* outputs of the various enterprises, the word 'net' being interpreted for this purpose *before* allowance for the consumption of capital and natural resources. The aggregate may be called the community's output 'gross of depreciation and depletion'. Unlike the preceding concept, it is independent of the business structure of the economy.

The *net* output of the community is plainly the sum of the net outputs of enterprises, 'net' being comprehensively interpreted to include deductions for depreciation of capital and depletion of natural resources. This is the concept that corresponds to our notions of 'real national income' or 'national dividend'. Again, since the appropriate deductions may be made with a greater or less degree of thoroughness, the aggregate so obtained may contain much or little duplication.

What purpose do such measures of output serve? In the long run, as a check upon deflated national income statistics they have perhaps some value. As a short run measure of real income, or of economic activity, such indexes as those compiled by the Federal Reserve Board in this country or the Board of Trade in Britain have obvious usefulness. But for the purpose of making comparisons over long periods of time, there is perhaps some risk of claim-

ing more for indexes of output than they can actually perform. For example, unless we make a whole series of further assumptions, none of which is easy to justify, an index of output (regarded as the equivalent of a measure of real income) in fact tells us little about variations, either in the amount of resources engaged in production, or in the real satisfactions obtained from consumption. Fortunately we have other, more direct ways of measuring the employment of resources. Some may claim that indexes of physical output have a more direct bearing upon the question of consumer satisfaction. Even here, however, it may be argued that the supply of certain socially significant sample commodities, e.g., the number of bathtubs per head, tells us more about consumer satisfaction than do composite measures of output or real income. Nevertheless, it remains tempting to assume that net output and the level of consumer satisfaction do, in general, move in the same direction, even if we can know nothing about the quantitative relationship between them.[1] However this may be, the primary purpose of constructing indexes of output remains the less ambitious one of keeping tab on the over-all efficiency of the economy, or of segments of it: regarding this efficiency as a technological rather than as a psychological concept.

UNITS

Suppose that the entire output of an economic system comprised a single uniform product, let us say oranges of a certain specified size, weight, color, juiciness, and so forth. In these peculiar conditions, to measure the physical output of the economy would be simple. By merely counting the number of oranges harvested from year to year, or weighing them, or measuring their juice content, an index of output would at once be available free both from ambiguity and from arbitrariness. Nor would it matter in the least which measure was chosen, for as long as output remained homogeneous each would yield the same result, i.e., disclose the same pattern of temporal variation. Only in this very special case does the problem of measuring physical output admit of a unique solution.

For as soon as the community's output is no longer homogeneous

[1] Cf. A. C. Pigou, *Economics of Welfare* (London, 1929), Part I, especially Ch. VII.

in respect of its physical characteristics, the measurement of its physical magnitude ceases to admit of the easy and simple solution just indicated, and becomes instead a more or less complicated statistical problem. This lack of homogeneity assumes two forms. First, the oranges may vary in quality. Second, the community may produce not only oranges but apples as well. This distinction between variations in quality and variations in kind, although often of immense biological or physical significance, is by no means fundamental from an economic standpoint. Technical differences between one grade and another, which appear at first sight of minor moment, may turn out to have great economic importance. The consumer, ultimate or otherwise, is often exigent in quite unexpected directions. For one grade an altogether different commodity may be a better substitute than another grade of the same commodity. Nevertheless, the contrast between distinctions of grade within a single commodity on the one hand, and the differentiation of separate and distinct commodities on the other, is a convenient one, provided that we do not overrate its significance.

First, then, suppose still that oranges are the only kind of output, but let us allow their quality to vary. Two such sorts of variation are relevant: (a) in respect of weight, juiciness, sugar content, and other *measurable* characteristics; and (b) in respect of flavor, color, texture, and other attributes that cannot be measured.

Now, as regards (a) — measurable characteristics — it is evident that each variable provides a separate and distinct measure of physical output. Thus we can use the number of oranges in the crop, or their total weight, or their total juice or sugar content, or indeed any other measurable characteristic. Since output is no longer homogeneous with respect to these characteristics, it is only to be expected that each such computation will yield a different result. Obviously no unique measure of output is any longer available unless we decide that some *one* variable — e.g., number or weight — is more fundamental than any of the others. It is important to realize that this is an essentially arbitrary decision. There is no more reason why we should measure oranges by the thousand than by the case or by the ton. For simplicity of exposition we have chosen oranges. But that a point of substance is involved is easily

seen if we consider for a moment the problem of interpreting the concept of a physical unit of output in such a field as transportation. Is the ton, the carload, the ton-mile, the carload-mile, a combination of these, or some altogether different measure to be taken as the fundamental unit of service rendered (i.e., of output) in the realm of freight transportation? For the moment this question is merely posed. At a later stage in the argument an approach to its solution will have to be attempted.

As regards (b) — nonmeasurable characteristics — the situation is different. Suppose the oranges vary in flavor. Such variations in quality between different units of output, where these cannot be quantitatively expressed, clearly cannot be made the basis for still further alternative measures of physical output. It is impossible to take account of them directly. What such variations in fact do, is to cast doubt upon the justification for choosing some other, measurable variable as the fundamental unit for measuring output. Suppose the oranges improve in flavor from year to year: unless this fact happens accidentally to be correlated with weight, or sugar content, or some other measurable characteristic, it will in no wise be reflected in any of the measures discussed above.

We come now to the second possibility just mentioned. So far the problems discussed already reach their full complexity in an economy producing what is ordinarily thought of as a single commodity, i.e., oranges. Suppose now that the community grows apples too. Having decided (with a greater or less degree of arbitrariness) what physical units to use for the measurement of oranges and apples separately, we are faced with the problem of combining them into a single measure representing the community's total output. It is obvious that this problem is different only in degree, not in kind, from the problem of dealing with the output of oranges, or other single commodity, when that output is not homogeneous. Still for the moment confining ourselves to variables of a purely physical nature, we might consider a single orange the equivalent of a single apple; or we might add tons of oranges and tons of apples; or we might perform the summation in terms of juice, or sugar content, or any one of an infinite number of more or less relevant and interesting physical characteristics. each time

reaching a different result. Perhaps it might even be possible, with sufficient ingenuity, to conceive of a context in which each of these results would be appropriate.

The absurdity from the economic standpoint of any such procedure may be seen, not only in the essential arbitrariness of the decisions to be taken, but also in the rapid and complete disappearance of common physical characteristics among the commodities involved as we extend our purview. It remains possible, however inappropriate, to compare a ton of radium with a ton of lead. But a ton of lead, a unit of electricity, a ton-mile of transportation, and a telephone call have on the other hand no physical characteristics even superficially in common. Plainly an altogether different line of attack must be sought.

VALUE AS A COMMON DENOMINATOR

Let us suppose that output consists of two commodities — apples and oranges — each of which individually is homogeneous with respect to all of its physical characteristics. The object of our search is of course a ratio between apples and oranges (in terms of number, tons, cubic feet — or other physical unit) that has some meaning economically and is not merely an arbitrary ratio, and that will allow apples and oranges to be added in a manner which does not have to look to some special context for its justification.

Now the fundamental unit in economic measurement is of course the unit of money value. A dollar's worth of oranges and a dollar's worth of apples are equivalent in the sense that they can be exchanged for one another in the market. For making comparisons between different commodities therefore, the physical unit we may label 'a dollar's worth' has a significance that a ton, cubic foot, or carload lacks.

From the viewpoint of ordinary common sense, it is of course precisely the lack of correspondence between dollars' worth and tons that is responsible for our instinctive unwillingness to compare, for example, a ton of radium with a ton of lead. The arbitrariness, indeed the absurdity, of such a comparison disappears once the two commodities are reduced to common values — that is, to physical units (i.e., dollars' worth) of such a size that the

market in fact treats them as equivalent. The process of summing amounts of different commodities in terms of dollars' worth is statistically equivalent to summing any arbitrarily chosen physical units, each weighted by its price.

While this solution is obviously of perfectly general application, and may be used for combining measures of physical output relating to any number of commodities, its requirements are not always easy to satisfy. Thus in order that a unique index of output shall emerge, the ratios between the market prices of given physical units of the various commodities must remain invariable. This is of course an impossible requirement. To put the matter otherwise, what we have in fact done is to assimilate the construction of an index of output to that of an index of prices. The record discloses both price changes and quantity changes. It is the business of an output index to abstract from the former, just as it is the business of a price index to abstract from the latter. No such abstraction can in the nature of things be performed unambiguously. It is not our purpose here to trace once more the familiar outlines of the 'index number problem'.[2] Choice of weight-base and formula will influence the outcome. The particular compromises embodied in the chronology and formulas used for computing purposes in the present study are described elsewhere.

Further, we have assumed each commodity to be homogeneous with respect to all of its physical characteristics. If, however, its output varies in quality at any given moment of time, either measurably or nonmeasurably, the difficulty can be overcome by grading, and treating each grade as a separate commodity. If this is done, account will be taken in the computation both of measurable and of nonmeasurable variations from one unit to another of the product, for both are equally reflected by the behavior of the market in setting prices. Specially large and specially flavorsome oranges both command a premium. So much — the reduction of physically nonmeasurable variations, as well as those which are measurable, to a common price basis — the use of market valuation does achieve, but only so far as these variations are contem-

[2] Cf. J. M. Keynes, *Treatise on Money* (London, 1930), Ch. 8; Irving Fisher, *The Making of Index Numbers* (Houghton Mifflin, 1922).

poraneous. Since abstraction is to be made from price changes from one moment to another — this being the whole object of an output index — no account can be taken of physical variation through time (whether measurable or not). If the quality of a commodity improves through an increase in the fraction of its output concentrated in the better grades, at the expense of inferior grades, this will be accurately reflected in the computation. If on the other hand the quality of a given grade — or of a single homogeneous commodity — improves with time, there is plainly no way of recognizing the fact. We may be reasonably sure that, especially in view of the comparatively coarse grading allowed by the statistics, most quality changes in practice come about by the latter method. We may be sure also that, on this account if on no other, production indexes contain a rather serious downward bias, in that they take too little account of changes in quality.

It might perhaps be thought that quality changes are no concern of an index of output. That it is not possible to place the quality of the products on one side, and to confine attention to measures of quantity which are independent of quality, may easily be demonstrated, and is indeed already implicit in what has been said above. Consider a single commodity whose output, though homogeneous at any given moment, is subject to improvement in quality through time. This improvement may be viewed as an alteration in some or all of its physical attributes, or in the relations between them. The chemical becomes more nearly pure, the automobile has more cylinders, the concrete lasts longer, the supply of electricity is less frequently interrupted. No doubt we are prevented, for the most part, from incorporating these developments in our output index. And yet, who will deny that *at any given moment of time* pure chemicals command a premium; so also do many-cylindered automobiles, long-lasting concrete, and electrical installations of unusual reliability. To the extent that we appeal to market valuation as a basis for the summations our measurements require, and weight products and grades according to their prices, quality — as reflected in price-differentials — becomes merely an aspect of quantity. The greater weight given to a superior grade — as the market rules it to be superior at any

chosen moment — amounts to a tacit admission that quality and quantity are, in large degree, interchangeable concepts.

This fusion of the concepts of quality and quantity results of course directly from the appeal to market valuation. That in performing the summations necessary to the measurement of output such an appeal is inevitable, and the only available alternative to a chaos of arbitrary decisions, has already been shown. But to argue that the judgments of the market are invariably a true criterion of economic significance, or that such judgments are always unambiguous, would be a clear perversion of the facts. Since it is impossible to construct a measure of output without a weighting system, since the value concept is a convenient source of such a system, and since this concept underlies all our computations, it seems desirable to pursue the matter somewhat further.

THE LOGIC OF THE VALUE CONCEPT

The use of market values, or prices, as weights in computing the output index was suggested above primarily as a means of avoiding the need for arbitrary decisions. Since the market regards a dollar's worth of apples and a dollar's worth of oranges as equivalent or interchangeable, therefore — so the argument ran — we may regard them as equal physical quantities. What this leads to in practice is the aggregation of dollar volumes of different commodities at fixed prices per ton, per yard, or other commercial unit. By this procedure, the universal measure of physical output, applicable to all commodities without exception, becomes the dollar's worth — measured at the base date or over the base period.

Now under very special circumstances — circumstances which may roughly be labelled those of perfect competition — this procedure would have much more than merely pragmatic justification. Let us assume an unreal world in which perfect equality exists everywhere in the marginal significance attached to consumer expenditure in different directions, and at the same time perfect equivalence between market price and marginal cost of production; and further in which resources are remunerated according to their marginal productivity so interpreted, complete mobility existing among occupations. In such a world the phrase

'a dollar's worth' has a universal significance which is partially denied to it as things actually stand in the world as we know it. In such a world a dollar's worth, no matter of what commodity, comprises on the one hand, from the viewpoint of any given consumer, a standard amount of satisfaction. It measures at the same time on the other hand the product of a standard amount of resources. Furthermore, a dollar's worth of resources, no matter of what kind, will everywhere produce the same output as a dollar's worth of any other kind. The 'dollar's worth' therefore constitutes at any moment, in this ideal world, an unambiguous physical unit, not only of output, but of resources and satisfactions as well. This is of course true only at any given moment, for in making comparisons through time the ambiguities inherent in the 'index number problem' are in no way mitigated.

Consider then just what — in such a world — our appeal to the judgment of the market would have achieved. It would have provided us with a measure of output enabling us (apart from the index number problem, and apart also from possible deficiencies of coverage) to settle certain questions unambiguously. A rise in our index would be uniquely correlated with a rise in the community's aggregate level of satisfaction. If the community did not consume more of one thing, we would know that the community had chosen to consume more of something else. A rise in the index, unaccompanied by a corresponding rise in the amount of resources employed in production, would argue a real increase of economic efficiency. The economy could now produce as much as it produced previously, and still have resources over.

Evidently the significance of any output index we can actually construct will in large degree depend upon how closely the behavior of actual markets conforms to the ideal outlined above. Some consideration of actual market conditions is therefore called for.

THE CHARACTERISTICS OF MARKET VALUATION

Of the markets in which commodity output is sold the great majority are more or less imperfectly competitive. Perfect competition is probably as rare as outright monopoly. To some extent no doubt

the values of farm products, minerals, and manufactures differ from the ideal values outlined above. Nevertheless, in the commodity field the difficulty is almost certainly less than in the production and sale of intangibles. Especially is this true of public utilities. The prices at which transportation, gas, and electricity are sold are notoriously the subject both of administrative control and of monopolistic discrimination. How then do these facts affect the construction and significance of our indexes of output?

Let us first consider the case of simple monopoly and see what becomes of the argument of the foregoing section. An electric utility, we will suppose, sells current at a price which, owing to the absence both of competition and of effective rate control, yields a particularly handsome return on its investment. The consumer pays more than the minimum necessary to attract and maintain resources in the industry, and purchases less current than he would do were the price per unit lower. To any given consumer, however, the significance of the marginal dollar's worth of electricity is still the same as the significance of the marginal dollar devoted to the purchase of any other commodity. From the viewpoint of consumer satisfaction, therefore, the fact that a certain commodity (electric current) is monopolized in no way invalidates our use of market prices as weights in the construction of an output index. Whatever the structure of the market, the prices the consumer pays are alone relevant to the measurement of output, when output is regarded merely as a source of consumer satisfaction.

But output has to be related also to the resources employed in its production. It is no longer true that a dollar's worth of electricity represents the product of the same amount of resources, in any intelligible sense, as does a dollar's worth of other commodities not monopolized.[3] The price at which a kilowatt-hour sells represents its cost to the consumer indeed, but to no one else. The cost of a unit of electricity to the community, in terms of the resources used up in its production, is measured by the sum for

[3] Unless of course monopoly power is itself regarded as a resource, whose services are appropriately priced. But this does not seem a reasonable interpretation.

which that unit would sell if return on investment were normal and monopoly profit were absent. If therefore the units in which, in our index, we measure output are to represent (at the base date) the consumption of a defined amount of resources, rather than the provision to some given consumer of a defined amount of satisfaction, we must work with cost, including a normal return to investment, rather than with selling price. Where monopoly profit accrues, these two evidently diverge. It no longer is possible to construct a single output index, perfectly correlated both with the level of satisfaction to the community and with the consumption of real resources of a given efficiency.

These two systems of weights — one based on selling price, the other on cost — of course coincide in the world of ideal competitive behavior considered at the outset of this discussion. In the case of our electric utility it was not the fact of monopoly, but the existence of monopoly profit, that caused them to diverge. Had an efficient public service commission been in control of rates, such divergence might not have occurred. In asking ourselves how far existing market valuations really are appropriate for weighting an output index, or how far they conceal ambiguities of the kind indicated, the use made of monopoly power is more important than the fact of its existence.

The ambiguity — insofar as it relates to conditions of simple monopoly — is illustrated more concretely in the following example. The community's output consists of two commodities, A and B. A we will suppose monopolized, while B is produced and sold competitively. In two years A costs $1 to produce and sells for $2 a ton, whereas B costs and sells for $1 a ton. Let the outputs be as follows:

	Year I	*Year II*
A, tons	100	140
B, tons	100	50

Using the two alternative systems of weights, we have the following output indexes:

	Year I	*Year II*
Weighted by selling price:		
Price-sum	$300	$330
Index of output	100	110
Weighted by cost of production:		
Price-sum	$200	$190
Index of output	100	95

Evidently the question, Is the community better or worse off in Year II than in Year I? receives no immediate answer.

In terms of dollars' worth of *satisfaction,* measured at the margin, output is larger, and the community appears to be better off. But consumers' preferences have evidently so altered — they now take nearly three tons of A for every ton of B, instead of ton for ton, at unchanged prices — that any statement about the comparative satisfaction yielded by a dollar's expenditure in the two years appears unwarranted. The best we can do is to remark that *if* the marginal utility of the dollar has not declined, then the community is better off, in the sense that its level of satisfaction is higher, in Year II than in Year I.

In terms of dollars' worth of *resources,* on the other hand, also measured at the margin, output is smaller. Certainly it would seem that, if resources are mobile, and if their efficiency has not declined, the output of Year II can be obtained with fewer resources than that of Year I. In the use made of its resources, the community would seem to be worse off, or less efficient. How output would have behaved had there been no monopoly, had A been sold at its cost of $1 a ton (as B is sold), we have of course no means of knowing. However, under such conditions, no such ambiguity would develop in the measurement of output as that present in the instance cited.

The principle involved here is a perfectly general one. Evidently an ambiguity of this kind will appear whenever the demand price for a commodity differs from its cost of production. Cost has to be interpreted to include all payments necessary in the circumstances to attract resources and maintain them in a given occupation. The case of simple monopoly was discussed above merely because it provides a convenient illustration of the difficulty which arises when prices and costs do not correspond — when market price, that is, ceases to measure the amount of resources employed in production. Further important cases of the same difficulty include commodities subject to taxation,[4] or to price discrimination, and commodities jointly produced but inappropriately priced. The first of these, taxation, is important for certain manufactures,

[4] Taxation can of course be regarded as the price of services rendered to production by the state, but even so it would be hard to argue that such services are appropriately priced in each individual case.

e.g., beverages and tobacco products, but does not much affect the market for public utility services.

Price discrimination and joint supply are more in point for our purpose and may conveniently be considered together, since they merge into each other. The production of electric current has at one time or another been viewed as embodying both principles. It is, for example, a commonplace that current for domestic use is sold at higher prices than current for industrial purposes. So that if we regard a kilowatt-hour of electricity as a uniform commodity, irrespective of the character of the purchaser and the conditions surrounding its sale, it is evidently the practice of electric utilities to discriminate among their customers.

On the other hand the cost of supplying a kilowatt-hour differs considerably according to the load factor associated with, or embodied in the agreement for, its use, and with the quantity and type of equipment involved in supplying individual consumers. Moreover, the generation of current for some uses affects the cost of its supply for other uses. If we argue in this fashion, it would seem foolish to regard the total supply of kilowatt-hours as a single homogeneous commodity. In fact the provision of current for different uses would appear to possess many of the elements commonly associated with joint supply.

However we may prefer to analyze the situation, we know that apparently similar commodities, such as kilowatt-hours, are — like ton-miles of transportation — sold to different customers at widely different prices. What we wish to discover is whether, if we use these prices as weights in computing our output index, an ambiguity of the kind discussed above will ensue. Clearly such an ambiguity will be introduced insofar as price differences fail to correspond to differences of cost. This is the relevant criterion, and some attempt must be made to judge how far in their price policies public utilities and railroads do or do not conform to it.

The business of rate-making almost always leads in practice to a compromise between what is commonly called the 'value-of-service' principle (in other words, what the traffic will bear) on the one hand, and the 'cost-of-service' principle (that is, the cost of handling a particular shipment) on the other. To take the latter

principle first: that each consumer of electricity or shipper of goods should bear at least the direct costs of the service he receives requires no special justification. That consumers are assessed, so far as general rules allow, with the cost of special equipment needed to serve them, or of specific charges entailed in handling their goods, is a well established principle of rate-making and need not detain us. Unfortunately, the costs common to the whole, or a large part, of the output of a utility or railroad are so considerable that the mere proviso that each consumer shall bear his own direct costs carries us only a very short distance. It does no more than set a floor below which individual rates must not be allowed to fall. To complete the schedule of rates (still for the time being adhering to the cost-of-service principle) it is necessary to distribute these common costs among the various classes of traffic. Authority exists for the statement that the proper interpretation of the cost-of-service principle results in distributing these common costs at a uniform rate per kilowatt-hour or per ton-mile, as the case may be.[5] To justify such a distribution we have to appeal to what would happen under simple competition. But such an appeal has little application in a field that is inevitably monopolized, and where competition may yield zero output. It would appear preferable to conclude that, if the cost-of-service principle alone were in question, the solution to the problem of railroad rate-making would be indeterminate.

According to the value-of-service principle, on the other hand, each consumer is charged whatever maximizes the net revenue of the enterprise. The prescription of the value-of-service principle therefore results in discriminating monopoly. Insofar as railroads and utilities follow this prescription — and there can be no doubt that they do so to a large extent — it might be thought the principle that prices and costs should correspond is reduced thereby to a mere pretence. That, even under a regime of discriminating monopoly, prices and costs are not *necessarily* unequal is best seen by reverting to the analysis of joint supply. Where several products come from a single process in unvarying proportions, the relationship between their selling prices in a competitive market will be

[5] Cf. A. C. Pigou, *Economics of Welfare*, Part II, Ch. XVIII.

such that the whole supply of each is absorbed without leaving unsatisfied customers. Provided that returns to the enterprise are normal, the aggregate proceeds will correspond to the aggregate costs of operation. While these costs cannot be imputed to particular products without reference to their selling prices, the price at which each product sells will of course measure its cost to the consumer, and in a real (if special) sense also its cost to the community at large, i.e., the amount of resources consumed in its production. Obviously true of all the products taken together, this statement is true also of each individual product, in the sense that only when these prices are charged is the market in equilibrium. In true cases of joint supply, therefore, the condition that price differences shall be such as to clear the market of each product, coupled with the further condition that the general level of these product prices shall secure normal returns to the enterprise — these two conditions taken together allow a complete determination of the costs of each and every product.

Unfortunately in the case of utilities and railroads so simple a solution does not exist. The provision of electric current or of transportation is not a true case of joint supply, because given quantities of service to one type of consumer do not imply stated quantities of service to another type. There is no such thing, for example, as clearing the market of any one kind of transport. In other words very considerable variations are technically possible in the relative degree to which a utility or railroad serves different classes of consumer. Nevertheless this problem equally is capable of a determinate solution, if we substitute for our previous condition, i.e., clearing the market, a new one, i.e., that the enterprise shall work as close to full capacity as is compatible with a normal return on its activities as a whole. This prescription may be described as a modification of the value-of-service principle, for the traffic is charged what it will bear in respect of the relation between rates, though not as regards their general level.[6]

[6] Neglecting prime costs, the condition is that the marginal revenues from each class of consumer shall be equal. If the monopoly dispenses service in two markets only, at prices y_1 and y_2 respectively, this is equivalent to the condition

$$\frac{y_1}{y_2} = \frac{e_1\ (1\ +\ e_2)}{e_2\ (1\ +\ e_1)}$$

In what sense can we say that such a plan keeps prices and costs equal to one another? Since returns are normal, there can be no doubt that the aggregate price paid for the services of the enterprise equals their aggregate cost. But there is no intelligible sense in which individual rates in the separate markets can be characterized as those which would prevail under competition. The most we can say is that the rate structure envisaged gives the community the maximum output it can obtain without a subsidy.[7] Any other set of rates would yield a smaller output and less efficient operation. Consumers in each market are charged, in the light of the elasticity of demand in that market, the minimum price necessary to cover normal returns. In this highly specialized sense, and in this sense only, can we say that prices and costs are equal, and that a weighting scheme which uses such prices is consequently appropriate.

In constructing our indexes of output for industries that practice monopoly pricing, we have presented more than one series. For railroads we have both weighted and unweighted ton-mile indexes, for electrical utilities both weighted and unweighted kilowatt-hour series. In some cases it does not much matter whether a weighting scheme is adopted or not; in others it makes a good deal of difference. Where monopolistic discrimination is practiced, it remains to ask, in terms of the preceding discussion, what degree of significance is to be attached to a weighted index of output, the weights being of course the actual prices charged by the monopoly in different markets.

Whether or not the rate structure conforms to the conditions prescribed above, conditions prescribed by social accounting, since

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where e_1 and e_2 are the respective elasticities of demand. For a real solution there must be at least one set of prices that yields sufficient revenue for a normal return. If the demands are elastic for high prices and inelastic for low prices, there may be two solutions, one with high output, the other with low output, intermediate outputs yielding more revenue than is needed. Where there are two or more solutions, that with the highest utilization of capacity is the one indicated.

[7] With proposals to subsidize diminishing cost industries I have much sympathy, but such proposals are not here in question. We are seeking a weighting system which will measure output, not the pricing policy which will maximize 'welfare'.

the prices are actually paid, they do of course reflect defined amounts of utility at the margin for any given consumer. The domestic consumer who uses electric current for lighting and heating at different rates must be assumed to adjust his consumption to the rates in question. To this extent therefore the prices are appropriate weights for the measurement of output, independently of any cost considerations, just as they would be in the case of a simple monopolist who did not discriminate.

But the prices charged in different markets have a further appropriateness, in terms of social cost, only if the conditions outlined above are fulfilled. Otherwise the ambiguity which arose under simple monopoly is present here, in even higher degree, and the problem of measuring output is not susceptible, even in theory, of a determinate solution.

This discussion, prompted by the character of the markets in which railroad and utility services are sold, has carried us to a rather high level of abstraction. We have in fact little means of telling just how far prices actually charged are appropriate in the above sense. No unregulated monopoly could be expected to practice discrimination along the lines indicated. On the other hand it may quite well be that the Interstate Commerce Commission, in regulating the railroads, and public service commissions in regulating electric utilities, have some such guiding principle as that developed above. It is certainly arguable that considerations of public policy lead to the conclusion that they *should* be guided by such principles. Common sense also suggests that discriminatory pricing by a commission-regulated monopoly will conform more closely to our criterion than that by an unregulated monopoly. Without an elaborate investigation of the policies of the various commissions, it seems impossible to be more definite than this. We can outline the conditions under which weighted indexes will be preferable to unweighted indexes, even if we cannot be certain that these conditions are fulfilled.

THE COMBINATION OF INDUSTRIES

The preceding sections were concerned mainly with combining the outputs of different products into a single measure for the

output of an entire industry. Broadly speaking we have been talking about gross output. The transition to net output (where this is statistically feasible) requires the insertion of input data, on the same principles, with of course negative weights. The combination of the outputs (gross or net) of different industries can then proceed, provided again we have a basis for weighting. Where gross outputs for various industries are summed (and this does not lead to duplication, or such duplication is to be neglected) the entire value of the industry's products affords an appropriate measure of the importance of the industry. Where net outputs are to be combined, the value added by the industry is the weight indicated.

In discussing industries in which monopoly (regulated or unregulated) is the rule, much the same problems have to be faced as those encountered in weighting individual products. Thus, where a monopoly earns more than the normal return, the usual ambiguity appears. Its value of products, or value added, continues to correspond (in the usual vague way) to the marginal level of consumer satisfaction, but ceases to bear any relation to the amount of resources consumed. The same is true where an industry earns subnormal returns, or is subsidized. In the first case, thinking in terms of units of resources of a given efficiency, the value of products, or value added, exaggerates the relative importance of the industry; in the second case, its relative importance is understated.

What of the actual state of affairs in the transportation industries? The appropriateness for weighting purposes of value of products or value added clearly depends upon the extent to which regulatory agencies do in fact secure (neither more nor less than) normal returns to these industries. In the case of railroads it is certainly arguable that the industry has failed even to earn normal returns since the advent of motor transport. In that case we are in danger of underweighting its importance in the economy as a whole.

Other transportation agencies have perhaps been subsidized. It has been claimed that inland waterways and truck and buslines have received subsidies through the provision of rights of way at public expense. The merchant marine and the airlines have been aided financially in more explicit fashion. In these industries if

returns, including subsidies, are normal, they are evidently subnormal when such aid is excluded. If the value of service as sold to the purchaser is used for weighting purposes (as, broadly, has been done here) such treatment may possibly be appropriate in terms of consumer satisfaction. But it evidently understates the resources employed.