# PRODUCTION AND PRODUCTIVITY AS SOURCES OF WELL-BEING

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The objective of the study is to explain how production and its essential feature, productivity, function as sources of well-being. The most important forms of production are market production, public production and production in households. In the study, the focus is on market production because it is the prime source and the "primus motor" of well-being.

The research problem is defined by the following question: What kind of information can we obtain about well-being and its development using accounting methods, when data on production is available, i.e., data on prices and quantities of outputs and inputs? We give the following answer to this problem: The common interest of a producing community (i.e., the labour force, the society and the owners) is to maximize the income from production and this income formation can be calculated from the production data. Furthermore it is shown that productivity is a critical factor in the income generation but the key objective is the maximization of income - not maximization of productivity.

**Terms used in this study**

**Income formation –** Income generation and distribution in production
**Production process** – Process of combining various production inputs to produce outputs
**Production data** – Measured data related to the production process in the form of prices and quantities of inputs and outputs
**Production model** – Production data based mathematical model of the production process
**Productivity model** – Production data based model for calculating productivity
**Production function** – Graphical or mathematical expression showing the relationship between the inputs used in production and the outputs achieved
**Production growth** – Growth of production output, economic growth
**Production performance** – Production's capability of generating income
**Real income** – Real process income, income generated from the production function
**Producer community** – Labour force, society and owners
**Producer income** – Income gained by the producing community
**Owner income** – Profit
**Surplus value** – Profit after the cost of the equity

## 1 INTRODUCTION

In principle there are two main activities in an economy, production and consumption. Similarly there are two kinds of actors, producers and consumers. Well-being is made possible by efficient production and by the interaction between producers and consumers. In the interaction, consumers can be identified in two roles both of which generate well-being. Consumers can be both customers of the producers and suppliers to the producers. The customers' well-being arises from the commodities they are buying and the suppliers' well-being is related to the income they receive as compensation for the production inputs they have delivered to the producers.

The well-being gained through commodities stems from the price-quality relations of the commodities. Due to competition and development in the market, the price-quality relations of commodities tend to improve over time. Typically the quality of a commodity goes up and the price goes down over time. This development favourably affects the production functions of customers. Customers get more for less. Consumer customers get more satisfaction at less cost. This type of well-being generation can only partially be calculated from the production data. The situation is presented in this study.

The producer community (labour force, society, and owners) earns income as compensation for the inputs they have delivered to the production. When the production grows and becomes more efficient, the income tends to increase. In production this brings about an increased ability to pay salaries, taxes and profits. The growth of production and improved productivity generate additional income for the producing community. Similarly the high income level achieved in the community is a result of the high volume of production and its good performance. This type of well-being generation – as mentioned earlier - can be reliably calculated from the production data. One of the key objectives of the study is to demonstrate this accounting procedure with our production model.

The method employed in the study is a demonstration. The demonstration here means a numerical and illustrative presentation. The demonstration is carried out by means of our production model. With the aid of the production model, the concept of "production process" can be operationalized, made measureable. The production model is a numerical description of the production process and is based on the prices and the quantities of inputs and outputs. The formulation explicitly shows how the incomes are generated and distributed in production. Our production model is used as an accounting procedure that allows us to identify the interesting features of the production process.

The production model sets requirements for the measurement of production. The information we acquire by measuring production is called production data. It is data in the form of prices and quantities of inputs and outputs. Productivity accounting requires unbiased production data. Unbiased data means that the different qualities of inputs and outputs must be measured separately, i.e., aggregation of different qualities is not allowed.

## 2 THE SOURCES OF THE WELL-BEING

It is not advisable to examine any phenomenon before carefully defining the whole process, the entity, of which the phenomenon under review forms a part. It will then be possible to analyse the phenomenon as part of such an entity. In our study one such an entity is defined as well-being.

We thus start from a wide welfare concept – the well-being of people – and in a process that resembles peeling an onion, we reach the focus of the study – production and productivity as sources of well-being. This approach is known as a top-down procedure. An important feature here is that we always ensure the presence of the wider entity to which the topic under review belongs. Due to the method used, a number of review levels must be described. For this purpose we describe the following four levels from the most general one to the most specific one.

1. Dimensions of well-being
2. Sources of economic well-being
3. Processes of market production
4. Production and productivity

The first three levels are reviewed only briefly. The fourth level is studied in detail.

### *2.1 Dimensions of well-being*

In February 2008, the President of the French Republic, Nicholas Sarkozy, unsatisfied with the present state of statistical information about the economy and the society, asked to create a Commission, subsequently called 'The Commission of the Measurement of Economic Performance and Social Progress' (CMEPSP). Commission's aim has been to identify the limits of GDP as an indicator of economic performance and social progress, including the problems with its measurement; to consider what additional information might be required for the production of more relevant indicators of social progress; to assess the feasibility of alternative measurement tools, and to discuss how to present the statistical information in an appropriate way. (Stiglitz & al. 2009, 7)

Well-being is a multi dimensional phenomenon. Therefore the first phase in the top-down approach is to identify the dimensions of well-being. Conclusions made by the Commission serve this purpose well.

The Commission has identified eight key dimensions that should be taken into account. At least in principle, these dimensions should, as far as possible, be considered simultaneously: (Stiglitz & al. 2009, 16)

- Material living standards (income, consumption and wealth)
- Health
- Education
- Personal activities including work
- Political voice and governance
- Social connections and relationships
- Environment (present and future conditions)
- Insecurity, of an economic, as well as a physical nature.

Economic well-being makes a contribution to all of these dimensions of well-being. It is a necessity for the first three dimensions, i.e., material living standards, health and education. The most important sources of economic well-being are identified next.

### *2.2 Sources of economic well-being*

Economic well-being is created in a production process. Production means, in a broad sense, all economic activities that aim directly or indirectly to satisfy human needs. The degree to which the needs are satisfied is often accepted as a measure of economic well-being. The satisfaction of needs originates from the use of the commodities which are produced. The need satisfaction increases when the quality-price-ratio of the commodities improves and more satisfaction is achieved at less cost.

The need satisfaction also increases due to the growth of incomes that are gained from the more efficient production. The most important forms of production are market production, public production and production in households. In order to understand the origin of the economic well-being we must understand these three processes. All of them have production functions of their own which interact with each other. Market production is the prime source of economic well-being and therefore the "primus motor" of the economy.

Note that when we later discuss production we refer to market production. When discussing a single unit in the production process, the term "company" is used.

Economic well-being originates in efficient production and it is distributed through the interaction between the company's stakeholders. The stakeholders of companies are economic actors which have an economic interest in a company. Based on the similarities of their interests, stakeholders can be classified into three groups in order to differentiate their interests and mutual relations. The three groups are as follows:

- Customers
- Suppliers
- Producers.

The interests of these stakeholders and their relations to companies are described briefly below. Our purpose is to establish a framework for further analysis.

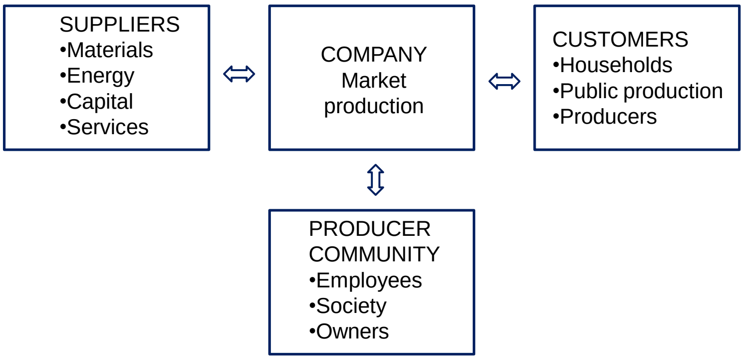



*Figure 1. Interactive contributions of a company's stakeholders*

*Customers*

The customers of a company are typically consumers, other market producers or producers in the public sector. Each of them has their individual production functions. Due to competition, the price-quality-ratios of commodities tend to improve and this brings the benefits of better productivity to customers. Customers get more for less. In households and the public sector this means that more need satisfaction is achieved at less cost. For this reason the productivity of customers can increase over time even though their incomes remain unchanged.

*Suppliers*

The suppliers of companies are typically producers of materials, energy, capital, and services. They all have their individual production functions. The changes in prices or qualities of supplied commodities have an effect on both actors' (company and suppliers) production functions. We come to the conclusion that the production functions of the company and its suppliers are in a state of continuous change.

*Producer community*

The incomes are generated for those participating in production, i.e., the labour force, society and owners. These stakeholders are referred to here as producer communities or, in shorter form, as producers. The producer communities have a common interest in maximizing their incomes. These parties that contribute to production receive increased incomes from the growing and developing production.

### *2.3 Processes of the market production*

Production operations can be divided into sub-processes in different ways. We identify the following five as main processes, each with a logic, objectives, theory and key figures of its own. We examine each of them individually, yet, as a part of the whole, in order to be able to measure and understand them. The main processes of market production (i.e. company) are as follows:

- Real process (or real income process)
- Income distribution process
- Production process

- Monetary process
- Market value process

Production output and real income are created in the real process, gains of production are distributed in the income distribution process, and these two processes constitute the production process. The production process and its sub-processes, the real process and income distribution process occur simultaneously, and only the production process is identifiable and measurable by the traditional accounting practices. The real process and income distribution process can be identified and measured by extra calculation, and this is why they need to be analysed separately in order to understand the logic of income formation in production.

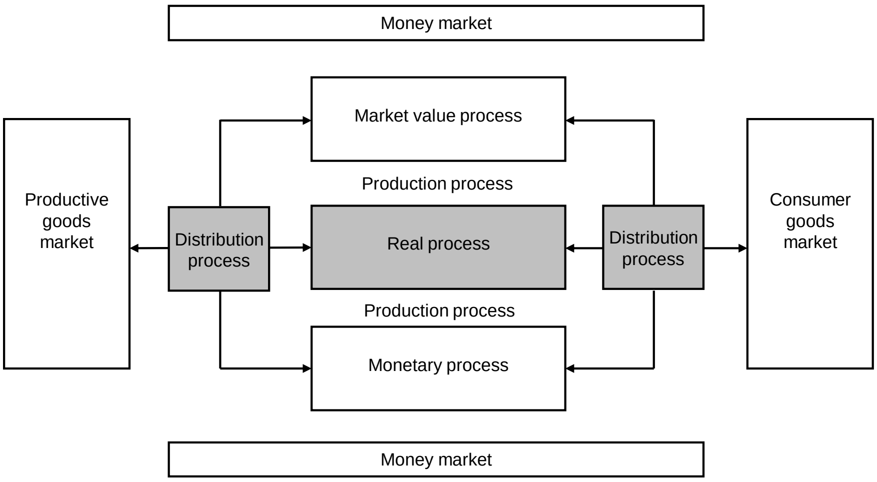



*Figure 2. Main processes of a company (Saari 2006)*

*Real process* generates the real output and the real income. It can be described by means of the production function. The real process refers to a series of events in production in which production inputs of different quality and quantity are combined into products of different quality and quantity. Products can be physical goods, immaterial services and most often combinations of both. The characteristics created into the product by the manufacturer imply surplus value to the consumer, and on the basis of the price this value is shared by the consumer and the producer in the marketplace. This is the mechanism through which the surplus value originates to the consumer and the producer likewise. Surplus value to the producer is a result of the real process. Measured in absolute terms it means real income (real output – real input) and measured proportionally (real output/real input) it means productivity.

*Income distribution process* of the production refers to a series of events in which the unit prices of constant-quality products and inputs alter causing a change in income distribution among those participating in the exchange. The magnitude of the change in income distribution is directly proportionate to the change in prices of the output and inputs and to their quantities. Gains of production are distributed, for example, to customers as lower product prices or to staff as higher pay.

Davis (1955) has deliberated productivity as a phenomenon in business, measurement of productivity, distribution of productivity gains, and how to measure such gains. He refers to an article (1947, Journal of Accountancy, Feb. p. 94) suggesting that the measurement of production shall be developed so that it ”will indicate increases or decreases in the productivity of the company and also the distribution of the ’fruits of production’ among all parties at interest”.

Davis regards the measurement of productivity gains distribution as an important part of the productivity phenomenon, and he deliberates the problems related to measuring it at great length. According to Davis, the price system is a mechanism through which productivity gains are distributed, and besides the business enterprise, receiving parties may consist of its customers, staff and the suppliers of production inputs. In this paper, the concept of ”distribution of the fruits of production” by Davis is simply referred to as *production income distribution* or shorter still as *distribution*.

*Production process* consists of the real process and the income distribution process. A result and a criterion of success of the production process is profitability. The profitability of production is the share of the real income the owner has been able to keep to himself in the income distribution process. Factors describing the production process are the components of profitability, i.e., returns and costs. They differ from the factors of the real process in that the components of profitability are given at nominal prices whereas in the real process the factors are at fixed prices.

*Monetary process* refers to events related to financing the company.

*Market value process* refers to a series of events in which investors determine the market value of the company in the investment markets.

### *2.4 Real process and production function*

The real process generates the real output and the real income of production. The process can be described by means of the production function. The production function is a graphical or mathematical expression showing the relationship between the inputs used in production and the output achieved. Both graphical and mathematical expressions are presented and demonstrated in this study.

*Economic growth means the growth of production output*

By help of the production function, it is possible to describe simply the mechanism of economic growth. Economic growth is a production output increase achieved by an economic community. It is usually expressed as an annual growth percentage depicting (real) growth of a nation. Economic growth is created by two factors so that it is appropriate to talk about the components of growth. These components are an increase in production input and an increase in productivity.

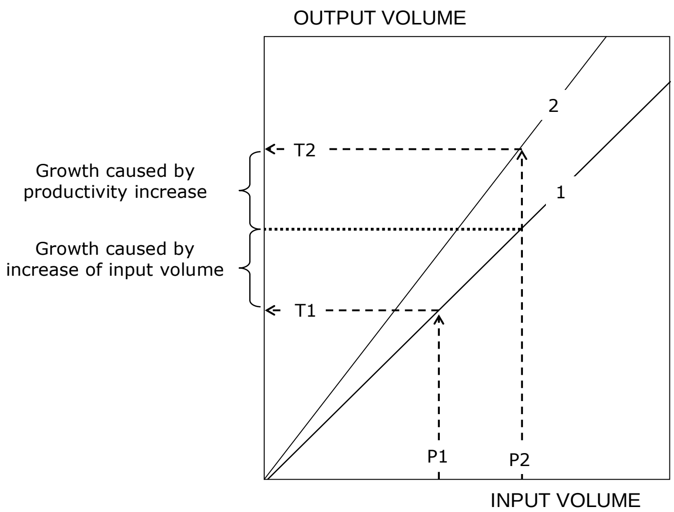



*Figure 3. Components of economic growth (Saari 2006)*

The above figure presents the economic growth process. By way of illustration, the proportions shown in the figure are exaggerated. Reviewing the process in subsequent periods, one and two, it becomes evident that production output has increased from Value T1 to Value T2. Measured in absolute terms, economic growth is T2 – T1, while proportionally speaking, it is (T2 – T1)/T1. At the same time, an increase from Value P1 to Value P2 was measured in the use of production input. Now, both periods can be described by a graph of production functions, each function being named after the respective number of the period, i.e., one and two. Two components are distinguishable in the output increase: the growth caused by an increase in production input and the growth caused by an increase in productivity. The output growth caused by an increased input is determined by moving along the production function for a respective input increase, i.e. from Value P1 to Value P2. Characteristic of the output growth effected by an input increase is that the relation between output and input remains unchanged. An increase in output means a shift of the production function simultaneously with a change in the output/input relation. In other words, the output growth corresponding to a shift of the production function is generated by the increase in productivity.

*The production performance means income*

Economic growth measures the growth of production output and, therefore, it is only a rough indicator of economic welfare. It does not reveal anything about the performance of the production process. The performance of production measures production's ability to generate income. Because the income from production is generated in the real process, we call it the real income. Similarly, as the production function is an expression of the real process, we could also call it "income generated by the production function".

The real income generation follows the logic of the production function. Two components can also be distinguished in the income change: the income growth caused by an increase in production input (production volume) and the income growth caused by an increase in productivity. The income growth caused by increased production volume is determined by moving along the production function graph. The income growth corresponding to a shift of the production function is generated by the increase in productivity.

The production performance can be measured as a relative or an absolute income. Expressing performance both in relative (rel.) and absolute (abs.) quantities is helpful for understanding the welfare effects of production. For measurement of the relative production performance, we use the known ratio

*Real output / Real input.*

The absolute income of performance is obtained by subtracting the real input from the real output as follows:

*Real income (abs.) = Real output – Real input*

The growth of the real income is the increase of the economic value which can be distributed between the production stakeholders. With the aid of the production model we can perform the relative and absolute accounting in one calculation. The differences between the absolute and relative performance measures can be illustrated by the following graph showing marginal and average productivity.

Figure 4 below is a traditional expression of average productivity and marginal productivity. The maximum for production performance is achieved at the volume where marginal productivity is zero. The maximum for production performance is the maximum of the real incomes. In this illustrative example the maximum real income is achieved, when the production volume is 7.5. The maximum average productivity is reached when the production volume is 3.0. It is worth noting that the maximum average productivity is not the same as the maximum of real income.

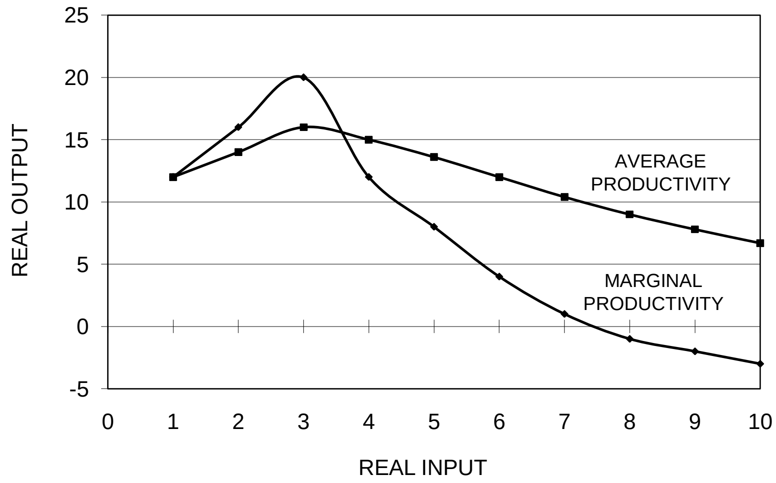



*Figure 4. The difference between average productivity and marginal productivity (Saari 2002)*

Figure 4 is a somewhat exaggerated depiction because the whole production function is shown. In practice, decisions are made in a limited range of the production functions, but the principle is still the same; the maximum real income is aimed for. The real income (abs.) and productivity (abs.) can be written in the same formula as follows:

*Change of real income (abs.) = +/- Effect of productivity change +/- Effect of production volume change*

An important conclusion can be drawn. When we try to maximize the welfare effects of production we have to maximize real income formation. Maximizing productivity leads to a suboptimum. Maximizing productivity also leads to the phenomenon called "jobless growth" This refers to economic growth as a result of productivity growth but without creation of new jobs. If there is unemployment in the society jobless people remain jobless. What we need is to create new low productivity jobs for the jobless people. Then the average productivity would decrease but the real income and well-being of society would increase. Average productivity is an essential factor in real income formation but it is not the objective to maximize this.

A practical example illustrates the case. When a jobless person obtains a job in market production we may assume it is a low productivity job. As a result average productivity decreases but the real income per capita increases. Furthermore the well-being of the society also grows.

## 3 THE REQUIREMENTS SET BY PRODUCTION MODELS

Operationalization is a process for defining a fuzzy concept so as to make it measurable and understandable in terms of the measurement results. In a wider sense operationalization refers to the process of specifying the boundaries of a concept - in other words, describing what is and what is not a part of that concept.

The title of the study "Production and Productivity as sources of well-being" implies that the concepts of productivity and production should be made measureable so that their effects on well-being can be analyzed. Operationalization leads to a model which defines the operating instructions on how to proceed in measuring and accounting. Such a model typically includes the following instructions:

- How should production data be measured? In other words, how should the data on the prices and the quantities of outputs and inputs be obtained and expressed?
- What kind of information do we need to obtain and how is this information derived by accounting from the production data?
- How should the accounting results be interpreted?

We note here that we often speak only about measuring. The question concerns not only measuring but also accounting and interpretation. In measuring production and productivity there are some very crucial criteria, which we discuss next.

### 3.1 The purpose of measuring

The first task in measuring is to define its purpose. It is important to understand what kind of information can be obtained by measuring and how the measured results can be used. The purpose of measuring must be defined precisely so that the validity of measured results can be critically evaluated.

In our study the phenomena measured are production and productivity. The aim of measuring is to show numerically how well-being effects can be accounted for from production data. With the aid of the production model we demonstrate that these effects are actually incomes. The income generation and income distribution we explicitly depict by our production model. The well-being effects of production which can, at best, only partly be accounted from the production data, are also described.

### 3.2 Recognizing the quality of the measurement object and its homogeneity

The most important criterion of good measurement is the homogenous quality of the measurement object. If the object is not homogenous, then the measurement result may include changes in both quantity and quality but their respective shares will remain unclear.

In practice, this criterion requires that every item of output and input must appear in accounting as being homogenous. In other words the inputs and the outputs are not allowed to be aggregated in measuring and accounting. If they are aggregated, they are no longer homogenous and hence the measurement results may be biased.

However, for practical reasons data is often aggregated. The possible sources of bias, therefore, have to be explained by the actors responsible for the measuring.

### 3.3 Validity

Validity is a characteristic of the measure (model in this case) which is used in measuring. Validity implies how exact information the used measure can generate from the phenomenon. We need to understand the phenomenon, the measure and the possible difference between them. The difference between the phenomenon and the measured value is an error. If the validity of the measurement is poor, the error becomes systematic.

Often when we aim at simplicity and understandability in measuring, we have to lower the requirements for validity. For this reason it is important to evaluate the validity of the measurements used, case by case. Good measuring presupposes that those responsible for measuring are familiar with the validity of the measurements and also keep users informed of the validity.

A case is problematic if the measure is known but the phenomenon is not identified. This is the case with Total Factor Productivity (TFP), also known as multifactor productivity. The history of the measurement of TFP goes back half a century but no consensus has been reached on what phenomenon actually is measured. Lipsey & Fraser (2001) studied the case and expressed the research problem with the question - What does the Total Factor Productivity measure? Their answer is as follows:

”We do not believe that we are alone in being uncertain as to what TFP actually measures…It is an understatement to say that all of these quotations cannot be correct; TFP clearly means different things to different informed observers. Surely it is something close to a scandal that a measurement that is so much relied on for so many purposes seems to be so poorly understood.”

They continue with the following conclusions of different opinion groups:

”One group holds that changes in TFP measure the rate of technical change. The second group holds that TFP measures only the free lunches of technical change, which are mainly associated with externalities and scale effects. The third group is sceptical that TFP measures anything useful."

With the help of our production model we have not been able to increase understanding of the phenomenon measured by TFP. We can, however, conclude from the analyses made with our production model that TFP has little to do with the well known concept of total productivity.

### *3.4 Defining the objective function*

Defining the objective function presupposes that we understand which variables we should try to maximize (or minimize) and which variables are regarded as constraints. Constraints are a means or restraining conditions for a production operation. When we discuss profit maximization, we maximize the owner's income and all other items of income formation are regarded as constraints. Measuring production performance may also include objectives other than profit. The different interests of stakeholders usually lead to different objective functions. In our study we review and demonstrate the following three objective functions:

- Real income – the income of the real process is maximized
- Producer income – the income of the producer community is maximized
- Owner income – the income of the owners is maximized.

Correct definition of the objective function is most important. Objectives must be distinguished from means and circumstances. When the objective function is correctly defined, the measured result is homogenous. All the units of measured results then serve the defined objective in the same way and they are equally valuable. Profit is a good example of a homogenous measurement result. Each euro or dollar measured as profit is equally valuable to the owner as income.

*The Biased GDP*

The Gross Domestic Product (GDP) is a technical quantity of national accounts that measures the value-added generated by a nation (or other economic entity).

According to OECD, Gross Domestic Product per capita measures economic activity or income per person and is one of the core indicators of economic performance. GDP per capita is a rough measure of average living standards or economic well-being. (OECD 2008, 14)

GDP is, for this purpose, only a very rough measure. Maximizing GDP, in principal, also allows maximizing capital usage. For this reason GDP is systematically biased in favour of capital intensive production at the expense of knowledge and labour intensive production. The use of capital in the GDP-measure is considered to be as valuable as the production's ability to pay taxes, profits and labor compensation. The bias of the GDP is actually the difference between the GDP and the producer income. The situation is demonstrated later with a numerical example.

### *3.5 The trap of Vygotsky*

Vygotsky (1962) cautions against the risk of separating the issue under review from the total environment, the entity, of which the issue is an essential part. By studying only this isolated issue we are likely to end up with incorrect conclusions. A practical example illustrates this warning. Let us assume we are studying the properties of water in putting out a fire. If we focus the review on small components of the whole, in this case the elements oxygen and hydrogen, we come to the conclusion that hydrogen is an explosive gas and oxygen is a catalyst in combustion. Therefore, their compound water could be explosive and unsuitable for putting out a fire. This incorrect conclusion arises from the fact that the components have been separated from the entity.

The risk identified by Vygotksy can arise in partial productivity measurement. We do know that total productivity change means a change of real income, which in turn has been caused by the shift of the production function. An interpretation of partial productivity is correct only if the effects on the real income are reliably understood. Too often partial productivity measures report something other than the effect of the real income.

# 4 ACCOUNTING WITH OUR PRODUCTION MODEL

Two production models developed by the author are now introduced. Production models are identified according to the year they were published. Model Saari 1989 was published in Finnish in 1989. It was used in the author's (Saari 2000) dissertation, where the typology of production models was successfully explained. Model Saari 2004 was published in Finnish in 2004 and in English in 2006. Because the accounting techniques of the two models are different, they give differing, although complementary, analytical information. The accounting results are, however, identical. Both models are adjustable and they, therefore, allow examination and simulation of the logic of other models.

## *4.1 Surplus value as a measure of production profitability*

The scale of success run by a going concern is manifold, and there are no criteria that might be universally applicable to success. Nevertheless, there is one criterion by which we can generalise the rate of success in business. This criterion is the ability to produce surplus value. As a criterion of profitability, surplus value refers to the difference between returns and costs, taking into consideration the costs of equity in addition to the costs included in the income statement as usual. Surplus value indicates that the output has more value than the sacrifice made for it, in other words, the output value is higher than the value (production costs) of the used inputs. If the surplus value is positive, the owner's profit expectation has been surpassed.

TABLE 1. PROFITABILITY OF PRODUCTION MEASURED BY SURPLUS VALUE (SAARI 2006)

| | Period 1 | | | Period 2 | | |
|---|---|---|---|---|---|---|
| | Quantity | Price | Value | Quantity | Price | Value |
| Product 1 | 210.00 | 7.20 | 1512 | 247.25 | 7.10 | 1755 |
| Product 2 | 200.00 | 7.00 | 1400 | 195.03 | 7.15 | 1394 |
| Output | | | 2912 | | | 3150 |
| | | | | | | |
| Labour | 100.00 | 7.50 | 750 | 115.00 | 7.70 | 886 |
| Materials | 80.00 | 8.60 | 688 | 79.20 | 8.50 | 673 |
| Energy | 400.00 | 1.50 | 600 | 428.00 | 1.55 | 663 |
| Capital | 160.00 | 3.80 | 608 | 164.80 | 3.90 | 643 |
| Input | | | 2646 | | | 2865 |
| Surplus value (abs.) | | | 266.00 | | | 285.12 |
| *Surplus value (rel.)* | | | *1.101* | | | *1.100* |

Table 1 presents an income statement using the surplus value as a performance criterion. This basic example is a simplified income statement used for illustration and modelling. Even as reduced, it comprises all phenomena of a real measuring situation and most importantly the change in the output-input mix between two periods. Hence, the basic example works as an illustrative "scale model" of production without any features of a real measuring situation being lost. In practice, there may be hundreds of products and inputs but the logic of measuring does not differ from that presented in the basic example.

Both the absolute and relative surplus values have been calculated in the example. The absolute value is the difference of the output and input values and the relative value is their relation, respectively. The surplus value calculation in the example is at a nominal price, calculated at the market price of each period.

## *4.2 Production model Saari 2004*

The next step is to describe a *production model* (Saari 2004, 2006) by help of which it is possible to calculate the results of the real process, income distribution process and production process. The starting point is a profitability calculation using surplus value as a criterion of profitability. The surplus value calculation is the only valid measure for understanding the connection between profitability and productivity or understanding the connection between real process and production process. A valid measurement of total productivity necessitates considering all production inputs, and the surplus value calculation is the only calculation to conform to the requirement.

The process of calculating is best understood by applying the clause of Ceteris paribus, i.e. "all other things being the same," stating that at a time only the impact of one changing factor be introduced to the phenomenon being examined. Therefore, the calculation can be presented as a process advancing step by step. First, the impacts of the income distribution process are calculated, and then, the impacts of the real process on the profitability of the production.

The first step of the calculation is to separate the impacts of the real process and the income distribution process, respectively, from the change in profitability (285.12 – 266.00 = 19.12). This takes place by simply creating one auxiliary column (4) in which a surplus value calculation is compiled using the quantities of Period 1 and the prices of Period 2. In the resulting profitability calculation, Columns 3 and 4 depict the impact of a change in income distribution process on the profitability and in Columns 4 and 7 the impact of a change in real process on the profitability.

TABLE 2. PRODUCTION MODEL SAARI 2004

| | | Period 1 | | | $Q_1 \times P_2$ | Period 2 | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | | Quantity | Price | Value | | Quantity | Price | Value |
| a | Product 1 | 210.00 | 7.20 | 1512.00 | 1491.00 | 247.25 | 7.10 | 1755.48 |
| b | Product 2 | 200.00 | 7.00 | 1400.00 | 1430.00 | 195.03 | 7.15 | 1394.46 |
| c | Output | | | 2912.00 | 2921.00 | | | 3149.94 |
| d | Labour | 100.00 | 7.50 | 750.00 | 770.00 | 115.00 | 7.70 | 885.50 |
| e | Materials | 80.00 | 8.60 | 688.00 | 680.00 | 79.20 | 8.50 | 673.20 |
| f | Energy | 400.00 | 1.50 | 600.00 | 620.00 | 428.00 | 1.55 | 663.40 |
| g | Capital | 160.00 | 3.80 | 608.00 | 624.00 | 164.80 | 3.90 | 642.72 |
| h | Input | | | 2646.00 | 2694.00 | | | 2864.82 |
| i | Surplus value (abs.) | | | 266.00 | 227.00 | | | 285.12 |
| j | *Surplus value (rel.)* | | | *1.101* | | | | *1.100* |
| k | Change of distribution (abs.); i4-i3 | | | | -39.00 | | | |
| l | Distribution index of output; c4/c3 | | | | 1.003 | | | |
| m | Distribution index of input; h4/h3 | | | | 1.018 | | | |
| n | Distribution index; l4/m4 | | | | 0.985 | | | |
| | Distribution process | | | | | | | |
| p | Productivity; c4/h4, c7/h7 | | | | 1.084 | | | 1.100 |
| q | Productivity index; p7/p4 | | | | | | | 1.014 |
| r | Change of productivity (abs.); (q7-1)×c4 | | | | | | | 41.12 |
| s | Volume index of output; c7/c4 | | | | | | | 1.078 |
| t | Volume index of input; h7/h4 | | | | | | | 1.063 |
| u | Change of input volume (abs); (t7-1)×(i4+r7) | | | | | | | 17.00 |
| | Real process | | | | | | | |
| v | Change of profitability; j7/j3 | | | | | | | 0.999 |
| x | Change of returns; c7/c3 | | | | | | | 1.082 |
| z | Change of costs; h7/h3 | | | | | | | 1.083 |
| | Production process | | | | | | | |

*Calculation of the income distribution process*

The key figures of income distribution can now be calculated from the surplus value calculations in Columns 3 and 4. The difference of 39.00 (unfavourable) between the surplus values indicates the impact on profitability in terms of money. Indices depicting the change in income distribution can now be calculated by the formulae presented both for output (1.003) and input (1.018), and as their ratio for the whole business

$$1.003/1.018=0.985.$$

It follows that the change in income distribution means a development in which the quality of output or input stays the same while the unit price changes. A change of price does not involve recompensing for the change in quality. In the short term, price changes do not follow a certain trend, yet, in the long term, the trend is transparent. Consumers benefit from lowering product prices and their buying power increases thanks to better compensation for selling their work input to production. Production income distribution is the mechanism by means of which productivity gains of the production are distributed to interested parties, and it can be measured by means of price changes.

*Calculation of the real process*

Columns 4 and 7 depict the change in performance in the real process. Surplus values have been calculated at a fixed price, in this case, at prices of Period 2. Fixed-price calculation is a method in which the quantities of the items of different qualities can be measured and added up. This concept is called the volume which is a measure of absolute value. The time series depicting its change is called the volume index.

The surplus value of the real process is called the real surplus value as distinct from the nominal price surplus value of profitability. All changes in the surplus value of the real process are changes of performance. Productivity is the surplus value of the real process proportionally measured. Now it is possible to calculate productivity (1.084 and 1.100) for Periods 1 and 2 using the formula of productivity output per input, and as their ratio we get the productivity index depicting the change in productivity.

$$1.100/1.084=1.014.$$

As a result, we can calculate the monetary quantity equivalent to the change in productivity, and in this case it is favourable 41.12 units.

### *4.3 Production model Saari 1989*

Another production model that gives complementary information on income formation is now introduced. The accounting technique for this model has been developed from standard cost accounting. The model was used when the typology of production models was successfully explained (Saari 2000). The model gives identical accounting results to the Saari 2004 model.

The principle of this model is to convert a nominal price income statement of production into a fixed price calculation. In the fixed price calculation we can easily compute and analyze the effects of the real process and the distribution process. A conversion to the fixed price calculation is made by expressing the unit prices of outputs and inputs as price indices. The fixed price quantities of outputs and inputs can then be computed with help of the indices.

TABLE 3. PRODUCTION MODEL SAARI 1989

| | Period 1 | | | | Period 2 | | | | Effects on profit | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quant. | Prod. | Price | Value | Quant. | Prod. | Price | Value | Prod. | Volume | Distr. | Value |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Product 1 | 1491 | 0.553 | 1.014 | 1512 | 1755 | 0.613 | 1.00 | 1755 | 159.80 | 104.67 | -21.00 | 243.48 |
| Product 2 | 1430 | 0.531 | 0.979 | 1400 | 1394 | 0.487 | 1.00 | 1394 | -118.68 | 83.15 | 30.00 | -5.54 |
| Ouput | 2921 | 1.084 | | 2912 | 3150 | 1.100 | | 3150 | 41.12 | 187.82 | 9.00 | 237.94 |
| | | | | | | | | | | | | |
| Labour | 770 | 0.286 | 0.974 | 750 | 886 | 0.309 | 1.00 | 886 | -62.70 | -52.80 | -20.00 | -135.50 |
| Materials | 680 | 0.252 | 1.012 | 688 | 673 | 0.235 | 1.00 | 673 | 46.94 | -40.14 | 8.00 | 14.80 |
| Energy | 620 | 0.230 | 0.968 | 600 | 663 | 0.232 | 1.00 | 663 | -3.84 | -39.56 | -20.00 | -63.40 |
| Capital | 624 | 0.232 | 0.974 | 608 | 643 | 0.224 | 1.00 | 643 | 19.60 | -38.32 | -16.00 | -34.72 |
| Input | 2694 | 1.000 | | 2646 | 2865 | 1.000 | | 2865 | 0.00 | -170.82 | -48.00 | -218.82 |
| Surplus value (abs.) | | | | 266.00 | 285.12 | | | 285.12 | 41.12 | 17.00 | -39.00 | 19.12 |
| *Surplus value (rel.)* | | | | *1.101* | | | | *1.100* | | | | |
| | | | | | | | *Output index* | | *1.014* | *1.063* | *1.003* | *1.082* |
| *Output vol.* | *1.000* | | | | *1.078* | | *Input index* | | *1.000* | *1.063* | *1.018* | *1.083* |
| *Input vol.* | *1.000* | | | | *1.063* | | *Surpl. value ind.* | | *1.014* | *1.000* | *0.985* | *0.999* |

The accounting procedure is as follows:

1. Current unit prices of the basic example are expressed as indices. (col. 3 and 7). Prices of outputs and inputs in Period 2 are given the value 1.000 and price indices for outputs and inputs in Period 1 are computed.
2. The fixed price quantities (col. 1 and 5) of outputs and inputs are computed by dividing their current price values (col. 4 and 8) by the price indices (col. 3 and 7)
3. Fixed price quantities of outputs and inputs are now commensurate. The total output and input are computed by summing up the fixed priced quantities of outputs and inputs (col. 1 and 5)
4. Productivity factors are computed in columns 2 and 6. The productivity factor is on the output side "Output quantity / Total output" and on the input side "Input quantity / Total input.
5. Finally, the profit effects of income components are computed row by row using the following formulae:

*Effect of productivity change* = $\Delta T \times V_1 \times H_2$
*Effect of volume change* = $T_2 \times \Delta V \times H_2$
*Effect of price change* = $T_1 \times V_1 \times \Delta H$
*where:*

*T = Productivity factor*
*V = Volume (input volume)*
*H = Price*
*indices refer to Periods one and two.*

This model also gives details of the income distribution. Note that income distribution is expressed row by row, that is, for each output and each input. A favourable change for the producer is shown by a plus sign and an unfavourable one by a minus sign. The effects of income distribution are shown by the producer's production function in the subsequent period. In the next section the income distribution and its effects on the production function are analyzed in greater detail.

## 5 ANALYSES

The production models described here are illustrative tools because they show explicitly how the accounting results are computed from the production data. Clarity and understanding can be increased with additional summaries, analyses and objective function formulations. Some typical cases are presented below.

### 5.1 Objective functions

An efficient way to improve the understanding of production performance is to formulate different objective functions according to the objectives of the different interest groups. Formulating the objective function necessitates defining the variable to be maximized (or minimized). After that other variables are considered as constraints. The most familiar objective function is profit maximization which is also included in our study. Profit maximization is an objective function that stems from the owner's interest and all other variables are constraints in relation to maximizing of profits.

The procedure for formulating different objective functions, in terms of our production model, is introduced next. In the income formation from production the following objective functions can be identified:

- Maximizing the real income
- Maximizing the producer income
- Maximizing the owner income.

These cases are illustrated using the numbers from the basic example. The following symbols are used in the presentation:
= signifies the starting point of the computation or the result of computing
+ / - signifies a variable that is to be added or subtracted from the function.

*Maximizing the real income*

The primary maximizing object is the real income because all other incomes are derivatives of the real income. The real income and its growth originate from quantitative ratios of the real process, or more precisely, from the volume and productivity of the production function. In the basic example this income generation can be calculated as follows:

| | |
|---|---|
| +/- Income growth from productivity | +41.12 |
| +/- Income growth from volume | +17.00 |
| = Real income growth | +58.12 |

Computing the real income does not in itself imply in any way how the income is to be distributed. It is important to note that the real income growth (change) during a given period of time is always the same as the change in income distribution. As a formula this is given as follows:

Real income growth = Income distribution = +58.12 units

This assumes that the real income growth is distributed to the stakeholders during the review period.

*Maximizing the producer income*

Other objective functions can be formulated by assuming that, for the use of the real income, there is a priority order that follows the logic of the market economy. Typically, the first use of the real income is to ensure the price competitiveness of products. After that the real income is used to meet the supplier's possible requirements for better prices. When these market requirements are regarded as constraints, we end up maximizing the producer income. The objective function of the producer income is now written as:

= Real income growth
+/- Ensuring the price competitiveness of products
+/- Responding to supplier's price requirements
= Producer income growth

In practice, producer income can be computed in two ways. Starting from the real income growth (change) and subtracting the requirements of the customers and the suppliers, we end up with the following calculation:

| | |
|---|---|
| = Real income growth | +58.12 |
| +/- Product 1 | -21.00 |
| +/- Product 2 | +30.00 |
| +/- Material supplier | +8.00 |
| +/- Energy supplier | -20.00 |
| +/- Capital supplier | -16.00 |
| = Producer income growth | +39.12 |

This method is called the subtraction method.

The producer income is consequently the income before labour compensation, taxes and surplus value. These are the components of the producer income which can simply be computed as a sum in the following way:

| | |
|---|---|
| +Labor compensation | +20.00 |
| +Taxes | N/a |
| +Surplus value | +19.12 |
| = Producer income | +39.12 |

For simplicity, taxes are omitted in our example. This calculation is called the addition method.

As a measure of well-being the producer income can be justified by the following arguments that follow our model:

1. Producer income is a measure of the income the producer community has generated for themselves. It is in the common interest of the producer community to maximize it.
2. Producer income is a measure of competitiveness. A company with a higher relative (i.e., relative to the company's size) producer income is more competitive.
3. Producer income can also simply and reliably be computed for projects and services; those domains totally lack the productivity measurement solution.
4. Producer income can be computed easily, precisely and reliably because here the aggregated production data does not cause an error as in productivity accounting.
5. Producer income is an addable quantity, i.e., incomes from different production units can be added so that no double accounting occurs.
6. Producer income is easily understood and, as such, it is a practical tool in the planning of income distribution within the producer community.
7. Producer income is a nominal quantity and, as such, it is suitable for international comparison based on purchasing power parity.
8. Nominal time series of producer incomes can be converted into a real time series by deflating it with a suitable price index.

*A practical example of the proper producer income*

An example of the producer income calculation with the empirical numbers is introduced next. The numbers in Period 1 below are from a capital intensive energy company (Million €). The numbers in Period 2 are fictive numbers which assume that ineffective investments have been made. These lead to an increase of all capital related inputs by 10 per cent; all other factors are assumed to be the same.

Note that the performance criterion "value added" does not show any change in performance but the criteria "producer income" does show a change. This difference is caused by the use of value added as a performance criterion. In the value-added calculation the capital related inputs are seen to be equally valuable indicators of performance compared to production's ability to pay labour compensation, taxes and surplus value.

TABLE 4. A PRACTICAL EXAMPLE OF THE PRODUCER INCOME

| | Period 1 | Period 2 |
|---|---|---|
| = Output | 6296 | 6296 |
| - Intermediate products | 3626 | 3626 |
| = Value added | 2670 | 2670 |
| - Depreciation | 560 | 616 |
| - Financing costs | 167 | 184 |
| - Cost of the equity | 437 | 480 |
| = Produce income | 1506 | 1390 |
| - Labour compensation | 507 | |
| - Taxes | 366 | |
| - Surplus value | 633 | |

| | | |
|---|---|---|
| Count of personnel | 11156 | 11156 |
| Producer income / person | 0.135 | 0.125 |

*Maximizing the owner income*

The objective function of the owner income is formulated by regarding the labour compensation and taxes as constraints. The owner's objective function can be shown in the following form:

| | |
|---|---|
| +/- Producer income change | +39.12 |
| - Taxes | N/a |
| - Labour compensation | -20.00 |
| = Owner income change | +19.12 |

The owner income here has the same significance as the profit. The profit can be computed in many different ways. We emphasize use of the surplus value (profit after the cost of the equity). It is a similar criterion even if the equity of the companies under comparison is different.

*Summary of the objective function formulations*

Objective function formulations can be expressed in a single calculation which concisely illustrates the logic of the income generation, the income distribution and the variables to be maximized.

TABLE 5. SUMMARY OF OBJECTIVE FUNCTION FORMULATIONS

| INCOME FORMATION - changes between two periods | | | |
|---|---|---|---|
| Income generation | | Income distribution | |
| | | = Real income | +58.12 |
| | | +/- Customers | +9.00 |
| | | +/- Suppliers | -28.00 |
| +/- Productivity | +41.12 | = Producer income | 39.12 |
| +/- Volume | +17.00 | - Labour compensation | -20.00 |
| | | - Taxes | N/a |
| = Real income | +58.12 | = Owner income | +19.12 |
| TOTAL GENERATION | 58.12 | TOTAL DISTRIBUTION | 58.12 |

The calculation resembles an income statement starting with the income generation and ending with the income distribution. The income generation and the distribution are always in balance so that their amounts are equal. In this case it is 58.12 units. The income which has been generated in the real process is distributed to the stakeholders during the same period. There are three variables which can be maximized. They are the real income, the producer income and the owner income. Producer income and owner income are practical quantities because they are addable quantities and they can be computed quite easily. Real income is normally not an addable quantity and in many cases it is difficult to calculate.

### 5.2 ”Fruits of production”

Davis (1955) suggested that the measurement of production should be developed so that the distribution of the ’fruits of production’ among all interested parties are measured. Davis called the ’fruits of production’, which are distributed through the price system, “gains” and “losses” (Davis 1955, p. 114). This terminology has been adopted in this study. A positive sign stands for a gain and a negative sign for a loss.

Income distribution calculation from the producer’s point of view was presented above. From the customers’ and suppliers’ point of view the calculation is the same but the signs are reversed. What for the company is a gain, is for the customer or supplier, a loss. In the example, the gains and losses of customers and suppliers are as follows:

| | |
|---|---|
| To customers | |
| +/- of product 1 | +21.00 |
| +/- of product 2 | -30.00 |
| To suppliers | |
| +/- of materials | -8.00 |
| +/- of energy | +20.00 |
| +/- of capital | +16.00 |

The numbers indicate the effects on customers’ and suppliers’ production functions. The mechanism functions as follows. Customers of product 1 gain the same quality and the same need satisfaction but pay 21.0 units less. Customers of the product 2 gain the same quality and need satisfaction but they must use 30.0 units more of income.

The example is valid for the current commodities because their qualities remain more or less unchanged. In this case the price change affects the production function of the company and the interest group with the same value, to one as a gain, to the other as a loss.

When a new product is launched, the case is different. The price of a new product is the same, both in the production function of producer and the customer. However, the new and improved quality affects only the production function of the customer. Therefore the product development benefits brought about by competition and technical advancement can never be measured from the production data. The major share of economic value created by technical advancement accumulates to the well-being of consumers. It is a well-known fact that this is very difficult to quantify and to measure.

### 5.3 Process analysis

Measurement results of a production process can be illustrated by models and graphic presentations. The following figure 5 illustrates the connections between the processes by means of indices describing the change (Loggerenberg et. al 1982, Saari 2004, 2006). A presentation by means of an index is illustrative because the magnitudes of the changes are commensurate. Numbers are taken from the above calculation example of the production model.

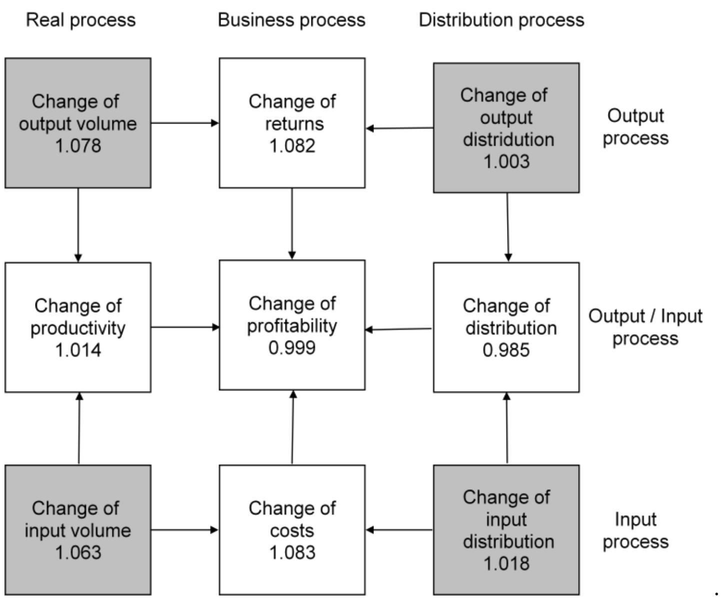



*Figure 5. Variables of production performance (Saari 2006)*

The nine most central key figures depicting changes in production performance can be presented as shown in Figure 5. Vertical lines depict the key figures of the real process, business process and income distribution process. Key figures in the production process are a result of the real process and the income distribution process. Horizontal lines show the changes in input and output processes and their impact on profitability. The logic behind the figure is simple. Squares in the corners refer to initial calculation data. Profitability numbers are obtained by dividing the output numbers by the input numbers in each process. After this, the production process numbers are obtained by multiplying the numbers of the real and income distribution processes.

### *5.4 Trends*

Development in the real process, income distribution process and production process can be illustrated by means of the time series. The principle of a time series is to describe, for example, the profitability of production annually by means of a relative surplus value and also to explain how profitability was produced as a consequence of productivity development and income distribution. A time series can be composed using the chain indices as seen in the following.

Now the intention is to draw up the time series for the ten periods in order to express the annual profitability of business by help of productivity and income distribution development. With the time series it is possible to prove that productivity of the real process is the distributable result of production, and profitability is the share remaining in the company after income distribution between the company and the interested parties participating in the exchange.

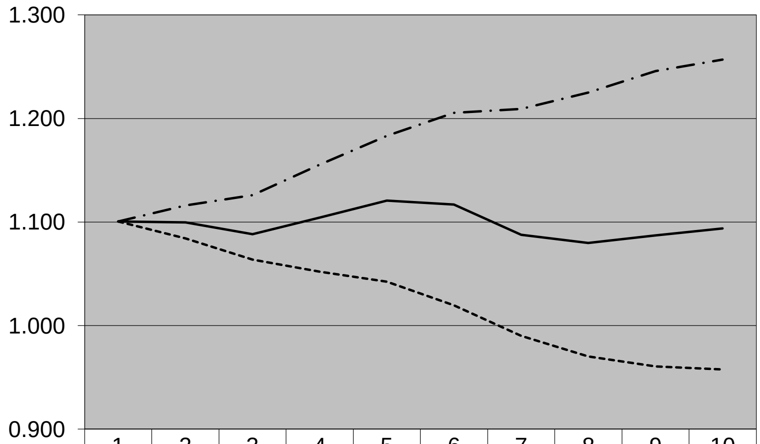
TABLE 6. PRODUCTIVITY AND INCOME DISTRIBUTION INDICES (SAARI 2006)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Chain index of distribution | **1.101** | 1.084 | 1.064 | 1.052 | 1.042 | 1.020 | 0.990 | 0.970 | 0.960 | 0.958 |
| Annual index of distribution | | **0.985** | 0.981 | 0.989 | 0.991 | 0.978 | 0.971 | 0.980 | 0.990 | 0.997 |
| Chain index of productivity | **1.101** | 1.116 | 1.126 | 1.155 | 1.183 | 1.206 | 1.209 | 1.225 | 1.246 | 1.257 |
| Annual index of productivity | | **1.014** | 1.009 | 1.026 | 1.024 | 1.019 | 1.003 | 1.013 | 1.017 | 1.009 |
| Production profitability (rel.) | **1.101** | **1.100** | 1.088 | 1.104 | 1.121 | 1.117 | 1.088 | 1.080 | 1.087 | 1.094 |

Numbers in bold are taken from the calculation example. They can describe the entire logic of the table. A common starting point for the time series is the profitability of the first period, being 1.101 measured by the surplus value. The profitability of production is presented as an annual relative surplus value. A change in profitability between two periods can be presented using the profitability and income distribution index. For example, the development between Periods 1 and 2 can be expressed as

$$1.101 \times 1.014 \times 0.985 = 1.100.$$

In a market economy the prevailing competition sees to it that the productivity rise achieved in production will be distributed to interested parties sooner or later. This phenomenon can be illustrated by drawing up a chain index of the development of productivity and income distribution. The chain index is drawn up by multiplying the index of previous development by the index of annual change. In other words, productivity is given its first numeral value (1.116) by multiplying the common starting point (1.101) by the annual productivity index (1.014). This is the procedure for dealing with every period, and the formula explaining profitability by means of productivity and income distribution indices holds to every period.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Productivity | 1.101 | 1.116 | 1.126 | 1.155 | 1.183 | 1.206 | 1.209 | 1.225 | 1.246 | 1.257 |
| Profitability | 1.101 | 1.100 | 1.088 | 1.104 | 1.121 | 1.117 | 1.088 | 1.080 | 1.087 | 1.094 |
| Distribution | 1.101 | 1.084 | 1.064 | 1.052 | 1.042 | 1.020 | 0.990 | 0.970 | 0.960 | 0.958 |

*Figure 6. Profitability as a function of productivity and income distribution development (Saari 2006)*

The above graph shows how profitability depends on the development of productivity and income distribution. Productivity figures are fictional but in practice they are perfectly feasible indicating an annual growth of 1.5 per cent on average. Growth potentials in productivity vary greatly by industry, and as a whole, they are directly proportionate to the technical development in the branch. Fast-developing industries attain stronger growth in productivity. This is a traditional way of thinking. Today we understand that human and social capitals together with competition have a significant impact on productivity growth. In any case, productivity grows in small steps. By the accurate measurement of productivity, it is possible to appreciate these small changes and create an organisation culture where continuous improvement is a common value.

## 6 PRODUCTION MODEL TYPOLOGY

The principle of comparing production models is to identify the characteristics that are present in the models and to understand their differences. This task is alleviated by the fact that such characteristics can unmistakably be identified by their measurement formula. Based on the model comparison, it is possible to identify the models that are best suited for production analyses. A criterion of this solution is the production theory and the production function. It is essential that the model is able to describe the production function because it depicts the real income generation of production.

### 6.1 Production Models

There are several different models suggested in the literature. Comparing the models systematically has proved most problematic. In terms of pure mathematics it has not been possible to establish the different and similar characteristics of them so as to be able to understand each model as such and in relation to another model. This kind of comparison is possible using the production model which is a model with adjustable characteristics. An adjustable model can be set with the characteristics of the model under review after which both differences and similarities are identifiable. A comprehensive comparison of productivity measurement models is presented in another publication (Saari 2000).

A characteristic of production models that surpasses all the others is the ability to describe the production function. If the model can describe the production function, it is applicable to production analyses. On the other hand, if it cannot describe the production function or if it can do so only partly, the model is not suitable for its task. The production models based on the production function form rather a coherent entity in which differences in models are fairly small. The differences play an insignificant role, and the solutions that are optional can be recommended for good reasons. Production models can differ in characteristics from another in six ways.

1. First, it is necessary to examine and clarify the *differences in the names* of the concepts. Model developers have given different names to the same concepts, causing a lot of confusion. It goes without saying that differences in names do not affect the logic of modelling. The name differences can be traced in the publication Saari 2000.

2. *Model variables* can differ; hence, the basic logic of the model is different. It is a question of the variables to be used for the measurement. The most important characteristic of a model is its ability to describe the production function. This requirement is fulfilled in case the model has the production function variables of productivity and volume. Only the models that meet this criterion are worth a closer comparison.

3. *Calculation order* of the variables can differ. Calculation is based on the principle of Ceteris paribus stating that when calculating the impacts of change in one variable all other variables are hold constant. The order of calculating the variables has some effect on the calculation results, yet, the difference is not significant.

4. *Theoretical framework* of the model can be either cost theory or production theory. In a model based on the production theory, the volume of production is measured by input volume. Accordingly, productivity is expressed as a ratio of output per one unit of input. In a model based on the cost theory, the volume of production is measured by output volume. Accordingly, productivity is expressed as a ratio of input usage per one unit of ouput.

5. *Accounting technique*, i.e., how measurement results are produced, can differ. In calculation, three techniques apply: ratio accounting, variance accounting and accounting form. Differences in the accounting technique do not imply differences in accounting results but differences in clarity and intelligibility. Variance accounting gives the user most possibilities for an analysis.

6. *Adjustability of the model*. There are two kinds of models, fixed and adjustable. On an adjustable model, characteristics can be changed, and therefore, they can examine the characteristics of other models. A fixed model can not be changed. It holds constant the characteristic that the developer has created in it.

### 6.2 Comparative summary of the PPPV models

PPPV is the abbreviation for the following variables, profitability being expressed as a function of them:

$$Profitability = f\,(Productivity, Prices, Volume)$$

The model is linked to the income statement so that profitability is expressed as a function of productivity, volume and unit prices. Productivity and volume are the variables of a production function, and using them makes it is possible to describe the real process. A change in unit prices describes a change of production income distribution.

PPPV models measure profitability as a function of productivity, volume and income distribution (unit prices). Such models are

- Japanese Kurosawa (1975)
- French Courbois & Temple (1975)
- Finnish Saari (1976, 1989, 2004, 2006)
- American Gollop (1979, 1982)

The following table presents the characteristics of the PPPV models. All four models use the same variables by which a change in profitability is written into formulae to be used for measurement. These variables are income distribution (prices), productivity and volume. A conclusion is that the basic logic of measurement is the same in all models. The method of implementing the measurements varies to a degree, depending on the fact that the models do not produce similar results from the same production data.

Even if the production function variables of profitability and volume were in the model, in practice the calculation can also be carried out in compliance with the cost function. This is the case in models Courbois & Temple as well as Gollop. Calculating methods differ in the use of either output volume or input volume for measuring the volume of production. The former solution complies with the cost function and the latter with the production function. It is obvious that the calculation produces different results from the same data. A recommendation is to apply calculation in accordance with the production function. According to the definition of the production function used in the production model and that of Kurosawa, productivity means the quantity and quality of output per one unit of input.

TABLE 7. SUMMARY OF THE PPPV MODEL CHARACTERISTICS (SAARI 2006)

| CHOICE | Saari | Kurosawa | Gollop | C & T |
|---|---|---|---|---|
| Variables used in the model | Distribution<br>Productivity<br>Volume | Distribution<br>Productivity<br>Volume | Distribution<br>Productivity<br>Volume | Distribution<br>Productivity<br>Volume |
| Theory, alternatives;<br>1. Production function<br>2. Cost function | Production function | Production function | Cost function | Cost function |
| Calculation order of variables | 1. Distribution<br>2. Productivity<br>3. Volume | 1. Volume<br>2. Productivity<br>3. Distribution | 1. Volume<br>2. Productivity<br>3. Distribution | 1. Volume<br>2. Productivity<br>3. Distribution |
| Accounting technique, alternatives;<br>1. Variance accounting<br>2. Ratio accounting<br>3. Accounting form | All changes; Variance accounting | All changes; Accounting form | Distribution; Variance acc.<br>Productivity; Ratio acc.<br>Volume; Account. form | All Changes Accounting; form |
| Adjustability, alternatives;<br>1. Adjustable<br>2. Fixed | Adjustable | Fixed | Fixed | Fixed |

The Saari 1989 model is the only model weighting quantity changes with new prices. The order of calculating the changes in the production model is as follows: 1.Prices, 2.Productivity and 3.Volume. The question is how the results of the real process should be valued. The solution is justified by the fact that the real process should be valued by the new prices because new prices are a spur guiding the management. This choice is followed by the fact that the changes in income distribution are valued on the basis of the quantities of Period 1.

Models differ from one another significantly in their calculation techniques. Differences in the calculation technique do not cause differences in calculation results but it is rather a question of differences in clarity and intelligibility between the models. From the comparison it is evident that the models of Courbois & Temple and Kurosawa are purely based on calculation formulae. The calculation is based on the aggregates in the income statement. Consequently, it does not suit to analysis. The Saari 1989 model is purely based on variance accounting known from the standard cost accounting. Variance accounting is applied to elementary variables, that is, to quantities and prices of different products and inputs. Variance accounting gives the user most possibilities for analysis. The model of Gollop is a mixed model by its calculation technique. Every variable is calculated using a different calculation technique.

The Saari 1989 model is the only model with alterable characteristics. Hence, it is an adjustable model. A comparison between other models has been feasible by exploiting this particular characteristic of this model.

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