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## FORMALIZATION OF DYNAMIC RELATIONS BETWEEN ENTERPRISE FINANCIAL INDICATORS

- A** Modern tools of enterprise financial management are defined. The expediency and the need to use the tools of system-dynamic modeling in assessing and forecasting the financial indicators of the enterprise are substantiated. The structural elements of the conceptual model of the dynamic relationships between the basic financial indicators of the enterprise are defined. It defines the principles for use the modern tools of system dynamics simulation in the financial decisions preparation in the company. The relationships of individual management models for the basic financial processes of the company are formalized (operating activities, cash flows, financial responsibility centers). The cause and effect relationships between the financial indicators in the management of the operating activities of the enterprise dynamics are determined. The dynamic relationships for the financial indicators in the company's cash flows management are formalized. The structural components of the dynamic model of the resources` allocation between the centers of the entity's financial responsibility are substantiated.
- B** Financial indicators, business management, system-dynamic modeling, operating activities, cash flow, center of financial responsibility.

### ФОРМАЛІЗАЦІЯ ДИНАМІЧНИХ ВЗАЄМОЗВ'ЯЗКІВ МІЖ ФІНАНСОВИМИ ПОКАЗНИКАМИ ПІДПРИЄМСТВА

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- A** Визначено особливості реалізації сучасних інструментів управління фінансовими процесами підприємства. Обґрунтовано доцільність і необхідність застосування інструментів системно-динамічного моделювання під час оцінки та прогнозування фінансових показників діяльності підприємства. Визначено структурні елементи концептуальної динамічної моделі взаємозв'язків між базовими фінансовими показниками підприємства. Відповідна модель визначає принципи застосування сучасних інструментів системно-динамічного моделювання під час підготовки та прийняття фінансових рішень на підприємстві. Формалізовані взаємозв'язки одиначних моделей управління базовими фінансовими процесами підприємства: операційною діяльністю, грошовими потоками, центрами фінансової відповідальності. Визначені причинно-наслідкові зв'язки між фінансовими показниками під час управління динамікою операційної діяльності підприємства. Формалізовані динамічні взаємозв'язки фінансових показників під час управління грошовими потоками підприємства. Обґрунтовані структурні складові динамічної моделі розподілу ресурсів між центрами фінансової відповідальності підприємства.
- B** Фінансові показники, управління підприємством, системно-динамічне моделювання, операційна діяльність, грошовий потік, центр фінансової відповідальності.

## ФОРМАЛИЗАЦИЯ ДИНАМИЧЕСКИХ ВЗАИМОСВЯЗЕЙ МЕЖДУ ФИНАНСОВЫМИ ПОКАЗАТЕЛЯМИ ПРЕДПРИЯТИЯ

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- А** Определены особенности реализации современных инструментов управления финансовыми процессами предприятия. Обоснована целесообразность и необходимость применения инструментов системно-динамического моделирования при оценке и прогнозировании финансовых показателей деятельности предприятия. Определены структурные элементы концептуальной динамической модели взаимосвязей между базовыми финансовыми показателями предприятия. Соответствующая модель определяет принципы применения современных инструментов системно-динамического моделирования при подготовке и принятии финансовых решений на предприятии. Формализованы взаимосвязи единичных моделей управления базовыми финансовыми процессами предприятия: операционной деятельностью, денежными потоками, центрами финансовой ответственности. Определены причинно-следственные связи между финансовыми показателями при управлении динамикой операционной деятельности предприятия. Формализованы динамические взаимосвязи финансовых показателей при управлении денежными потоками предприятия. Обоснованы структурные составляющие динамической модели распределения ресурсов между центрами финансовой ответственности предприятия.
- Б** Финансовые показатели, управление предприятием, системно-динамическое моделирование, операционная деятельность, денежный поток, центр финансовой ответственности.

### Formulation of the problem

Financial indicators on enterprise are the integral part of any management mechanisms. Thus, along with classical approaches to forecasting and using of financial indicators on enterprise, the innovation instruments of making and preparation of management decisions that enable to secure the timely counteraction to negative effects of risks and to provide competitive advantages are more actively studied. The necessity of using of modern instruments of management is particularly evident at the moment of break of continuous operational and financial processes in time and space. For example, appropriate financial resources are withdrawn from circulation during the capital investment in production throughout the production cycle, so there is a need for additional funds for parallel launching of other production processes. Therefore, the dynamic component deserves attention within the mechanisms of modern enterprise's management along with classical forecasting, optimization and control methods. However, just classical financial indicators are focused on the definition of static components and do not include the dynamics and relationships of internal and external factors in the full amount. Thus, providing conditions for the enterprise's sustainable functioning and development on a long-term planning horizon is impossible without the use of dynamic methods of preparation and making of decisions, within the financial subsystem as well.

Taking into account the fact that modern enterprises must consider a significant number of factors and relationships during the management, it is impossible to ensure the effective implementation of any management influence on the base of use of unit and static

methods, including management accounting and financial analysis, which is a common practice for local managers. On the other hand, significant negative consequences of implementation of unfounded financial decisions require the search of more universal alternatives and combination of modern approaches to preparation and making of management decisions, including methods of analysis and synthesis of systems.

### Analysis of recent publications

As a result of development and active dissemination of methods of system analysis, specific principles and rules of construction, use and interpretation of a complex of mathematical and economic models were founded, including models of financial mathematics, budgeting and so on. However, the development of economic relations, formation and theoretical designing of a new finance paradigm and approaches to management the enterprise's finance, using of modern technologies of collection and processing of data provided an impetus to the development of researches in the sphere of enterprise's management using modern computer technology and simulation models [2; 13; 15; 18; 19; 20; 21; 22].

One of the modern methods of support of financial decision-making is a method of simulation modeling, which combines the advantages of classical tools of financial analysis, economic, statistical and probabilistic models, neural network modeling, fuzzy-set theory and so on. That is why we will consider several statements of simulation models of business management, which are based on modern methods of system dynamics or system-dynamic modeling [1; 11; 12].

The method of system dynamics appeared as a kind of balance dynamic models and simulation modeling and immediately gained popularity among scientists and economists-practitioners. System dynamics provides a high level of abstraction [12; 15; 18], which is largely inherent to the processes of functioning and development of the financial system of the enterprise. Appropriate set of instruments allows to overcome many difficulties of classical methods of formalization, mainly the problem of dimension, through the use of electronic computers and algorithmic simulation models. At the present moment the system-dynamic approach combines both individual methods of system analysis (qualitative and quantitative) and principles of information theory and management of organizations [7; 14; 15; 18; 19].

A set of principles and methods of analysis of dynamic systems with feedback and their applications for solving production, organizational and socio-economic problems are inherent for the system dynamics. In systems of support of decisions-making an application of system dynamics allows to combine together several functional spaces and provide organizational and quantitative basis for the development of the most effective management policy [1; 12; 15; 16; 18].

The following advantages of the method of system dynamics in systems of management and control of financial processes can be highlighted [12; 15; 16; 17; 18; 19]:

- complicated, weekly formalized situations, when the use of analytical methods is impossible, or they are so complex and time-consuming, that dynamic modeling gives the simplest way to solve the problem;
- modeling of behavior of systems in situations that were not previously met. In this case, imitation serves for pre-testing of new strategies of business management before the conducting of the experiment on real object;
- modeling of situations, which observation is complicated by a long duration of their development, or vice versa, when it is necessary to control the development of the situation by accelerating or decelerating of the effects in the process of simulation.

Moreover, the streaming principle of system-dynamic models and a developed complex of instruments of taking delays into account determine their indispensability under implementation of a complex of mechanisms of management of enterprise's financial processes [4; 5; 9; 12; 13; 14].

Despite the incontestable advantages of the method of system dynamics in business management, it is rather universal today. It means that the formalization of key financial dependence and building of conceptual cause and effect models as to key financial indicators of the enterprise's activity are necessary, which led to the choice of the theme of the research.

*The aim of the article* is to formulate theoretical and methodological basis of formalization of dynamic relationships between financial indicators of the company, as well as to identify key financial cause and effect relationships for the operating activity, cash flows management and resources' allocation between the centers of the financial responsibility of the company.

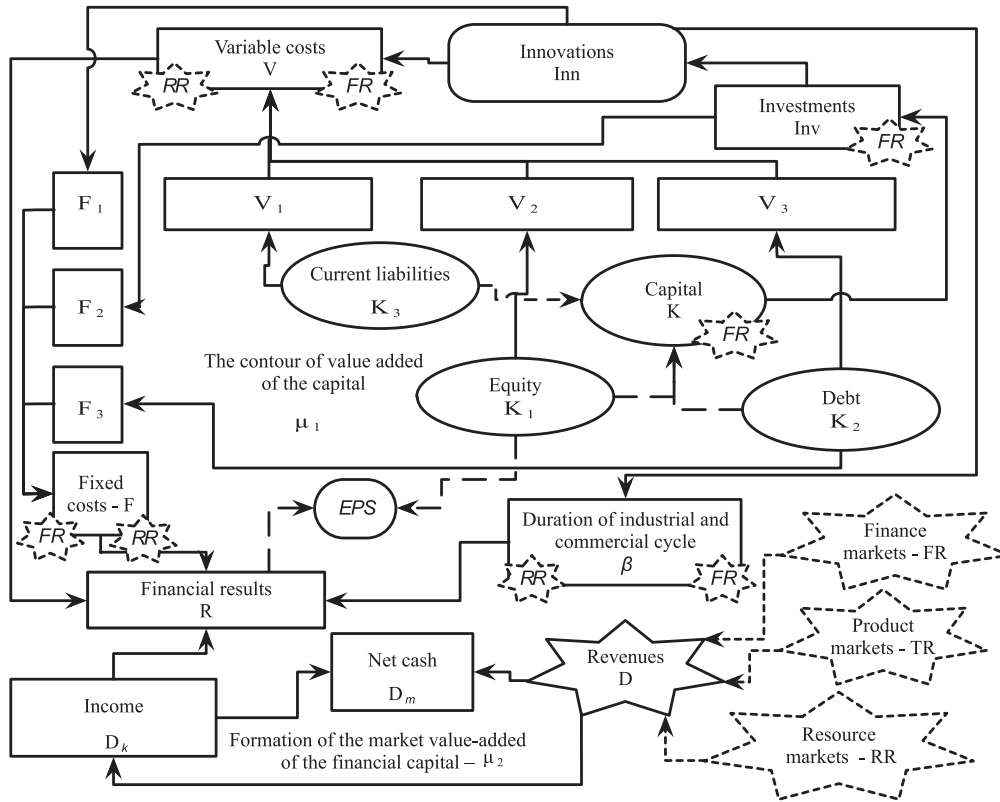
### **The main material of the research**

In the general form the conceptual model of basic relationships of financial indicators of enterprise's functioning and development is determined by a compromise between the increase of the direct economic effect (eg, profit per unit of invested equity – EPS) and by the risk of bankruptcy (capital losses partially or fully) (fig. 1).

The value of variables that are shown in fig. 1, is follows:  $V = V_1 + V_2 + V_3$  – the amount of conditional variable costs per unit of finished product;  $V_1$  та  $V_3$  – a part of variable costs, financed by own ( $V_1$ ) and debt ( $V_3$ ) capital;  $V_2$  – is a part of variable costs, that are financed by short-term borrowings;  $F = F_1 + F_2 + F_3$  – basic value of the conventionally fixed costs of the company;  $F_1$  – a part of fixed costs, which makes industrial and commercial constraints of the enterprise's functioning;  $F_2$  – a part of fixed costs that is associated with the development of the investment risk;  $F_3$  – a part of fixed costs that is related to the costs on raising of financial funds (long-term and commercial loans).

The operating cycle, according to fig. 1, takes into account both the technological features of the main activity and marketing and other related activities and their characteristics. It means that the final step of realization of the finished product within the mentioned model is a period of a full payment for production, goods and services. The main factors of risk that cause the stability of the enterprise's economic activity, are:

- short-term reduction  $D$  of effects of national and foreign currencies' inflation, including freely convertible currency, as the result of the declining of demand on production in the form of declining of its prices or volumes of sales, changes in competitive advantages on global markets etc;
- long-term reduction  $D$  as a result of lack of investments and introduction of innovations;
- an increase  $V$  of current resources due to the increasing of the value (price), changes in costs of labor force etc.;
- an increase of fixed costs, in particular as a result of changes in capital structure;
- an increase of non-payments ( $V_2$ );
- an increase of the industrial and commercial cycle ( $\beta$ ), a reduce of the level of net cash of profits ( $D_m$ ).



**Fig. 1. The conceptual model of basic relationships of financial indicators of the enterprise's development and functioning**

As it is shown in fig. 1, the value added of capital is formed within the industrial cycle (the cycle of main activity) by the use of assets of enterprise. However, market conditions of enterprise's functioning correct the meaning of the value added, that may be connected with changes in the price or with the volume of demand for the finished product, a decrease of the level of cash payments. Therefore the created value added and marginal profit are defined both by technological characteristics (the level of fixed and variable costs) and market conditions within the industrial cycle.

Within the indicated conceptual approach the following classification of levels of management that is based on changes of appropriate financial indicators, notably on the level of sustained functioning (without changes of fixed costs), the level of investment development (increase of fixed costs without significant changes of relative variable costs) and the level of innovation development (the structure of costs, revenues, risks etc. is changing essentially) is studied. In terms of sustainable functioning the meanings of indicators of industrial capacities and remain constant  $F_1$ , but in case of negative conditions they can be changed by the relation between  $\mu_1$  and  $\mu_2$ , and also an indicator of payment on credit ( $D_k/D$ ), that reduces to the decreasing of the amount of working capital and the further increase of  $V_2, F_3, V_1 + V_3$ . Implementation of projects of development is concerned with increasing of the level of fixed costs  $F_2$ , but the possibility of

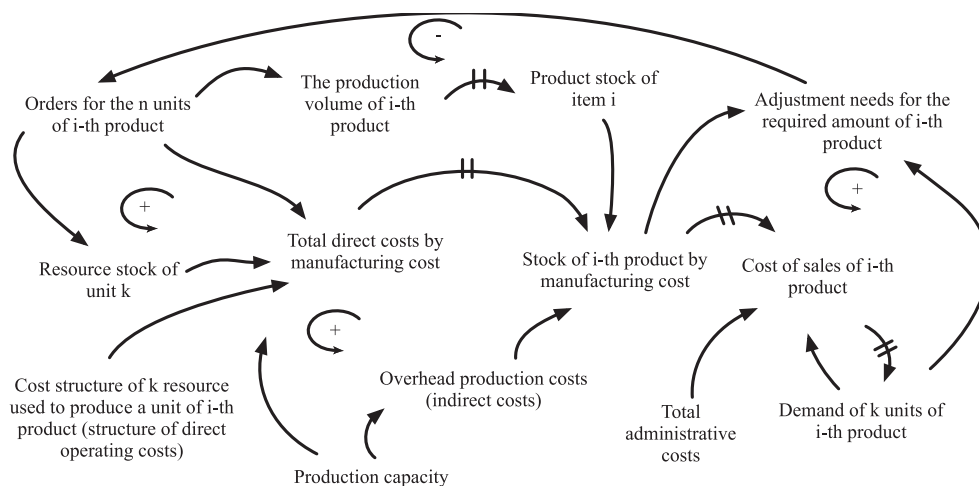
increasing of the marginal income is deferred in time, that is an additional complicational factor.

In mentioned terms the possibility of bankruptcy is taking into account on the assumption of inefficient use of capital (significant increase  $F_3$ ) as well. Innovative development is related with principled changes of the conditions of production and decision-making mechanisms, notably by a change of correlation  $V/D$ , and also  $\mu_1$ . Moreover, levels of functioning and development also may be divided into two subgroups according to the sources of attraction of financial resources and capital: with a constant structure and a cost of capital and with significant changes in the structure and cost of capital [4; 23].

Taking into account the basic assumptions of the conceptual model of basic relationships of financial indicators of the enterprise's development and functioning let's consider ways of its implementation in single sub models of the financial management of operational activity, cash flows and resources' allocation between the centers of financial responsibility.

*Model 1. Model of management of the operating activity of the enterprise* can be formalized as the following diagram of cause and effect relationships (fig. 2). As it is shown in fig. 2, the industrial process (the main activity of the enterprise) is represented by the processing of production resources (conversion of capital) that leads to the creating of finished product, that is further liable for realization.





**Fig. 2. The diagram of cause and effect relationships of the system-dynamic model of management of the enterprise's operating activity**

Two parallel processes are illustrated on the diagram (fig.2): creation of a natural part of the finished product, and creation and distribution of cost valuation of results. Natural indicators (conventional units of production) are introduced into the financial model for further implementation of the function of distribution of financial indicators (costs, profit). In particular, the direct production costs can be distributed without the use of natural component, but overhead and general running costs require the additional input of the conventional base of distribution. Similarly the meaning of the natural base of distribution affects the assessment of indicators of production prime cost of finished goods and prime cost of products sold, that complicates the implementation of the basic model in the practice of management as well. However, the noted system-dynamic approach rejects the need for introduction of conventional factors and patterns of distribution of indirect costs.

The model which is shown in fig. 2 is a formalized presentation of complex of basic mechanisms of financial management of enterprise's operational activity. However, even in a such generalized form noted dynamic relationships allow to assess the possibilities for enterprise's sustainable functioning in medium and long term prospects, to clarify the parameters of the production plan, to determine the reference values of the operating budget of enterprise etc.

A simulation model of financial management of the enterprise's operational activities (fig. 2) confirms to the principles of the conceptual model of basic relationships and financial indicators of enterprise's functioning and development that were proposed earlier (fig. 1), notably:

- the main emphasis is made on the information-analytical aspect of modeling;
- the economic system as object of modeling includes basic financial indicators that can be

expressed in money terms and can be associated with relationships of distribution and redistribution;

- requirements to modern systems of management accounts are the basis of the model.

Further we will consider the setting of the model of management of enterprise's money funds for the grounding of the basic proposals for improving of the efficiency of management of the enterprise's operating activity.

*Model 2. Enterprise's cash flow management provides the definition of such input constraints, namely:*

1. In the context of the managerial system the operations are detailed only within the processes of operating activities. However, further conditions of model building allow to include variables in it, associated with processes of development.

2. There are no restrictions to attract short-term liabilities and debts receivable formation, but the raising of capital cost and resources is taken into consideration as a result of breaking of the payment discipline, that further leads to reduction of the level of stability of the enterprise's financial system as a whole.

3. It is expected that the structure of expenditures of enterprise is known beforehand. Despite the fixing of parameters of prime cost, the behavior of the system may be investigated on basis of a model as a result of changes in the structure of costs.

4. Prices for resources are unchanged over time, in particular, the inflation level, level of exchange rates are not taken into consideration, changes in demand are expressed in the increasing of the level of lack of demand on product. This limitation can be easily removed, however it does not have an essential loading within the proposed model, but only complicates the task formulation.

5. Classification of product's costs and period's expenses. In order to make the most accurate valuation of cost of inventories and determination of the financial result of enterprise's activity, the management

distribution of costs for some key groups is expected. In particular, the financial result as the difference between revenues and expenses in the reporting period within the mechanisms of management of payment flows supposes the necessity to define which costs refer to the reporting period and which costs increase or reduce the expenditures of the following period. Therefore it is necessary to separate the costs for past and unexpired. In particular, past costs on production are reflected in reports and budgets of revenues and expenditures during the formation of financial result and prime cost of products sold, are defined by taking into account the changes of remains of inventories. On the other hand, all costs are directly associated with the production or acquisition of goods. Therefore, to determine the prime cost of production the costs of production and costs of period are distinguished. This approach to costs is quite reasonable, since the cost of rent, for example, should be funded regardless of the number of purchased or sold goods. However, costs on goods will be exhausted only when goods are sold and the revenue is received [3].

Taking into account certain conditions, the effect of financial leverage of the working capital [6] and the risk of attracting of current credit resources, [4; 9] the processes of appearing and repayment of current liabilities deserve attention in a relationship with directions of their use to finance certain current assets that is presented as a diagram of cause and effect relationships of the appropriate system-dynamic model of management of enterprise`s cash flows. (fig. 3).

The economic content of dependencies within the determined approach (fig. 3) is a following. During the formation and repayment of current debt, as the result of the effect of the financial leverage of working capital [6], fixed costs *are increasing* on the cost of borrowed funds in the same period of modeling and in the future, taking into account the specific delay in time (indicated

on the figure by parallel lines), the price of resources is changing as a result of a negative market reaction to the change in a payment discipline. A similar negative impact with a delay in time causes a significant long-term increasing of the debts receivable, that is connected with a loss of confidence to certain buyers.

As shown in fig. 3, the model of management of enterprise`s monetary funds is based on an accurate distribution of appropriate objects of management, including the separation of the concepts of «capital», «assets» and «financial resources». In addition, the implementation of appropriate management decisions determines the need for extension of the classical meaning of the effect of financial leverage by including parameters and characteristics of the calculation of the effect from changes of the structure of enterprise`s working capital and from sources of financing of current assets.

The internal structure of financial relations of the enterprise can be presented as a set of interrelated processes that are arranged by links between centers of financial responsibility. Thus, further attracting and using of enterprise`s financial resources are detailed within certain responsible persons [9; 10] that requires the necessity of formalization of processes of management of resources distribution between the centers of financial responsibility.

*Model 3. The model of resources` allocation between the centers of financial responsibility.* Taking into account defined basic approaches to identifying the indicators of financial self-organization [5] let`s define the basic cause and effect dependencies of the model of resources` allocation of enterprise`s centers of financial responsibility.

Key principles of realization of the mechanism of self-organization of financial centers of responsibility, that are based on the indicated model are following: [4; 8; 9; 10]:

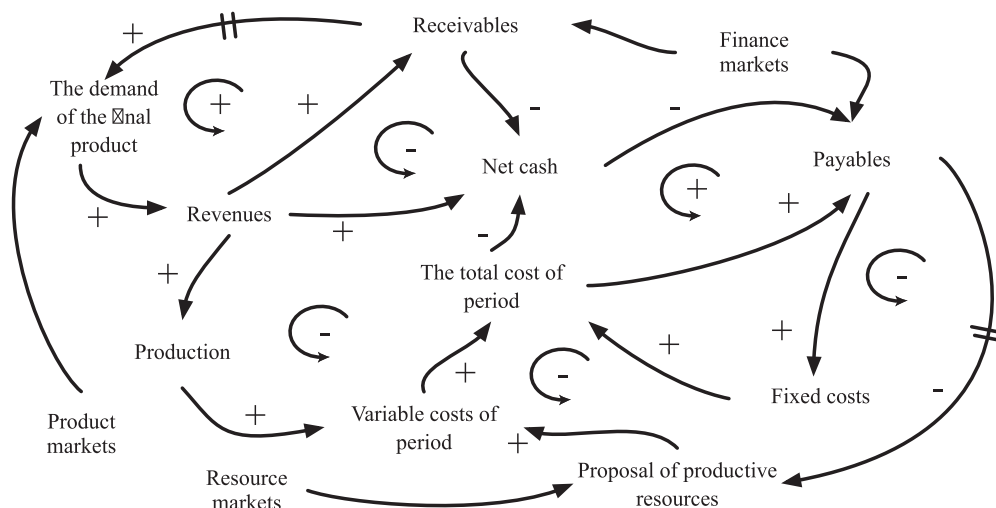


Fig. 3. The diagram of cause and effect relationships of the system-dynamic model of management of enterprise`s flows of monetary funds

- increasing of the efficiency of functioning of a certain center of responsibility (income, expenses, cost) is caused by the expansion of financial powers and duties of its managers and personnel;

- the superfluous restriction or expansion of financial powers and duties leads to a significant reduction of efficiency.

*Management of resources` allocation of centers of financial responsibility refers to following tasks:*

- creating of conditions for expanded reproduction of capital value of the enterprise as a whole and it`s certain centers of financial responsibility taking into account the action of the synergistic effect as a result of use of limited financial resources that can be shown in increasing of the economic value added, value added of equity, reduce of raised capital cost etc.

- improving of the efficiency of resources` allocation by centers of responsibility on the basis of conducting of the generalized valuation of complex of property, selection of rational scenarios of enterprise`s development, formation and implementation of the program of control of operational activity etc;

- unloading of feedback informational channels on the basis of the improvement of methods of financial control, which involves the formation and organization of financial calculation center as a center of responsibility; profit sharing based on the comparative effectiveness of functioning of centers of responsibility; use of generalized powers and methods to encourage processes of distribution at the strategic and tactical levels [5].

During determination of the basic dependencies of the system-dynamic model of resources` allocation of centers of enterprise`s financial responsibility the following input conditions are introduced:

- the use of the universal instrument for attracting of additional funds by the center of responsibility and

an asset of its profitable use (the only universal asset with stable marginal income of the center of responsibility) is expected;

- financial self-organization factors are introduced to a model with the help of further forecasted functional dependencies that are defined by the level of financing of subdivisions from centralized and decentralized sources, additional bonuses to subdivisions` managers;

- the availability of restriction of mastering of additional funds by the center of responsibility is expected, and also the recession of the impact of use of assets is taken into consideration as the result of the significant increase of financing.

Mentioned restrictions can be taken away during the practical implementation of the model, but within this research their implementation significantly increases the visibility of proposed results to implement the methods of financial self-organization.

As shown in fig. 4, processes of income and expenditure from management block (internal system financial center or regulation center) and external financing of centers of responsibility at the expense of the debt capital *are studied within* the model. If total resources of the enterprise have been reducing or have not been increasing during the certain period of time, a decision about additional financing of the centers of responsibility is taken. The assumption that the efficiency of the funds use, that were raised at the initiative of the center of responsibility, is higher than incomes from invested financial assistance from the center of regulation is admitted. All available funds are used for the formation of incomes of the center of responsibility within "The restrictions for mastering of resources". The average balance of own funds of the center of responsibility, debts, financial assistance and financial resources of the system is calculated on the basis of variables with delay of information. Let`s assume also

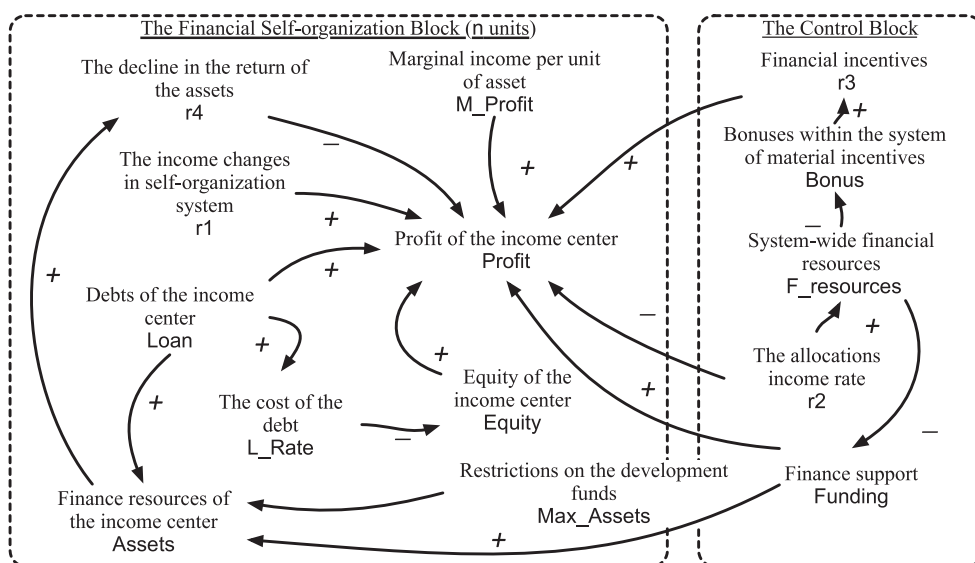


Fig. 4. Diagram of cause and effect relationships of the model of distribution of resources between the enterprise`s centers of financial responsibility



that the enterprise concluded a treaty for current crediting and in case of reduction of internal system financing, additional credit resources are involved automatically. Conversely, financial assistance from the financial center displaces the credit financing.

Thus, the main directions of regulation of financial self-organization processes from the side of the general system financial center are mutual payments in the form of fees and financial aid. The production function that is based on the assumption that the excessive growth in the structure of financial resources of the proportion of "center" or separate structural subdivisions leads to the reduce of the efficiency of activity as a whole is the most appropriate for the overall valuing of processes of self-organization of centers of financial responsibility.

### **Conclusions of the research and prospects of further development**

1. Taking into account the fact that modern instruments of enterprise's financial management have to consider a large number of factors and relationships, it is impossible to ensure the effective implementation of any management influence on the basis of use of unit and static methods, including management accounting and financial analysis, that is a widespread practice for local managers. On the other hand, significant negative implications of realization of unfounded decisions for enterprise's financial system require the search of more universal alternatives and the combination of modern innovative approaches to preparation and acceptance of management decisions. Thus the expediency and the need for innovative instruments of preparation and acceptance of use of system dynamics during the preparation and implementation of financial decisions on the enterprise is proved.

2. The principles of building and basic relationships of financial indicators of the functioning and development of the enterprise are determined. The necessity of conventional separation of instruments of enterprise's financial management on three levels (conditions) of changes in the financial indicators, notably: the stable functioning (without change of fixed costs and relative variable costs), investment development (growth of fixed costs without significant changes of relative variable costs) and innovative development (the structure of costs, receipts, risks etc. is changing essentially) is proved. According to sources of attraction of financial resources and capital, levels of functioning and development can be also divided into two groups: with a constant structure and cost of capital and with significant changes in the structure and cost of capital. Identified interdependencies and principles require the necessity of formalization of single sub models of operational activity and management of enterprise's cash flows as well as distribution of resources between the centers of financial responsibility.

3. The processes of operating activity within defined system-dynamic approach is a generalization of the classical principles of capital and resourced transformation during the production use of assets, that leads to the creation and realization of the finished product. Two parallel processes in the model of management of enterprise's operational activity are observed: the creation of a natural part of finished product as well as the creation and distribution of value part of production which allows to determine the limit and amounts of use of financial instruments. The implementing of the appropriate model enables to estimate the forecasted financial indicators and risks of the enterprise's stable functioning in the medium and long term perspective, to clarify the parameters of the production plan, to determine the review of enterprise's operating budget etc.

4. Appropriate cause and effect relationships of the appropriate model are determined as a formalized introduction of the mechanism of management of enterprise's cash flows, that allows to determine the forecasted indicators of interconnected increasing of the productivity of use of production and financial resources. The possibility to study the impact on the structure and effectiveness of the capital and cash flow dynamics of such indicators of activity as: the level of debts receivable and accounts payable, average balances, prices and demand for the finished product, fixed and variable costs, the cost of attracting of financial resources, the efficiency of processes of operational activity etc. appears.

5. The basic cause and effect relationships of the system-dynamic model of financial distribution of resources between the centers of enterprise's financial responsibility are determined on the basis of defined approaches to assess the effect of financial self-organization. The appropriate model predicts that in case if the amount of enterprise's financial capital is decreasing or increasing during a certain period of time, a decision to further investment in the development of the center of financial responsibility is accepted. The efficiency of use of funds that are involved on the initiative of the center of financial responsibility is higher than returns from financial aid from the «center» of corporate financing. In case of the reduction of financial aid by the center of financial responsibility, additional credit resources are involved (the effect of financial leverage is realized). Thus, the indicated approach allows to determine the optimal level of powers and apartness of centers of enterprise's financial responsibility.

The main direction of further development of determined principles and formalized dependencies is their practical application during the construction of complex of models of enterprise's management in various sectors of economic activity and summarizing of received results.



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