ON THE CONCEPT OF PRODUCTIVITY

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Productivity denotes the capacity of the economic production process for converting the input of the productive forces it employs into products which satisfy human needs. According to a definition in general use, productivity is the output: input ratio of production. If the total output in real terms is Y, the total input X and productivity P, we obtain the formula

$$P = \frac{Y}{X}$$

It is perhaps easier to understand the content of productivity if we clarify the factors that may cause changes in productivity in agriculture. For instance, if the problem is grain cultivation and the increased use of commercial fertilisers, the crop will increase up to a certain limit. The yield increase is counterbalanced by the increase in fertilisers and, perhaps, also other additional effort or labour input such as more harvesting work, etc. As long as the yield increase measured in kilograms or other technical units is greater than the labour input, the ratio between the production output and the effort put into it improves for total production, the "exchange ratio" is improved, i.e. productivity rises. However, it must be noted that we are concerned here with the technical aspect of production, not with a change due to price relations or price changes. It is another matter how we decide what quantity of grain in the technical sense corresponds to a given amount of commercial fertilisers and work. This point will be dwelt upon later in this paper. In every case, the increase in productivity itself is caused by the increase in the ratio production output (in natura): total input. This happens when the output of production grows more than the additional effort put into it, as is the case when the quantity of commercial fertiliser is increased within certain limits or when a better result is obtained by e.g. using the same amount of commercial fertiliser but in a more practical ratio than before. Another way of increasing productivity is the possibility of producing certain goods with less work by better methods and planning. Breeding of plants and livestock gives better varieties and individuals and thus improved production. Mechanisation correctly implemented may reduce decisively the share of work in production and thus produce an essential change in productivity. And even if there are no other changes, changing the proportions on which different plants are cultivated, the number of livestock and the general line of production alone change productivity too from the standpoint of the economy as a whole. The increase in productivity is also known as the rationalisation benefit. The term is descriptive, but not entirely correct because rationalisation involves not only technical improvements but also price considerations, whereas price fluctuations are not included in productivity. Hence, increased productivity does not always imply improved profitability or lowered production costs, both of which are the general aim of rationalisation. Productivity and rationalisation, therefore, must not be identified, although in practice they usually do change in the same direction (SUOMELA 1958).

Productivity is a very complex concept the import and content of which may differ according to what is included in output or input factors in a given case and according to the point of view from which productivity and its development are examined. Output can be calculated in different ways when calculating productivity, and it can be expressed in terms of all or only one of the input factors.

If the total output and all the input factors are taken into consideration when calculating productivity, we can speak of complete or total productivity as distinguished from partial productivity defined in different ways. The latter refers to productivity which is obtained by dividing the output not by the sum of all the input factors but by the utilisation quantity of only one of them. The most common input factor groups used in calculating partial productivities are labour (L), area (A) and capital (C) which give, respectively, the productivity of labour, area or capital.

Hence, productivity of labour $= \frac{Y_1}{L}$

productivity of area $= \frac{Y_2}{A}$

productivity of capital $= \frac{Y_3}{C}$

If the production volume is calculated as gross output $Y_1 = Y_2 = Y_3$. For net output, again, which should generally be used when calculating productivity, the answer is different in different cases.

If output is calculated per given variable factor of production, we can distinguish in addition to total productivity, which means here net output per total amount of the variable input, mean productivity and marginal productivity. Mean productivity denotes the output per unit of the variable input factors employed in production. Marginal productivity means the ratio between the additional yield obtained by a certain increase in input and the increase in the amount of the input factor. Using a variable factor in production, X units, we obtain the following:

total productivity Y

mean productivity $\frac{Y}{X}$

marginal productivity $\frac{\Delta Y}{\Delta X}$

It must be emphasised that the development of total productivity is not the same as the development of the production volume. If the volume of production at a certain time has been Y and the quantity of the input factors used X, total productivity calculated for X is = Y as stated above. If the volume of production changes and is Y_1 at another point of time, the change in total productivity is not $Y_1 - Y$ but $\frac{Y_1 - Y}{X_1 - X}$ if X_1 = the quantity of the input factors used at the latter time. The relative change in total productivity is the same as the change in the production volume only if the input factors used are unchanged when production volume changes.

Unless otherwise stated, productivity according to established usage means the productivity of labour, which is calculated in the following manner:

$$P = \frac{Y - X_0}{L}$$

in which P = productivity, Y = the total value of output, X_0 = the total value of all production inputs except labour, and L = the labour input. Production costs include the calculated interest on agricultural capital, although for practical reasons it is not always taken into account.

Two more concepts, capacity and effectiveness, are close to the concept of productivity. Capacity is the ability of a fixed input factor to assimilate and utilise in production other, variable input factors. According to Heady (1952), capacity refers to the amount of variable factors of production which a fixed factor (technical unit) might absorb without causing the marginal product to become zero or negative. Effectiveness, on the other hand, denotes how effective or intensive the utilisation of the input factors is in reality. The mutual relationship of these concepts in business economics has been particularly studied in the USA where Taylor (1949) has defined productivity as a product of capacity and effectiveness. Black et al. (1947, p. 407) mentioned that if one acre yields a bigger potato crop than another when the same quantities of fertilisers, seeds and other input factors are used, the former is more productive. It produces more potatoes also per input factor unit, in other words its effectiveness is greater. One acre may also utilise more fertilisers than another, i.e. its capacity is greater. Effectiveness and capacity are thus two dimensions of productivity. Bail (1957) speaks of effective and potential productivity, meaning that if land or another such factor determines the scale of production the firm cannot always fully utilise the capacity and its effective productivity is then smaller than its potential productive capacity.

As with productivity, there are several, at least somewhat divergent, interpretations of capacity and effectiveness. However, capacity can doubtless be most clearly understood as the maximum amount of variable factors of production that can be utilised with certain fixed factors of production and within a certain period without marginal output becoming nil or negative. What remains is to express by effectiveness the way and the extent to which variable factors of production are actually utilised. Some authors state that when capacity is being explained from the economic standpoint both it and effectiveness must be measured at the point of highest profit combination (Black et al., Forster 1950). Although measurement at an economic optimum may in fact be necessary, e.g. to compare two types of soil, what is in issue, according to the above, is no longer capacity as such but rather the combined effect of capacity and effectiveness and how far the utilisation of the capacity in each case is economically advantageous. In fact, that the concept of capacity in cases of this kind is very close to that of intensity, and they are often used to denote exactly the same thing. Perhaps even closer to one another are the concepts of productivity and effectiveness. The mean productivity and effectiveness mentioned above actually mean exactly the same thing.

Productivity was originally just a technical concept, and accordingly output too was regarded as a specifically technical output, expressed in units, kilograms, cubic metres, etc. In practice, this is possible only when a single product is produced or if the products are so homogeneous that they can be summed as such by, for instance, weight. This is rarely possible in agricultural production. To mention an example, the cultivation of crops yields grain and straw, but adding them together in kilograms would be misleading. The broader the sphere of agricultural production, the greater is the need to find a unit that can be used to measure the combined volume of heterogeneous products. The main technical measurements that can be considered are calories, fodder and crop units or grain units. Another possibility is to measure output according to its money value in which case in addition to quantitative factors the effect of prices is also associated to some extent at least with productivity calculations. The potential uses of the different methods and their significance in the definition of productivity are examined in greater detail in the following.

If only one product is produced or a product whose by-product such as straw is of such small significance that it can be disregarded, output can be measured in terms of units, weight or volume. No other units are needed nor, generally speaking, should they be used when these physical units are practicable. Examples of such cases are yields per hectare and the milk output per cow or man-hour of work. To what extent we can call these simple and generally applied quantities productivity is another matter, although they do in a sense denote it.

Methods of calculating output in terms of calories, fodder units or grain units differ from one another only in regard to the unit of measure employed. Conversion into calories, fodder units or grain units from the tables published in many professional calendars, textbooks and handbooks present no difficulties for most of the products. But there are many products the calorie, fodder unit or grain unit quantity of which cannot be measured directly because they are used for totally different purposes. An example is the fodder unit equivalent of flax. We can, however, in cases like these, calculate the quantity in question with sufficient accuracy by comparing it with other products of the same kind. Conversion may be more complicated for plants that are not used for human or animal feed and whose crop quantity is not directly comparable because of quality differences. Examples are hay and sugar beet seeds the conversion of which into fodder units would obviously not give a correct picture when their production is compared with that of, say, bread grain. In these cases, the basis of comparison might be with plants with similar requirements of soil, work expenditure, etc. As the seed crop of sugar beet is 1/12 of the root crop, and as 100 kg of sugar beet is equivalent to 0.25 grain units, it can be estimated that 100 kg of sugar beet seeds corresponds to $0.25 \times 12 = 3$ grain units (Nou and Nilsson 1955). Also in a special position are livestock products whose energy content is smaller than the energy content of the fodder used for their production. Energy losses thus originate in processing, and the process as a whole is a productivity problem of its own. We can avoid this difficulty if we calculate the nutritive value of livestock products in terms of the nutritive value of the fodder used for their production (Mielck 1943).

There are many limitations to the use of the technical units mentioned in the foregoing. Output may and generally does comprise either direct services or other items impossible to measure in terms of nutritive value. It is even more difficult to measure the sum of input factors by the above-mentioned units and net output can be calculated with the aid of technical units only in some exceptional cases. Nor is it possible as a rule to take quality differences into account in calorie, fodder unit or grain unit calculations. It is generally necessary in these calculations to attribute to a kilogram of malting barley and a kilogram of fodder barley or a kilogram of potatoes for household use and a kilogram of potatoes for industrial use the same value, although malting barley and potatoes for household consumption differ from fodder barley and potatoes for industrial use in both quality and per-hectare yield. In other respects, too, the above-mentioned units may give a correct picture only when applied to certain purposes. If we wish to calculate the quantity of the products in terms expressly of their use for human nutrition, we are justified in using grain units or calories. Fodder units, likewise, can be used as the measure for different products provided that the use in question is fodder. But none of these units are suitable if we have to add up products a part of which is utilised typically for human nutrition and a part solely as fodder. The private farmer does not care about how many calories he produces and, for many products, his goal is not the greatest possible number of fodder units. The technical measurements mentioned far from always illustrate the ratio between different products with sufficient diversity in the technical sense and even less in the economic sense; the profitability of activity is the principal aim of production as a whole in a private economy. These difficulties do not occur or are diminished when output is determined in terms of the money value of the various products instead of technical units. It is then easy to sum up different products. Their prices, also, usually illustrate the quality differences between them and in other respects as well give a more understandable picture of output than, say, the calorie can.

Nou and Nilsson (1955) distinguish on the basis of the technical or economic nature of productivity between technical productivity, economic productivity and technical-economic productivity. Technical productivity is obtained by calculating both output and the sum of input factors as technical units. Economic productivity is calculated by using money values as the indicators of both output and the sum of input factors. These authors call productivity technical-economic when one of the two components, usually output, is measured by money value and the input factors employed according to their technical quantity.

It would be justifiable in point of principle to speak of technical productivity in all cases if we could compare as such the output and the sum of input factors without converting them into calories, fodder units, etc. We saw that this is possible only in simple cases such as calculating the crop per hectare, the milk output per cow, crop per man-hour of work, etc. We would be right to use technical measurements in these cases, but is it necessary to stress just the concept of productivity in such connections? It would surely be simpler to go on speaking of crops per hectare and mean livestock yields than to adopt the terms productivity per area and productivity of capital or property, for these are established and readily comprehensible concepts. As regards the calorie, fodder units and grain units, we have already decided that their use is justifiable and purposeful only in measuring the productivity of the spheres for which these units of measure were expressly intended. In agriculture, then, to speak of pure technical productivity is seldom correct irrespective of whether we are concerned with a particular farm or with agriculture as a major entity.

Economic productivity is obtained by calculating both output and the sum of input factors in terms of money. It is possible technically to increase output, e.g. crop outputs, up to a certain maximum, but it is rarely advantageous in practice to develop production so far. What is decisive is to establish the economic optimal point. This does not depend solely on the technical output but equally much on the prices prevailing at a given time. Productivity and profitability can be linked by means of economic productivity. Nou and Nilsson, in fact, correlate economic productivity and profitability by describing economic productivity as the output: costs ratio at current prices. They state that it is then better instead of calculating the quotient of output and costs to calculate their difference, from which we arrive even formally at the concepts of profitability and business results. Austad (1957) also correlates economic productivity and profitability.

Enlargement of the concept of productivity to include current prices, that is to make it the concept signifying profitability, must, however, be regarded as misleading and unwarranted. Such a correlation would mean either substituting the concept of productivity for that of profitability or accepting that both concepts mean the same thing, which is completely unnecessary. The concept of profitability needs no such addition, and the concept of productivity would become even vaguer than it was. In addition, confusing these concepts would not just produce formal or terminologic confusion, it would also give the wrong meaning to the concept of productivity from the practical point of view. So-called economic productivity should never be confused with productivity if the former is used to denote the inclusion of price fluctuations in the calculation of output. This does not mean that we cannot use the current prices in productivity calculations when we are concerned with a comparison of productivity at a certain time (horizontal comparison) as opposed to the development of productivity at different times (vertical comparison) in the prevalence of different prices. On this condition, productivity calculations can be made on the basis of current prices also in planning the economy, as is customary especially in the USA. This implies the use of the same prices in all calculations, in other words the calculation of productivity at fixed prices and, thus, the use of current prices does not signify the inclusion of price fluctuations in the productivity calculations.

The condition made by Nou and Nilsson is that prices corresponding to normal price relations are employed in the calculation of technical-economic productivity. The simplest way of doing this is to use the mean prices for a certain period. As the question in this case is, on the one hand, fixed prices and, on the other hand, often prices which are not current, prices play no essential role in the calculation of productivity. They are merely weights by which the summed-up amount of the different products can be measured in exactly the same way as e.g. by using fodder units or calories. The only difference is that when calories or other such units are employed the mutual value relations of the various products are measured by a certain technical unit which often refers to a narrow range of use, whereas, when prices are used, the mutual importance and value of the various products conform better to reality and depend less on the purpose for which the products are used in a given instance. From this viewpoint, the use of fixed prices in calculating productivity means some consideration of the economic significance in the calculation of productivity, but, as was mentioned above, the prices are only weights even then and the numerical value of productivity is really important only as a ratio and in a certain technical sense. The use of fixed prices is in practice generally the only way to calculate productivity.

To summarise, the distribution into technical and economic productivity is foreign to the concept of productivity. Price fluctuations do not belong to the sphere of productivity, and productivity does not mean the same as profitability. The use of fixed prices as weights is not changing from the technical concept to the economic, but is the use of a unit which conforms better with practice than most purely technical units. Viewed as a whole, productivity must be understood first and foremost as a technical concept of significance and use mainly in economics and economic policy.

Although, in the calculation of productivity, output and the sum of the input factors are calculated at fixed unit prices in terms of money values, there can be difficulties about using them. Referring to the calculation of productivity, Böker (1952), says that there is obviously no method for diversified agricultural production or national agriculture against which comment cannot be made. Even unit prices do not illustrate the mutual relations of different products absolutely "correctly". The development of productivity even in the same industry may depend, therefore, on the period chosen to represent the base prices and price relations. This point is perhaps even more important when the productivity of different industries is compared. In a comparison of productivity in different countries, additional considerations enter the picture, such as the conversion of the monetary units and the possibilities of error.

The use of fixed prices does not eliminate completely the effect of price variations. If price changes influence the structure of production and the trend of production, they are also reflected as a change in productivity. Price fluctuations may in this way influence the changes in productivity equally much when fixed prices are applied as when e.g. the fodder unit or other technical measurements are employed. The question is closely associated with productivity for changes in productivity normally occur in consequence of both purely technical changes and the changing of the production structure. A technical or internal change in productivity means that the efficiency for an individual product or process changes. A structural change in productivity, again, is caused by the movement of production factors from less productive fields to fields in which productivity is above-average, or vice-versa. Structural changes raise the productivity of the national economy in the long run even if no technical changes occur in production (Niittamo 1954, Clark 1951). However, it is not always possible to distinguish very accurately between a structural and technical productivity change.

It may be particularly difficult to eliminate price fluctuations in studying fairly long-term development in productivity. It is common for price relations at the beginning and end of the period to differ, and the development of productivity will differ according to whether the former or latter prices are used as the weights. The use of the prices of the beginning of the period requires the application of Laspeyres's type of formula and that of the prices for the final part the application of P a a s c h e' s type of formula to eliminate price variations. P a a s c h e' s formula consistently gives a higher or lower production than L a s p e y r e s' s depending on whether the greater price increases occurred in connection with above-average or below-average increases in quantity. The differences in the result is illustrated by the following schematic example which is roughly illustrative of the conditions in Finnish agriculture in the early 1930s and 1950s.

	At the beginning of the period		At the end of the period	
	Nominal	According to the prices at the end of the period	Nominal	According to the prices at the beginning of the period
Returns	3,000	60,000	64,000	3,200
Costs (excluding labour)	1,000	10,000	12,000	1,300
Net returns	2,000	50,000	52,000	1,900
Labour input,	300	300	250	250
Numerical value of productivity	6.67	167	208	7.60
Ratio of productivity	100	100	125	114

Ratios of productivity indicate that if net returns and costs are calculated at the prices of the beginning of the period, the increase in productivity is 14 per cent, but according to the prices of the end of the period 25 per cent. Consequently, the use of different price levels (price relations) gives quite a different result.

If the price relations at the beginning and end of the period are different, their mean or the average relations of the entire period can be used as the basis of calculation. If the price variation is considerable, even the mean will not give a reliable result by itself. It is better in such cases to use the prices which were most common or typical of the conditions to be compared. To understand the development it is often advisable to calculate productivity separately according to the prices at the beginning and end of the period.

In addition to the variations in price relations, there are other difficulties in explaining the development of productivity and the interpretation of the results. For instance, the calculation of productivity per unit of labour input is only a technical process of calculation which by no means indicates that the development was caused just by the intensification of work. On the contrary, what is at issue is the joint effect of all the factors of input compared with only one factor, labour input. It may often be pertinent especially in business economics to use in addition to labour productivity total productivity. On the other hand, some calculation of gross productivity, using the gross value of production per labour input unit, gives a misleading picture and does not conform in practice with the productivity concept. Its use can be rational only if the volume of production per worker is of especial importance because of a shortage of labour or some other reason.

A similar inaccuracy to that encountered in business economics in the use of the productivity concept is seen in national economy. This is especially apparent when the productivity of different industries is compared. Comparisons of productivity in a hihgly mechanised branch of production (e.g. manufacturing) and a labour-intensive branch (e.g. agriculture) give a clear idea of the direction in which labour should move in the economy, but if these productivity figures are also interpreted as indicators of the superiority of the industries in question, there is a risk of biased and erroneous interpretation. The main question is whether the mutual price relations of the products and input factors of the different industries are correct, or whether the different values of production per unit are attributable to e.g. a traditional difference in the income level which need not have had, at least not in all spheres and at all times, anything to do with the productivity of the industry in question. The same point can be made by asking what the differences in productivity in such cases really show if they are only due to, for example, the fact that an agricultural worker moving a sack of grain is paid 2 marks per hour while the payment for the same work in a flour mill or bakery with similar equipment, the same training and work efficiency is 3 marks per hour.

Productivity comparisons between different industries must indeed be treated with reserve, like all absolute figures illustrating productivity. The relativeness of the concept of productivity and the fact that productivity must be used primarily as an indicator of changes and not of static conditions must be especially emphasised.

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SELOSTUS

TUOTTAVUUDEN KÄSITTEESTÄ

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Maatalouden taloudellinen tutkimuslaitos

Kirjoituksessa käsitellään tuottavuuden käsitettä ja määrittämistä. Tuottavuus tarkoittaa tuotannon tuloksen ja käytettyjen tuotantovälineiden määrien keskinäistä suhdetta. Periaatteessa tuottavuus perustuu tuotannon teknilliseen tulokseen ja käytettyjen tuotantovälineiden määriin eikä niiden raha-arvoihin.

Käytännössä tuottavuuden määrittäminen ei ole kuin poikkeustapauksissa mahdollista muuten kuin kiintein hinnoin laskettu tuoton ja kustannuksen perusteella. Milloin ei erikseen toisin mainita, tuottavuudella käytännössä vakiintuneen tavan mukaan tarkoitetaan nimenomaan työn tuottavuutta. Viimeksi mainittu lasketaan vähentämällä tuotosta kustannukset työkustannusta lukuun ottamatta ja laskemalla erotus tuotannossa käytettyä työpanosta tai sen yksikköä kohden.

Tuottavuutta ei pidä sekoittaa kannattavuuteen. Kannattavuuskäsitteisiin liittyvät hinnat olennaisena osana, kun sen sijaan tuottavuuskäsitteeseen hinnat ja nimenomaan hintavaihtelut eivät lainkaan kuulu.

Tuottavuus on luonteeltaan lähinnä teknillinen käsite, jonka merkitys ja käyttö kohdistuu pääasiassa talouden ja talouspolitiikan piiriin. Tuottavuutta osoittavat luvut on ymmärrettävä mieluummin suhteellisina kuin absoluuttisina, ja niitä on käytettävä lähinnä muutosten eikä staattisen tilan osoittajana.