МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ

ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ АВТОНОМНОЕ
ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ
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ИНЖЕНЕРНАЯ ЭКОНОМИКА: МАТЕМАТИЧЕСКИЕ МЕТОДЫ И МОДЕЛИ

ENGINEERING ECONOMICS: MATHEMATICAL METHODS AND MODELS

Рекомендовано редакционно-издательским советом федерального государственного автономного образовательного учреждения высшего образования «Самарский национальный исследовательский университет имени академика С.П. Королева» в качестве учебного пособия для студентов, обучающихся по основной образовательной программе высшего образования по направлению подготовки 38.04.02 Менеджмент

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В пособии рассматривается теория производства через понятие производственных функций, раскрываются вопросы теории деятельности и издержек коммерческой организации, а также исследуется теория потребительского выбора. Даются основы использования математического моделирования в деятельности коммерческой организации.

Предназначено для студентов, обучающихся по направлению подготовки 38.04.02 Менеджмент.

Разработаны на кафедре математических методов в экономике.

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Preface

The course aims to form the following common cultural and professional, general professional competencies in order to accept the decisions that make engineering projects economically effective:

- ability of abstract thinking, analysis and synthesis;
- ability to conduct self-guided research; to prove relevance and significance of research;
- ability to analyze behavior of economic agents and markets using economic and strategic methods.

Objectives of the study guide:

- obtaining and specifying **knowledge** on main principles, laws and conceptions of economic theory according to its logic entirety and connection with the engineering; principles of providing economic feasibility of taken decisions while engineering projects execution; global area and specifics of economic agents behavior.
- gaining and training **ability** to use basics of economical knowledge for estimation and evaluation of technological processes, engineering projects, accepting economically feasible choice of investment projects; to calculate, estimate and minimize production costs; to calculate, estimate and maximize profit; give economic estimation to business-plans of engineering projects; to identify key market players and detect the type of their market behavior.
- developing **skills** of economic-oriented work while addressing certain problems in spheres of research, theoretical production, managerial and project work; of using basic computer programs for economic analysis calculation and economic efficiency estimation of engineering projects; methods of agents' behavior economic analysis and market environment condition estimation.

The course provides a complex of knowledge, skills and abilities.

Introduction

Engineering economics represents appliance of economic methods and principles in the engineering projecting process. The engineering project must necessarily be technically valid, and moreover, economically reasonable.

Many basic economics principles can be used in engineering and economic analysis depending on its applicability. The time value of money appears to be one of these principles used in many ways: to count the value of a project, draw a conclusion about economical effectiveness, to calculate annual cash flows, i.e. investments and profit.

Moreover, a manufacturer needs to estimate income and costs, make breakeven analysis, which can calculate a minimum needed rate of production so that a company doesn't bear losses.

It is also important while performing engineering projects to know and be able to solve main problems of economics – to reduce costs and to maximize profit.

Thus, engineering economics study helps to accept more appropriate decisions while executing engineering projects, taking into account its economic benefits, which makes it possible for manufacturer to become more competitive.

UNIT 1 Introduction into Engineering Economics

1.1 What is engineering economics

Engineering economics deals with the methods that enable one to make economic decisions toward evaluation of design and engineering alternatives. It helps in examining the relevancy of a project, estimating its value and justifying it from the engineering viewpoint.

1.1.1 Role of Engineering Economics in modern engineering theory development

Technological advances in machines, materials, computers, structures, and electronics have changed the job description of the engineer rapidly. Economic merits of the different alternatives available to the solution of a given problem can be evaluated in a systematic manner [1].

Engineering is defined by ABET (Accreditation Board for Engineering and Technology) as the profession in which the knowledge gained in physics, chemistry, life sciences, and mathematics is applied to make products that increase the prosperity of men. This must be achieved with a judicious choice of materials, at the lowest cost in a manner that is benign to the environment, and that keeps all the stakeholders safe. The Economist's *Dictionary of Economics* [2] defines economics as "the study of the production, distribution, and consumption of wealth in human society."

Before 1940, engineers were mainly concerned with the design, construction, and operation of machines, structures and concerns.

Besides the traditional work of transforming scientific discoveries into useful products, engineers are now also expected to generate novel technological solutions, along with making skillful financial analysis of the effect of the implementation. In today’s close and tangled relations among the industry, public and government, costs

and value analysis are expected to be more detailed and inclusive (e.g. worker safety, environmental effects, consumer protection, resource conservation) than ever before. Without these analysis, project can easily become more a burden than a benefit.

Examples of engineering achievements [3]

1. Electrification
2. Automobile
3. Airplane
4. Water Supply and Distribution
5. Electronics
6. Radio and Television
7. Agricultural Mechanization
8. Computers
9. Telephone
10. Air Conditioning and Refrigeration
11. Highways
12. Spacecraft
13. Internet
14. Imaging
15. Household Appliances
16. Health Technologies
17. Petroleum and Petrochemical Technologies
18. Laser and Fiber Optics
19. Nuclear Technologies
20. High-performance Materials

Most definitions of engineering suggest that the mission of the engineers is to transform natural resources for the benefit of the human race. The types of resources susceptible to engineering enrichment include everything from ores and crops to information and energy. A growing awareness of the finite limits of the earth's resources has added a pressing dimension to engineering evaluations. Thus, focus on scarce resources welds engineering to economics.

1.1.2 Connection between economics and engineering economics

Engineering Economics is simply the application of the principles of economics to the evaluation design and engineering alternatives. The role of engineering economics is to assess the appropriateness of a given project, estimate its value and justify it from an engineering standpoint.

1.2 Basic macroeconomic definitions

1.2.1 Review of key macroeconomic definitions

DEFINITION	*Market* is an actual or nominal place where forces of demand and supply operate, and where buyers and sellers interact (directly or through intermediaries) to trade goods, services, or contracts or instruments, for money or barter. [4]

Markets include mechanisms or means for (1) determining price of the traded item, (2) communicating the price information, (3) facilitating deals and transactions, and (4) effecting distribution. The market for a particular item is made up of existing and potential customers who need it and have the ability and willingness to pay for it [5].

Consumption means the use of resources or wealth in order to satisfy one's needs. It also means destruction of resources by human beings. The study of consumption includes the study of human wants, their characteristics, and the laws which provide maximum satisfaction out of limited income.

Consumption is only possible when there is a production. As consumption is a destruction of utilities, similarly the *production* is a creation of utilities to satisfy the human wants. The production is possible by the combination of four factors: land, labour, capital and organization. The process of production involves the creation of three types of utilities that are the following: form utility (e.g. making paddy rice), place utility (e.g. transporting rice from mill to shop) and time utility (e.g. rice stored in summer and sold in rainy season at a higher price).

The land owners get rent, labourers get wages, suppliers of money get rate of interest, and organizers get profit. How much each of them should get constitutes the subject matter of distribution.

DEFINITION

Distribution means dispensation of national income among various factors of production.

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1.2.2 Economic agents, their role and interrelations

Firms are the production units. They produce goods, commodities and services. For this they require labour, factories and capital. Which in turn are provided by household units. For providing such services and labour, the household units get payment. These payments otherwise become the income of households. They then spend this income in purchasing commodities produced by the firms. The payments the households make become the income of the firms. These payments are made in terms of money. Therefore the transactions that take place between the households and the firms lead to flow of money from the firms to the households and back. Hence, we call this circular flow of income. This simple model of interdependence between firms and households is illustrated in Figure 1.1. It is to be remembered that here we have shown two flows. 1 – the flow of goods, commodities, services and factors, 2 – the flow of money in terms of payment. The flow of goods, commodities, services and factors is known as real flow. The figure shows interdependence of the firm and the household sector in respect of providing services (firm) and payment for these services (households).

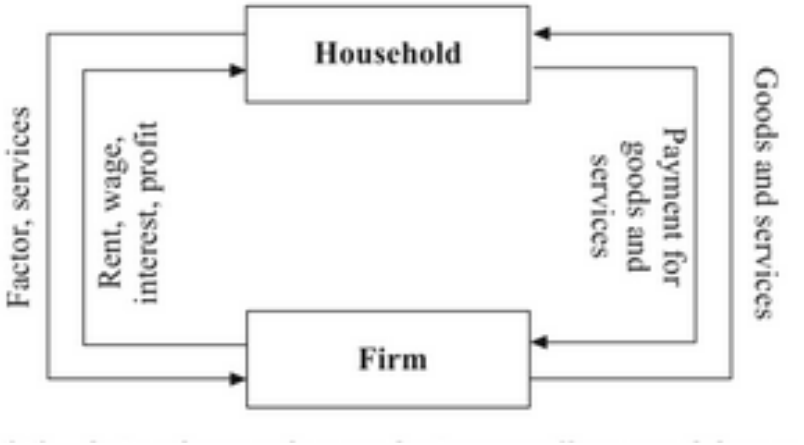


Figure 1.1 – Circulation between firms and households

We need to remember two things here. First, it is not easy to distinguish between producers and consumers. A person can be both a producer and a consumer. For example, in the factory he is a producer and makes production decisions. At home, however, he is a consumer and makes consumption decisions. Secondly, a firm does not always sell as the household. There are different stages of production in which a firm sells to another firm which produces raw materials, e.g. steel, sells to another firm who makes grills and doors and, finally, sells the end product to the consumer. Therefore, a firm may not sell always to the household directly. It may first sell to other firms.

From the simplified circular flow of income, we can construct a complex flow of income where we can show three basic units of economics: firms, households, and Government. Firms purchase goods and services from the Government and the latter takes from the former exports and revenue. Similarly, Government supplies general service to the households, and they in turn pay taxes. This is shown in the Figure 1.2.

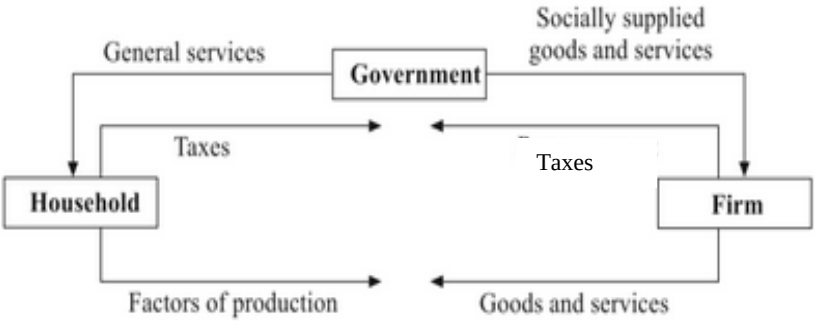


Figure 1.2 – Interdependence between firms, households and government

The entire network of economy is independent on each individual unit. Households pay Government taxes and the Government sells general services to them. Firms receive from the Government socially supplied goods, such as electricity, transportation facilities like roads and railway, market facilities and a host of other services. They in turn supply the Government with revenues and money in the form of exports. So the entire economic system is interdependent.

1.3 Demand and supply theory

1.3.1 What is demand and supply, market balance, producer and customer surplus

DEFINITION

Demand is a set of relationships showing the quantities of a good that consumers will buy at each of several prices within a specific period of time.

The demand quantity for any commodity, at a given price, is the quantity of it, which will be bought per unit of time at that price.

Individual demand – demand of one person for a good or service.

Market demand is a demand of all market consumers for a good or service. The summarized market demand curve is built up by adding up the individual demand curves on the horizontal axis.

Aggregate demand characterizes the demand of all consumers in all markets, i.e. for all goods and services. It occurs in the framework of macroeconomics.

Law of demand – establishes a relationship between the price and the quantity demanded of a commodity. Other things remaining the same, when the price of a commodity falls, its demand will go up. Likewise, when the price of a commodity rises, its demand will fall. Price and demand move in opposite directions.

Demand curve is the graph depicting the relationship between the price of a certain commodity and the amount of it that consumers are willing and able to purchase at that given price.

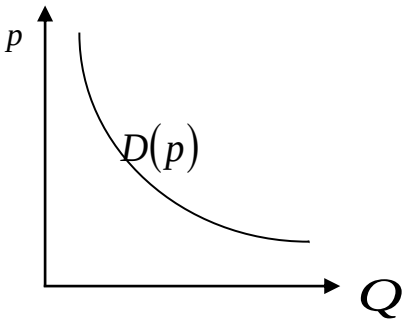


Figure 1.3 – Demand curve

Demand function is a function that determines the magnitude of demand, depending on the various factors affecting it. The most important of them is the price per unit of the good at the moment. Change in this factor leads to a transition from one point of the demand curve to another, i.e., changes in the volume of demand.

In addition to price, demand is effected by some of the non-price factors, such as consumers' income, the substitute products availability and their prices, tastes and preferences of customers, accumulated property, customers’ expectations of the best prices and incomes, etc.

Changes in any of these factors appear to shift the curve demand, i.e. demand change.

DEFINITION

Supply is a set of relationships showing the quantities of a product that a firm will offer at each of several prices within a specific period of time.

Supply quantity – quantity of goods and services offered for sale on the market under the given conditions.

Law of supply – a firm will offer more for sale at (relatively) higher prices than at (relatively) lower prices.

Supply curve – represents a firm's or industry's supply schedule plotted on a two dimensional graph.

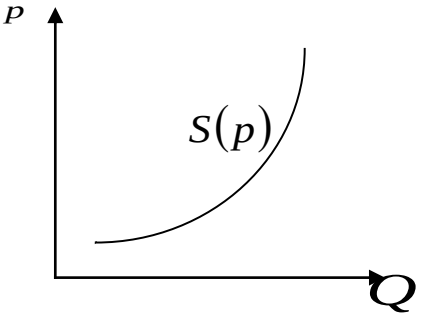


Figure 1.4 – Supply curve

Supply function is a function that determines the magnitude of supply, depending on the various factors affecting it. In addition to the price the supply is affected by non-price factors: the price of resources, production technology, taxes and subsidies, the price of other products, producers expectations for a change in price, the number of sellers in the market, the number of buyers, specific factors.

Interaction of supply and demand - the process of generating the creation of market price that satisfies both a seller and a buyer.

DEFINITION

Equilibrium price – the price *p**, at which the quantity demanded equals the quantity supplied.

It is a market-clearing price:

$$Q_S(p^*) = Q_D(p^*).$$

Market equilibrium is a state of the market, which is characterized by the equality of demand quantity and supply quantity with no trends to the market price or sold goods volume changes (Figure 1.5).

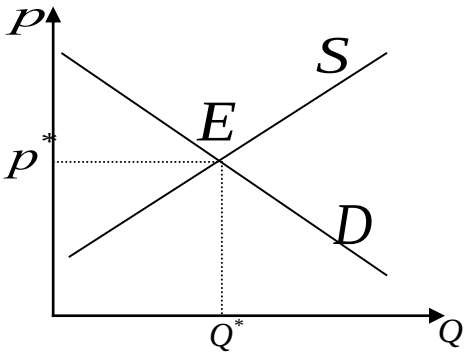


Figure 1.5 – Market equilibrium

The deficit - the excess of demand over supply:

$$Q_D(p) > Q_S(p).$$

The surplus - the excess of supply over demand:

$$Q_D(p) < Q_S(p).$$

Consumer surplus - the difference between the price the consumer is willing to pay for the goods, and the price that he really pays. In the Figure 1.6 the consumer surplus is the area of the triangle $p_1 p^* E$.

Producer surplus - additional revenues received in case the product price exceeds the estimated or planned price. In the Figure 1.6 the producer surplus is equal to the area of the triangle $p_2 p^* E$.

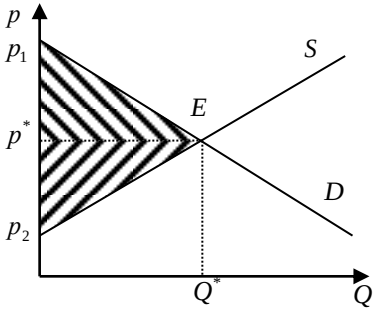


Figure 1.6 – Customer and producer surplus

1.3.2 Government's ability to impact the market balance: taxes, grants, fixed prices

The main tools of state for market regulation are taxes, subsidies, fixed prices.

Tax – an obligatory uncompensated payment, individually collected from firms and households in the form of money take-over for the purpose of the state's financial support.

If the seller pays the excise tax in the amount of *T* US $ per unit the supply curve shifts to the right by the amount of *T* US $, quantity of sales reduces, and the price for customers increases (Figure 1.7). The total amount of tax to the budget is equal to the area of a rectangle, which consists of buyers' payment and sellers' payment.

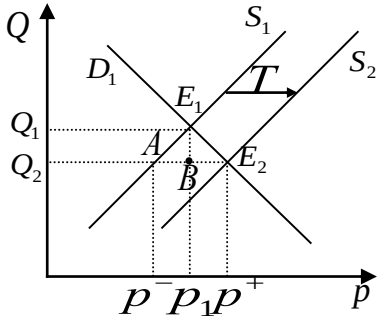


Figure 1.7 – Market equilibrium for the payment of excise tax by sellers

If the customer pays the excise tax in the amount of *T* US $ per unit the demand curve shifts to the left by the amount of *T* US $. New sales volume Q_2, prices p^+ and p^- (Figure 1.8) will be similar to the situation, when the tax is paid by sellers: it does not matter who is a direct taxpayer, as the proportion of the tax burden distribution between sellers and buyers remains the same.

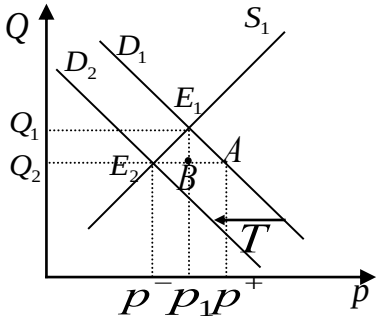


Figure 1.8 – Market equilibrium for the payment of excise tax by customers

Donations - cash benefits in the form of additional payments provided to households and individual businesses by the state for special purposes; are set as a percentage of the price of the good or in the absolute amount per unit of goods.

With the introduction of donations to a producer of a good in amount of *V* US$ per unit the supply curve shifts to the left, the volume of sales increases, price for buyers decreases and the price received by producers increases (Figure 1.9). Thus, the manufacturer receive only a part of donations, the other part goes to the customer's budget. A similar result will be in situation of customers' donations: the supply curve will shift by the same value *V* $US.

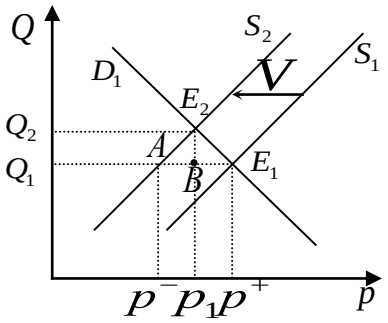


Figure 1.9 – The impact of donations on market equilibrium

Establishing fixed prices by the state.

The upper limit of the price (the "ceiling") - the price below the equilibrium price that is determined in order to protect the interests of low income customers of the a good; It leads to a chronic shortage of goods.

The lower price limit ("floor") - the price is above the equilibrium level that is determined for the purpose of state support for certain sectors of the economy; It leads to an excess of goods.

In both cases, the sales volume will be lower than the equilibrium Q_E: at the upper limit of the price it will be Q''_S , at the lower - Q'_D (Figure 1.10).

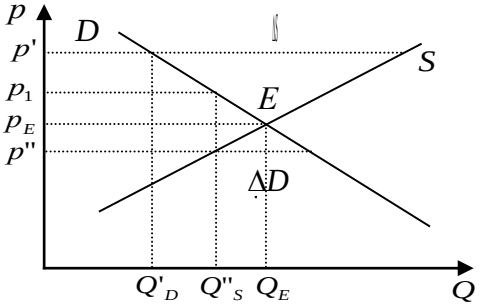


Figure 1.10 – Fixed price

1.3.3 Elasticity. Types of elasticity. indexes of elasticity. Identifying the type of product by the value of elasticity indexes

DEFINITION

Elasticity - an indicator of the percentage change in the volume of demand or supply at one percent change in one of their determinants (factors).

Price elasticity of demand is the proportionate change in quantity demanded in response to a small change in price, divided by the proportionate change in price:

$$E_D^p = \frac{(\Delta Q_D(p))\%}{(\Delta p)\%} = \frac{\Delta Q_D(p)}{\Delta p} \cdot \frac{p}{Q_D(p)}.$$

Price elasticity of demand depends on factors such as the availability of substitute products, time to adapt to changes in prices, the consumer budget share and so forth.

Price elasticity of demand can appear in several forms (table 1.1):

Table 1.1 – Demand price elasticity forms

The value of the elasticity coefficient	Demand features
$E_D = 0$	Perfectly inelastic demand - the quantity demanded does not change when the prices change (essential goods).
$E_D < 1$	Inelastic demand - when the demand quantity changes by a smaller percentage than the price (basic goods, irreplaceable goods)
$E_D = 1$	Unitary elasticity of demand - the price change is absolutely proportional to the change in demand quantity.
$E_D > 1$	Elasticity of demand - demand quantity is changed to a larger percentage than the price (goods not important for consumer, replaceable goods).
$E_D = \infty$	Perfectly elastic demand - demand quantity is not limited when the price falls below a certain level.

Price elasticity of demand in different parts of the same demand curve can take on different values (Figure 1.11):

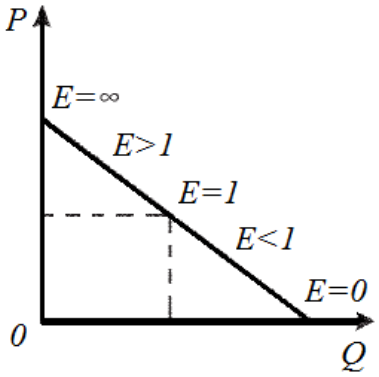


Figure 1.11 – Elasticity at different points of the demand curve

Cross-price elasticity of demand expresses the relative change in the volume of demand for one good at change of prices for another good, other conditions being equal:

$$E_{XY} = \frac{(\Delta Q_X)\%}{(\Delta p_Y)\%} = \frac{\Delta Q_X}{\Delta p_Y} \cdot \frac{p_Y}{Q_X}.$$

DEFINITION

Interchangeable products (substitutes) - two goods for which an increase in the price of one leads to an increase in demand for the other (positive cross elasticity).

DEFINITION

Complementary (complementary) products - two goods for which an increase in the price of one leads to a decrease in demand for the other (negative cross elasticity).

Goods may be neither interchangeable nor complementary. In this case the cross-price elasticity of demand equals zero, that is a good consumption does not depend on the price of another good.

Income elasticity of demand - a measure of the sensitivity of demand to changes in income; it reflects the relative changes in demand for any good in respect to consumer income changes:

$$E_D^I = \frac{(\Delta Q_D)\%}{(\Delta I)\%} = \frac{\Delta Q_D}{\Delta I} \cdot \frac{I}{Q_D}.$$

Income elasticity of demand depends on the following factors: the importance of the good for a family budget, the good belonging to the luxuries or necessities, demand conservatism, etc.

Normal goods - goods, the quantity of demand for which at other conditions being equal increases with increasing income (positive income elasticity of demand).

Inferior goods - goods, the quantity of demand for which increases with a decrease in consumer income (negative income elasticity of demand) at other conditions being equal.

Goods may not apply either to normal or to inferior ones. For such goods income elasticity of demand equals zero, i.e., the demand quantity is not sensitive to changes in income.

Price elasticity of supply is the percentage change in the supply quantity of goods, caused by a one percent change in its price with other factors affecting the supply quantity being fixed:

$$E_S^p = \frac{(\Delta Q_S(p))\%}{(\Delta p)\%} = \frac{\Delta Q_S(p)}{\Delta p} \cdot \frac{p}{Q_S(p)}.$$

Elasticity of supply depends on many factors: the possibility of long-term storage and storage costs, the specifics of the production process, the time factor, the price of other goods, including resources, the achieved level of resources exploitation (manpower, material, natural and other resources).

1.3.4 Sensitivity analysis methods

Sensitivity analysis allows to determine a respond of a production result to a factor change.

Tools for sensitivity analysis:

- One-way sensitivity analysis: determines the amount of an individual input parameter value needs to change, all other parameters held constant, in order for output parameter values to change by a certain percentage.

- Scenario analysis: involves calculating different scenarios, to analyse the influence of discrete input parameters on either output parameter values or priorities.

- Factorial design and multivariate analysis (MVA): changes in the discrete input variables are represented by the high and low levels in factorial design.

- Ratio sensitivity analysis: in ratio sensitivity analysis, which is applicable only in comparative studies, a ratio is calculated to determine the percentage an input parameter value needs to change in order to reverse rankings between two alternatives.

- Critical error factor: is a measure of the sensitivity of a priority between two alternatives to an input parameter value *x*.

- Tornado diagrams: illustrate the change in output parameter values for equal levels of change in input parameters

UNIT 2 Production theory

2.1 Production factors and their role in economics

Any commercial organization in the normal course of business consumes certain resources. In the role of resources there may be everything that is necessary for the functioning of the organization - raw materials, energy, labor, equipment, buildings, etc.

Production factors – resources used in production that determine the quantity of output. These are such factors as land, labor, capital, entrepreneurial activity (entrepreneurial skills), as well as scientific and technological progress, knowledge, information, etc.

Production factors market – economic sphere where they are purchased and sold and where as a result of the interaction of supply and demand the prices are generated for labor, natural resources, capital, entrepreneurial ability in the form of wages, rent, interest, profit.

The common resources:

1. Raw materials;
2. Labour costs;
3. Energy;
4. Research and development resources;
5. Technological resources;
6. Transport resources and others.

2.2 Economic view upon production process. Alchian's model of a firm

Alchian and Demsetz reported the emergence of firms to be a sequence of a team work [6]. Team work presents production, in which:

· several types of resources are used;

- team work product is more than the sum of the results of each included resource;

- resources used in production do not belong to one person.

A team work causes synergy - a greater effect of the whole comparing with the sum of units' effects. A total team release may be greater than the sum of the individual contributions made separately.

Alchian company model is a black box with the resources at the input (labor and capital), and products (services) at the output, and the firm goal is obtaining the maximum profit**.**

Consider a model with two resources as follows: *L*– labour (may be the number of man-hours, number of employees, the number of workdays), *K* – capital, consisting usually of two parts - fixed and floating assets.

Production may be measured in items, kilograms, and other physical units *Q*, and maybe in monetary units *P*.

For *K* and *L* may stand other factors, for example, *L* - the analyzed resource (electricity), *K* - all other resources (so-called composite resource).

Schematically, the manufacturing process can be represented as some system, processing various types of resources into finished products.

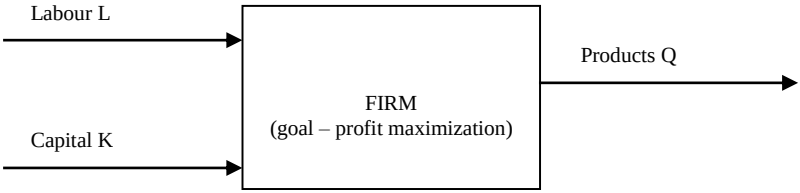


Figure 2.1 – The process of resources transformation into products

Firms will develop when two conditions are obtained:

- It is possible to increase production through team effort. Think of two men loading bulky cargo onto a truck. By working together, they can load the cargo in far less time than

if they worked separately; the product of their efforts exceeds the sum of their individual contributions. When there is a team effort like this, you have information problems: it is hard to tell who is shirking.

- It is possible to meter each input's (laborer's) marginal contribution, either by observation or specification of the inputs.

2.3 Production function in short-term period. Exhaust line. Average and marginal quantity, elasticity of production

To find out how much of the raw material is necessary to produce a given quantity of goods, or vice versa, check the amount of release of goods at a definite amount of resources, one must clearly understand the production process.

Each organization has its production process described by a unique production function, since it uses different technologies, principles of the work organization, equipment, personnel and other resources. Therefore, the amount of product obtained with the same resources may be different. Company executives must reject the variants of production, giving a smaller volume of production, if the same expenditure of each type of resource can give more products. Likewise, they must reject variants, requiring larger expenditures of at least one resource without increasing the quantity of output and reducing other resources. Variants that are rejected for these reasons are called technically inefficient.

Production functions (PF) take into account variants of only technically efficient production options.

Here is the definition of the production function.

DEFINITION

The functional relationship between input and output is called *production function.*

The relation described in the production function is a technical relation. The minimum of inputs required to produce a given output is technologically determined. The relationship can be expressed mathematically as follows:

$$Q=f(L*K)$$

where Q – output,

L and K denote labour and capital respectively.

The concept of production functions appeared in the US in the early twentieth century, when trying to analyze the agricultural production of the country the functions connecting yields and fertilizers were offered, and a number of other functions.

And in 20-30 years of the twentieth century American economists built a functional relationship between the growth of national income and certain capital and labour costs.

$$Q = A \cdot L^{\alpha} \cdot K^{\beta}, \qquad (2.1)$$

where Q — national income;

L and K —quantity of labour and capital costs respectively;

A – a coefficient, which reflects the level of technological performance, and it does not change in the short term; coefficients of degree: α - coefficient of elasticity for labour, β - coefficient of elasticity for capital. They show the proportion of capital and labor in total income. If the sum of coefficients is 1, it indicates the homogeneity of a function: it increases in proportion to the increasing resources. But there are also cases when the sum of the coefficients is greater or less than one; it indicates that the increase in costs leads to a disproportionately greater or disproportionately less output growth.

The properties of the production function:

1) If at least one of the production resources is zero, the function is equal to zero, and it is impossible to manufacture.

$$\text{If } \begin{matrix} L=0 \\ \text{or} \\ K=0 \end{matrix} \text{ then } Q=0.$$

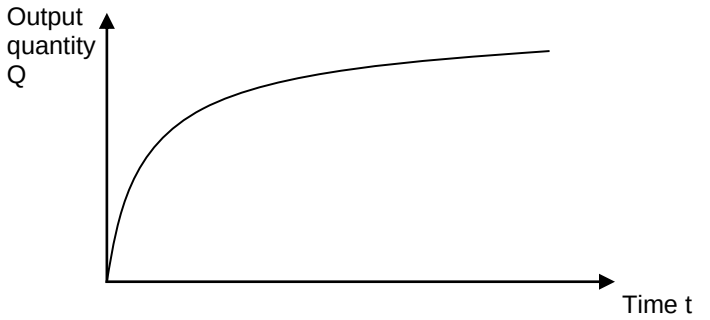


Figure 2.2 – The release curve of the Cobb-Douglas production function

2) With increasing resources expenditure the production function increases. This follows from the fact that in the production there are only those resources involved that increase the volume of the issue.

3) With the increase of one resource and at a constant value of the another output growth rate slows down, that is, increase in output volume decreases.

To quantify the production, the three interrelated indicators are used: average product (*AP*), marginal product (*MP*) and the elasticity of output with respect to the variable factor.

DEFINITION *Labour efficiency* – is the ratio of the manufactured product to total labour costs.

$$AQ_L = \frac{Q}{L}.$$

This formula denotes an average labour quantity (AQ).

DEFINITION *Average labour quantity* is a ratio of an average production quantity to a unit of labour.

EXAMPLE Count a labour efficiency for the Cobb-Douglas production function:

$$AQ_L = \frac{Q}{L} = \frac{AK^{\alpha}L^{\beta}}{L} = AK^{\alpha}L^{\beta-1}. \qquad (2.2)$$

DEFINITION

Marginal labour quantity (*MQ*) – is a production quantity increase at increasing quantity of labor per unit and other resources fixed.

$$MQ_L = \frac{\partial Q}{\partial L}.$$

EXAMPLE

Count a marginal labour quantity for the Cobb-Douglas production function:

$$MQ_L = \frac{\partial Q}{\partial L} = \frac{\partial (AK^{\alpha} L^{\beta})}{\partial L} = \beta A K^{\alpha} L^{\beta - 1}. \qquad (2.3)$$

DEFINITION

Output elasticity on labour shows the percentage of output increase if labour increases by 1 percent.

$$E_L = \frac{\partial Q}{\partial L} \cdot \frac{L}{Q} (\%).$$

EXAMPLE

Count output elasticity on labour for the Cobb-Douglas production function:

$$E_L = \frac{\partial Q}{\partial L} \cdot \frac{L}{Q} = \frac{\partial (AK^{\alpha} L^{\beta})}{\partial L} \cdot \frac{L}{AK^{\alpha} L^{\beta}} = \frac{\beta Q K^{\alpha} L^{\beta - 1} L}{AK^{\alpha} L^{\beta}} = \beta.$$

Similarly calculate the second production factor performance of Cobb-Douglas function - capital.

DEFINITION

The ratio of the manufactured product to a unit of production capital costs is *capital efficiency.*

Average capital efficiency is calculated as follows:

$$AQ_K = \frac{Q}{K}.$$

Marginal capital efficiency can be evaluated as a partial differential derivative of output by the volume of capital:

$$MQ_K = \frac{\partial Q}{\partial K}.$$

Relative marginal capital efficiency, or the *elasticity of output in terms of capital*, is determined by the expression

$$E_K = \frac{\partial Q}{\partial K} \cdot \frac{K}{Q} (\%).$$

Listed parameters characterize the PF indicators individually. Correlation of PF indicators reveals a capital-labour ratio.

DEFINITION

Capital-labour ratio shows what percentage of capital (fixed assets) is per capita (per one labourer):

$$RQ = \frac{K}{L}.$$

DEFINITION

Marginal rate of substitution - a coefficient that indicates in what proportion one share is replaced with another, provided that the production volume remains the same.

With the reduction of one resource its marginal rate of substitution increases.

$$MRS = \frac{dL}{dK}. \qquad (2.4)$$

Properties of marginal rate of substitution:

- this ratio is always negative,

- marginal rate of resource L substitution by resource K is the ratio of their marginal values MQ_K to MQ_L.

$$\frac{dL}{dK} = \frac{MQ_K}{MQ_L}. \qquad (2.5)$$

The higher capital-labour ratio, the higher the rate of substitution of human labour cost by production capital costs. Obviously, if the capital-labour ratio increases, for example, two times, then the marginal rate of substitution increases 2 times.

2.4 Production function in long-term period. Isoquant and its features. Returns to scale

$$Q(x_1,x_2)=const,$$

Express the second resource x_2 in the Cobb-Douglas function through Q = *const* and x_1:

$$x_2 = \left(\frac{Q}{A}\right)^{\frac{1}{\beta}} x_1^{-\frac{\alpha}{\beta}}. \qquad (2.6)$$

Graphically isoquant is as follows (Figure 2.3).

The figure 2.3 depicts a sample isoquant. Isoquant for Cobb-Douglas is a decreasing curve. At any point of this curve the production volume is the same, and the proportion of resource expenses is different.

According to Figure 2.3, the same production quantity can be produced with either x_{1A}, x_{2A} quantity of resources or with x_{1B}, x_{2B} quantity of resources.

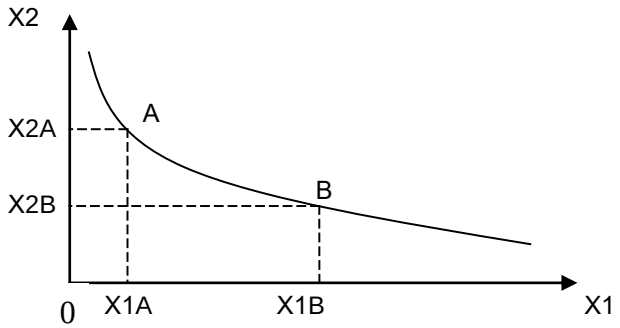


Figure 2.3 – Sample isoquant

Economic sense of isoquant: isoquant shows the number of the second resource needed to produce a certain amount of products at various expenditures of the first resource.

Isoquant properties*:*

Has no points in common with the coordinate axes, if all the resources are necessary.

The greater the volume of production, the more removed an isoquant from the beginning of coordinates is.

Is convex to the origin of coordinates. The convexity of equal product curves means that, as we move down the curve, less and less of factor x_1 is required to be substituted by a given increment of factor x_2 so as to keep the level of output unchanged. Thus, the convexity of equal product curves is due to the diminishing MRTS. If the equal product curves were concave to the origin, it would mean that MRTS increased as more and more of factor x_1 was replaced by factor x_2. This could be valid if the law of increasing returns is applied. Since in the real world it is the law of diminishing returns which is more true, the principle of diminishing MRTS generally holds good and it makes the equal product curves convex to the origin.

No two equal product curves can intersect each other.

Slopes are downwarded from left to right, i.e. it has a negative slope. This is so because when the quantity of factor x_1 is increased, the quantity of factor x_2 must be reduced so as to keep the output constant.

Returns to scale effect.

Returns to scale characterizes the change of output with increasing expenses of all resources and depends on the technology of production.

Increasing returns to scale characterizes the increase in output to a larger multiplier than the increase in expenses of all resources:

$$Q(kK,kL) > kQ(K,L).$$

Constant returns to scale characterizes the increase in output by the same multiplier as the increase in the expenses of all resources:

$$Q(kK,kL) = kQ(K,L).$$

Decreasing returns to scale - characterized by an increase in output to a smaller multiplier than the increase in expenses of all resources:

$$Q(kK,kL) < kQ(K,L).$$

Table 2.1 – The volume of output in the long-term period

Production technology	$L=4, K=4$	$L=16, K=16$ Returns to scale	
$Q(K,L)=L^{0,5}K^{1}$	8	64	increasing
$Q(K,L)=L^{0,5}K^{0,5}$	4	16	constant
$Q(K,L)=L^{0,5}K^{0}$	2	4	decreasing

Let us investigate the returns to scale variants.

1. Increasing returns to scale.

EXAMPLE Increasing of the resources usage by 10% caused an increase in issue by 12%. In this case α and β are connected by the inequality: $\alpha+\beta>1$.

There are several factors that *make economies of scale* of production:

a) the specialization increases the productivity. Division of employees' functions on simple tasks increases the speed of the job. This applies both to production workers and to management personnel;

b) the production indivisibility. There is a minimal amount of production resources which are spent constantly. You cannot use, for example, half of the minimum quantity of resources when you change the quantity of the release. As the company's cost of such resources do not increase, the value of their costs per unit of output falls;

c) the use of new technologies. Appliance in the manufacture of various technical innovations require significant financial and other inputs. The effectiveness of the new technology more fully manifests itself in a high volume production;

d) the production of sideline products. Large firms are not able to effectively use the unavoidable waste in the production. Its processing is performed by auxiliary units, which ultimately leads to a decrease in long-term average total cost. [7]

The Figure 2.4 depicts increasing returns to scale: the output growth Δq is larger than the costs growth Δc.

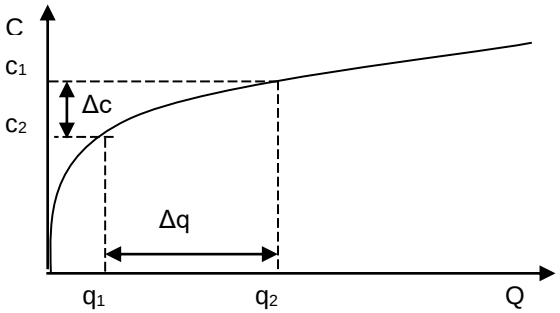


Figure 2.4 – Increasing returns to scale

2. Constant returns to scale.

EXAMPLE Increasing of the resources usage by 10% caused an increase in issue by 10%. In this case α and β are connected by the equation: α+β=1.

The Figure. 2.5. depicts constant returns to scale: the output growth Δq is equal to the costs growth Δc.

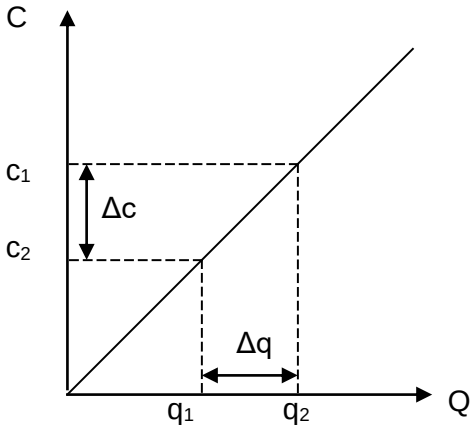


Figure 2.5 – Constant returns to scale

3. Decreasing returns to scale.

EXAMPLE Increasing of the resources usage by 10% caused an increase in issue by 7%. In this case α and β are connected by the inequality: $\alpha+\beta<1$.

The Figure 2.6 below depicts decreasing returns to scale: the output growth Δq is less than the costs growth Δc.

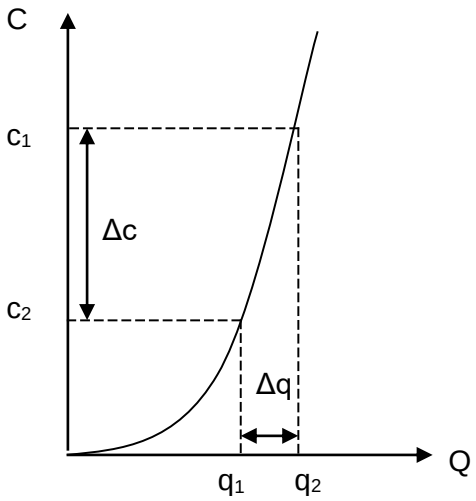


Figure 2.6 – Decreasing returns to scale

UNIT 3 Fixed and current assets

The main document of an enterprise to describe its performance is a Balance Sheet. The Balance Sheet (table 3.1) consists of 2 major parts – Liabilities and Assets. Both parts represent information in order of decreasing liquidity, i.e. from the most liquid to the less liquid items. The Liabilities side of the Balance sheet includes the following items: current liabilities, long term liabilities and fixed liabilities. The Assets side includes liquid assets, floating assets and fixed assets.

Table 3.1– Balance Sheet

Liabilities	**Rs**	**Assets**	**Rs**
Current Liabilities		*Liquid Assets*	
Bills Payable Sundry Creditors Bank Overdraft		Cash in hand Cash at Bank	
Long Term Liabilities		*Current Assets*	
Loan from Bank Debentures		Sundry Debtors Investments Bills Receivable Stock in trade Prepaid Expenses	
Fixed Liabilities		*Fixed Assets*	
Capital		Plant and Machinery Buildings Furniture & Fixtures Land	

3.1 Fixed assets

DEFINITION

Fixed assets is part of production assets, that is engaged in the production process for a long time, while maintaining its natural form, and their cost is transferred to the output gradually, piece by piece. Fixed

assets refer to productive assets, as are created and used in the production process. They are also called capital assets.

The essence of fixed assets:

- they are translated into real instruments of labor;
- their value is transferred to the products;
- they retain the natural form for a long time in process of depreciation;
- are compensated on the basis of depreciation at the end of useful life.

3.1.1 Classification of fixed assets

To study the composition of the group of fixed assets the following features are used:

- by economic sector - fixed assets of the industries producing goods and providing services;
- by ownership - fixed assets owned by the state, private and other types of property;
- by participation in the production process - the fixed assets used directly in the production process of goods (works, services), and inactive fixed assets, including those being left on the conservation, repair, reconstruction;
- by affiliations - owned and leased fixed assets;
- by territory - fixed asset by areas, republics, territories, regions and cities.

Also, fixed assets are divided into tangible and intangible.

Tangible assets include:

- Buildings (except for housing).
- Facilities.
- Cars and equipment.
- Vehicles.
- Tools - industrial and economic.
- The working and productive livestock.

- Perennial plantations.
- Other fixed assets.

Intangible assets:

- Expenditures on mineral exploration.
- Computer software and databases.
- Original works of entertainment, literature and art.
- High industrial technology.
- Other intangible fixed assets, which are the objects of intellectual property, the use of which is restricted by the ownership rights.

3.1.2 Estimation of fixed assets. Types of capital consumption

There are the following *types of valuation* of fixed assets:

- Total initial cost (TIC);
- TIC excluding depreciation;
- full reproduction cost (FRC);
- depreciated reproduction cost;
- book value (BV);
- market value (MV).

The initial cost of fixed assets - is the actual amount of costs for manufacturing or purchasing the assets, their delivery and installation.

Full reproduction cost of fixed assets is determined by existing fixed assets revaluing in accordance with their physical and moral deterioration.

Depreciated reproduction cost is determined by multiplying of FRC, received after capital assets revaluation, by the ratio of their deterioration.

The net book value is the difference between the initial or replacement cost and the amount of depreciation, i.e. that part of the cost of fixed assets, which is not yet transferred to manufactured products.

The residual value — the sales cost of depreciated and took out of production fixed assets (often the scrap price).

DEFINITION

The book value of fixed assets — is the value from the balance sheet of the enterprise.

Fixed assets at the disposal of companies and organizations until the last revaluation are recorded at full reproduction cost, and that part of the fixed assets, which was implemented after the revaluation is taken into account for the total initial cost. Therefore, the BV is mixed evaluation.

Market value —estimated sales value of fixed assets based on their real condition, physical and moral deterioration, the levels of actual and expected utilization, the expected profitability of the exploitation, the ratio of consumer demand and supply.

DEFINITION

Capital consumption – is a partial or total loss of the value and consumer properties of fixed assets both in the process of exploitation and when they are inactive.

There are two types of capital consumption - physical and moral.

Physical capital consumption means the loss of initial properties of work equipment, i.e. degradation of technical, economic and social performance under the influence of the labor, the forces of nature, and as a result of non-use of fixed assets.

The level of physical depreciation of fixed assets depends on:

- the original quality of fixed assets;
- the extent of their use (the number of work days in a year or shifts per day);
- the technological process;
- the level of aggressiveness of the environment in which they operate and the quality of care for the assets;
- qualifications of operating personnel;
- timeliness of preventative maintenance, etc..

The physical deterioration is uneven, even by the same elements of fixed assets. There are full and partial depreciation of fixed assets.

When the depreciation is full operating assets are liquidated and replaced by new ones (capital construction or current replacement of worn-out fixed assets).

The partial depreciation is compensated by repair. Physical depreciation of capital assets may be calculated as the actual period of service related to the normative, multiplied by 100.

With a significant proportion of outdated fixed assets the enterprise economy carries significant losses: first, aging buildings and equipment requires an increase in investment in capital repair to keep them in working conditions; second, the old equipment often degrades the quality of products and services and because of the technical backwardness an unprofitable production appears.

Moral capital consumption (obsolescence). Along with the physical depreciation there is also the moral deterioration (depreciation). Obsolescence appears in the fact that obsolete fixed assets in its design, performance, efficiency, quality of the products lag behind the latest models. Obsolescence usually comes before physical deterioration. The essence of obsolescence is that the means of labor depreciate, lose their cost before the physical deterioration, i.e. fixed assets, which can still be used, are already economically inefficient.

Obsolescence appears in two forms.

The first type of obsolescence is depreciation of machines of the same design, which were produced in the past, due to the reduction in price of their reproduction in modern conditions. Obsolescence of the first type is not associated with life duration of the equipment and the degree of its physical deterioration. It is connected with the rate of technological progress, leading to a decrease in manufacturing cost of similar machines of the same design as a result of labor productivity growth in the industry, producing new fixed assets.

With the moral deterioration of of the first type use-value of fixed assets does not change. In new machines, similar to previous, there are no structural changes; equipment performance also remains the same. Only the value of fixed assets changes (their cost is less).

The second type of obsolescence is connected with depreciation of machines, still physically suitable, as a result of the emergence of new, more technologically advanced and productive, which displace the old. Further operation of old cars comparing to the new leads to increased production costs, i.e. the use of new machines is more cost-effective.

Under the influence of these types of moral depreciation the fixed assets become out-of-date in their technical characteristics and economic efficiency.

The main source of covering expenses connected with the upgrade of fixed assets is internal funds of enterprises. They are accumulated over the lifetime of fixed assets in the form of depreciation expenses.

In order to characterize the degree of fixed assets depreciation, a number of indicators is used.

Rate of physical deterioration of fixed assets ($К_{f.d.}$):

$$К_{f.d.}=D/A_{initial}*100\%, \quad (3.1)$$

where D – sum of capital consumption (depreciation) for the entire period of fixed assets operation;

$A_{initial}$ – initial (balance) or replacement value of fixed assets.

The physical deterioration coefficient of fixed assets can be determined by a separate inventory objects and on the basis of the actual period of exploitation.

For objects, the actual service life is lower than the standard, the calculation is carried out according to the formula:

$$К_{f.d.}=T_{actual}/T_{standard}*100\%,$$

where T_{actual} и $T_{standard}$ – actual and standard periods of work of the inventory item.

For objects that have actual life equal to the normative or exceeded it, the coefficient of physical deterioration is calculated by the following formula:

$$К_{f.d.}=T_{actual}/(T_{standard}+T_{possible})*100\%,$$

where $T_{possible}$ – possible residual lifetime of the inventory item. More often it is determined by an expert.

Rate of validity of fixed assets characterizes their physical condition to a specific date and is calculated by the formula:

$$K_v = (A_{initial} - D)/ A_{initial} * 100\%. \quad (3.2)$$

Rate of validity can be determined via rate of physical deterioration as well:

$$K_v = 100\% - K_{f.d}.$$

All these formulas assume a uniform physical deterioration of fixed assets, which do not always coincide with reality, and this is their main disadvantage.

Moral deterioration of the first type is determined by the ratio of the book and replacement costs:

$$M_1 = (A_{initial} - A_{repl})/A_{initial} * 100\%, \quad (3.3)$$

where $A_{initial}$ – initial (balance) value;

A_{repl}– replacement value.

Moral deterioration of the second type is most often determined by comparing the performance of equipment:

$$M_2 = (P_2 - P_1)/P_1 * 100\%, \quad (3.4)$$

where P_1 – performance of existing fixed assets;

P_2 – performance of new fixed assets.

3.1.3 Amortization of fixed assets. Types of amortization

Depreciation of capital equipment is an important component of many after-tax economic analysis for it lowers income taxes via the relation

Taxes=(Income-Expenses-Depreciation)*(tax rate)

Depreciation is the reduction in value of an asset.

Depending on a purpose for reducing asset value the depreciation is divided into *book depreciation* (used for internal company's financial accounting) and *tax depreciation* (used for government in tax calculations).

The most common methods of depreciation calculation are:

1. Straight line depreciation (SL).
2. Sum-Of-Years-Digits depreciation (SOYD).

3. Declining balance depreciation (DB).

4. Modified accelerated cost recovery system (MACRS).

It depends on the country's law system which method to use in depreciation evaluation. For example, in the USA the required tax depreciation method is MACRS, in the RF there can be a straight line method used. [8]

1. Straight line depreciation

$$D = (P-S)/n, \quad (3.5)$$

where D – annual depreciation charge,

P – first cost,

S – estimated salvage value,

n – recovery period.

2. Sum-Of-Years-Digits depreciation

D=(P-S)*remaining depreciable life at beginning of year/SOYD,

Where SOYD - Sum of years digits for total useful life,

$$SOYD= (n+1)*n/2. \quad (3.6)$$

3. Double declining balance depreciation

$$D=BV*2/n, \quad (3.7)$$

where BV – book value,

BV= P-Depreciation charge to date.

4. Modified accelerated cost recovery system depreciation

Modified accelerated cost recovery system (MACRS) depreciation is based on three main features:

1) a property class life is generally less than the actual useful life of the property;

2) a salvage value is assumed to be zero;

3) the varying depreciation percentage must be used from a table 3.2.

Table 3.2 – MACRS depreciation rates,%

Year	n=3	n=5	n=7	n=10	n=15	n=20
1	33.33	20.00	14.29	10.00	5.00	3.75
2	44.45	32.00	24.49	18.00	9.50	7.22
3	14.81	19.20	17.49	14.40	8.55	6.68
4	7.41	11.52	12.49	11.52	7.70	6.18
5		11.52	8.93	9.22	6.93	5.71
6		5.76	8.92	7.37	6.23	5.29
7			8.93	6.55	5.90	4.89
8			4.46	6.55	5.90	4.52
9				6.56	5.91	4.46
10				6.55	5.90	4.46
11				3.28	5.91	4.46
12					5.90	4.46
13					5.91	4.46
14					5.90	4.46
15					5.91	4.46
16					2.95	4.46
17						4.46
18						4.46
19						4.46
20						4.46
21						2.23

3.2 Floating assets

DEFINITION

Floating (current) assets - cash and operating assets that are convertible into cash within a year.

3.2.1 Classification of floating assets and their sources

Floating assets are classified according to various criteria:

- type of floating capital;
- service of the two areas of the assets circulation;

- peculiarities of planning;
- sources;
- liquidity degree.

Floating assets are used to purchase raw materials, goods, materials, to buy low value items, materials for household needs. They are presented as cash on hand, on the current, the currency and on other bank accounts and securities. On the basis of their composition, the following group of floating (working, current) assets exist:

- cash;
- bills receivable;
- material assets.

Depending on the service of the two areas of the assets circulation there are floating operating funds and floating funds in circulation.

Floating operating assets funds include:

- inventories;
- raw stores;
- unfinished production;
- prepayments;
- low-value assets;
- tools.

To ensure the continuity of the production process of floating operating funds the additional funds are needed for maintenance of the sphere of circulation, which are called in circulation funds.

These are as follows:

- merchandise inventory;
- financial resources (in hand, at bank and cash at bank, in letters of credits, etc.);
- short-term deposits.

Due to the specifics of the planning the floating assets are classified into standardized and non-standardized.

The standardized floating assets include:

- inventories;
- cash on hand and in transit;

- production stocks;
- raw stores;
- low-value and short-time items;
- prepayments.

The non-standardized floating assets include:

- cash at bank;
- funds in the calculations with debtors;
- goods loaded and held in safekeeping.

These funds are called the non-standardized because they are not planned, are not provided with remains guidelines.

According to sources of formation the floating assets are classified into own, equated to them and borrowed.

Sources of floating funds

Own assets play a major role in the organization of the circulation of funds, as enterprises operating on the basis of commercial calculation, should have a certain property and operational autonomy in order to conduct business profitably and to take responsibility for decisions.

Formation of floating funds occurs at the moment of creation of the authorized capital of the organization. Further, during the work, a source of working capital can be the obtained profits, as well as the so-called stable liabilities that are equivalent to own funds. It is funds that do not belong to the company, but are constantly in the turnover. These include: minimum passing from month to month wages payable to employees, reserves for future expenses, minimum passing debts to the budget and extrabudgetary funds, money of creditors, received as an advance payment for the products (goods and services), customer funds on deposits for a returnable packagings, carry-overs of the consumption fund, etc.

To reduce the overall company's requirements for working capital, as well as to promote their effective use it is advisable to attract borrowed funds.

Borrowings are mainly short-term bank loans that help to satisfy temporary additional working capital needs. The main areas of attraction of loans for the formation of floating funds are the following:

- crediting seasonal stocks of raw materials and the costs associated with the seasonal production process;
- temporary replenishment of working capital;
- conducting payments and settlement of payment turnover.

There are also *other sources* of floating funds, which include the assets of the enterprise, currently not used as its intended purpose (funds, reserves, etc..).

The right balance between own, borrowed and other sources of floating assets plays an important role in strengthening of the financial state of a company.

3.2.2 Standardization of floating assets

Efficiency of floating funds is characterized by a system of economic indicators, primarily the floating assets turnover.

The floating assets turnover means the duration of one full circulation of funds since the conversion of floating funds in cash into production reserves and until the release of the finished product and its implementation. Turnover of assets finishes with earnings depositing on the company's account.

The duration of one turnover of floating assets in days (*S*) is calculated by the formula

$$S = C\ (T/D),$$

where *C* — floating assets balances (average or for certain date);

T — production volume;

D — the number of days in the reporting period.

Reducing the duration of one turnover indicates an improvement in use of floating assets.

The number of turnovers for a given period, or floating assets turnover ratio (K_t), calculated according to the formula

$$K_t = T/C.$$

The higher the turnover ratio under these conditions, the better the floating assets are used.

The assets load index in the turnover (K_{load}), inverse to the turnover ratio is determined by the formula

$$K_{load} = C/T$$

In addition to these indicators there also can be used an index of floating assets return, which is calculated as the ratio of sales profit to floating assets balances.

UNIT 4 Costs theory

4.1 Costs. Classification of costs. Production prime cost

Organization carries significant costs to purchase resources. Obviously, it wishes to use a manufacturing process in which a specified volume of production could be achieved at the lowest cost of the used resources.

DEFINITION Acquisition costs of production resources are called the *costs of production*.

Input is the expenditure of resources in their physical, natural form, in the amount of x_1, x_2, and the *costs* - valuation of resources used, purchased at prices p_1,p_2.

Thus, the amount of the costs is as follows:

$$C=p_1x_1+p_2x_2. \quad (4.1)$$

Isocost. A line of fixed costs.

DEFINITION *Isocost* - a straight line, every point of which shows the various combinations of the two resources with the same costs for their acquisition.

Isocost can be depicted for different costs:

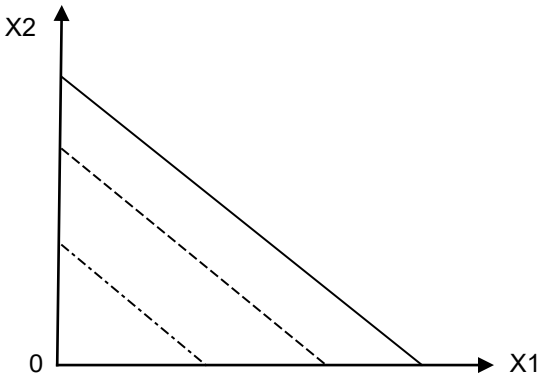


Figure 4.1 – Isocost map

Let us define x_2 from the formula of the costs, then we will see the isocost explicitly:

$$x_2 = \frac{C}{p_2} - \frac{p_1}{p_2} x_1 . \qquad (4.2)$$

Economic sense of Isocost: it shows how much of the second resource x_2 must be spent at different costs of the first resource x_1 so that the total costs remained unchanged.

Features:

1) by increasing the amount of company's costs and constant prices isocost moves parallel to itself upward from the origin;

2) with an increase in the price of one resource the isocost angle of slope increases to the axis of the resource that became more expensive.

All the combinations of resources, corresponding to points of the isocost and beneath, are available to the manufacturer, but above of this line - are not.

Classification of costs

Depending on the time required to change the amount of resource used in production, there can be short and long periods distinguished in the company's production.

DEFINITION

Long-term period is a time period, during which the firm is able to change its input amounts including the production capacity.

In the long term the company has the opportunity to buy not only a large number of raw materials or increase the number of workplaces, but also to make investments. Therefore, it is believed that in the long period all costs are variable.

DEFINITION

Short-term period is a time period, during which the firm is not able to change its production capacity.

The firm can influence the course and efficiency of production only by changing the intensity of the use of its capacities. During this period, it can quickly change its variable factors - the amount of labor, raw materials, auxiliary materials, fuel.

In the short-term period costs are divided into fixed and variable. Variable costs in the short term include cash to purchase raw materials, materials, labor costs and workers, etc. Fixed costs in the short term include: salaries of administrative staff, rent, depreciation of fixed assets.

DEFINITION *Fixed costs CF* - are the costs, the value of which does not change depending on changes in the production volume.

DEFINITION *Variable costs CV* - are the costs, the value of which changes depending on changes in the production volume.

These include labor costs, purchase of raw materials, fuel, auxiliary materials, payment of transport services, the relevant social security contributions, etc. In many cases, variable costs are directly proportional to the volume of production:

$$CV=cv*Q,$$

where *cv* – variable costs for one unit of production.

The amount of fixed and variable costs for any given volume of production defines the total costs C.

$$C=CF+CV=CF+cv*Q. \quad (4.3)$$

The dependence of the fixed and variable costs dynamics from the change in output volume is graphically represented in fig. 4.2 and 4.3.

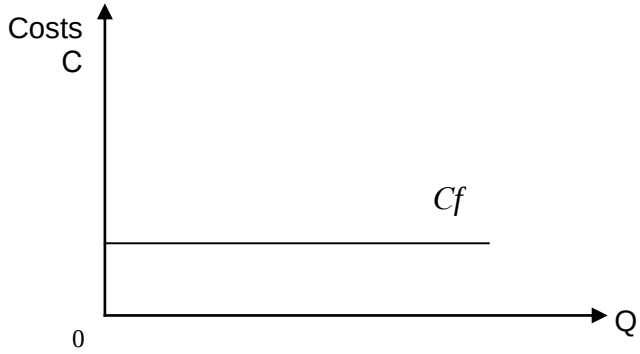


Figure 4.2 - Fixed costs

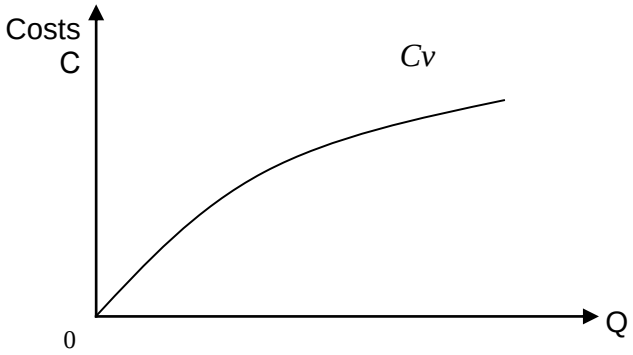


Figure 4.3 - Variable costs

Fixed and variable costs add up to total, or gross production costs. Graphically dependence of the total costs from the output dynamics can be shown by applying the graphs of fixed and variable costs (Fig. 4.4).

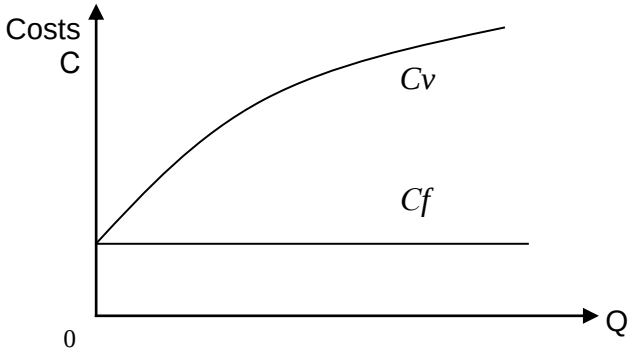


Figure 4.4 - Total costs

To measure the costs for production the concept of average total, average fixed and average variable cost of production is used.

DEFINITION *Average costs AC* - are the firm's costs per unit of production.

$$AC = \frac{C}{Q} = \frac{CF + cvQ}{Q} = \frac{CF}{Q} + cv.$$

To determine the maximum output that a company can give, the marginal cost is calculated.

DEFINITION *Marginal costs MC* - are additional costs associated with the production of each subsequent product unit.

$$MC = \frac{\partial C}{\partial Q} = \frac{\partial (CF + cvQ)}{\partial Q} = cv.$$

4.2. Costs minimization. Factors of costs reducing

Since there are many combinations of resources, the problem of determining such a combination arises in which the total costs for the company is minimal, and a predetermined volume of the issue is reached. Businessman solves this task considering that the prices of each resource are different.

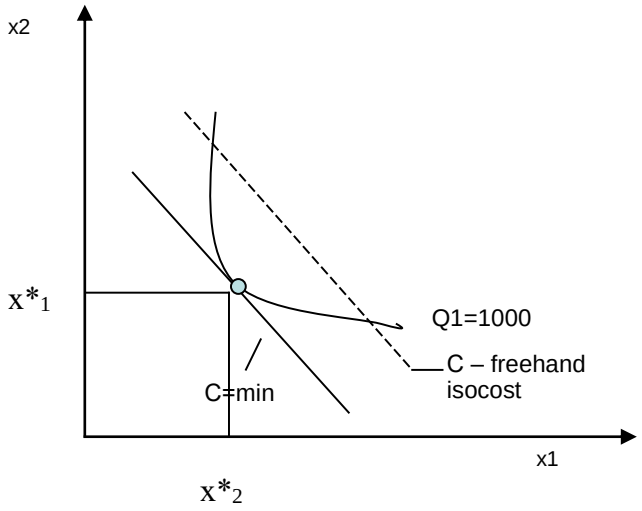


Figure 4.5 – Solution to the minimum cost problem

The solution to this problem is represented graphically (Figure 4.5).

The graph depicts an isoquant for a certain output Q1= 1000 units and the isocost corresponding to a random amount of company's costs. According to the first feature of isocosts, while moving it down parallel to itself, the company's costs reduce.

The lowest of the isocost position at which a company has the ability to produce the required amount of output - is the position of the isocost when it touches the isoquant. This touch point shows the amount of resources x_1, x_2, which is the minimum necessary for the production of the desired output. In other words, the company manufactures products at minimum cost.

Assuming that the production process is described by Cobb-Douglas function, there are two resources used in the production - labor *L* and capital *K*. Price p_L of labor unit is 3 rubles, the unit price of capital p_K - 5 rubles. The predetermined amount of output is achieved by the use of such combinations of production factors, as 10L and 1K, 2K and 7L, 8L, and 4K, 7K and 7L. Based on these data an isoquant of *X* output units can be build (Figure 4.6).

Then output isoquant of *X* units aligns with a map of isocosts. The Figure shows that the isoquant at point A tangets the isocost of 35 rubles. This means that the cost of the entrepreneur for the purchase of factors of production will be minimal under the condition that it acquires 10 units of labor, and one unit of capital*: (3 rub.*10)+(5 rub.*1)=35* rubles.

This is the optimal combination of the used resources providing minimization of their acquisition costs. Any other combination (7L and 2K, 8L and 4K, 7L and 7K) will cost the entrepreneur more.

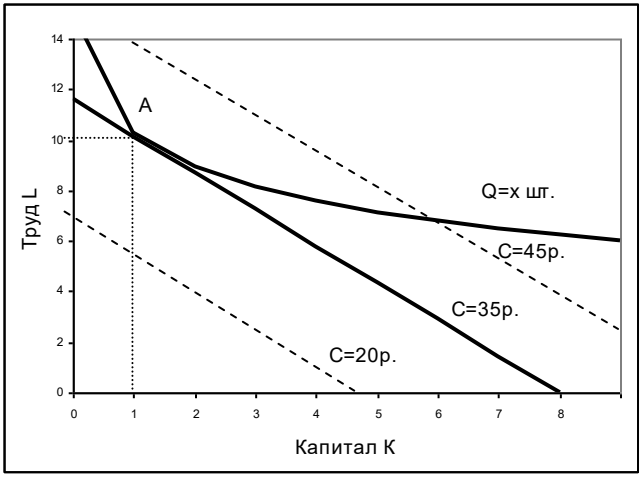


Figure 4.6 – The optimum combination of the production factors

Different values of the volume output have its own optimal isocost. The greater the volume of production, the greater the company's costs, and graphically the higher the isoquant is, the higher is the isocost corresponding to the minimum cost.

DEFINITION

The set of points of the resources plane corresponding to the production of a certain output volume at minimum cost, is called a *long-term development line* of a company.

Graphically, this line connects the points that are the minimum cost points for all possible values of the issue volume (Figure 4.7).

Economically the line defines the development plan of production in the most economical way.

Since at each point of the long-term development line the isoquant tangets the isocost, the angle of inclination of both lines is the same, the angular coefficients at these points are equal. The slope ratio of the isocost is equal to the prices ratio: $\frac{p_1}{p_2}$, it follows from the equation explicitly (2.2).

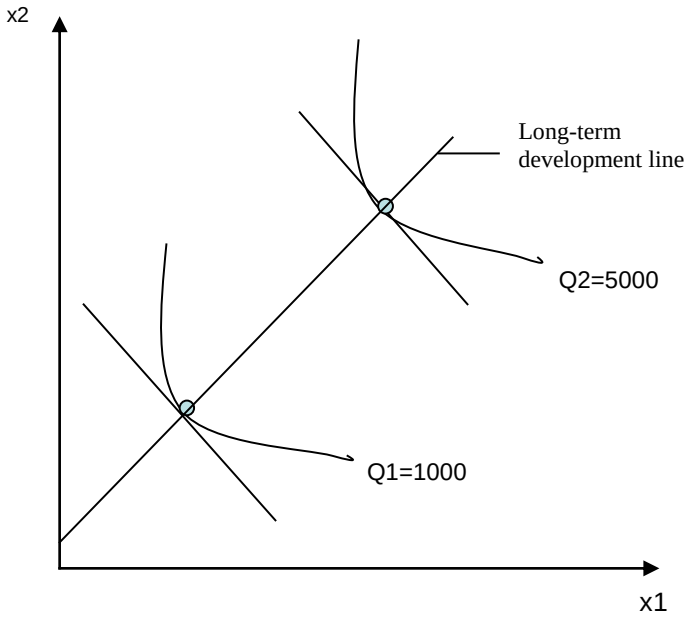


Figure 4.7 – Long-term development line

An isoquant slope is the marginal rate of substitution (1.5).

Thus, the main condition, which is satisfied is right in all points of the line of long-term development, is the following:

$$\frac{p_1}{p_2} = \frac{MQ_1}{MQ_2}. \qquad (4.4)$$

It shows how much greater is the effect from the first resource compared with the second.

This implies that to minimize the costs (for a given volume of the production), the company needs to substitute one resource with another as long as the marginal product related to the resource price will not be equal for both resources.

4.3 Development path of a company. Economy of scale

In the long term, there can be all three effects of scaling (Figure 4.8).

The initial stages of company development are characterized by underutilized production (0-A). This means that the increase in the number of products will not cause a large growth of the additional costs, since fewer output required the same production capacity. This means a **positive effect** of increasing the scale, production is growing rapidly, and AC and MC are reduced.

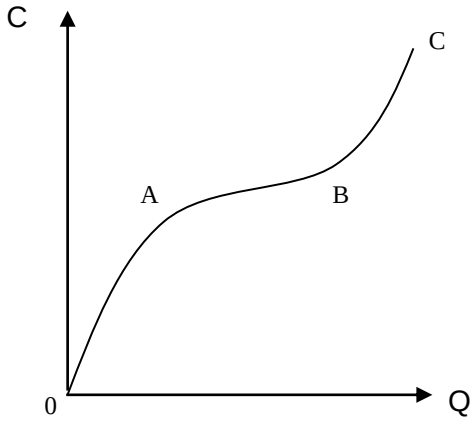


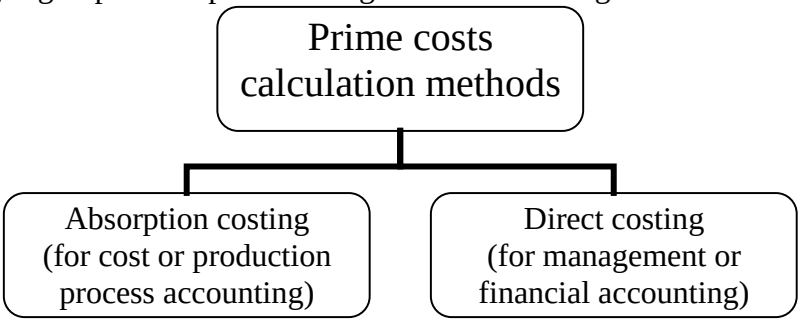
Figure 4.8 – Costs in long term

Upon reaching the full production load there is **no effect of scales** (AB), each additional unit of output is proportional to the growth of MC. This situation is the most common for many companies.

As the company grows the returns of scale becomes negative (B-C). This may be caused by the fact that doing a greater amount of tasks becomes more difficult, labour costs are becoming correspondingly higher, and coordinating the process becomes more expensive. It is called the negative effect of scales.

4.4 Prime costs calculation methods

All the methods for prime costs calculation can be divided into two major groups: absorption costing and direct costing.



The absorption costing methods are classified as follows:

– **calculation object**:

- *by units of production*;
- *by job costing* (accounting and calculation object is a separate production order for a predetermined number of products. The planned cost of the order is determined by the sum of all costs of production over the life of the order (job));
- *by operation costing* (to account the materials the job method is used, and for payroll accounting and overhead cost – the process-costing method*)*;
- *by process-costing* (used when there is a mass production of similar products, where the costs associated with individual units of output cannot be differentiated from each other. Cost of a unit is determined by dividing the total production cost of output for a certain period by the number of units produced);
- *JIT just in time* (information on the actually spent material and overhead costs is collected through departments every month. Consequently, the number of units produced and their cost are evaluated).

– **calculation method:**

- *by direct account or unit costs* (involves determining the unit cost by dividing the total costs by the number of produced units) ;
- *by standard /equivalent* (based on the norms and standards for the use of material, financial and human resources);
- *computational and analytical* (direct costs per unit are calculated on consumption rates and indirect costs - in proportion to the basis established in the industry);
- *parametric* (establishment of costs change laws on the basis of the production parameters);
- *by costs exclusion* (one type of product, obtained as a result of complex processing of raw materials, is considered a major one and the rest types – are non-operating. The total cost of the raw material is decreased by the by-products, and the remaining amount is attributed to the cost of the basic products);
- *by coefficient* (based on the use of coefficients when distributing the complex costs between the obtained products. Here one of the products is assigned a coefficient 1, and the others are compared with it based on the selected feature);
- *combined* (a combination of costs exclusion and a coefficient methods).

The direct costing method – is a system of financial accounting of variable costs, which implies finding a prime cost disregarding fixed costs.

UNIT 5 Economic results of corporate performance

The purpose of any commercial organization is gaining profit. Managers tend to increase profits by solving the following tasks:

1) increasing income,

2) reduction of production costs.

In general, the profit is the difference between revenue R and costs C.

$$Pr = R\text{-}C. \quad (5.1)$$

If the revenue is an intersection of the quantity produced Q and the price p_0,, at which the product is sold,

$$R = Q\, p_0,$$

and the costs C depend on resources' prices p_1, p_2 and the quantity of their consumption

$$C = p_1x_1+p_2x_2,$$

then the formula (3.1) can be changed into (3.2):

$$Pr = R\text{-}C = Q\, p_0 - p_1x_1 - p_2x_2. \quad (5.2)$$

DEFINITION

The main objective of the commercial organization is to choose the quantity Q of the products and involved resources x_1, x_2, which provide it with maximum profit.

5.1 Classification of factors which estimate economic results of corporate's performance

The effectiveness of the company can be characterized by the following indicators:

- economic effect;
- profitability indicators;
- liquidity;

- performance indicators;
- break-even point.

DEFINITION	*Economic effect* - it is an absolute indicator (profit, revenue from sales, etc.), characterizing the results of the company. The main indicator of the economic effect from the activity of a production company is a profit.

Profit – is a positive financial result of the organization. A negative result is called a loss.

There are the following types of profit:

1. Book profit - part of the revenue, which is the total revenue after the compensation of external costs, i.e. payment for suppliers' resources.
2. Economic (net) profit - what is left after deducting from the total income of all costs.
3. Balance (gross) profit - the difference between revenue from sales and the amount of material costs, depreciation and wages.

DEFINITION	*Profitability* - is an important indicator of economic efficiency of companies, associations, industries and the economy as a whole. It reflects the utilization degree of material, labor and financial resources, as well as natural resources.

- Return on Fixed Assets is a profit ratio to the amount of fixed assets.

ROFA = Profit/Fixed assets * 100 %

- Margin on Sales, Return on Sales — the ratio of earnings before interest and taxes (EBIT) to company's sales.

ROS = EBIT/SALES * 100 %

- Return on Labour is a profit ratio to the average number of employees.

ROL = Profit / Average number of employees

- Basic earning power is the EBIT ratio to the assets of the company.

BEP = EBIT/Assets * 100 %

- Return on Assets is a profit ratio to the average assets.

ROA = Profit/ Assets * 100 %

- Return on Equity is a profit ratio to the average equity.

ROE = Profit/Equity * 100 %

DEFINITION *Liquidity* is an ability of assets to be sold quickly at a price close to the market. Liquidity - the ability to turn into money.

Liquidity ratios are the ratios that measure the ability of a company to meet its short term debt obligations. These ratios measure the ability of a company to pay off its short-term liabilities when they fall due.

The liquidity ratios are a result of dividing cash and other liquid assets by the short term borrowings and current liabilities. They show the number of times the short term debt obligations are covered by the cash and liquid assets. If the value is greater than 1, it means the short term obligations are fully covered.

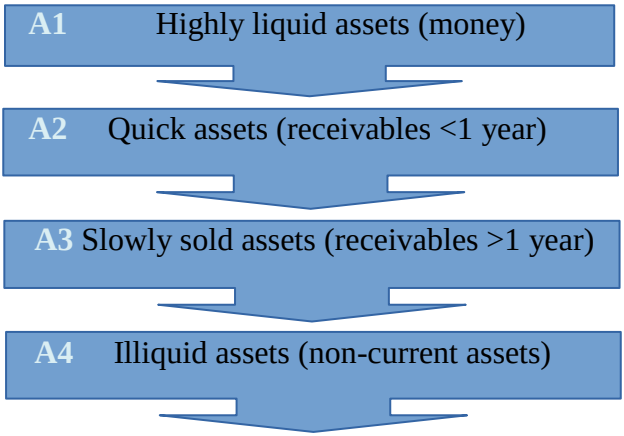


Figure 5.1 – Liquidity ratios

Generally, the higher the liquidity ratios are (Figure 5.1), the higher the margin of safety that the company possesses to meet its current liabilities. Liquidity ratios greater than 1 indicate that the company is in good financial health and it is less likely to fall into financial difficulties.

In the financial analysis, liquidity is assessed using absolute and relative indicators. The figure 5.2 below shows the diagnosis of various types of liquidity ratios.

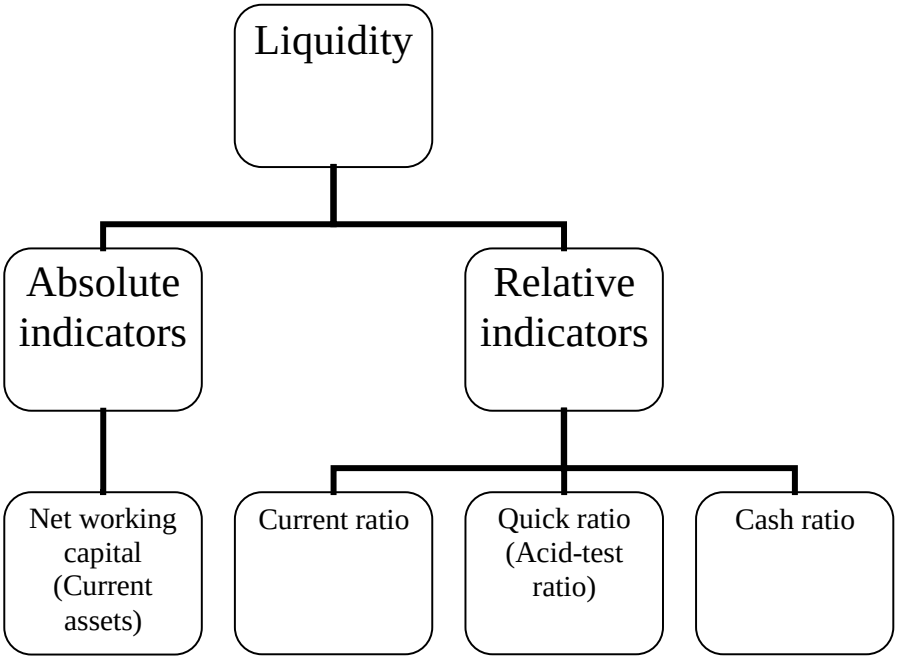


Figure 5.2 – Diagnosis of various types of liquidity ratios

Net working capital (NWC) = current assets minus current liabilities.

Working capital is the amount by which the value of a company's current assets exceeds its current liabilities. Also called net working capital. Sometimes the term "working capital" is used as synonym for "current assets" but more frequently as "net working capital", i.e. the amount of current assets that is in excess of current liabilities. Working capital is frequently used to measure a firm's ability to meet current obligations. It measures how much in liquid assets a company has available to build its business.

Current ratio is a balance-sheet financial performance measure of a company liquidity.

The current ratio indicates a company's ability to meet short-term debt obligations. The current ratio measures whether or not a firm has enough resources to pay its debts over the next 12 months. Potential creditors use this ratio in determining whether or not to make short-term loans. The current ratio can also give a sense of the efficiency of a company's operating cycle or its ability to turn its product into cash.

The current ratio is also known as the *working capital ratio***.**

The current ratio is calculated by dividing current assets by current liabilities:

The current ratio = Current Assets / Current Liabilities

Both variables are shown on the balance sheet (statement of financial position).

The term "*Acid-test ratio*" is also known as *quick ratio*. The most basic definition of acid-test ratio is that, "it measures current (short term) liquidity and position of the company". To do the analysis accountants weight current assets of the company against the current liabilities which result in the ratio that highlights the liquidity of the company.

The formula for the acid-test ratio is:

Quick ratio = (Current Assets – Inventory) / Current liabilities

This concept is important as if the company's financial statements (income statement, balance sheet) get through the analysis of the acid-test ratio, then the short term debts can be paid by the company.

Cash ratio (also called *cash asset ratio*) is the ratio of a company's cash and cash equivalent assets to its total liabilities. Cash ratio is a refinement of quick ratio and indicates the extent to which the readily available funds can pay off current liabilities. Potential creditors use this ratio as a measure of a company's liquidity and how easily it can service debt and cover short-term liabilities.

Cash ratio is the most stringent and conservative of the three liquidity ratios (current, quick and cash ratio). It only looks at the company's most liquid short-term assets – cash and cash equivalents – which can be most easily used to pay off current obligations.

Cash ratio is calculated by dividing absolute liquid assets by current liabilities:

Cash ratio = Cash and cash equivalents / Current Liabilities

Both variables are shown on the balance sheet (statement of financial position).

5.2 Profit maximizing

DEFINITION

Isoprofit (line of constant profit) - the curve connecting different combinations points of production Q and resource x to ensure the same profit.

Let us find the equation from the formula profit (3.2):

$$Q = \frac{p_1}{p_0} x_1 + \frac{p_2 x_2 + \mathrm{Pr}}{p_0} \qquad (5.3)$$

Assuming that one resource, e.g., x_2, is fixed ($x_2 = const$), we can construct a graph of isoprofit (Figure 5.3)

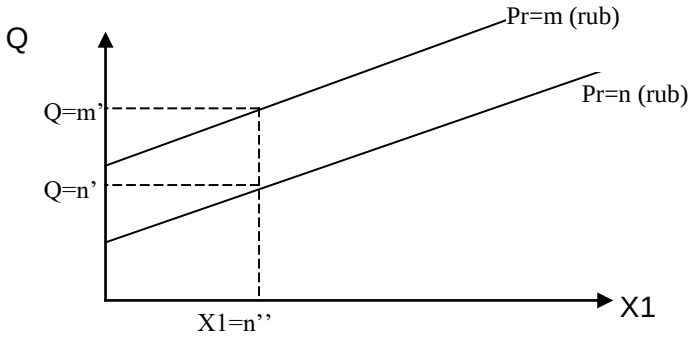


Figure 5.3 – Isoprofit

Isoprofit's economic sense: it shows the volume of company's output, which is necessary to produce at different costs of resources to keep the company's profits unchanged.

Features of isoprofit:

1. The greater amount of profit corresponds to isoprofits located upstream from the origin.
2. By increasing the amount of the firm's profits and constant resources costs the isoprofit moves parallel to itself upward from the origin.
3. By increasing the price of the product the coordinates of the isoprofit's intersection with the vertical axis move down.

Solve the problem of a commercial organization graphically.

Depict the isoprofit for an arbitrary value of profit and a production curve (Fig. 5.4).

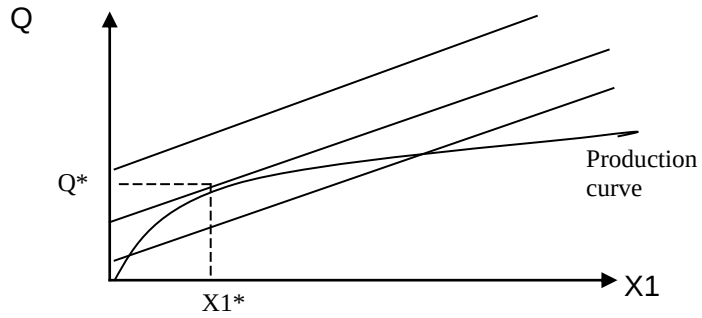


Figure 5.4 – Graphic determination of the maximum profit

According to a first feature of isoprofits, moving it parallel to itself up the company profit increases. But the isoprofit cannot be higher than the production curve due to the production technology. Therefore, the maximum profit is achieved at the touch point of isoprofit and the production curve, i.e. when the amount of the first resource is x_1* and the quantity is Q*.

From the tangency hypothesis follows that the isoprofit and the production curve have the same angular coefficients. The isoprofit's angular coefficient as it can be seen from equation is $\frac{p_1}{p_0}$. And the slope of the production curve is equal to the marginal product of the

first resource. Thus, the optimal condition for the production program providing company with the maximum profit, is given by the formula (5.4)

$$\frac{p_1}{p_0} = MQ_1 \ . \qquad (5.4)$$

5.3 Break even analysis

DEFINITION

Break-even condition – such state of a company, in which the production costs of a certain output volume equal to the sales revenue of this products volume.

The volume of production, providing break-even of a company, is called *the critical*.

Break-even analysis is performed under the following conditions:

1) company sells its products in a competitive market, that is the price of products is constant and independent of the company's sales volume,

2) the company operates in the short-term planning , i.e. total costs of the company consist of two parts - fixed and variable,

3) there is no returns of scale i.e. the marginal cost of the firm are constant and equal the costs of an additional unit of production.

Below is a graph of the break-even analysis of a company (Fig. 5.5).

Let us find the expression for the critical volume of production. At the point of intersection of the total expenses and income, the equality exists $R = C$,

$$p_0 Q = CvQ + CF \ .$$

Express Q, we get the formula for calculating the critical volume of production:

$$Q^* = \frac{CF}{p_0 - Cv} \ . \qquad (5.5)$$

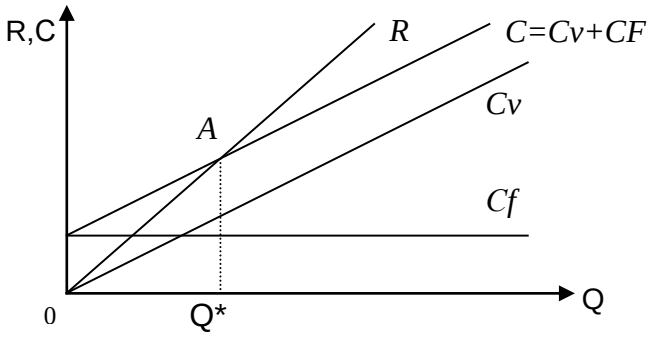


Figure 5.5 – Break-even analysis

Knowing the critical volume of production, marginal profit analysis can be carried out: in the point *Q* * on the x-axis, the profit comes from negative to positive. (Fig. 5.6).

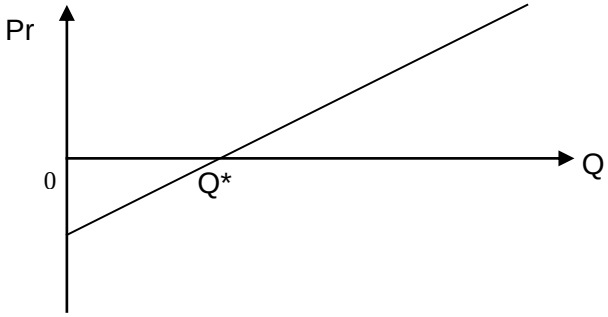


Figure 5.6 – Marginal profit analysis

UNIT 6 Time factor in economics. Investments

6.1 Time value of money. Discounting and compounding.

The value of money over time - is a term used in the theory of evaluation of investment projects by taking into account the time factor.

The need to introduce this concept arose from the fact that people tend to prefer having a definite sum of money now to this sum of money in the future, since they can put the money in the bank, and in the future, this amount will increase due to the payment of interest.

To summarize the different-time cash flows, they should be discounted.

Discounting - counting the cost of money in the future to the present moment.

Compounding - the calculation of the present value of money for the future time.

6.1.1 Discount rate. Methods of its calculating

DEFINITION

Discount rate is an interest rate that consists of alternative investing object rate and other factors that need compensation.

The main factors that require compensation are the following ones:

- loss of profit (an investor can invest his funds, for example, in a bank at interest);

- inflation (over the planning period the inflation rate in the country may change);

- risks.

The rate is used in a formula of present value calculation:

$$PV = FV/(1+i)^n, \quad (6.1)$$

where *PV* - present value,

FV - future value of cost or benefit in monetary terms,

i - the rate of discount,
n - number of periods under consideration (e.g. years).

There are different methods used in practice for determining the discount rate. Let us consider the most common ones.

As there is an ample number of methods we suggest classifying them into 2 categories: methods for non-stock corporations and equity evaluation-based methods.

Methods for non-stock corporations

Fisher's equation

In case of exchange rates instability, inflation, changes in the refinancing rate and other factors affecting the final profitability of the project, two interest rates appear: nominal and real. There should be consistency in the use of these rates throughout the calculations. Moreover, the final discount rate should be real or nominal depending on the flows it is being used to discount. Regarding this, the discount rate is calculated by **Irving Fisher equation**. Letting *r* denote the real interest rate, *i* denote the nominal interest rate (i.e. without inflation), and *I* denote the inflation rate, the Fisher equation is:

$$(i+1) = (1+r)(1+I),$$

From here the nominal interest rate can be solved:

$$i = (1+r)(1+I) - 1. \qquad (6.2)$$

Risk evaluation-based method

Risk evaluation-based method or cumulative method for discount rate determination according to the risk premium value is based on cumulation of the risk-free rate of return and the various types of risk as shown in the following equation.

$$r_p = r + P_1 + ...P_n, \qquad (6.3)$$

r_p –discount rate, taking into account the risk of the investment project,

$P_1 + \ldots + P_n$ – risk premium for different risk factors.

Cumulative method implies consideration of 3 risk types: the country risk, the project's stakeholders insecurity risk and the risk of not receiving revenues stipulated by the project.

Expert poll method to evaluate the discount rate

The method of expert poll is applied in conditions of limited information about the environment and the potential risks. To determine the discount rate investors pay to specialists in the field of investment planning.

The most common practice in the techniques of expert assessment method include: establishment of a commission (open, brainstorming, or even voting); by the Court (appointed experts, advocates and their opponents and judges); Delphi method (individual questioning of experts, feedback between experts and collectively discussing). The final percentage may be calculated by finding the arithmetic average of the interests offered by all the specialists, or may be chosen the most suitable variant of the rate based on the analysis risk and profitability.

Methods based on equity evaluation

WACC

WACC (*Weighted Average Cost of Capital)* method is applied when a company has multiple sources of loans or loss of profit variants.

$$WACC = i_D (1 - i_T) \frac{D}{V} + i_E \frac{E}{V}, \qquad (6.4)$$

where i_D – cost of debt,

i_T – corporate tax rate,

i_E – cost of equity,

D – market value of the firm's debt,

E – market value of the firm's equity,

V – total market value of the firm's financing (equity and debt), $V=D+E$,

$(1-i_T)$ here is so-called «tax shield», which determines the effective rate of debt capital.

If the project is more risky or more reliable than the assets of the firm, the M. Miller and F. Modigliani formula is used, adjusted by J.Miles and R. Izzel:

$$WACC = i - Li_D \cdot \mathrm{i}_\mathrm{T} \cdot \frac{1+i}{1+i_D},$$

where i – the expected rate of return,

L – ratio of a company's debt burden (it is the ratio of loans to total assets).

CAPM

Capital Asset Pricing Model– CAPM was introduced independently by Jack Treynor in 1962, William F. Sharpe in 1964, John Lintner in 1965 and Jan Mossin in 1966 to evaluate the future profitability of companies' assets. CAPM calculates a required return based on a risk-free rate and risk measurement.

The CAPM formula is sometimes called the Security Market Line formula and consists of the following equation:

$$r_i = r_f + \beta(r_m - r_f), \tag{6.5}$$

where r_i – required return,

r_f – the risk-free rate,

r_m – expected market return, calculated as an average return according to market indexes (RTS for Russia, S&P for USA),

β - the beta coefficient of the market portfolio. It can be calculated as ratio of the standard deviation of the stock yield changes depending on changes in market yields σ_{im} to market yield dispersion σ^2_m:

$$\beta = \frac{\sigma_{im}}{\sigma_m^2}.$$

6.2 Cash flows. Budgeting

Cash flow CF — the difference between the revenues and costs of the company, expressed as the difference between the received and made payments. Generally it is the sum of retained earnings of the company and its depreciation.

The cash flow consists of flows from the individual activities:

- cash flow from investing activities;
- cash flow from operating activities;
- cash flow from financing activities.

In each period of the investment project cash flow is characterized by the following:

· *cash inflow* equals to the size of the cash receipts;

· *cash outflow,* equals to payments at this stage;

· surplus (positive balance, effect) equals to the difference between the inflow and outflow.

6.3 Methods of simple and compound interest

The following notation is used for calculating the discounted value of cash flows of the project:

PV_0 *(present value)* is the initial cost of money.

FV_n *(future value)* is a final cost of investments after an interest for n periods.

Period of interest accrual is called the *period of capitalization.*

Simple interest

Calculations using the simple interest are only for short-term loans for a period less than 1 year.

The simple formula of the future value FV_n:

$$FV_n = PV_0(1+ni), \tag{6.6}$$

Discounting to present value involves calculating the current equivalent value of a cost or benefit associated with a project, given a prevailing interest (or discount) rate. The formula used to calculate the present value of a future cost or benefit in monetary terms is:

$$PV_0 = \frac{FV_n}{(1+ni)}. \tag{6.7}$$

Compound interest

The compound formula of the future value:

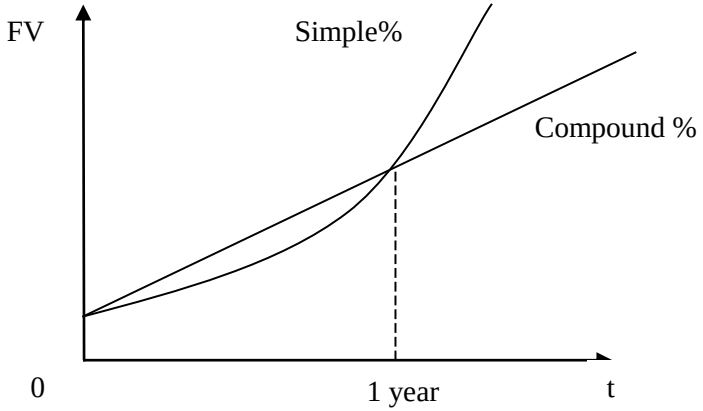
$$FV_n = PV_0 \cdot (1+i)^n. \tag{6.8}$$

When investing under the compound interest the revenue is calculated not only on the amount of the deposit, but also on the receipt (or accrued) interest.

Doing the reverse operation (discounting), we can find the present value of money at a certain future value. The formula of the present value (discounted operation) with compound interest:

$$PV_0 = \frac{FV_n}{(1+i)^n}. \qquad (6.9)$$

Diagram of increasing the cost of the deposit in simple and compound interest calculation is shown in Fig. 6.1.



interest calculation

Figure 6.1 – Increasing the deposit cost in simple and compound

6.4 Annuity payments

The future value of a series of cash flows FV_n - is the total value of the individual future values.

$FV_n = CF_0(1+i)^n + CF_1(1+i)^{n-1} + CF_2(1+i)^{n-2}$ .....+.....CF_n

The future value of cash flow series can be represented schematically as shown in Fig. 6.2.

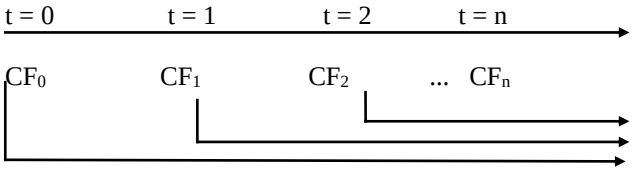


Figure 6.2 – The future value of cash flow series

Let the $CF_0=0$ and $CF_1 = CF_2 = CF_3 = ... = CF_n = CF$.

A series of *n* equal recurring amounts of money is called annuity. Its future value equals:

$$FV_n = CF\frac{(1+i)^n - 1}{i}. \qquad (6.10)$$

Present value of payments series - is the total value of the individual present values.

$PV_0 = CF_0 + CF_1/(1+i) + CF_2/(1+i)^2 + ... + CF_n/(1+i)^n$

$$PV_0 = CF\frac{(1+i)^n - 1}{i(1+i)^n}. \qquad (6.11)$$

6.5 Methods of investments efficiency estimation

Methods used in assessing the economic efficiency of the projects are divided into 2 groups:

- simple;
- complex (dynamic).

6.5.1 Simple methods

Simple methods include methods that do not take into account nonequivalence of cash flows arising at different times. These methods are used for the rapid evaluation of projects at the preliminary stage of analysis.

Return of Investments ROI is calculated as the ratio of the average value of the net profit for the whole period of the project to the total volume of investment expenses.

$$ROI = \frac{\Pr}{I}, \qquad (6.12)$$

where *Pr* – average value of the net profit,

I – total volume of investment expenses.

Economic sense of ROI is that it assesses which part of the investment costs shall be compensated in the form of profit for one planning period.

There is no regulated value for this indicator but there is a general rule: the value of ROI should be at such a level as to ensure the liquidity of the project. Investor determines the acceptable level of ROI for an individual project, based on the ratio of liquidity and profitability of the project. Therefore, ROI does not have to be as high as possible.

When comparing the estimated value of ROI with the minimum or average rates of return, the investor can draw preliminary conclusions about the appropriateness of this investment, as well as whether or not to continue further analysis of the investment project.

Simple payback period PP shows the time during which all the investment in the project are recovered by the net income. This index can be calculated in two ways:

1) If the project income is distributed evenly over the period, and a one-time investment is made at the beginning of the project, you can use the formula:

$$PP = \frac{I}{CF_{year}}. \tag{6.13}$$

2) If the revenue is unevenly distributed over the years, the payback period is calculated by direct counting of the number of years, during which the investment will pay off.

$$PP = \mathrm{n}_{pp} - \frac{\mathrm{CF}_{\mathrm{negat}}^{\mathrm{cumulat}}}{\mathrm{CF}_{\mathrm{pp}}}, \tag{6.14}$$

where n_{PP} – number of years before the payback period,

$\mathrm{CF}_{\mathrm{negat}}^{\mathrm{cumulat}}$ – the last negative cumulative cash flow,

CF_{PP} – cash flow in payback year.

6.5.2 Complex (dynamic) methods

Complex methods are based on discounting, i.e. take into account the time factor. At the same time more complex mathematical apparatus is applied that allows to make reasonable conclusions about the effectiveness of the project.

Net Present Value NPV— is a sum of the present values of cash flows associated with a project.

$$NPV = -I + \sum_{t=1}^{T} \frac{CF_t}{(1+i)^t}, \qquad (6.15)$$

This formula is used with the following assumptions:
a) one-time investment are implemented at the beginning of the project,
b) the discount rate remains unchanged throughout the life of the project.

The project will be approved if NPV > 0, i.e. profitable.

If NPV < 0, the project is unprofitable and it is to be rejected.

If NPV=0, то project is not unprofitable, and not profitable.

When considering the number of projects you need to choose the one with the higher NPV.

Profitability Index PI – an indicator of the efficiency of investment expenses.

$$PI = \frac{PVCF}{PVI}, \qquad (6.16)$$

where *PVCF* – discounted cash flow,

PVI – discounted investments.

Economic sense: it shows the level of income per unit of input.

If PI ≤ 1, the project is unprofitable, it should be rejected.

If PI >1, the project will bring additional revenue to the investor, the project should be accepted.

Internal rate of return IRR – is an index, which is a discount rate at which the net present value of the project NPV=0.

IRR value can be calculated in several ways.

1. If the number of periods of the project does not exceed two, it is recommended to use the equation NPV=0:

$$-I + \sum_{t=1}^{T} \frac{CF_t}{(1+i)^t} = 0 .$$

It can be rewritten:

$$I = \frac{CF_1}{(1+i)} + \frac{CF_2}{(1+i)^2} .$$

2. The calculation can be performed using an iterative selection of the values of the discount rate.

The algorithm of this method:

- chose two values of a discount rate so that the NPV value of the first was less than zero, and of another more than zero.

- values rates and a corresponding NPV substituted into the interpolation formula:

$$IRR = i_1 + \frac{NPV_1}{(NPV_1 - NPV_2)}(i_2 - i_1), \qquad (6.17)$$

where i_1 – the discount rate at which NPV is positive,

NPV_1- positive NPV,

i_2 – the discount rate at which NPV is negative,

NPV_2- negative NPV.

- iterate NPV values in accordance with a predetermined interest rate to narrow the range of IRR.

Economic sense of internal rate of return: it defines the maximum rate of payment for the attracted funds in which the project is still break even.

Discounted Payback Period DPP shows the time for all the project investments to be recovered with received discounted income.

The payback period is calculated by direct counting of the number of years, during which the investment will pay off.

$$DPP = \mathrm{n}_{pp} - \frac{\mathrm{CF}_{\mathrm{negat}}^{\mathrm{cumulat}}}{\mathrm{CF}_{\mathrm{pp}}} , \qquad (6.18)$$

где n_{PP} – number of years before the payback period,

$\mathrm{CF}_{\mathrm{negat}}^{\mathrm{cumulat}}$ – the last negative cumulative **discounted** cash flow,

CF_{PP} – **discounted** cash flow in payback year.

6.6 Antimonopoly policy

The monopolization of production leads to a significant **loss of communit**y:

- compared to the competitive market, the monopoly sets generally higher prices along with limited production;
- monopoly is able to gain excessive profits and assign a significant portion of consumer surplus;
- monopoly hinders the efficient allocation of resources costs as the monopoly firms does not necessarily produce at minimum average costs, as in perfect competition;
- monopoly hinders market competition by fixing prices, erecting artificial barriers to entry to the market, replacement of competitors out of business by predatory practices.

Fundamentals of Russian antimonopoly policy are fixed in the Federal Law "On competition and restriction of monopolistic activity on commodity markets" adopted in 1991. In 1999 was significantly revised the Federal Law "On competition and restriction of monopolistic activity on commodity markets».

Antimonopoly policy is a system of measures directed at strengthening and protection of competition by limiting the monopoly power of firms.

Among the main areas of antimonopoly policy of a government can be named the following ones:

- direct regulation of prices;
- taxation;
- regulation of natural monopolies.

UNIT 7 Macroeconomic basics of engineering economics

7.1 Basic definitions of national accounts system

Macroeconomics examines the economy of regional, national and international levels (in order to provide the conditions for sustainable economic growth, full employment of resources and minimization of inflation). [9]

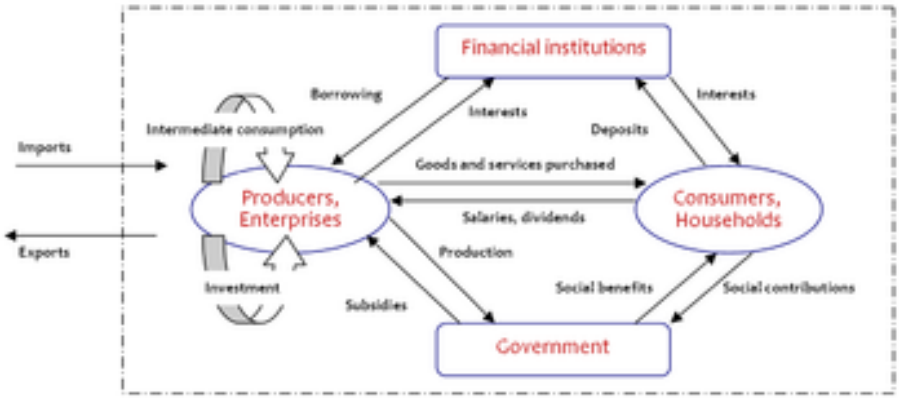


Figure 7.1 – National economy circuit

System of National Accounts (SNA) - a set of common economic terms, systems, indicators and accounting rules used at the national (state) and international level for compiling macroeconomic reports. SNA is used for the analysis of the current macroeconomic situation and justification of forecasts; comparing the operating results with the state of the economies of the different countries of the world; implementation of economic strategy.

The main indicators of the SNA are: gross national product (GNP), net national product (NNP), national and personal income, general price level , the rate of economic growth, inflation and employment, budget indicators, balance of payments.

To calculate the GNP, 4 approaches can be applied: calculation of expenditures, of outcomes and investments, of incomes, of added value.

GNP calculation *based on expenditures* means a sum of households' expenditures *C*, entrepreneurs' investments *I*, government's purchases *G*, foreign expenditures N_E:

$$Y_{GNP} = C + I + G + N_E . \quad (7.1)$$

GNP calculation *based on outcomes and investments* means a sum of households' expenditures *C*, aggregate savings *S*, net taxes *T*:

$$Y_{GNP} = C + S + T , \quad (7.2)$$

where $S = S_H + S_U + S_g + S_W$ – aggregate savings;

$T = T^{ind} + T_H^{dir} + T_U^{dir} - Tr_H - Tr_U$ – net taxes.

Outcomes and investments are equal:

$$I + G + E = S + T + Z ,$$

where $\gamma = I + G + E$ – investments (in addition to consumer spending on goods and services produced within the country); $\xi = S + T + Z$ – outcomes (outward flow of potential costs of revenues).

GNP calculation *based on added value* means a sum of added values of all the businesses. *Added value* is a product market price of all the country's firms minus the cost of raw materials and auxiliary materials purchased and consumed by these firms for production.

GNP calculation *based on incomes* means a sum of personal income Y_{PDI}, direct taxes on households T_H^{dir}, savings of entrepreneurs S_U, direct taxes on businesses T_U^{dir}, indirect taxes T^{ind}, depreciation D, net factor income Y_W minus transfers Tr_H, Tr_U:

$$Y_{GNP} = Y_{PDI} + T_H^{dir} + S_U + T_U^{dir} - Tr_H + T^{ind} - Tr_U + D + Y_W . \quad (7.3)$$

DEFINITION

Gross domestic product (GDP or Y_{GDP}) is the amount of market value of final goods and services produced in the territory of the country for a certain period.

The relationship between GNP and GDP:

$$Y_{GNP} = Y_{GDP} + Y_W ,$$

where Y_W – net factor income – the difference between the income from the use of overseas production factors, which are owned by residents and payments to non-residents for the use of factors of production owned by them in a given country.

Net national product (NNP or Y_{NDP}*)* represents the difference between GDP and the sum of depreciation *D* or the cost of depreciation of equipment and buildings for production purposes in the process of creating GNP: $Y_{GDP} = Y_{NDP} + D$.

National income (NI or Y_{NI}*)* – is a measure of income generated only by the factors of production: $Y_{NDP} = Y_{NI} + T^{ind} - Tr_U$.

Personal income (PI or Y_{PI}*)* consists of all income received by individuals, whether from production or by transfer payments:

$$Y_{NI} = Y_{PI} + S_U + T_U^{dir} - Tr_H .$$

Disposable income (DI or Y_{DPI}*)* is the portion of people's incomes that they have control over: $Y_{PI} = Y_{DPI} + T_H^{dir}$.

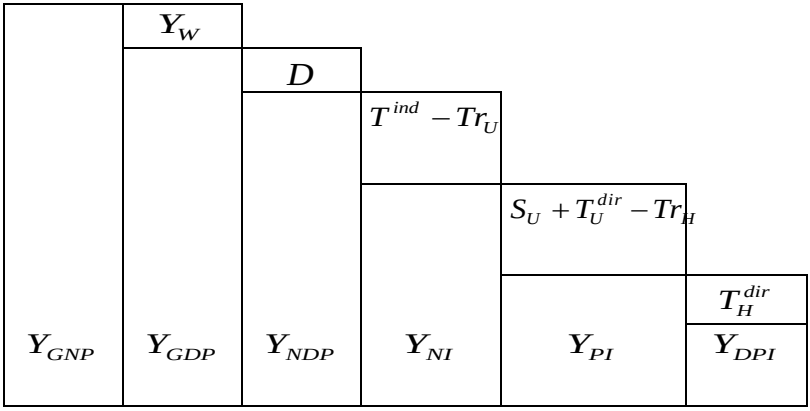


Figure 7.2 – Diagram of the volume indicators relationship

DEFINITION

Market Price Index (GDP deflator) - the ratio of the cost of the market basket in the prices of the current year to its value in the base year prices.

Market Basket - a set of products taken at the proportions in which they are presented in the GDP this year.

Deflator - an indicator of the level of prices, calculated as the ratio of nominal GDP to real GDP.

7.2 Entity of inflation, reasons, types, consequences

Inflation – a long-term sustainable growth in the general price level, leading to a decrease in the purchasing power of money. The inflation level is determined by the price growth rate:

$$\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}.$$

Causes of inflation:

• an increase in the monetary base and the growth of the quantity of money;

• an increase of money velocity in comparison with the production;

• an increase in demand at full employment and full capacity utilization;

• rising costs.

Seigniorage – state income with inflation (inflation tax equals to the difference between the value of additionally issued banknotes and the costs of their manufacture)

The real interest rate – the percentage increase for the year of purchasing power of money on the term deposit, depends on the nominal interest rate and the annual inflation rate:

$$i_r = \frac{i - \pi}{1 + \pi}.$$

7.3 Foreign trade activity of an organization

Foreign economic activity (FEA) – a set of organizational, economic, industrial and commercial, operational and commercial functions of enterprises oriented on the world market, taking into account the chosen foreign economic strategy, forms and methods of work in foreign markets.

The following *types* of FEA exist:

- Trading activities;
- the international division of labor;
- industrial cooperation;
- currency and financial and credit transactions;
- relations with international organizations.

To become wealthier, countries want to use their natural resources such as land, labour, capital and entrepreneurship, in the most efficient manner. However, there are differences among countries in the quantity, quality and cost of these resources. The *advantages* that a country has may vary according to the following.

- Abundant minerals
- Climate suited to agriculture
- Well-trained labour force
- New innovative ideas
- Highly developed infrastructure like good roads, telecommunication systems, etc.

Instead of trying to produce everything by themselves, countries often concentrate on producing things that they can produce most efficiently. They then trade those for other goods and services. In doing so, both the country and the world become wealthier.

Law of Comparative Advantage: Even if a country can produce everything more efficiently than another country, there is still scope for trade. A country can maximize its wealth by putting its resources into its most competitive industries, regardless of whether other

countries are more competitive in those industries. This is called the law of comparative advantage.

Methods of Protection: governments use a variety of tools to manage their countries' international trade positions.

Tariffs are taxes on imports. Tariffs make the item more expensive for consumers, thereby reducing the demand.

Import Quotas: Governments sometimes restrict the sale of foreign goods by imposing import quotas. These limit the quantity of foreign goods that can be imported and help domestic producers by limiting the share of the market that can be taken by foreigners.

Voluntary Restraints: Sometimes governments negotiate agreements whereby a country agrees to voluntarily limit its export of a certain product. Japan voluntarily limited its export of cars to the United States in 1992 to 1.65 million cars per year.

With tariffs, it is the importing country that stands to gain through increases in the tax revenue. However, in case of quantitative restraints, the exporting country gains as the price of the imported good rises.

Both import quotas and voluntary restraints towart the functioning of the free market. The quantity of goods remains constant while the price changes, instead of demand and supply determining both quantity and price.

Subsidies. Another way to achieve the goals of protectionism is to make the domestic industry more competitive. Subsidies, which are grants by the government to an industry, can accomplish this. Subsidies can be:

- Direct outright payments,
- indirect special tax breaks or incentives, buying of surplus goods,
- providing low-interest loans or guaranteeing private loans.

Trade Ban: Sometimes governments ban trade with certain countries for political reasons during times of war or political crises. Governments also ban imports of certain products to protect domestic

industries. For instance, Japan bans importation of rice to protect its domestic rice industry.

Imposing Standards: Health, environmental and safety standards often vary from country to country. These may act as a barrier to free trade and a tool of protectionism. For example, the European Union has very stringent health and safety standards that goods have to meet in order to be imported.

Others: Apart from the legal restrictions there may be other less formal obstacles that impede trade. Cultural factors are one such obstacle.

CONCLUSION

The appliance of economics in engineering makes it possible to solve tasks of engineering. It is a key for an engineer's effective work.

The course of engineering economics is complex, covering a wide variety of topics including costs analysis and depreciation, the time value of money, theory of production, effectiveness of investment projects and so on. If an engineer possesses knowledge in this spheres, he is more likely to develop his research so that it can become useful for society.

Firms are the production units. They produce goods, commodities and services. The entire network of economy is independent on each individual unit. Households pay Government taxes and the Government sells general services to them. Firms receive from the Government socially supplied goods, such as electricity, transportation facilities like roads and railway, market facilities and a host of other services. They in turn supply the Government with revenues and money in the form of exports. So the entire economic system is interdependent.

Any commercial organization in the normal course of business consumes certain resources. To find out how much of the raw material is necessary to produce a given quantity of goods, or vice versa, check the amount of release of goods at a definite amount of resources, one must clearly understand the production process. For this purpose the book contains information about production function, isoquant, returns to scale.

The main document of an enterprise to describe its performance is a Balance Sheet. It consists of 2 major parts – Liabilities and Assets. There are 6 types of valuation of fixed assets and four types of amortization counting. Each one is applied in different countries and types of companies.

Organization carries significant costs to purchase resources. Obviously, it wishes to use a manufacturing process in which a

specified volume of production could be achieved at the lowest cost of the used resources. The firm can influence the course and efficiency of production only by changing the intensity of the use of its capacities. To measure the costs for production the concept of average total, average fixed and average variable cost of production is used. Since there are many combinations of resources, the problem of determining such a combination arises in which the total costs for the company is minimal, and a predetermined volume of the issue is reached. Businessman solves this task considering that the prices of each resource are different. In order to minimize the costs (for a given volume of the production), the company needs to substitute one resource with another as long as the marginal product related to the resource price will not be equal for both resources.

The purpose of any commercial organization is gaining profit. Managers tend to increase profits by solving the following tasks:

1) increasing income,

2) reduction of production costs.

Graphically, the maximum profit is achieved at the touch point of isoprofit and the production curve, i.e. when the amount of the first resource is x_1* and the quantity is Q*.

To summarize the different-time cash flows, they should be discounted. There are different methods used in practice for determining the discount rate. As there is an ample number of methods we suggest classifying them into 2 categories: methods for non-stock corporations and equity evaluation-based methods.

Methods used in assessing the economic efficiency of the projects are divided into 2 groups:

- simple;
- complex (dynamic).

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