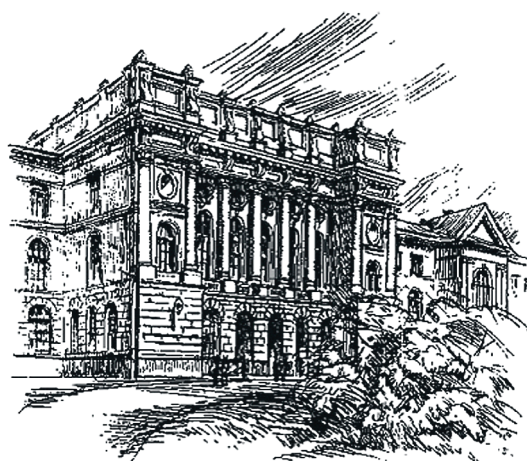


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**ST. PETERSBURG STATE  
POLYTECHNICAL UNIVERSITY  
JOURNAL**

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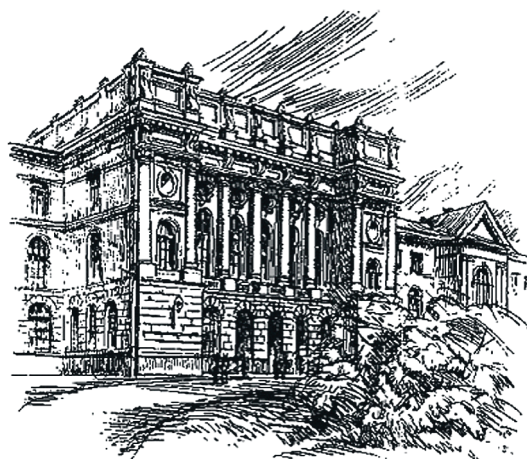
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МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ



# НАУЧНО-ТЕХНИЧЕСКИЕ ВЕДОМОСТИ

САНКТ-ПЕТЕРБУРГСКОГО ГОСУДАРСТВЕННОГО  
ПОЛИТЕХНИЧЕСКОГО УНИВЕРСИТЕТА

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# НАУЧНО-ТЕХНИЧЕСКИЕ ВЕДОМОСТИ САНКТ-ПЕТЕРБУРГСКОГО ГОСУДАРСТВЕННОГО ПОЛИТЕХНИЧЕСКОГО УНИВЕРСИТЕТА

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**V.V. Pshenichnikov****DISCUSSIONS ON THE NEED FOR A SINGLE WORLD CURRENCY  
IN TODAY'S GLOBALISED MULTIPOLAR WORLD****В.В. Пшеничников****ДИСКУССИИ О НЕОБХОДИМОСТИ ЕДИНОЙ МИРОВОЙ ВАЛЮТЫ  
В УСЛОВИЯХ ГЛОБАЛИЗАЦИИ И МНОГОПОЛЯРНОСТИ  
СОВРЕМЕННОГО МИРА**

This paper discloses the manifestations of globalization in the overall monetary and financial sphere; the practice of using a national currency as an international currency in the second half of the 20th century; the conflicting economic interests of Euro-Area countries at the beginning of the 21st century; the concept of creating a global reserve currency and its criticism. An attempt was made to assess positive and negative consequences of using the US dollar as the world's reserve currency in the 20th century; to consider the main advantages and contradictions in the functioning of the Euro as a regional currency; to present various positions on the political benefits and economic contradictions with respect to using the global reserve currency; to justify the assumption that the system of multiple reserve currencies should be preserved and further developed. However, the author does not exclude the possible emergence of a global supranational currency, the functioning of which will not be subject to the political will or economic conditions of individual states or their groups. It is hypothesized that the single international currency of the future will be electronic. The singular and specific character of electronic money is exemplified by the experience of using the digital currency known as Bitcoin. Its introduction spurred the creation of a new way of money emission and turnover, and generated a number of controversial opinions on the perspectives of its application. Most significantly, Bitcoin differs from traditional types of electronic money and cashless payment instruments in the way that Bitcoin emitters assume no liability whatsoever. Bitcoin is a virtual currency, a number associated with a number of conditions. Only the person who meets access requirements can use the money. It is typical to use a Bitcoin address, but there are other options as well. Bitcoins can be used only within the Bitcoin payment system. The value of Bitcoin is not pegged to the value of any other currency or asset. Its exchange rate is determined only by supply and demand. The issues of how distant the above-described future is and whether the cyber currency will still be called Bitcoin remain pending. The answers will unfold along with further development of information technology and deepening globalisation of international economic relations. It is infinitely more difficult to foretell the name of this global electronic currency and its emitter, or, at least, the institution that would support and regulate the issue, turnover, and destruction of electronic payment instruments.

THE GLOBALIZATION; WORLD CURRENCY; REGIONAL CURRENCY; POLITICAL INDEPENDENCE;  
ECONOMIC SOVEREIGNTY; ELECTRONIC MONEY.

Раскрываются: проявления процессов глобализации в мировой валютно-финансовой сфере; практика применения национальных денежных единиц в качестве мировой валюты во второй половине XX в.; конфликт экономических интересов стран зоны евро в начале XXI в.; идеи создания глобальной резервной валюты и их критика. Предпринята попытка оценить позитивные и негативные последствия использования доллара США в качестве мировой резервной валюты в XX в. Дана оценка основным преимуществам и противоречиям функционирования региональной валюты евро. Сопоставлены мнения различных позиций о политических выгодах и экономических противоречиях при использовании глобальной резервной валюты. Обосновано предположение о необходимости сохранения и дальнейшего развития системы множественности резервных валют. При этом не исключается в будущем появление

глобальной наднациональной валюты, функционирование которой не будет подчинено политической воле отдельного государства или группы стран и соответственно не будет зависеть от экономического состояния последних. Высказывается гипотеза о том, что единой мировой валютой будущего станут электронные деньги. Уникальность и специфику электронных денег наглядно иллюстрирует опыт функционирования цифровой валюты — биткоин, породившей абсолютно новый механизм эмиссии и оборота денег и сформировавшей множество самых противоречивых мнений о возможности и перспективах ее применения. Одно из главных отличий биткоинов от традиционных электронных денег и безналичных платежных средств заключается в том, что биткоины не являются долговыми обязательствами эмитента. Биткоины нематериальны и являются всего лишь числом, связанным с набором условий. Воспользоваться данной суммой может только тот, кто выполнит все необходимые условия допуска. Стандартным условием является использование bitcoin-адреса, но условия могут быть и другими. Биткоины могут быть использованы только для передачи внутри этой платежной системы. Их стоимость не привязана к какой-либо валюте или другому активу. Курс обмена на разные валюты сейчас определяется исключительно балансом спроса и предложения на эту валюту. Открытыми пока остаются вопросы, насколько отдалено от нас такое будущее и будут ли иметь сетевые деньги название биткоин. Ответы на эти вопросы будут раскрываться по мере дальнейшего развития информационных технологий в связке с дальнейшим процессом глобализации мирохозяйственных связей. Гораздо сложнее предсказать название глобальной сетевой валюты и ее эмитента или, по крайней мере, организации, которая будет обеспечивать и регулировать выпуск, хождение и уничтожение сетевых средств платежа.

ГЛОБАЛИЗАЦИЯ; МИРОВАЯ ВАЛЮТА; РЕГИОНАЛЬНАЯ ВАЛЮТА; ПОЛИТИЧЕСКАЯ НЕЗАВИСИМОСТЬ; ЭКОНОМИЧЕСКИЙ СУВЕРЕНИТЕТ; ЭЛЕКТРОННЫЕ ДЕНЬГИ.

*Introduction.* The enhancement and deepening of such processes as international division of labour, specialisation and cooperation in the production of goods and services, the growth of transnational corporations and regional economic associations require adequate transformations in building currency relations between countries. The efforts to use freely convertible currencies (US dollars, British pounds, Japanese yens, etc.), an International Monetary Unit (IMU), a Common European Currency (the Euro) as a universal money represent the attempts to design a single global currency. The experience of applying various currency derivatives as a universal money throughout almost the whole 20th century makes us face such issues as: who will be the issuer of this universal money and lay down the rules governing its turnover, what amount of such money are to be issued, who will be able to use it, and on which conditions it can be used.

In search for the possible answers to the above stated questions we will briefly look at the history of the international monetary system in the 20th century so as to summarise the experiences and the ideas of those who stood at its origins and those who now offer different options concerning the creation of a global reserve currency.

In relation to the latter, we would like to focus on some points of view and certain statements made by such experts as J.M. Keynes, who proposed the idea of an international reserve

currency to be issued by a supranational bank over 70 years ago; R. Mundell, the 1999 Nobel Prize Laureate in Economics, who developed the theory of optimum currency areas, which played a significant part in establishing the Economic and Monetary Union of European countries; Joseph Stiglitz, a Nobel Prize Laureate in Economics, who supervised the work of a UN Commission of Financial Experts on the report «On Reforms of the International Monetary and Financial System: Lessons from the Crisis» in 2010; I.G. Pashkovskaya, who studied the fundamental legal principles of European economic and monetary integration.

**1. Manifestations of globalization in the world monetary and financial sphere.** The early 21st century is marked by the global economic crisis, local military conflicts and revolutions that led to a political regime change in more than one country. We consider these processes to be closely interconnected and caused by at least two oppositely directed processes — the globalisation of the world economy on the one hand, and multipolarity in the political interests of independent states and state groups on the other hand.

By globalisation we mean the process by which national borders cease to be significant, countries lose their economic independence, and cultural differences brought about by differences in social patterns become a critical business concern [4]. Due to these complex and dynamic





factors, the world is turning into one great market-place.

Financial globalisation manifests itself in the following processes:

1. The consolidation of bank, insurance and loan capitals, which manifests itself in massive mergers and acquisitions of banking, insurance and reinsurance societies in international financial markets and leads to the development of transnational financial groups.

2. The formation of clusters among consumers of financial services, which manifests itself in the growing capitalisation of transnational financial groups and changes their demand for traditional banking services.

3. The change in demand for «mass» banking services, including stepped up participation of banks in mortgage credit lending amid the increased paying capacity of the population in developed countries and decreased social support from the state.

4. The change of the market environment in the age of computer-wise consumers of banking services and the Internet being used to sell banking services, to introduce the uniform management system for banking organisations, to organise the domestic market, and to create promotional networks.

5. Changes in international economic activities brought about by a number of factors. Among them there are the establishment of a single market (for instance, EU), an increase in foreign investment spending in emerging industrial economies, new scopes for investment found in post-socialist states as well as the further development of science and technology, global economic liberalization and growing competition.

6. Changes in the impact of time and distance. It is well known that doing business across borders implies covering long distances. Achievements in the communications area, such as satellite communications, do not only accelerate cooperation, but also allow for real-time control over international transactions.

7. Changes in global competition. Due to rising competition, banking organisations are progressively affected by international markets. On the contemporary stage in the development of the world economy, a business does not have to expand overseas to face international competition.

8. Technological developments in the area of telecommunications exercise significant influence over the global financial market, on the one hand, providing consumers all over the world with direct access, and on the other hand, creating demand for the new banking services able to offer protection from illegal access to electronic information [11.].

**2. Precedents in using a national currency as the world currency in the second half of the 20th century.** If we referred back to the creation and development of the global currency system, we would discover that world wars and economic crises consistently induced world society to transit from one common currency to another.

In point of fact, the global currency crisis caused by World War II and the preceding events compelled Anglo-American experts to develop a project for a new international monetary system. Its basic principals were stated at the UN Monetary and Financial Conference held from 1 to 22 July 1944 at Bretton-Woods, USA.

The original gold exchange standard to be introduced was based on two currencies – the US dollar and the British pound. Eventually, though, the pound depreciated while the dollar strengthened, so the standard evolved into a gold-dollar exchange one. To grant the dollar the status of the world's main reserve currency, the US Treasury continued to allow foreign central banks to exchange dollars at the 1934 rate of \$35 per troy ounce of gold.

The exchange rates could deviate from the established parity but fluctuate only within narrow limits ( $\pm 1\%$ ). Moreover, central banks were required to maintain these margins with currency interventions; a more than 10% devaluation of the currencies could occur only with the permission of the International Monetary Fund, which meant introducing a currency corridor for the currencies of the countries that joined the Bretton-Woods Agreement. The central banks of these countries were to accumulate reserves in US dollars in order to conduct necessary currency interventions. In case the exchange rate of a national currency went down, the central banks unloaded their dollar reserves. But if otherwise, they had to acquire US dollars. Thus, currency interventions were seen as a self-adaptation mechanism that helped the international monetary system to

adjust to the changing outer conditions, not much unlike transferring gold reserves to regulate the balance of payments under the gold standard. In practice, this meant that state banks of other countries had to bear expenses of supporting the US dollar, which was one of the signs of US hegemony in global currency relations. On top of that, the duty to accumulate dollar reserves contributed to the strengthening of the US dollar.

The US dollar-based monetary system could only be stable if the USA stayed in the driver's seat of the world economy, and until their gold reserves could provide for the conversion of the overseas dollars into gold. To this purpose, in the late 1940s the USA accounted for about 75 % of the world's gold reserves, over 50% of the world's industrial production, and 30 % of the capitalist economies' export. However, by the 1970s the world's gold reserves had been redistributed in favour of Europe, where they amounted to 47 billion dollars against 11.1 billion dollars in the USA. That was also when the problem of international liquidity arose: from 1948 to 1969 gold production increased by 50% and the world export grew two and a half times, which resulted in there being not enough gold to maintain the gold parity rate of the US dollar. The second factor contributing to the crisis in the international monetary system was the enormous balance-of-payments deficit incurred by the US. It was caused by the outflow of dollars from the country, which led to the development of the Euro-dollar market and declining trust in the dollar as a reserve currency. Finally, the rise of new financial centers in Western Europe and Japan deprived the USA of their dominant position in world finance [11].

Currency crises occurred at different times. They varied in scope and left no country unaffected. The USA were persistently reluctant to admit the failure of the Bretton-Woods system, all the while trying to shift the financial burden of keeping it on track onto other countries by resorting to:

a) the revaluation of certain currencies (for instance, both the Swiss franc and the Austrian schilling were revalued in May 1971), which practically equalled the indirect devaluation of the dollar, but did far less damage to the image of the country;

b) an increase in import duties;

c) the cancellation of the convertibility of US dollars to gold.

The understanding eventually came with the abovementioned developments that the basics of the then existing monetary system were due to be revised. On 16 March 1973, during the International conference in Paris, it was decided that currencies would no longer be pegged and that exchange rates were to be regulated by supply and demand forces, notwithstanding what was expressed in the IMF Charter. In such a manner, the Bretton-Woods system ceased to exist.

The first attempts to put together a bailout plan that would help to overcome the currency crisis were made in the academic community and later resumed within the establishment and in numerous committees. A number of monetary reform projects were proposed, varying from the creation of a collective reserve unit, a single global currency backed by gold and commodities, to the return to the gold standard. In 1972–1974 the IMF Committee of 20 prepared a project aimed to reform the international monetary system. After all, agreement was reached on the introduction of the current international monetary system at the IMF conference in Kingston, Jamaica, in January 1976. Amendments to the IMF Charter became effective in April 1978 with the consent of the majority of the IMF member countries. Under the arrangement, the newly established system gave member countries a free choice of an exchange rate regime (mostly, free float, hard peg or their combination) and a multicurrency standard, in other words, an opportunity to choose a type of international liquidity. This meant that the new monetary system was designed to be symmetrical.

The transition to flexible exchange rates involved reaching three main goals:

1) equalising inflation rates in different countries;

2) balancing payments statements;

3) expanding opportunities for certain central banks to carry out an independent monetary policy.

The Jamaica agreements called for:

1) polycentrism, i. e. the new system was based on a number of key currencies: the US dollar, the British pound, the Japanese yen, the Deutsche Mark and the French franc;



2) formally abolishing the mint parity defined by the gold contents;

3) employing freely convertible currencies, the SDR, and reserve positions in the IMF as the main forms of international liquidity;

4) no fluctuation limits for exchange rates. Foreign exchange rates are determined by supply and demand for currencies;

5) national central banks were no longer required to maintain exchange rates of their national currencies linked at fixed parity. However, they have the right to stabilise them through currency interventions;

6) the ban to express the chosen exchange rate regime in gold;

7) the IMF closely monitors developments in exchange rate policies; IMF members are not to manipulate their exchange rates to gain competitiveness.

By now, all developed countries have adopted floating exchange rates. The SDR plays a certain role in the world monetary system, having become a measure of the international value of a currency, an important reserve asset, and a popular means of international payments. The SDR is an artificially created international reserve currency, meant to manage balances of payments, to replenish foreign currency reserves and to perform settlements with the IMF. The allocation of SDRs to IMF member countries does not require any foreign currency amounts to have been transferred to the Fund or any goods or services to have been sold. The SDR is not secured by collateral of any kind. Its use relies on the agreement between member states of the SDR system to accept this reserve means in return for convertible currencies.

The way the Jamaica monetary system operates is not without a certain level of controversy. Some of the original expectations about the introduction of floating exchange rates turned out to be unjustified. One of the reasons why it happened is there is a vast variety of actions available to member countries. In practice, it has been a while since exchange rate regimes were practiced in their pure form. For instance, the number of countries that pegged their currencies to the US dollar reduced from 38 to 20, to the SDR – from 11 to 5, and then to 4 in the period from 1982 to 2001. It is worth noting that, eight countries practiced independent floating regimes in 1982, but by 1994, their

number increased to 52. The countries that announced their currencies as free floating maintained the exchange rates through interventions, so, in fact, those were not free but managed floating regimes [8].

Another reason is that the US dollar still dominates the Jamaica monetary system. This fact can be explained by the following:

a) individuals and governments all over the world have been in possession of significant dollar reserves since the Bretton-Woods epoch;

b) there will be a deficit of universally accepted alternative reserve and transaction currencies as long as the balance of payment in those countries whose currencies can claim the US dollar status (Switzerland, Japan) continues to feature a surplus;

c) the Euro-dollar market creates dollars regardless of the condition of the US balance of payments, providing the global monetary system with a means of transactions.

The Jamaica monetary system is characterized by volatile fluctuations in the exchange rate of the US dollar resulting from the controversial economic policy of the USA shaped by their expansionary fiscal and restrictive monetary policies. Fluctuations in the dollar have caused a number of currency crises. The developments listed above show that, firstly, under the Jamaica monetary system, there appeared a group of dollar-oriented countries (forming, in fact, a new dollar zone), and, secondly, this monetary system, contrary to what it was thought to be, turned out to be asymmetric. Furthermore, the goals the system was initially meant to achieve should have been laid down in its basis, i. e. it was advisable to wait until all member countries came to the more or less stable equilibrium of inflation and balance of payments which could have provided a stable groundwork for the system. As for the third goal – the independent domestic monetary policy, – its implementation does not contribute to the development of the system quality.

The SDR concept did not go far in terms of practical application; its share in total foreign currency reserves (excluding gold) reduced from 5.5% in late 1975 to 1.2% in late 2000. Regarding the market price of gold, the SDR share in the total volume of international liquidity reserves amounts to a miserable 1.1% [8].

As the result, demands for a, more balanced international monetary system are being made.

For instance, in October 2000 over 30 members of the Italian Senate came forward with the initiative to reintroduce a new version of the Bretton-Woods Agreement.

R. Mundell, the 1999 Nobel Prize Laureate in Economics, suggested establishing a new fixed exchange rate area which would use a platform made up of the dollar, euro, and yen. His theory of optimum currency areas provided important insights into the creation of European Economic and Monetary Union.

**3. Conflicting economic interests of Euro-Area countries in the early 21st century.** It is debatable whether the problems of the existing monetary system can be solved by introducing a supranational international reserve currency. Indeed, the concept of an international reserve currency issued by a supranational bank dates back to 1930, when it was put forward by J. M. Keynes in his work «A Treatise on Money». Keynes further developed his ideas and eventually made a proposal for an International Clearing Union at the Bretton-Woods conference.

The experience of European Economic and Monetary Union (EMU) reveals a number of disproportions at the institutional development level of its components. The Maastricht Treaty does not contain statutes on the institutionalisation of the Economic Union in the EMU framework. Some of its complexity is attributable to the fact that the establishment of a central economic body of the European Community involves signing a new association agreement, as the Community law refers to the international law procedure of establishing a new institution or body within the Community.

The Community has no body to design and carry out a uniform economic policy that all member states of the EU would be subject to. This can produce an overall negative impact on the EMU, since it can function properly only when all its member states coordinate their monetary, economic and financial policies. Experts are of the same opinion. They believe that «the introduction of a single currency inevitably leads to the creation of a European economic government» as there is a need for «a closer coordination in tax policies» [6].

The natural need for a single economic body within the EMU system which would define and carry out economic policies, uniform for all

member states of the EU and aimed at inducing their economic prosperity, is indicative of a centripetal tendency in the economic union. However, there is another reason why the creation of such a body would be most welcome. The fact of the matter is that ECB and the ESCB are the institutions whose independence protects them not only from the political influence of other institutions and bodies of the Community, but also from the influence of EU member states. Still, this independency factor has a negative aspect as the institutional structure of the Community lacks an economic body which could counterbalance the ECB.

There is another factor that adds to the complexity of the problem connected with the institutionalisation of the Union's single economic body. Basically, European economic and monetary integration comprises two non-equal components: economic and monetary – which are interdependent, but function differently. The monetary policy is used as carrot and stick incentives to influence an economy in a desired way. It is commonly known that monetary policy is the most effective tool that national governments can use to improve the economic situation inside the country. Nowadays, there is an underlying paradox within the Community: on the one hand, the ECB defines and implements the unified monetary policy of the Community, while on the other hand EU member states have varying domestic economic conditions. This implies that different member states should be able to conduct different economic and monetary policies.

According to the earlier view, the introduction of a uniform currency should have induced Germany and France, who account for over half of the Community's GDP, to develop at an equal pace and drive economic growth throughout the whole of Europe. However, experts point at the opposite tendencies in the development of European economies. In 2002 inflation in the Eurozone exceeded the acceptable level for those EU member states that participate in the EMU. It is inappropriate to apply a uniform currency and economic policy to EU member states when their economies experience difficulties. It can be compared to a situation when a doctor prescribes the same scheme of treatment to patients suffering from different diseases, or when an examiner gives one



and the same grade to a group of students instead of assessing each student's answer individually.

Another observation that argues against institutionalising the economic union entails that the creation of a central economic body within the Community would mean that the budget and taxation policies of its member states would become subject to it. This, in its turn, would authorise this body to manage the state incomes, assignations for support and development of all the areas of member states' activities, including the most important ones, such as national defense, energetics and infrastructures. For member states, this would equal surrendering certain elements of their state sovereignty to the Community.

The creation of a central economic body in the Community is impossible without touching upon the basic features of member states' constitutions. This can be explained by the following: to create such an economic body, EU member states would have to pass on their sovereign right to control their national budgets, which lies within the competence of their national parliaments. The delegation of the right to control the budget to the Community would lead to the disruption of structural balance in the highest agencies of EU member states, as this would restrict the authority of their parliaments in comparison to other supreme bodies of state power, and besides, the parliaments would be deprived of an important tool of control over their national executive branch.

EU member states have different points of view on the issue of creating a single economic body, which can be explained by the differences in the levels of their economic development. As a result, EU member states have divided into two groups according to their economic interests: the developed industrial economies of the North and the less developed economies of the South of Europe. Wealthy EU member states oppose the idea of creating a central decision-making body, while poorer ones support this idea as they hope to redistribute a part of the Community budget and obtain some of the funds that come from their wealthier counterparts.

The development of the EMU is sustained by two tendencies. On the one hand, a growing economic interconnection of EU member states leads to the demand for a better coordination of

their economic policies as well as association of their budget and tax efforts. This is reflected in the work by P. Manin «Les Communautés Européennes. L'Union Européenne. Droit Institutionnel», who, giving estimate to «communitarisation» of monetary policy and the absence of the same process in the economic sector, comes to the conclusion that «beyond doubt, this difference is pretty much artificial, and if monetary policy remained the same, as it was designed in the Agreement, the economic independence of EU member states would be substantively limited» [6].

On the other hand, industrially developed EU member states, who define the position of the European Convent, speak out against the institutionalisation of the EMU and for the reservation of their sovereign right to define and implement their own national economic, budget and tax policies. In the speech delivered in December 2002 by V. Giscard d'Éstaing, it was pointed out that «economic policies remain within the competence of EU member states. The Convent has reached no consensus over a better way to coordinate economic policies. No one can argue that the fiscal competences of EU member states as they were formulated in the Association Agreement», which stated the position of the European Convent towards the perspectives of the EMU development [6].

**4. Creating a global reserve currency: pros and cons.** At present, there are several alternative proposals for a new universal reserve currency, a system of possible currency changes, its emission and allocation, as well as the ways to secure the most effective transfer to a new currency. To solve all transfer-related problems, a serious discussion at the level of the world community is needed. However, the time to implement the idea has already come. The proposal is reasonable and conforms to the demand of the time.

The global reserve currency related to no country's external economic position could provide a more effective way to solve the problems of global liquidity and to maintain the global macroeconomic stability. It is also meant to reduce the risk of accumulating excess liquidity in the country of the reserve currency. The reformation of the world monetary system must also include innovations to improve risks sharing in an effort to reduce the need for

reserve accumulation and, consequently, to reduce the required amounts of liquidity.

According to Joseph Stiglitz, a winner of the Nobel Prize in Economics, the system being formed should also possess tools to put countries under pressure in order or to force them to decrease their excess reserves and by that – their «contribution» to the insufficiency in total demand. This, in his opinion, would establish a better balance in international accounts [5]. However, we do not share this point of view since we doubt the practicability and lawfulness of interfering into foreign economic policies for the sake of resolving problems in international accounts. Furthermore, when it comes to putting pressure on independent states, there arises the question of who, for whose benefit, and how is going to use it.

J. Stiglitz emphasises that the system based on several competing reserve currencies would be unable to solve the problems of the current system, since the latter cannot solve the problems connected with national currencies used as reserve assets. This mostly refers to industrially developed countries [5].

At the same time, the main advantage of a plural reserve currency system is its diversified nature. This, however, may cause certain instability. If central banks and individual mediators in respond to the fluctuations of currency exchange rates change the asset composition, they will create a friendly environment for currency exchange rates instability. Under such circumstances, the introduction of a multicurrency reserve system may provoke a backlash and induce return to a fixed exchange rate. Yet, its reintroduction is a risk alert for the main currencies in the world of free capital movements; to complete this task, the coordination of actions and reneging on independent credit and monetary policies are required, which is considered impossible today.

Finally, turning national currencies into reserve ones is particularly exigent for countries with limited scope for their monetary and budget policies.

All these contradictions came forth in the period before the current financial crisis and could contribute to its aggravation. The desire of countries to increase their holdings of domestic currency assets and international reserves in

response to the atmosphere of uncertainty on world markets adds to the problem of aggregate demand which the world economy is now faced with.

An increasing national debt of the USA and balance of payments considerations in regard to the Federal Reserve System generate uncertainty about the stability of the dollar and thus have become major causes for concern among the countries with US dollar holdings. Besides, low (almost flat) profitability of their dollar reserves means there is no security for their currency risks. However, any attempt to reduce their dollar reserves will make them face the Triffin Dilemma, which states that such an action can lead to a fall in the value of their dollar assets, which is their greatest fear. These facts speak out in favour of the introduction of a universal reserve currency. Such a global reserve system would provide for global de-risking, since trust in its stability would not depend on any country's unpredictable economic processes or policies.

We are positive that sufficient latitude should be built into the system of a global reserve currency, especially when it comes to its emission and turnover as well as quotation and access provision. We find introducing and using electronic money like Bitcoin, whose emission and turnover are dependent from no organisation or country, a noteworthy experience [9].

According to J. Stiglitz, responsibility for managing the global reserve system could be given to the IMF, which currently issues the only global currency, Special Drawing Rights (SDRs), on which the system could be built. But it could also be given to a new institution, such as a «Global Reserve Bank». Return to present institutions would be possible after their reformation.

One of the possible approaches here is to have countries agree to exchange their national currencies for the new one, for example, International Currency Certificates (ICCs), which could be SDRs, – and, vice versa, in much the same way as IMF quotas are made up today (except that developing countries would make their quota contributions in their national currencies, not in SDRs or convertible currencies, as is the rule today). The functioning of this system would be similar to a system of worldwide «swaps» among central banks. Therefore, the



global reserve currency would be fully backed by a basket of the currencies of all member states [5]. However, we believe that this approach restricts economic sovereignty of independent states.

The existing regional agreements could provide an alternative way for a gradual transfer to the global reserve system. Regional mechanisms have their own advantages. They can be based on agreements among central banks on swaps, or association of reserves in foreign currency pools. As governments are not apt to release control over their own reserves, swap agreements look more preferable.

Association reserves have other advantages, such as the possibility to allot credits from a common pool in difficult situations, and, as it was stated before, issue currency or reserve assets to be used at the regional and global levels. In the 1980s, for instance, the Latin American Reserve Fund was allowed to issue Andean pesos. This asset, which had never been utilised before, was meant for international trade and periodic settlement of obligations between central banks of member countries through clearing accounts. Another important example of regional cooperation is the Chiang Mai Initiative – a system launched in 2000 by ASEAN states, China, Japan and the Republic of Korea. If this Initiative was implemented by creation of a reserve fund, it could be a guarantee of asset emission, which could become attractive for central banks in other parts of the world as a part of their reserve assets. However, in order for the Chiang Mai Initiative to be more effective in its stabilising role, the issue with the IMF and the eligibility criteria it imposes to restrict access to its swap lines has to be resolved.

Regional mechanisms were subject to general criticism for their inability to diversify the means of resistance to system crises, as member countries of regional groups also appear to be susceptible to their adverse effects, if we take into account that the decisions made at the regional level are addition to, but not in lieu of decisions made at the global level. Although the capacity of regional mechanisms to resist negative external effects depends on the capacity of member states to neutralize them by combined efforts, these mechanisms can be effective if negative external factors affect them with different intensity or at different times. Such a state of things would allow

a number of member states to allocate credits from their reserves to those member countries that suffer more serious negative effects. Furthermore, the right to resort to credit provision when there is a liquidity problem can limit the effects of a crisis to the country it broke out in, and thus protect other countries. By this, risks of contagion would be significantly reduced. Overall, the country will eventually benefit from joining regional agreements if variable constituent of a regional reserve pool is lower than it is in the reserves of the member countries, and if there is a potential access to the associated reserves restricts the possibility of harm to the other member countries. Such regional agreements serve as a tool of collective insurance, which is always more effective than self-insurance.

*Conclusions.* Therefore, we take the position that favours sustaining and further developing plural currency practices based on two-sided swap agreements between countries. However, we cannot exclude the possibility that a global supranational currency might appear in the future that would function with no regard to the political will of one state or a group of states, and, accordingly, would be independent from the economic situation in such a country or a group of countries. In all likelihood, electronic money will become a new global currency [12]. The singular and specific character of electronic money is exemplified by the digital currency known as Bitcoin. Its introduction spurred the creation of a new way of money emission and turnover, and generated a number of controversial opinions on the perspectives of its application. Most significantly, Bitcoin differs from traditional types of electronic money and cashless payment instruments in the way that Bitcoin emitters assume no liability whatsoever. Bitcoin is a virtual currency, a number associated with a number of conditions. Only the person who meets access requirements can use the money. It is typical to use a Bitcoin address, but there are other options as well. Bitcoins can be used only within the Bitcoin payment system. The value of Bitcoin is not pegged to the value of any other currency or asset. Its exchange rate is determined only by supply and demand.

The issues of how distant the above-described future is and whether the cyber

currency will still be called Bitcoin remain pending. The answers will unfold along with further development of information technology and deepening globalisation of international economic relations. It is infinitely more difficult

to foretell the name of this global electronic currency and its emitter, or, at least, the institution that would support and regulate the issue, turnover, and destruction of electronic payment instruments.

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**A.S. Marahovskij, A.V. Babkin, N.V. Shiryayeva**  
**OPTIMAL CONTROL**  
**OVER UNSTABLE MACROECONOMIC SYSTEMS**

**А.С. Мараховский, А.В. Бабкин, Н.В. Ширяева**  
**ОПТИМАЛЬНОЕ УПРАВЛЕНИЕ**  
**НЕУСТОЙЧИВЫМИ МАКРОЭКОНОМИЧЕСКИМИ СИСТЕМАМИ**

The article presents a mathematical description of the process of an optimal control over an unstable macroeconomic system based on the Leontief's input-output model. The optimal equation allows setting a balanced growth rate for a macroeconomic system. It is the main problem in the current development of regional and national economies. The methods of an optimal control are generally applicable to stable systems. This article shows that a developing macroeconomic system is unstable and therefore an optimal control over it has its peculiarities. An unstable macrosystem is divided into two subsystems: a stable multidimensional and an unstable one-dimensional. The stable system is optimized via standard methods, where a single growing exponent sets the growth rate of the entire system from the second unstable system. In order to divide the system, the author suggests using a homothetic transformation. To calculate the parameters of an optimal control a Riccati equation is used. The results of solving a matrix of factors determine the cost of restructuring unstable macroeconomic systems with a balanced growth rate. The knowledge of the cost of an optimal control and restructuring creates prerequisites for a more effective process to manage socio-economic politics in the region and the whole country. These results play a vital role in decision-making processes of management and administrative bodies concerning statistical analyses and managing the economic situation. The results are based on the hypothesis that the dynamic models of macroeconomic systems are linear. In practice, actual economic systems are subject to various effects like synergy and self-organization. They cannot be described under the linearity hypothesis. Our future research requires the elaboration upon the problems of an optimal control over nonlinear and unstable economic systems.

MACROECONOMIC SYSTEMS; ECONOMIC GROWTH; MATHEMATICAL MODELING; CONSUMPTION; GROSS OUTPUT; OPTIMAL CONTROL, RESTRUCTURING.

Представлено математическое описание процесса оптимального управления неустойчивой макроэкономической системой на основе модели Леонтьева. Оптимальное управление позволяет перевести макроэкономическую систему на сбалансированные темпы развития, что является основной проблемой развития региональных и страновых экономик. Методы оптимального управления в основном применимы для устойчивых систем. Показано, что развивающаяся макроэкономическая система является неустойчивой и поэтому оптимальное управление в ней имеет особенности. Неустойчивая макросистема делится на две подсистемы: устойчивую многомерную и неустойчивую одномерную. Далее устойчивая система оптимизируется стандартными методами, причем темп роста всей системы контролируется единственной растущей экспонентой от второй неустойчивой системы. Для разделения системы используется преобразование подобия. Расчет параметров оптимального управления основан на решении уравнения Риккати. Полученные в результате решения матрицы коэффициентов определяют стоимость реструктуризации неустойчивых макроэкономических систем со сбалансированным темпом роста. Знание стоимостных данных затрат на оптимальное управление и реструктуризацию создает предпосылки для более эффективного ведения процесса управления социально-экономической политикой внутри региона и страны в целом. Область применения результатов распространяется на управленческие административные органы, принимающие решения по вопросам статистического анализа и управления макроэкономической ситуацией. В основе полученных результатов лежит гипотеза о том, что динамические модели макроэкономических систем являются линейными. На практике в реальных экономических системах наблюдаются различные эффекты, например, синергия и самоорганизация, которые невозможно описать в рамках линейных предположений. Раскрытие вопросов оптимального управления в нелинейных и неустойчивых экономических системах является продолжением данных исследований.

МАКРОЭКОНОМИЧЕСКИЕ СИСТЕМЫ; ЭКОНОМИЧЕСКИЙ РОСТ; МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ; ПОТРЕБЛЕНИЕ; ВАЛОВОЙ ВЫПУСК; ОПТИМАЛЬНОЕ УПРАВЛЕНИЕ, РЕСТРУКТУРИЗАЦИЯ.

**Problem statement.** To ensure an optimal control over macroeconomic systems is a serious problem. Its solution will allow the radical restructuring [1, 2] of the economy at a macro- and meso-level and at minimal cost. This restructuring is essential to achieve a balanced



growth of gross output, GDP and other macroeconomic indicators [3–6].

It is widely known that an optimal control can be achieved in stable systems. That is why the economic community frequently raises a question about the stability of certain economic systems, e. g. a firm or a country. There is a variety of methods to achieve a stable growth [7]. However, there is a contradiction in the definition of a «stable growth» itself.

On the one hand, if a system is growing, then its parameters increase, i. e. grow. It is desirable for economic systems to be constantly growing. However, on the other hand, systems with an indefinite increase in any parameter are unstable. Hence a macroeconomic system with constantly growing parameters is unstable as well. To achieve a stable growth in an unstable system is rather difficult but possible. This article presents an approach to solve this problem.

The process of restructuring the macroeconomic system is based on an optimal control. It should follow a certain plan in order to set a balanced growth rate of the system while maintaining a certain proportion of material [8], capital, labour and other costs. Any system operates to achieve some sort of goal. That is why for a further discussion we should introduce a concept of an ideal macroeconomic system where all cost proportions are balanced. Let us call a system with balanced development trajectories an ideal model. This article presents the method of forming ideal trajectories, to which every macroeconomic system should aspire in order to achieve desired growth rates and proportions. It is necessary to create an optimal criterion for control signifying an actual optimal control over an economic system. Both ideal and growing systems are unstable.

**Problem solution.** Regarding theoretical grounds of the article, we should mention that modern theories on economic growth are based on two sources: the neoclassical theory conceived by J.B. Say and fully formed in the works of J.B. Clark (1847-1938) and the Keynesian theory of macroeconomic equilibrium [9].

We will point out the Neumann model and the Leontief's model in dynamic contrast among all the models of economic dynamics. Most of them are able to demonstrate the transient processes and control over them, the structural shifts and statistical stability more complete [10, 11]. One of the most useful properties of these models is their ability to be presented in a form

of differential equations that describe the dynamic economic systems.

Balanced trajectories with the maximum growth rate are called turnpikes. The term was proposed by a Nobel Prize winner, Paul Samuelson. John von Neumann created the first turnpike model was in the 1930s. His model of an expanding economy had a deep impact on the making of mathematical economics [12]. The theoretical principles of the turnpike were summarized in the Gale model. The Leontief model is a special case of it, as it is shown in [13].

A dynamic variation of the Leontief model [14] is a system of inhomogeneous linear differential equations:

$$\dot{X}(t) = AX(t) + B\dot{X}(t) + Y(t).$$

$$\text{or } \dot{X}(t) = B^{-1}(E - A)X(t) - B^{-1}Y(t). \quad (1)$$

The formal solution to the system (1) has two parts – a free  $X_{cb}(t)$  and a forced  $X_{bbh}(t)$ :

$$X(t) = X_{cb}(t) + X_{bbh}(t) \quad (2)$$

$$\text{or } X(t) = e^{B^{-1}(E-A)t} X(0) - e^{B^{-1}(E-A)t} \int_0^t e^{-B^{-1}(E-A)\tau} B^{-1}Y(\tau) d\tau. \quad (3)$$

where  $e^{B^{-1}(E-A)t}$  is a matrix exponent.

The equation (3) is greatly simplified, if you assume that there is a connection between the end product and the gross output by introducing a norms of consumption matrix  $Q$ :

$$Y(t) = QX(t). \quad (4)$$

This assumption can be considered valid because, the gross output for consumption will be constant for rather large intervals of time. The simplified system will have a consumption loop and will look like this:

$$\dot{X}(t) = GX(t). \quad (5)$$

The matrix  $G = B^{-1}(E - A - Q)$  is a homogenous matrix. The solution to this matrix will no longer be so complex. In fact, it will be quite compact:

$$X(t) = e^{Gt} X(0), \quad (6)$$

where  $X(0)$  are the starting values of the system representing the level of gross output for the current year.

Using a classic method of calculating transient processes, we get a solution to (5) that looks like this:

$$X(t) = C_1 e^{\lambda_1 t} + C_2 e^{\lambda_2 t} + \dots + C_n e^{\lambda_n t}, \quad (7)$$

where  $C_1, C_2, \dots, C_n$  are integration constants;  $\lambda_n$  are eigenvalues of matrix  $G$ , that define the unique dynamic properties (UDP) of a socio-economic system [15].

In accordance with the system of national accounts, production records in Russia is kept for 17 types of economic activities. In order to predict the growth of gross output we need to solve a system of differential equations with a degree of 17. The best way to solve such a multi-dimensional problem is to do it through a matrix using a homothetic transformation. In this case, we can present our model as a state space model:

$$\dot{X}(t) = \bar{A}X(t) + \bar{B}Y(t), \quad (8)$$

where  $\bar{A} = B^{-1}(E - A)$  is the main matrix, and  $\bar{B} = -B^{-1}$  is a matrix of external influences.

Solving the system of differential equations (8) will allow us to determine the expected values of the gross output of a country or its regions. Obviously, disregarding the effects of external influences from the government and an ineffective production will make the resulting values unbalanced. It points out an important issue to balance the main macroeconomic factors for all types of economic activities. Thus, we need to establish such level of socio-economic consumption that would let the system stay in a constant and balanced expansion. Classical economists call this his expansion a turnpike development or Neumann ray [16]. This problem is solved by using Pontryagin's maximum principle from his optimal control theory.

The problem for decision makers is that they need to know not only the expected gross output values but also the optimal level of social consumption that takes into account all socio-economic capacity. The problem boils down to defining matrix  $Z$  that connects the end product  $Y$  with the gross output:

$$Y(t) = ZX(t). \quad (9)$$

The statement (9) lets us present the model with a consumption loop like this:

$$\dot{X}(t) = (\bar{A} + \bar{B}Z)X(t). \quad (10)$$

The information about an optimal control over the system consists in matrix  $\bar{B}Z$ . This is the value at which we have to change the coefficients of matrix  $\bar{A}$  to achieve the balanced

function of the macrosystem as a result of an optimal control.

Now we have the system with positive feedback. Systems with positive feedback are unstable. Methods for determining matrix  $Z$ , which contains the information about socio-economic norms and costs, are developed for stable systems. Now the problem of separating the generally unstable system (10) into subsystems arises. One of which would be stable and multidimensional and the other would be unstable and one-dimensional. Such division can be achieved by using a homothetic transformation that would outline  $n$  of new phase variables  $\tilde{X}_h$  by using:

$$X_i = \sum_{h=1}^n t_{ih} \tilde{X}_h \text{ or } X = T\tilde{X}. \quad (11)$$

As a result, system

$$\left. \begin{aligned} \dot{\tilde{X}}(t) &= \tilde{G}\tilde{X}(t), & \tilde{X}(0) &= \tilde{X}_0 \\ \text{where } \tilde{G} &\equiv T^{-1}GT, & \tilde{X}_0 &\equiv T^{-1}X_0 \end{aligned} \right\} \quad (12)$$

will contain matrix  $\tilde{G}$ , the structure of which is far simpler than the initial one. If there is a possibility to use a homothetic transformation (11) to transform matrix  $G$  into a diagonal matrix, then the initial system can be transformed to a system with separated variables by using coefficients  $\tilde{X}_h$ :

$$\frac{d\tilde{X}_h}{dt} = l_h \tilde{X}_h. \quad (13)$$

The solution to such a system will look like this:

$$\tilde{X}_h = \tilde{X}_{h0} e^{l_h t} \quad (h = 1, 2, \dots, n). \quad (14)$$

The final solution to the system using the homothetic transformation method will contain a diagonal matrix  $\text{diag}(e^{\lambda t})$ :

$$X(t) = T \cdot \text{diag}(e^{\lambda t}) T^{-1} X(0), \quad (15)$$

where  $\lambda$  and  $T$  are eigenvalues and eigenvector of matrix  $G$ .

Using a homothetic transformation lets us transform the matrix into a diagonal one where it can be divided into subsystems. These systems can be connected parallel. The body of mathematics

for parallel system connection has been developed in control engineering and it is widely known. A homothetic transformation is applicable not only to closed-loop systems but also to open-loop ones. In this case, we need to do the following action on the transformed (converted) matrix:

$$\tilde{A} = T^{-1} \bar{A} T, \quad \tilde{B} = T^{-1} \bar{B}. \quad (16)$$

The dynamic properties of the converted system and that of the initial system are identical, because they have the same spectrum of eigenvalues. The main matrix of the converted system is diagonal. Thus it can be divided into parallel subsystems. In order to do that we use the Perron–Frobenius theorem. It states that in a model of a macroeconomic balance system, among positive eigenvalues there will surely be a minimal number, which would correspond to the entire positive eigenvector. To find the subsystem with the lowest eigenvalue is not a difficult task. It will be one-dimensional and the presence of a positive number in the index of an exponent will signify a constant growth, which in its turn would make it one of the unstable systems. The other subsystem will be stable and it is possible to synthesize an optimal control for it.

Let us present the converted system in the following form:

$$\begin{pmatrix} \dot{\tilde{X}}_1 \\ \dot{\tilde{X}}_2 \end{pmatrix} = \begin{pmatrix} \tilde{A}_1 & \tilde{A}_2 \\ \tilde{A}_3 & \tilde{A}_4 \end{pmatrix} \begin{pmatrix} \tilde{X}_1 \\ \tilde{X}_2 \end{pmatrix} + \begin{pmatrix} \tilde{B}_1 & \tilde{B}_2 \\ \tilde{B}_3 & \tilde{B}_4 \end{pmatrix} \begin{pmatrix} \tilde{Y}_1 \\ \tilde{Y}_2 \end{pmatrix}; \quad (17)$$

$$\tilde{X} = \begin{pmatrix} \tilde{X}_1 \\ \tilde{X}_2 \end{pmatrix}, \quad \tilde{A} = \begin{pmatrix} \tilde{A}_1 & \tilde{A}_2 \\ \tilde{A}_3 & \tilde{A}_4 \end{pmatrix}, \quad \tilde{B} = \begin{pmatrix} \tilde{B}_1 & \tilde{B}_2 \\ \tilde{B}_3 & \tilde{B}_4 \end{pmatrix}.$$

This would let us divide the matrices and vectors of the initial system into subparts by these dimensions:

$$\tilde{X}_1[1], \tilde{X}_2[n-1], \tilde{A}_1[1], \tilde{A}_2[1, n-1],$$

$$\tilde{A}_3[n-1, 1], \tilde{A}_4[n-1, n-1].$$

The dimensions of the submatrices in the matrix  $\tilde{A}$  and  $\tilde{B}$  are identical. The matrix of the converted system is diagonal. It means that the coefficients of submatrices  $\tilde{A}_2$  and  $\tilde{A}_3$  contain zeros that would let us present system (17) as a parallel connection of two subsystems:

$$\dot{\tilde{X}}_1(t) = \tilde{A}_1 \tilde{X}_1(t) + \tilde{B}_2 \tilde{Y}_1(t); \quad (18)$$

$$\dot{\tilde{X}}_2(t) = \tilde{A}_4 \tilde{X}_2(t) + \tilde{B}_4 \tilde{Y}_2(t). \quad (19)$$

Fig. 1 shows this connection graphically.

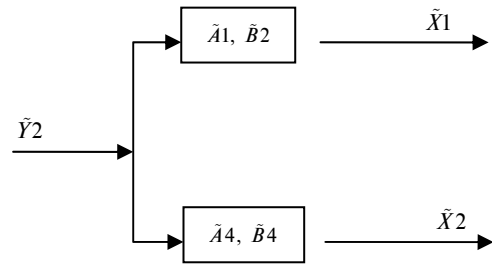


Fig. 1. Parallel connection of two subsystems

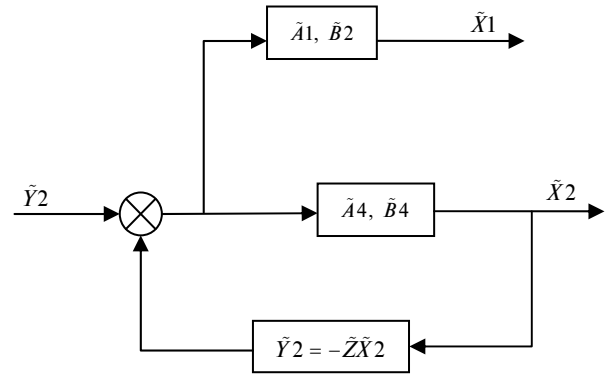


Fig. 2. Connecting subsystems with feedback

The entrance  $\tilde{Y}_2$  has an effect on both subsystems. It can be optimized by the optimal synthesis of the linear-quadratic regulator. Based on the structure of the system (17) the same entrance will influence an unstable system. Of course, this effect will be suboptimal. However, as a whole the system will perform more effectively because one of its subsystems would be optimized. Fig. 2 shows this situation graphically. The second system is controlled by the feedback from the linear-quadratic regulator. Therefore it can be considered optimal.

In order to determine  $\tilde{Z}$  in the chain of a negative feedback  $\tilde{Y}_2 = -\tilde{Z} \tilde{X}_2$  we need to minimize the square functional:

$$J(X) = \int_0^{\infty} (\tilde{X}_2^T Q \tilde{X}_2 + \tilde{Y}_2^T R \tilde{Y}_2) dt. \quad (20)$$

Here  $Q$  and  $R$  are matrices of the weight coefficient. These matrices set the ratio of the quality of the economic process management to the cost of management.

The functional (20) let us optimize the management in the system while spending minimum of effort to manage the dynamics of

exit  $\tilde{X}2$  by means of entrance  $\tilde{Y}2$ . To solve the minimization problem of (20) we will use the classic method of the calculus of variations. To do that let us introduce an auxiliary functional:

$$J(X) = \int_0^{\infty} [(\tilde{X}2^T R \tilde{X}2 + \tilde{Y}2^T Q \tilde{Y}2) - 2\lambda^T (\tilde{X}2 - \tilde{A}4 \tilde{X}2 - \tilde{B}4 \tilde{Y}2)] dt, \quad (21)$$

where  $\lambda - (n-1)$  is a dimensional vector of Lagrange multipliers.

The solution of the minimization problem (21) for subsystem (19) yields the following system:

$$\begin{cases} \dot{\tilde{X}}2 = \tilde{A}4 \tilde{X}2 + \tilde{B}4 \tilde{Y}2; \\ \dot{\lambda} = -Q \tilde{X}2 - \tilde{A}4^T \lambda; \\ \tilde{Y}2 = -R^{-1} \tilde{B}4^T \lambda. \end{cases} \quad (22)$$

By substituting value  $\tilde{Y}2$  into the first equation of system (22), we get:

$$\begin{cases} \dot{\tilde{X}}2 = \tilde{A}4 \tilde{X}2 - \tilde{B}4 R^{-1} \tilde{B}4^T \lambda; \\ \dot{\lambda} = -Q \tilde{X}2 - \tilde{A}4^T \lambda. \end{cases} \quad (23)$$

In order to solve this system we need to substitute the corresponding variables:

$$\lambda = P \tilde{Y}2. \quad (24)$$

Multiplying the left part of the first equation in system (23) by matrix  $P$  and subtracting from it the second equation of the system will lead us to:

$$P \tilde{A}4 + \tilde{A}4^T P - P \tilde{B}4 R^{-1} \tilde{B}4^T P + Q = 0. \quad (25)$$

The equation (25) is the Riccati algebraic matrix equation [17], which comes as a result of the Riccati differential equation being set in conditions of  $t \rightarrow \infty$ . To solve this equation is a difficult task. However, it is standardized and it has solutions in some cases. It allows us to determine the coefficients of matrix  $P$ . Having substituted the statement (24) into the last equation of system (23), we get the desired equation of optimal control:

$$\begin{aligned} \tilde{Y}2 &= -R^{-1} (\tilde{B}4)^T P \tilde{X}2 = -\tilde{Z} \tilde{X}2, \\ \tilde{Z} &= R^{-1} (\tilde{B}4)^T P. \end{aligned} \quad (26)$$

The closed-loop matrix of the second subsystem with the linear-quadratic regulator  $\tilde{Z}$  will be determined by the formula:

$$\tilde{G}4 = \tilde{A}4 - \tilde{B}4 \cdot \tilde{Z}. \quad (27)$$

Then the converted (and already optimized) system (17) will look like this:

$$\begin{pmatrix} \dot{\tilde{X}}1 \\ \dot{\tilde{X}}2 \end{pmatrix} = \begin{pmatrix} \tilde{A}1 & \tilde{A}2 \\ \tilde{A}3 & \tilde{G}4 \end{pmatrix} \begin{pmatrix} \tilde{X}1 \\ \tilde{X}2 \end{pmatrix}. \quad (28)$$

Or in its condensed form:

$$\dot{\tilde{X}}(t) = \tilde{A}onm \tilde{X}(t), \quad (29)$$

where  $\tilde{A}onm$  is the matrix of optimized closed-loop converted system coefficients.

**Results.** Determining the close-loop matrix of the macrosystem's coefficients is achieved by means of an inverse homothetic transformation:

$$\bar{A}onm = T \tilde{A}onm T^{-1}. \quad (30)$$

This matrix is necessary to calculate the addition to the coefficients of that first unstable system. So we can get the optimal equation:

$$\bar{B}Z = \bar{A} - \bar{A}onm. \quad (31)$$

The equation (12) can help evaluate the optimal level of the end product accounting for the costs from socio-economic transformations of the macrosystem.

**Conclusion.** As we can see, dividing an unstable macroeconomic system into subsystems makes it possible to determine the optimal level of expenses for the system. It creates prerequisites for a more effective management of socio-economic policies inside a region or an entire country.

**Directions for future research.** The results are based on the hypothesis that the dynamic models of macroeconomic systems are linear. In practice, actual economic systems are subject to various effects like synergy and self-organization. [18, 19] They cannot be described under the linearity hypothesis. Our future research requires the elaboration upon the problems of an optimal control over nonlinear and unstable economic systems.



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**Iu.S. Pinkovetskaya, E.N. Kataev**

**ANALYTICAL REVIEW OF CHANGES IN ENTREPRENEURIAL INTENTIONS  
IN VARIOUS COUNTRIES ACCORDING  
TO DATA OBTAINED VIA GLOBAL MONITORING**

**Ю.С. Пиньковецкая, Е.Н. Катаев**

**ИССЛЕДОВАНИЕ ИЗМЕНЕНИЙ ПРЕДПРИНИМАТЕЛЬСКИХ НАМЕРЕНИЙ  
В РАЗЛИЧНЫХ СТРАНАХ  
ПО ДАННЫМ ГЛОБАЛЬНОГО МОНИТОРИНГА**

The article provides an analysis of such indicators as entrepreneurial intentions and entrepreneurial status. The indicators of entrepreneurial activity were studied in respect to various factors and incentive motives to start a business. The Global Entrepreneurship Monitor (GEM) database was used. Data obtained in the course of the survey of the economically active population in such countries as Russia, China, the United States, India, Germany, France, the United Kingdom, Spain, Italy and Japan were studied. The analysis of entrepreneurial intentions and other indicators was conducted for each country, which resulted in producing comprehensive summaries. Entrepreneurial activity is of interest for the economically active population in all the countries considered in this paper, as it is a good career choice. Successful entrepreneurs enjoy high social status among the population of all the reviewed countries. The index of early-stage entrepreneurial activity is significantly higher than the rate of business discontinuation, which testifies to the ongoing rapid development of entrepreneurship. Entrepreneurship has now become one of the most important life spheres for a considerable part of the adult population to apply their efforts in. In some cases, their entrepreneurial activities are not considered primary and are pursued on an occasional basis, in spare time. In the Russian Federation, entrepreneurship has gained momentum in recent years. It ranks quite high in the public's mind. There is a number of prospective entrepreneurs, well-grounded and not averse to taking risks with their own businesses. The further development and the support of entrepreneurial activity in the Russian Federation require institutional changes, including eliminating ambiguities and uncertainties in the legislation and ensuring its ability to respond to present-day challenges, improving mechanisms for state regulation and reducing administrative barriers. It is of particular importance to provide access of entrepreneurs to financial resources by reducing credit interest rates and developing special loan programs for budding entrepreneurs.

ENTREPRENEURSHIP; MONITORING; ENTREPRENEURIAL ACTIVITY; BUSINESS CREATION; REGIONAL ECONOMY; DEVELOPED COUNTRIES.

Анализируются такие индикаторы, как предпринимательские намерения и статус предпринимателей. Исследованы индикаторы предпринимательской деятельности по различным факторам и побудительные мотивы к началу бизнеса. Использованы данные глобального мониторинга предпринимательства (ГЕМ). В процессе анализа использованы данные, полученные как результат опроса экономически активного населения в таких странах, как Россия, Китай, США, Индия, Германия, Франция, Великобритания, Испания, Италия и Япония. По каждой стране проведен анализ предпринимательских намерений, оценены другие показатели. В соответствии с полученными результатами сформированы выводы и предложения. Предпринимательская деятельность представляет интерес для экономически активного населения во всех рассмотренных странах, она является хорошим вариантом выбора карьеры. Статус успешных предпринимателей для населения всех стран высок. Индексы желающих начать предпринимательскую деятельность существенно выше уровней выхода из бизнеса по всем странам, что свидетельствует о продолжающемся ускоренном развитии предпринимательства. Предпринимательство в настоящее время стало одной из важных сфер применения усилий существенной части взрослого населения, в том числе в качестве деятельности, которая не является основной, осуществляется нерегулярно и в свободное время. Предпринимательская деятельность получила в последние годы в Российской Федерации значительное развитие. Ее оценка в общественном мнении достаточно высока. Отмечается наличие значительного числа потенциальных предпринимателей, причем они обладают хорошей подготов-

кой и не особенно опасаются возможных неудач в организации собственного бизнеса. Дальнейшее развитие и поддержка предпринимательской активности в Российской Федерации требуют институциональных изменений, в том числе однозначности и определенности законодательной базы, ее соответствия требованиям сегодняшнего дня, совершенствования механизмов государственного регулирования и снижения административных барьеров. Особое значение имеет обеспечение доступа предпринимателей к финансовым ресурсам на основе снижения процентных ставок по кредитам и разработки специальных кредитных программ для начинающих предпринимателей.

ПРЕДПРИНИМАТЕЛЬСТВО; МОНИТОРИНГ; ПРЕДПРИНИМАТЕЛЬСКАЯ АКТИВНОСТЬ; СОЗДАНИЕ БИЗНЕСА; РЕГИОНАЛЬНАЯ ЭКОНОМИКА; РАЗВИТЫЕ СТРАНЫ.

Entrepreneurial structures are created and managed by entrepreneurs. They are the main driving forces behind most national economies. Despite earlier assumptions that production is concentrated in the hands of large corporations and concerns, including transnational ones, the importance of small and medium-sized enterprises in the majority of economically developed countries has not abated in recent years. Their production volume and the number of employees continue to grow [3].

In accordance with the decisions made by the President and the Government, a share of entrepreneurial businesses in the Russian economy is projected to grow significantly. At the meeting with the leaders of the All-Russian Public Organization of Small and Medium-Sized Enterprises «OPORA Russia» of 15 November 2012, Russian President Vladimir Putin noted that «the number of small and medium-sized enterprises is growing, but, of course, this level is still far from the desired one» [4].

So today, analysis of entrepreneurship, the public perception of this field of activity, the formation of entrepreneurial intentions and identification of incentives to create a business are considered topical issues. This paper dwells on those, drawing on the example of some of the largest economies in the world.

Business sector analysis, particularly the analysis of entrepreneurial attitudes and perceptions, as well as business activity, was carried out by various authors.

The nature and significance levels of such indicators were described in Z.J. Acs, S. Desai and L.F. Klapper [5], where the dependence of the indicators and their levels of variation on institutional, legal, and even ecological factors was analyzed specifically. A global assessment of the applicability of the GEM (Global Entrepreneurship Monitor) data was carried out by H. Bergmann, S. Mueller, T. Schrettle [14],

who, on the basis of practical developments introduced by other authors, analyzed all available information in the entrepreneurial sphere and the potential of research on the basis of the GEM data. R. Justo, J.O. De Castro and A. Maydeu-Olivares [22] analyzed entrepreneurial activity based on a model-based approach and the social network theory used in combination.

As for territorial and regional differences in the level of business development, entrepreneurial activity and entrepreneurial attitudes and perceptions, the work by N. Bosma and V. Schutjens [19], who have researched these issues in 127 regions of 17 European countries, appears to be one of the most notable. Eventually, it became possible to reveal the close relationship between the indicators and their close interdependence, as well as to assess the level of the latter. C. Alvarez, D. Urbano [9] and J.E. Amory S.O. Cristi [11] analyzed entrepreneurial activity in Latin American countries. They revealed, inter alia, a strong connection between the level of political stability, corruption and entrepreneurial activity. They also discovered that these countries feature no close connection between procedures, time to establish a business and entrepreneurial skills, and the level of entrepreneurial activity. Some efforts were made to conduct the analysis of indicators in individual countries, for example, R. Aidis and S. Estrin [8] explored entrepreneurship development in Russia and identified the dependence of entrepreneurial activity on various factors, while H. Bergmann and R. Sternberg [15] studied the face of entrepreneurship in Germany.

Russian entrepreneurial activity is discussed in O. R. Verkhovskaya, M. V. Dorokhina, and specifically in article [1].

Some authors undertook a gender analysis of entrepreneurial activity and intentions. K. Klyver [26] studied differences between men and women, and determined how they behave in



different conditions, under the influence of various external and internal factors. J. Levie and M. Hart [30] conducted a gender analysis within a given country (the UK) and revealed the interrelationship between gender balance in business and overall entrepreneurship development.

The key aspects of entrepreneurial activity are considered in the works by such foreign authors as P. Arenius, M. Minniti, D. Aldrich, M. Keilbach, E. Lehmann, M. Carr, A. Thurik, A. Stel, Z. Acs, L. Szerb, P. Koellinger, R. Thurik [6, 7, 12, 13, 21, 27, 34].

The following are the results of the analysis of trends in respect of the main indicators, which measure entrepreneurial attitudes and perceptions as well as entrepreneurial activity. The analysis used data from the GEM database. In terms of entrepreneurship study, GEM is the most comprehensive research project in the field by the number of observations and its account of regional patterns of entrepreneurship across the world. The distinctive feature of this global monitoring project is a detailed record of all the stages in the entrepreneurial process from the emergence of a desire to participate in business activities and ideas about how to fulfill it to setting up a business and ensuring its staying power. [33]. To get the data, opinion polls among the adult working-age population and national expert interviews were conducted.

As of today, GEM reports provide data on entrepreneurial attitudes and genuine entrepreneurial activity in the majority of entrepreneurially savvy countries. The number of countries being monitored is constantly increasing. In 2013, the opinions of over 197,000 people from 70 countries, obtained in the process of sociological surveys, were explored. In addition, 3,800 experts specializing in entrepreneurship studies in the monitored countries were engaged to review the results of the global monitoring.

The analysis this article draws on included the data from global monitoring reports for the years 2007-2013 [10, 16, 17, 18, 23, 24, 36] and accounted for the indicators which characterize entrepreneurs in such economically developed countries as Russia, the USA, Japan, France, the UK, Italy, Germany, Spain, India and China. The choice of these countries stems from the following: they display a high level of entrepreneurial activity, the total GDP of these countries reaches 75 % of the total GDP of all

economies in the world and, lastly, these countries are home to nearly half the world's population. Note that the monitoring data is incomplete as the surveys are exclusive of input over a few years in a number of countries and of some of the indicators under consideration. However, in our opinion, this does not interfere in the making of valid conclusions about the existing trends.

The trends typical of various stages in the formation of entrepreneurial intentions and their actualization are discussed below.

The first indicator of entrepreneurial attitudes and perceptions are perceived opportunities. This indicator shows the proportion of residents of a country between the ages of 18 and 64 who see good opportunities to start a business in this country to the total economically active population.

In China, the UK, Germany, the proportion of such residents exceeds 30 %. Japan exhibits a low level of perceived opportunities. It used to be 10 % but grew to 13 % in 2008. High values of this indicator were observed in India. Since 2010, there has been a significant increase in the indicator of perceived opportunities in the United States. For other countries, including Russia, the average values of the indicator for the years 2007–2013 are in the range from 20 to 30 %. At the same time, in the Russian Federation, the highest value (39 %) was observed in 2008, and the smallest (17 %) during the global economic crisis of 2009. In 2011, the indicator increased, but in 2012 and 2013, it decreased significantly, and in 2013 it amounted to 18.2 %. Let us consider the main trends in other countries. China, Italy and Spain have displayed a similar decreasing trend in the indicator in recent years. In China, the indicator reached its maximum (48.8 %) in 2011 and then decreased significantly. In Italy, this indicator was constantly decreasing over the period 2007-2013 from 39 to 17.3 %, and in Spain, respectively, from 33 to 16 %.

The indicator of perceived capabilities reflects the proportion of the population aged 18 to 64 years, having (in their own opinion) the necessary skills and knowledge to start a business, to the total economically active population. The highest values (of about 50 %) of this indicator are evidenced in India and the United States. In the United States, this indicator increased from 43 to 55.7 % over the

2007–2013 period. The minimum values of the indicator of perceived capabilities are observed in Japan. During the period under consideration, the value of the indicator did not exceed 14 %, while in 2007, it was only 9 %. In the Russian Federation, the indicator maintained quite a stable growth trend, and in 2013, it amounted to 28.2 %. In Europe, the greatest values of this indicator are typical of countries such as Spain and the United Kingdom. The values of the indicator in these countries in certain years exceeded 50 %. Moreover, while the level of the indicator in Spain was more than 48 % in 2013, its value in the UK the same year amounted to 43.8 %. In Germany, Italy and France, an indicator of perceived capabilities rarely exceeded 40 %. But in recent years, it decreased significantly in Italy and now equals just a little over 30 %. A similar trend is typical of China, in which, the indicator has been decreasing since 2011.

The indicator of fear of failure displays the proportion of economically active population with a positive perception of their opportunities, whose alleged fears of failure, however, stop them from starting a business. The strongest fear of failure at the beginning of their entrepreneurial activity is experienced by the citizens of Japan, where the value of the indicator in different years varied in the range from 30 to 50 %. Thus, the analysis confirms the above mentioned regularities of low entrepreneurial aspirations. This is most likely due to a low estimate that the Japanese have of their perceived capabilities and opportunities. In 2008 and 2009, the value of the indicator in Russia exceeded even the value in Japan. These years, the fear of failure experienced, respectively, 66 % and 52 % of Russian people. However, by 2013, the value of this indicator in Russia decreased to 29 % and become one of the lowest among the countries under consideration. The minimum value of the indicator is observed in the USA, where the corresponding values fluctuate in the range from 24 to 32 %. The low value of an indicator of fear of failure is also recorded in China, where the corresponding range is from 30 to 36 %. Despite the fact that Indians rate their capabilities and opportunities in business sufficiently high, their level of fear of failure is high as well. So, in 2007, the value of this indicator in India amounted to 47 %, but, in recent years, it has decreased to 39 %. In respect

to the indicator, European countries occupy the middle of the ranking. In these countries, this value ranges from 30 to 45 %. However, in such countries as Italy and Spain the indicator reaches 50 %. In 2012, Italy registered the maximum level of fear of failure (58 %) among the countries under consideration. The average value of this indicator in European countries hovers around 40 %.

One of the essential characteristics of entrepreneurial intentions is the amount of adult individuals who plan to take up a business responsibility. It is clear that without such intentions, an increase in entrepreneurial activity is impossible [29].

The indicator characterizing entrepreneurial intentions reflects the percentage of the population aged 18 to 64 years who intend to start a business within three years. When calculating this indicator, those people who are now engaged in entrepreneurial activity are not taken into account. By this indicator, China is the matchless leader. In comparison to other countries, the value of the indicator in China exceeded the corresponding values in the other countries. However, it is not quite so simple. China had exhibited high values of the indicator up until 2011. Then, the share of the population with entrepreneurial intentions varied in the range 23–42.8 %.

However, recent years have seen the indicator in the downtrend mode, and by 2013, its value was 14.4 %. A high level for this indicator is characteristic of India, where it was 22.7 % in 2013. In the United States, the indicator of entrepreneurial intentions has been growing since 2011: it was only 7 % in 2007, but now fluctuates around 12 %. The minimum value of the indicator is observed in Russia and Japan, where it barely exceeds 3 %. In Russia, the documented maximum amounted to 3.6 % in 2011. When discerning entrepreneurial intentions in Russia, it is necessary to make allowances for the following Russia-specific phenomenon: a significant number of the economically active population pursue entrepreneurial activities without any official registration. Accordingly, in the monitoring process, they also do not provide any information about their intentions. European countries do not display high values of the indicator. For example, in 2013, the European indicator fluctuated between 7–12 %, with the maximum of 12.6 % in



France and the minimum of 6.8 % in Germany. With regard to the United States and European countries, it is important to pay due attention to an inherently high level of their entrepreneurial development: since a large part of the economically active population has long been engaged in entrepreneurial activities, the monitoring methodology excludes them from participating in the survey on perceived entrepreneurial intentions.

Such an indicator as viewing entrepreneurship as a good career choice reflects the proportion of the adult population who believe that entrepreneurial activity in their country will provide for its welfare. This indicator has a high value in countries such as Italy, China, Russia, the USA, India, France and Spain. These countries exhibit the corresponding indicator in the range from 55 to 72 %. Despite a slight decrease in recent years, it remains quite high. Germany, the UK and Japan give a slightly lower estimate for prospects of entrepreneurial success. The values of this indicator in Germany and the UK fluctuate around 50 %, and in Japan it is significantly (20 %) lower. At that, in 2013, Japan registered an increase to 31.3 % from 26 % of the year 2011.

Another indicator of entrepreneurial attitudes is the perception of entrepreneurship as high status activity. This indicator reflects the proportion of the population aged 18 to 64 who agree that successful entrepreneurs rank high in their country's status hierarchy. Among the countries considered with respect to this indicator, the highest level is characteristic of the UK, China, the USA and Germany. In these countries, over 70 % of those who participated in the survey share the above described opinion. Russia, Italy, France and Spain show slightly lower values of this indicator. In these countries, they range from 60 to 70 %, and some years even exceeded the level of 70 %. Only Spain has recently seen a small decrease in the value of the indicator. The minimum values of this indicator are registered in Japan, where they do not reach 55 %. In 2013, the value of the indicator was 52.7 %.

The indicator reflecting entrepreneurial attitudes and perceptions has low values in Japan due to the fact that large company jobs are considered more prestigious. They are preferred to employment in small businesses, which mostly are family firms that have been around for a long time, passing on from generation to generation.

The last of the indicators characterizing entrepreneurial attitudes is a level of media attention for entrepreneurship. This indicator reflects the proportion of the population who believes that the media in their country pay a great deal of attention to successful entrepreneurs. Among the countries under consideration, the highest values of this indicator is exhibited by China, where it varies from 71 to 80 %. However, in 2013, the value of this indicator decreased compared to the earlier years, to 71.3 %. In the United States and India, the values of the indicator are also impressive, but it is difficult to make informed conclusions in regard to these countries, because the monitoring process includes data only on the last three and two years, respectively. In European countries, the indicator value varies from 37 to 55 %. In Italy and Spain, it had been on the decrease and amounted to 37 %, but in 2013, it increased to 48.1 % and 45.6 %, respectively. In Germany, the indicator almost never changed, slightly fluctuating between the minimum 49 % and the maximum 50 %. As of 2013, its value was 49.9 %. In France, the indicator had been over 45 % until 2011, but in 2012, it was down to 41 %, and in 2013 – 41.4 %. In the UK, the value of the indicator in 2008 amounted to 54 % but then decreased to 47 %. In 2013, the indicator was 49.6 %. It is noteworthy that in respect to the indicator of the media attention for entrepreneurship, the opinion of the Japanese is the same as the opinion of the population of European countries. Thus, the indicator was 61 % in 2009, and its value decreased slightly in 2013, to 57.6 %. The value of this indicator in Russia stays about the same. The peak was registered in 2011 (55.3 %), followed by a decrease. In 2013, the value of the indicator amounted to 49 %.

It should be noted that when entrepreneurs start implementing their intentions to launch a new venture, they should consider the uncertainties associated with this decision and the corresponding risks they have to take «with their eyes open». The relevant socio-economic aspects are considered specifically in a number of papers. This said, according to some researchers [25, 28], the ability to take risks is what being an entrepreneur is all about and what distinguishes them from managerial employees. However, there is a reverse viewpoint [20, 31, 32, 35] on the

matter, namely, that entrepreneurs are typically more averse to risk taking than salaried employees. Perhaps this is due to the fact that the latter do not put their own but others' financial and material resources at risk.

Next, let us consider the indicators of entrepreneurial activity.

The indicator of the nascent entrepreneurship rate reflects the proportion of the economically active population who at the time of the survey were new entrepreneurs. They were either starting up or were the owners or co-owners of enterprises established no more than three months before, and salaries and other kinds of remuneration were yet to be paid. The values of this indicator are quite high in China and the United States. In China, it had been on the increase up until 2011 when it reached its peak of 10.1 %. In 2012 and 2013, the values of the indicator decreased significantly and nearly halved. In the United States, this indicator has remained high over the last three years. Its value is now greater than 8 %, which is significantly higher than the level typical of the rest of industrialized countries. This American trend is associated with a large number of private entrepreneurs who use no hired labor. These self-employed entrepreneurs account for 77 % of all operating business entities. They are often engaged in economic activities on a part-time or occasional basis: as those activities are not considered primary, they are pursued in their spare time. India displays relatively high values of the indicator, varying from 5.1 to 7 %. When it comes to Russia, it is worth noting that there has been a steady growth trend in this indicator. While the value of the indicator was 1.3 % in 2007, it grew to 3 % by the end 2013. However, the activity level of nascent entrepreneurs in Russia remains low. In Japan, the indicator values are similar to those in Russia, but the trend is still not clearly defined. So, up until 2009, it had increased to 3.2 %, then there was a significant decrease to 1.5 % in 2010, then it grew again to 3.3 %, then fell, and eventually stayed at 2.2 % in 2013. In European countries, the indicator values fluctuate within a wide range from 1.3 to 5 %. In Spain, the value of the indicator amounted to 3.1 % in 2013, in Italy – 2.4 %, in Great Britain – 3.6 %, in France – 2.7 %, and in Germany – 3.1 %. It is important to note that, overall, these countries exhibited the highest values of the indicator in 2011-2012.

The indicator of the new business ownership rate reflects the proportion of the population aged 18 to 64 years who at the time of the survey are owner-managers of a new business. Besides, they are supposed to have been receiving salaries and other types of remuneration from their companies for more than three months but no longer than 42 months. The highest indicator values are characteristic of China, where the indicator value amounted to 8.9 % in 2013. In the period from 2007 to 2011, the indicator increased from 10 to 14.2 %. The value of the indicator in the United States in 2013 was 3.7 % and mostly stayed in that period within the range from 2.8 to 5 %. In the UK, this indicator grew in the period from 2007 to 2013, from 2.7 to 3.6 %. In Germany and Spain, in 2013, the value of the indicator amounted to about 2 %. In Russia, despite a general upward trend, it did not overcome the threshold of 2.3 %. In Japan, the activity rate is one of the lowest. It generally did not exceed 2.3 %, and amounted to 1.5 % in 2013. In our opinion, the phenomenon of Japanese entrepreneurship stems from how the Japanese conduct their small business [2]. Working for large companies is considered more prestigious. Small businesses are traditionally run by families and have been passed on from generation to generation for quite a while. Notwithstanding a low level of entrepreneurial intentions among the Japanese, a considerable proportion of the economically active population owns well-established enterprises.

Such an indicator of early-stage entrepreneurial activity as the Total Entrepreneurship Activity Index (TEA) characterizes the level entrepreneurial activity in the early stages. That is, it takes into account nascent entrepreneurs who own newly created enterprises. Note that this is not just a sum of the two indicators discussed above. If a respondent is engaged in both types of entrepreneurial activities, only one of them is registered.

The next indicator of entrepreneurial activity is the established business ownership rate. It is characterized by the proportion of the economically active population who were owner-managers of an established business that had been in existence for more than 42 months at the time of the survey. The indicator values in China vary quite strongly in the period under consideration. So, an increase to 17.2 % was over in 2009; it was



followed by a decrease and the resulting value was 11 % in 2013. In 2011, the United States registered the maximum value of the indicator (9.1 %), but then there was a reduction to 7.5 % in 2013. In India, the value of the indicator in 2013 was 10.7 %. In Japan, there was a consistent decrease in the indicator value, from 8.7 % in 2007 to 5.7 % in 2013. In France and Italy, the level of activity of established entrepreneurs in 2013 was 4.1 % and 3.7 %, respectively, however, trends relating to the indicator value in these countries are quite opposite. While the trend is mostly upward in France, it is downward in Italy. In Germany, the value of the indicator ranges from 5 to 6 %. In the UK, the level of activity is somewhat higher, and reached 7.2 % in 2013. Among European countries, the highest indicator values are in Spain. In this country, the indicator reached 9.1 % in 2008, and despite a significant decrease in the next year, managed to rise to 8.4 % in 2013. In Japan, the indicator is quite high, and the average is 7.4 %. The previous assumption that established entrepreneurs with a low level of entrepreneurial intentions tend to display significant activity is confirmed. In Russia, the activity value of established entrepreneurs was 1.7 % in 2007 and 3.4 % in 2013. As for entrepreneurial activity in Russia, is necessary to take into account a specific phenomenon of Russian entrepreneurship associated with a considerable number of people doing business without any official registration. Accordingly, they do not provide any information about their business activities during the monitoring process.

The monitoring process dealt not only with data characterizing the establishment of entrepreneurial entities, but also their discontinuation. The corresponding indicator reflects the proportion of the population aged 18 to 64 years who have in the last 12 months, sold, shut down or otherwise ceased to be the owners of a business. The level of discontinuation of businesses is the most significant in the United States and in China. However, while there was a reduction of this indicator value in China, from 6.6 % in 2009 to 2.7 % in 2013, in the United States, the indicator ranges from 3.4 to 4.4 %. In Russia, the level of of business discontinuation is low, which is due to the fact that the number of entrepreneurs in the country is relatively small. In 2013, it reached the value of 1.6 %. In the rest of the countries under consideration, the

indicator values in 2013 stayed below 2 %. In Japan, this indicator was 1.5 %. In India and Germany, the value of the indicator is similar (1.5 %). In France, the UK, Spain and Italy the indicator value was mostly the same (1.9 %). However, while Italy displayed an upward trend, in France and the UK, the trend was negative.

Early-stage entrepreneurs are divided into two groups in accordance with the level of activity they showed in the process of global monitoring. The first group includes necessity-driven entrepreneurs, those who are engaged in early-stage entrepreneurial activity out of necessity, i. e., they have no other income opportunities. The second group includes improvement-driven opportunity entrepreneurs, those for whom entrepreneurship serves as a mechanism to increase income and gain independence at work. Note that during the survey, a number of respondents were unable to identify themselves with either of the two groups.

As for the proportion of necessity-driven entrepreneurs, it is apparent that the countries under consideration have opposite trends relating to this indicator. In China, the indicator value has been on the decrease: it was 48 % 2009 and merely 33.9 % in 2013. In Russia, by contrast, we can see an upward trend, and the value of the indicator grew from 26.9 to 36 % in 2012. In the United States, this indicator has remained at about 21 % over the past three years. In Japan, the indicator had been increasing until 2010, then it began to decrease and then started to grow again, reaching 25 % in 2013. In India, the value of the indicator in 2013 was 38.8 %. In European countries, the indicator values vary considerably. In 2013, the indicator value amounted to 15.7 % in France and to 16.1 % in the UK. In Italy, the indicator grew and reached 18.7 % in 2013. In Germany, the value of the indicator was 33 % in 2012, the next year, though, it dropped to 18.7 %. At the end of 2013, the maximum value in Europe was registered in Spain (29.2 %).

The rate of improvement-driven opportunity entrepreneurial activity reflects the share of individuals engaged in entrepreneurial activity and motivated by the opportunities to increase income and gain independence. As for the value of this indicator in the countries under consideration, it may be noted that the highest values of the indicator were in France. In this country, the indicator values reached 70.7 % in 2011 and

60.9 % in 2013. Sufficiently high levels of the indicator values were registered in Japan (about 60 % over the last three years). In the United States, the indicator varied from 51 to 59 %. Germany demonstrates a stable upward trend, the indicator there has increased from 43 to 55.7 % in recent years. But Italy is characterized by a downward trend (18.4 % in 2013). China, Russia and India display relatively similar values of the indicator. The indicator value in Great Britain varies insignificantly: it was 43 % in 2009 and 45.2 % in 2013. In Spain, the indicator decreased from 41 % in 2009 to 33.2 % in 2013.

Ultimately, the analysis led to the following conclusions:

1. Entrepreneurial activity is of interest for the economically active population in all the countries considered in this paper as it is a good career choice. Successful entrepreneurs enjoy high social status among the population of all the countries (except Japan).

2. The index of early-stage entrepreneurial activity is significantly higher than the rate of business discontinuation in all the countries, which is indicative of the ongoing accelerated development of entrepreneurship.

3. In all the considered countries, entrepreneurship has now become one of the most important life spheres for a considerable part of the adult population to apply their efforts in.

4. The largest proportion of nascent entrepreneurs is in the United States, China and India. However, in the United States, a major role is served by the entrepreneurs for whom

their entrepreneurial activities are not considered primary and pursued on an occasional basis, in their spare time.

5. During the review period, improvement-driven opportunity entrepreneurs prevailed in all the countries except China and India. Besides, this trend also became typical of China as of 2012.

In the Russian Federation, entrepreneurship has gained momentum in recent years. It ranks quite high in the public's mind. There is a number of prospective entrepreneurs, well-grounded and not averse to taking risks with their own businesses. Entrepreneurial activity is of interest for economically active population and is seen as a good career choice. In 2013, Russia registered a disposition towards assertive entrepreneurship. The index of early-stage entrepreneurial activity in our country is significantly higher than the rate of business discontinuation, which testifies to the ongoing rapid development of entrepreneurship. However, it has yet to reach the level characteristic of the most economically developed countries.

The further development and support of entrepreneurial activity in the Russian Federation require institutional changes, including eliminating ambiguities and uncertainties in the legislation and ensuring its ability to respond to present-day challenges, improving mechanisms for state regulation and reducing administrative barriers. It is of particular importance to provide access of entrepreneurs to financial resources by reducing credit interest rates and developing special loan programs for budding entrepreneurs.

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**Е.Р. Karlina, N.A. Dubinina**

## **INDUSTRIAL POLICY: SYSTEMIC-STRUCTURAL CHARACTERISTIC**

**Е.П. Карлина, Н.А. Дубинина**

### **ПРОМЫШЛЕННАЯ ПОЛИТИКА: СИСТЕМНО-СТРУКТУРНАЯ ХАРАКТЕРИСТИКА**

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To determine the essence of the concept of industrial policy a system paradigm is used, which allowed presenting it in the form of specific patterns and identify the components. Interaction of subjects and objects of industrial policy is studied based on complex tools, goals, appropriate for levels of management. The mechanism of coordination of interests of the subjects and objects of industrial policy was proposed as a matrix, which makes it possible to determine the most effective methods of its formation and implementation that are based on selection of the industrial activities of strategic importance for different levels of management.

INDUSTRIAL POLITICS; STRUCTURE; SUBJECTS AND OBJECTS OF INDUSTRIAL POLITICS; PURPOSE OF FORMING AND TOOLS OF IMPLEMENTATION; METHODS OF FORMING AND IMPLEMENTATION.

Для определения сущности понятия «промышленная политика» использована системная парадигма, позволившая представить ее в виде определенной структуры и выявить состав компонентов. Рассмотрено взаимодействие субъектов и объектов промышленной политики на основе комплекса инструментов, целей, соответствующих уровням управления. Предложен механизм согласования интересов субъектов и объектов промышленной политики в виде матрицы, позволяющий определить наиболее эффективные методы ее формирования и реализации на основе выделения видов промышленной деятельности, имеющих стратегическое значение для различных уровней управления.

ПРОМЫШЛЕННАЯ ПОЛИТИКА; СТРУКТУРА; СУБЪЕКТЫ И ОБЪЕКТЫ ПРОМЫШЛЕННОЙ ПОЛИТИКИ; ЦЕЛИ ФОРМИРОВАНИЯ И ИНСТРУМЕНТЫ РЕАЛИЗАЦИИ; МЕТОДЫ ФОРМИРОВАНИЯ И РЕАЛИЗАЦИИ.

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Modern trends in socio-economic development of Russia are characterized by dynamic transformations, aimed at achieving sustainable growth in industrial production and resulting in instability of the external environment economic security of the national economy. The effectiveness of these reforms is largely preconditioned by the status of the basis, strategically important industries, aimed at formation of new operating practices. The slow pace of structural transformation of the industry, imbalance of the reproduction mechanism, deficit and write-note state legal regulatory and management tools, significant depreciation of fixed assets have led to a decline in industrial production, the level of its

competitiveness, increase in the number of unprofitable enterprises and sectors of the national economy, highly dependent on imported components.

The main cause of this situation is the lack of a state control system for the domestic industry, aimed at ensuring the uniformity of strategic goals and tools for their achievement at the federal, regional and sector levels, as well as at the level of an individual enterprise.

In this regard, industrial policy, being one of the most important institutions of a market economy, should become the main tool for implementing the country's interests in the processes of economic modernization.



The main aspect of industrial policy should include promotion of formation of a new type of structure of an industrial complex that supports sustainable development of industrial production, efficiency and competitiveness, through enhancing investment and innovation potential of the industry [1].

This approach will ensure the coordination of industrial policy between regional and federal authorities and create economic interest of economic entities in achieving high production capacity on the basis of main methods of its formation and implementation.

Analysis of theoretical and practical studies of the meaning of the concept of industrial policy has allowed us to identify four main approaches, including:

- process one, considering the industrial policy in the process of industrial development, economic entities or entrepreneurial initiative [2, 3];
- structural one, when the main objective of industrial policy is to restructure the industry [4–6];
- competitive one, with the priority goal of improving the competitiveness of the industry [7, 8];
- system one, characterizing the industrial policy system of relationships, attitudes, different activities [9, 10].

Ultimately, analysis of the existing approaches to the definition of industrial policy allows us to conclude that each of them characterizes only one among many of its aspects, taking into account only some specific research area. All the authors see the industrial policy as one of the directions of economic policy of the state [11].

The essence of industrial policy, as the main directions of economic policy of the state, manifested in the relationship of the main participants of economic relations at the federal, regional, and sector levels, consists in implementing its purpose – formation of high-tech, competitive industrial sector, ensuring sustainability of economic systems.

In this regard, in our view, industrial policy should be seen as an instrument of government market environment, as well as individual industries and enterprises, with the aim of sustainable development of industrial production on the basis of enhancing investment and innovation potential, providing accelerated development of strategically important industries.

To determine the content of the notion of industrial policy, in our opinion, the first priority is a systematic approach that lets us focus the study on disclosing its integrity and identifying multiple interconnections and interdependencies of its constituent elements and blending them into a single theoretical picture.

Application of the system approach to research is possible with the built system paradigm, through combining the achievements of the theory of systems and system analysis with the basic concepts of the modern economic theory. The actual content of the procedure for the use of the system paradigm, as a rule, is based on identifying the constituent elements, components, and studying their complex combinations.

The built system paradigm to the content of industrial policy allows considering it as a complex object, which has a certain structure, internal consistency and external relationships with other types of policies. The basic principle of building a system paradigm is consistent and mutually accounted requirements as to the types of government policies and their requirements to the formation of goals, principles, forms and methods of implementing industrial policy.

Thus, in our opinion, it is necessary to distinguish in the entire system of industrial policy, its structure, and the set of stable relationships and interactions between its components, their role (function) relative to each other.

The basis for the practical application of the system paradigm in public policy making is a universal approach, proposed by Y. Kornai and allowing determining feasibility of comprehensive reform package implementation as a whole or in stages, a procedure for passing new laws. In addition, the system paradigm, as the author believes, allows you to identify changes that can be initiated and carried out through participation of the state or in an evolutionary way [12].

In the future, the economic policy of the government based on the system paradigm was developed in the works of Kleiner. With the system paradigm, the author presents the economy as a whole system, whose composition is determined by interacting socio-economic systems and subsystems at meso-, micro- and nano-economic levels, sectors, territories, corporations, private citizens, community groups,

and other formations significant for the economy [13]. An important advantage of this provision for composition and interaction of the structural elements, in our opinion, lies in the possibility of simultaneous consideration of not only functioning, but also interaction of individual economic entities of different levels and at different levels of the external environment.

In addition, based on the classification of economic systems with regard to location, scale (macro – and micro – economic systems), internal structure, distribution of property, inherent methods of regulating the author has presented the fundamental typology of economic systems. A distinctive feature of this typology is its formation taking into account the factors of time and space, based on the key characteristics of relationships of the systems with the external environment, which allows us to define it as a new spatio-temporal typology.

Further research results by Kleiner were used by the academician of the Russian Academy of Sciences A.I. Tatarkin when forming the structure of industrial policy. Tatarkin considers it appropriate to provide the constituent elements of industrial policy in the form of model economic systems, such as: objects, environments, processes, and projects. To set objectives of the industrial policy the author has used the typology of economic systems, developed by the Institute of Economics, Ural branch of RAS, determining the development of the industrial sector:

- system entities, combining state and municipal bodies, economic, scientific and public organizations can affect the development of the industrial complex;
- the system of subjective actions (decisions, laws) adopted by the subjects for the development of the industrial complex;
- system objects, including organizations, enterprises, firms, legal and physical persons implementing reproductive functions in the industry;
- final results as a set of indicators, thoroughly and completely reflecting what is happening in the object of quantitative and qualitative changes in the industrial complex [14].

In the author's opinion, a decisive role in the industrial development is played by the objects, which are considered organizations, such as enterprises, legal entities and individuals, etc.

those which implement reproductive functions. The underlying basis for implementing the system of economic interest interaction is the environment. Moreover, accounting for its structural components, the environment can be considered as institutional, in case its character is emphasized, the environment acts as competitive. It is the environment, according to the author, which is a framework that allows innovation to spread from one object to another. While specific elements of innovation contribute projects to the industry, which are relatively short-term, significant change in the industrial sector of the economy. Consistent and, most of all, evolutionary changes of status for certain environments or objects, disseminating innovations in economic space are called «processes» by the author. According to the research results the author concluded that industry, as a system, has the characteristics of all four types of economic systems, but it best combines the properties of the production objects with properties of communication environments [15].

The comparative analysis allowed the author to reveal the identity of abilities of economic systems and industrial policy. In reality, every economic system, living certain stages of the life cycle, is implemented in creation, support of existence, development, and interaction with other systems, and, in addition, in the ability to limit or terminate the operation of, or interaction with other systems to maintain its own existence and development. It is fair to assume that the expressed abilities of economic systems are common for industrial policy at different stages of functioning and development of the industry, which achieves specific goals, in terms of its industrial structure formation.

Thus, it is worth agreeing with the author's statement that the structure of industrial policy varies, both in the context of time and space, which suggests its possible change depending on the stage of the life cycle of the economic system, serving as an object of the industrial policy.

But, at the same time, in our opinion, the elements of the industrial policy structure, presented by the author, are somewhat duplicated. In particular, processes and projects essentially reflect changes either in the industrial sector or in certain environments or objects in terms of economic space. In addition, the author does not



specify the methods to be used to implement these elements, or the need to implement them.

In the Soviet period objectives, methods and measures (tools) for the industrial policy structure implementation were used as its fundamental elements. Among the key policy instruments the dominating ones were administrative-command and fiscal tools, the state monopoly on foreign trade. The administrative-command tools are represented with: «pressure», repression, centralized regulation of cash flows to maximize the use of savings as investments in the development of industry, currency regulation and control, aimed at preventing the export of capital from the country, price regulation, consumption regulation, income regulation, demand management.

An interesting approach to the content of industrial policy elements was reflected in the report developed by the Committee for Industrial Policy of the Federation Council “Aims, methods, and measures of industrial policy of the Russian Federation” in 2004, therewith the producer of goods and services is considered as an object of industrial policy – an enterprise in any field of activity that delivers goods or services (trade, transport, or insurance company, bank, warehouse and so on). The subject of industrial policy is defined as a state of the modern type in the form of an abstract corporation, including the government and citizens that has a clearly defined boundaries and exists only on the basis of recognition by other nations.

A variety of tools, as means of industrial policy presented by the authors in the form of measures of state influence on concrete blocks of the producer’s model: owner (or joint owner), provider of production factors, consumer of the produced goods, recipient of tax payments, controller of production factors markets, final products, the manufacturer’s activities, an arbitrator in economic disputes, political entity in international relations, affecting the operation of the manufacturer or the markets in which it participates [16].

Thus, the above approaches to the definition of the structural elements of industrial policy and their composition, allow us to conclude about their possible variability due to the diversity of changes in either the industrial sector or in certain environments or objects within the economic space.

However, most authors identify the concepts of structure elements (components) and the

composition of the elements (components) patterns of industrial policy that do not allow to clearly articulate goals and objectives of industrial policy as a system, tools and methods of its implementation at different levels of management.

According to the authors, industrial policy as a complex system must have a certain structure, describing its organization, sustainable order of elements and relationships, regardless of the level of the hierarchy. In this regard, it is advisable to highlight the following elements of the industrial policy structure: subjects, objects, goals, tools, and methods of forming and realization.

The composition and content of each element of industrial policy is determined depending on the hierarchy level of development, management and implementation.

Moreover, development and implementation of the state industrial policy should be based on the projected national strategic objectives for a specific local area, a cluster or a corporation. The main function of this type of policy lies in the development of a set of management actions aimed at developing the potential of territorial and sectoral industrial complex, satisfying the interests of the subjects of industrial policy at all levels.

Therefore, the level of industrial control policy determines the structure and content of its structural components – subjects and objects, the purposes of establishing, tools and methods of implementation.

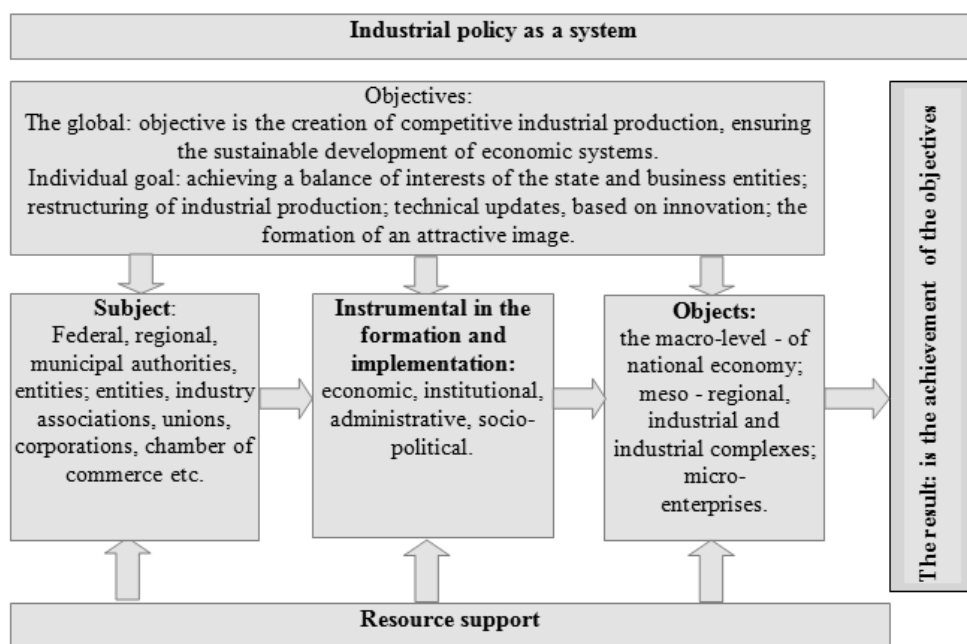
The composition of the goals of industrial policy should be determined on the basis of allocation of global goals and corresponding private purposes.

The global objective of industrial policy should include creation of competitive industrial production, ensuring sustainable development of economic systems.

The following can be distinguished as sub-purposes:

- the balance of interests of economic entities and the state;
- restructuring of industrial production;
- technical updates on the basis of innovation;
- creation of attractive investment image.

Objects of industrial policy are economic entities, the composition of which is defined by an appropriate level of review: industry, territorial production complexes, individual industrial enterprises, corporations or clusters.



Concept of industrial policy as a system

Considering the traditional interpretation, which limits the subjects of industrial policy only by federal and regional authorities, we find it necessary to expand their composition.

First of all, it is not necessary to limit the management processes of adaptation and development industry, by just federal and regional level, but also consider a municipal level in a subject of the Russian Federation.

The second aspect is based on the fact that in achieving the objectives of industrial policy significant role belongs to economic entities, namely, representatives of industrial businesses in various sectors (public, private, mixed), and legal forms. In addition, you must consider investors as participants, as they have a significant impact on the pace and quality of innovative production development [17].

Thirdly, implementation of industrial policy implies presence and active participation of sectoral management bodies (ministries, centers of cluster development, specialized managing companies and so on), institutional infrastructure (tax and banking structure, Chambers of Commerce, agencies for strategic initiatives, industry associations, unions, public organizations and associations, and so on), which are systems of a higher order and which specify requirements and limitations for the objects of industrial policy.

Subjects and objects of industrial policy interact by means of a complex of tools, been

interdependent due to the objectives of industrial policy, which correspond to the levels of control (Figure).

Considering the virtual absence of effective instruments for implementing industrial policy in the framework of the established state legal and economic mechanism of management in the 1990s in Russia, in our opinion, a large-scale restoration of legal regulation of industrial policy is needed. This idea is justified by the fact that, as practice shows, simultaneous use of many tools, among which there are conflicting ones causes certain difficulties. First of all, the issue is about methods of state regulation, with the help of which the goals and objectives of industrial policy can be settled:

1. Economic methods, combining in its structure:

- financial methods, including leasing, lending, warranting, foreign currency exchange and investment regulation, subsidy mechanisms;
- tax methods (tax regimes, depreciation policy, target allocations for science, training, and related social problems);
- tariff and non – tariff methods of customs regulation (tariff policy on services of natural monopolies);
- banking regulation, stimulating inter-sectoral capital mobility.

2. Institutional approaches, including investment instruments for using off-budget and target





budget funds, special operations on the stock markets, stimulating development of industry.

3. Administrative methods that are implemented by specially authorized bodies of regulation, coordination, consulting, public administration.

4. Socio-political practices aimed at effective solution of social problems in industry, adhering to special policy for state-owned and state unitary enterprises, and enterprises with mixed capital. Implementation of these methods should be helped by target programs of the federal and regional level, target address federal laws.

It must be emphasized that implementation of the above methods is possible through cooperation of industrial enterprises and public authorities. However, the determining factor of the possible active and dynamic application of the above methods is state legal administration.

The abovementioned helps to clarify the content of industrial policy as a set of economic relations of the state, regional and municipal authorities, business entities, providing conditions for high-tech, competitive industrial complex in order to achieve sustainable development of the national economy.

You should note that industrial policy should be implemented based not only on ensuring internal coordination of its constituent elements, but also relationships with other policies – economic, regional, innovation, investment, personnel, social and other. Being one of the directions of the state policy, with specific points of contact with other areas, industrial policy commonly has the specific objectives and implementation tools.

A systematic approach to understanding industrial policy means that the state should provide appropriate support not only to specific economic entities, but also to form the priorities of implementation of industrial potential and structural reforms, to take into account territorial features of economic development, to initiate the formation and development of a favorable institutional environment. When developing industrial policy on the basis of system approach, special attention should be paid to consistency and mutual accounting of requirements to other types of government policies, and requirements of these policies to goals, principles, forms and methods of industrial policy implementation.

Therefore, the strategic goal of industrial policy is manifested in enhancing national competitiveness through production of goods and

services in competition with other countries, compliance with international standards and expansion of the share of national companies in domestic and global markets.

The principal features of the industrial policy of Russia at the present stage are:

- the priority of state interests when formulating and implementing industrial policy at all levels of economic systems;

- concentration of investment resources on strategically important kinds of industrial production;

- creation of large industrial corporate structures based on the principles of vertical production, technological conglomerate and horizontal integration [18];

- sequential update of the technical base of industry based on high-tech industries.

Goals, tools and methods of industrial policy implementation, in our opinion, should be carried out depending on the level of control that determines the feasibility of industrial policy structuring.

Industrial policy can be structured in different ways: type of activity (industry), hierarchical levels of governance (national, regional, municipal, enterprise). In turn, each level of industrial policy structuring is a set of elements that interact with each other, the main purpose of which is to coordinate the interests of its subjects and objects.

Coordination of interests of the subjects and objects of industrial policy is carried out in accordance with the development of economic systems at the macro (national economy), meso- (subjects of the Federation, territorial education, industrial complexes, clusters) and micro levels (industrial enterprises).

To organize the interests of the subjects and objects of industrial policy at different levels of governance, we use the method proposed by A.S. Likhachev [19] so as to understand the mechanism of coordination matrix, where at the intersection of columns and rows you can define the subjects and the level of industrial policy implementation. Possible types of subjects of industrial policy are represented by the federal authorities, regional authorities and bodies of local self-government, and business entities. Rows of the matrix are presented by a possible scale, or level of industrial policy implementation: macroeconomic, mesoeconomic and microeconomic (Table).

**Methods of formation and implementation  
of industrial policy**

Subjects and levels of management	Federal authorities	Regional and municipal authorities	Business subject
1. Serial method			
macroeconomic level	×		
mesoeconomic level		×	
microeconomic level			×
2. Vertical method			
macroeconomic level	×		
mesoeconomic level	×		
microeconomic level	×		
3. Vertical-horizontal method			
macroeconomic level	×		
mesoeconomic level		×	×
microeconomic level		×	×
4. Vertically integrated method			
macroeconomic level			×
mesoeconomic level			×
microeconomic level			×

The constructed matrices allowed us to identify four methods of formation and implementation of industrial policy.

The sequential method implies that when formulating and implementing industrial policy the goals and interests of the subjects of a higher level are taken into account. The advantage of the consistent method of formation and implementation of industrial policy is expressed in the dominance of indirect stimulation of competitive industries based on the concept of «soft» industrial policy.

However, poorly developed methodological, organizational and managerial aspects of industrial policy at all levels complicate practical application of this method.

In the vertical method, industrial policy is developed at the macro – level of federal authorities. A set of measures elaborated at this level is aimed at supporting particular sectors,

contributing to the creation of the institutional infrastructure of the meso-level (region) or private enterprises through targeted support. This method is commonly characterized with «tough» policy based on direct budget subsidies to industries or enterprises, projects where administrative levers are used.

The vertical-horizontal method involves territorial principle of formation and implementation of industrial policy, which allows solving national problems and territorial socio-economic problems, increasing the efficiency of support measures. This approach makes it possible to develop territorial-production complexes, clusters, considering the current structure of industrial activities at the regional level, the degree of production potential being used.

The object of the formation and implementation of industrial policy in the vertically integrated method are corporate structures (state corporations), which unite individual enterprises.

In our opinion, the most effective method of formation and implementation of industrial policy in modern conditions of the national economy is vertical-horizontal, allowing you to align the interests of the nation and territories on the basis of allocation of industrial activities of strategic importance both for the region and the national economy.

In conclusion, it should be noted that the national industrial policy of Russia at the present stage of development of the economy must first be formed with regard to understanding the new role of the Russian state in the world and feasibility of targets. This policy has, in our opinion, a number of essential features:

- equal participants in the development and implementation of industrial policy are public authorities, business, scientific and public organizations, emerging civil society institutions;
- objects of modern industrial policy at the macro level are separate sectors of the economy, large corporate structures with state participation in the capital; at the meso level are industrial complexes, clusters; industrial enterprises, producers of goods and services are at the micro level;
- subject to the control of the national industrial policy is the state, at the regional and



municipal level these are authorities of the Russian Federation, municipalities; private business also may be subject to industrial policy;

– the basis for enhancing competitiveness of industrial companies should be creation of national own production of imported goods analogues, diversification into new types of products, facilitation of insourcing-outsourcing;

– change of the main principle of management is transition from situational regulation to self-regulation, which will contribute to the reorientation of industrial policy from solving situational tasks of development to sustainable quality development.

Thus, industrial policy needs to become a system factor to increase the competitiveness of the Russian economy, which preconditions usefulness of the normative-legal framework for its development and implementation.

During the research the following results were obtained:

– the existing approaches to the definition of «industrial policy» were studied, which made it possible to use system-structural representation to describe its structure and composition of the components;

– formation of the structure of industrial policy was proposed by five key components: subjects, objects, goals, tools, methods of formation and implementation, whose composition is determined depending on the level of governance;

– methods of formation and implementation of industrial policy were selected based on the matrix approach: sequential, vertical, vertical-horizontal, vertically integrated;

– the most effective method of formation and implementation of industrial policy in modern conditions was substantiated: vertical-horizontal one, allowing you to accommodate the interests of the state and territories on the basis of distinguishing the industrial activities of strategic importance both for the region and for the national economy.

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**V.G. Basareva**

## **THE INFLUENCE OF SMALL BUSINESSES ON THE ECONOMIC GROWTH IN RUSSIA**

**В.Г. Басарева**

## **ВЛИЯНИЕ МАЛОГО БИЗНЕСА НА ЭКОНОМИЧЕСКИЙ РОСТ В РОССИИ**

The given paper focuses on the theoretical approaches that enable to estimate the influence of the development of small business on the factors of the economic growth. It discusses the evaluation of the role of small business in the context of the theories of reforms at the present stage. It is proved that the functioning technology of the short-term and medium-term forecasting hardly takes into account the enterprising potency of the population and it leads to the reduction of efficiency of the taken decisions both on the federal and regional levels. It is shown that the decisions to change the conditions of the functioning of small business should account for the estimation of the labour market and the regional peculiarities. It is necessary to develop and expand the existing practice of the medium-term forecasting with the procedures and methods that allow to estimate the decisions taken by the authorities regarding small business from the position of their influence on the factors of the economic growth. These approaches and procedures are performed on the formal level using the methods of econometric simulation, and they will considerably facilitate the process of complex expert analysis of consumer demand and income which usually was executed.

Within the frame of the short-term forecast, it is offered to develop the procedures and methods that make it possible to modify the rational correlation of small forms and large enterprises in accordance with the tasks of the modernization period of the country.

CORRELATION OF SMALL AND LARGE ENTERPRISES; NATIONAL FORECAST; ECONOMIC GROWTH; REGIONAL FACTORS; ECONOMETRIC MODELS; ESTIMATION OF THE CONSEQUENCES OF DECISIONS.

Представлены теоретические подходы, позволяющие оценивать влияние развития малого предпринимательства на факторы экономического роста. Обсуждается оценка роли малого предпринимательства на современном этапе в контексте положения теории реформ. Доказывается, что действующая технология краткосрочного и среднесрочного прогнозирования слабо ориентирована на учет предпринимательской активности населения, что приводит к снижению эффективности принимаемых решений, как на федеральном, так и региональном уровнях. Показано, что решения по изменению условий функционирования малого предпринимательства должны приниматься во взаимосвязи с оценкой рынка труда и спецификой региона. Предлагается разработать и дополнить сложившуюся практику среднесрочного прогнозирования процедурами и методами, которые позволят давать оценку решений, принимаемых властными структурами в отношении малого предпринимательства с позиций их влияния на факторы экономического роста.

Выполненные на формальном уровне с применением методов эконометрического моделирования эти подходы и процедуры, значительно упростят процесс экспертного комплексного анализа состояния потребительского спроса и доходов, который обычно выполнялся. Позволят корректировать рациональное соотношение малых форм и крупных предприятий в соответствии с задачами этапа модернизации страны.

СООТНОШЕНИЕ МАЛЫХ И КРУПНЫХ ФИРМ; НАЦИОНАЛЬНЫЙ ПРОГНОЗ; ЭКОНОМИЧЕСКИЙ РОСТ; РЕГИОНАЛЬНЫЕ ФАКТОРЫ; ЭКОНОМЕТРИЧЕСКИЕ МОДЕЛИ; ОЦЕНКА ПОСЛЕДСТВИЙ РЕШЕНИЙ.

The point of view that the growth of small enterprises is an unambiguously positive fact symbolizing the economic growth of the country is prevailing in the modern Russian researches. The stagnation of this process or retardation of the speed of new small enterprise formation is considered to be negative. Because of that, the actions of the government, which despite the undertaken efforts have quite a weak result, are criticized. Y.G. Chernyshova [9], Z.V. Shvarzburg [10], O.V. Rusezkaya share this point of view [8].

The low efficiency of undertaken actions is noted by E. Bukhvald [2], A.V. Vilenskiy [3].

L.I. Evalenko considers that «the continuation of the paternalistic policy of federal, regional and local authorities is capable of certain increase in the number of small enterprises and the quantity of those engaged in small enterprises but the fundamental increase of the quantitative parameters of this business is hardly probable in the years to come» [4].

In the foreign literature we may find a far greater number of supporters of the moderate



point of view on the employment growth within small enterprises and its connection to prosperity (D. Keeble [11], D. Storey [14], P. Reynolds [12, 13]). The defenders of the theory of reforms support such a moderate estimation. This branch of science has been intensively developing over the recent years. Its task lies in compiling an instruction for the reformers to find the rational strategies of the transformation of various institutes under certain circumstances. Such a moderate assessment of the role of small business is given within the postulates of this theory. In addition, the necessity of the temperate policy in the period of transformational changes is stated.

For example, the academician V. Polterovich writes: «To fulfill a quick growth the state should follow quite a complex strategy choosing the policy adequate for the exact stage of modernization and then changing it promptly when moving from one stage to another. As applied to the issue of the development of small business this thesis implies the necessity to consider the dynamics of rational correlation between large and small enterprises depending on the stage of the modernization of the economic system. In the period of large-scale reforms the understanding of the dynamics of the correlation between large and small enterprises is especially important» [6, p. 191].

Let us use this approach to estimate the place and the role of small business as a factor of growth of modern Russia. It is appropriate to view the studied correlation of small and large enterprises in accordance with the regional peculiarities of the subjects of the Federation for a country with a federal structure and a great spatial diversity [1, 24–25].

This point of view has become topical due to the situation in which Russia has been since the beginning of 2013. Since then, the model of the development oriented to the growth of the world economy and high oil prices, which functioned before the start of the crisis of 2008–2009, has run out of its potential. When the export dynamics weakens and the growth of investments into the basic capital slows down, the consumer demand ensured by the growth of the per capita income remains the main factor of the growth [5].

The Forecast of the socio-economic development of the Russian Federation for 2014 and the plan period of 2015–2016 developed by the Ministry of Economic Development formulates this aim: «The household consumer expenses, the dynamics of which will be relatively stable, remain the main drivers of the growth for 2014 and the plan period of 2014–15. Also taking into

account the high percent of consuming in the aggregate demand this dynamics will ensure about two thirds of the economic growth» [7, p. 77].

Thus, the economic policy should focus on the factors ensuring the growth of the population income and the development of such spheres of specialization, engagement in which would be highly profitable for the population.

Does the development of small business contribute to the growth of the population income at this stage? To check the position of the theory of reforms it is necessary to find out the influence of the industrial employment structure of the population and the number of those engaged in small business on the average per capita income in a federal subject. If at this stage of modernization one of the spheres of economy or the level of engagement in small business contribute to the bigger growth of the population income, then, according to the above-mentioned situation, the economic policy of the state should support these spheres as much as possible to guarantee the growth of the economy.

Let us mention that this interpretation of the hypothesis of V. Polterovich is right only under the circumstances where the economic growth is determined by the consumer demand of the population and its income.

Using the econometric models makes it is possible to verify the hypothesis regarding the influence of the employment structure on the consumer demand and the income of the population of the regions. We have formed a model of the multiple regression reflecting the influence of the regional factors on the per capita income of the population. Moreover, we have conducted some calculations according to the panel data of 2006–2012 including 324 observations. We have used the method of stepwise regression, the essence of which lies in the consistent inclusions of socio-economic factors into the regression equation and the subsequent examination of their significance.<sup>1</sup>

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<sup>1</sup> If at the inclusion of a new factor in the model the coefficients of regression did not change, their indices and symbols and the multiple coefficient of correlation was growing, then the given factor was considered worthwhile of inclusion to the model. At the expansion of the list of factors, a test on multicollinearity was conducted. Such occurrence could be brought out by the complexity and the mutual influence of the processes in the economic systems. If the pair correlation coefficient is greater than 0.8, it is generally accepted as a sign of multicollinearity.

We have conducted a series of calculations with the purpose to find out the influence on the value of per capita income in the region of industry specialization, and the values characterizing the development of small business, poverty and the inequality in the income of the population in the region. The following model was evaluated:

$$DDN_{it} = s_1 + s_2 \text{Prom}_{it-1} + s_3 \text{Sel}_{it-1} + s_4 \text{Str}_{it-1} + s_5 \text{Torg}_{it-1} + s_6 \text{MB}_{it} + s_7 \text{Bed}_{it} + \varepsilon,$$

where  $DDN_{it}$  – per capita income in the region of  $i$ , in the year of  $t$ , where  $t = 2009, 2010, 2011, 2012$ ;  $\text{Prom}_{it-1}$  – the part of those employed in mining, manufacturing, production and distribution of electric energy, gas and water in the general number of the employed in the regions of  $i$  in the year of  $t$ , where  $t = 2009, 2010, 2011, 2012$ ;  $\text{Sel}_{it-1}$  – the part of those employed in agriculture, hunting, forestry, fishing and fish breeding in the region  $i$  in the year  $t$ , where  $t = 2009, 2010, 2011, 2012$ ;  $\text{Str}_{it-1}$  – the part of those employed in construction in the region  $i$  in the year  $t$ , where  $t = 2009, 2010, 2011, 2012$ ;  $\text{Torg}_{it-1}$  – the part of those employed in wholesale and retail trade, repair of motor vehicles, motorcycles in the general number of the employed in the regions of  $i$  in

the year of  $t$ , where  $t = 2009, 2010, 2011, 2012$ ;  $\text{MB}_{it-1}$  – the number of those employed in small business in the region of  $i$  in the year of  $t$ , where  $t = 2009, 2010, 2011, 2012$ ;  $\text{Bed}_{it}$  – the number of population with an income lower than the living wage in the region of  $i$ , in the year of  $t$ , where  $t = 2009, 2010, 2011, 2012$ ;  $\varepsilon$  – symbol of the mistake

Table shows the results of the calculations.

The explanatory ability of this model is equal to 65 %. We can interpret the signs of the regressors of this model in the following way: the higher the number of those employed in industry, agriculture and trade was, the lower the per capita income of the population was. The high number of those employed in construction was typical for the regions with a higher per capita income of the population.

The regions where the number of people with the income lower than the living wage was higher had a lower per capita income. The sign of the significant regressor of the dynamics of the average number of those employed in small business is positive. The regions where the number of those employed in small business was bigger in the period from 2008–2011 had a bigger value of per capita income in the period of 2009–2012.

**The dependent variable: per capita income of the population of the region**

Constant	46071 [13.702476846]**
The part of employed in the industry	–374 [–6.4507821374]**
The part of employed in agriculture	–608 [–10.824630296]**
The part of employed in construction	442 [3.6975345095]**
The part of employed in trade	–594 [–7.0089652444]**
The part of employed in small business	8[5.1766736486]**
The number of the population with per capita income lower than the living wage	–522 [–9.0485942589]**
The number of observations	324
R <sup>2</sup>	65 %
F-statistics	F(6,317) = 97.12584 [0.0000]

T-statistics is given in the brackets, \* – 5 % the level of significance, \*\* – 1 % the level of significance





The specifying calculations have shown that there was quite a high and significant correlation (+0.4) in the period of 2009–2012 between the average per capita income of the population and those employed in small business. The correlation was based on the panel data consisting of 325 observations. The correlation between the indices characterizing the income of the population and the number of individual enterprises was not revealed. However, the high significant correlation exists between the index of the number of individual entrepreneurs in the region and the part of the population with the income lower than the living wage – 0.25. In addition, this index significantly influences the average per capita income of the population.

Thus, the calculations prove that the number of those employed in small business and the number of individual entrepreneurs positively and considerably influences the factors forming the consumer demand. It is the main driving force of economic growth at this stage of modernization of the economy. Besides, those branches, which are traditionally connected to large enterprises, above all industry, do not currently possess the necessary potential that might bring to the growth of an average per capita income of the population. Now this is an additional reasoning in favour of the development and all-round support of small business if there is the task of the preservation and increasing of the growth of economy.

However, what is happening in reality? According to the official data, registered in the Forecast of socio-economic development of the Russian Federation for 2014 and the plan period of 2015–2016, there were some negative trends in the sector of small and medium business for the first six months of 2013. For the period from December 1, 2013 to August 13, 2013, the number of individual entrepreneurs rapidly decreased by 422.2 thousand people which is equal to 10.5 %. According to the data of Federal State Statistics Service, in the first quarter of 2013 in comparison to the first quarter of 2012, the number of medium enterprises shortened by 3.4 %, and the number of the workers employed in medium enterprises shortened by 0.8 % [7, p. 330]. Federal State Statistics Service also reports that the number of substituted workplaces by the workers on the payroll, part-time workers and those who

performed work under the civil law contracts in large and medium-sized companies also decreased for the period from January to May 2013 in comparison to the same period of 2012.

According to the data announced in the media, the shortening was much more considerable. With the same reference to the Federal Tax Service as the Ministry of Economic Development, the media informed that more than 600 000 individual entrepreneurs had been closed up by April 2013 [5].

There is no doubt that the growth of the financial responsibility of individual entrepreneurs influences on this tendency. This was facilitated by the law adopted December 3, 2012 N 243-FZ «On introducing the changes to certain legal acts of the Russian Federation on the obligatory retirement insurance». It has doubled the fixed size of the insurance premium up to RUB 32479.2 (the calculation is based on the size of two minimum wage rates).

The adoption of the law contradicted the statute of the theory of reforms. According to it, with the purpose of the fast growth of economy, the state should regulate the rational correlation between small and large enterprises at every stage of modernization of economic system. In fact, it leads to the shortening of the employment of the population in small enterprises at the stage of modernization while it would be reasonable to increase the number of small enterprises. The taken decisions are contributing to the formation of conditions leading to the reduction of the economy growth. That is precisely what happened.

The consumer demand was lowering the speed of growth at the same period. The rates of retail trade growth in the first 6 months of 2013 lowered to 3.7 against 7.7 % in the first six months of 2012 and the amount of paid services to the population – from 4.2 to 2 % respectively.

Despite the fact that according to the data of Federal State Statistics Service about 25.5 percent of retail turnover falls to the share of small business enterprises, the analysis of the reasons of lowering of the trade growth rates do not take into consideration the negative facts connected with small business.

In the part of the Forecast dedicated to the analysis of the state of economy in 2013, lowering dynamics of the retail turnover is influenced by the changes of state-financed

salaries and the acceleration of the consumer prices growth.

Why is it happening? We believe that one of the reasons is that the functioning methodology of the medium-term forecast of the national economy does not enable to estimate the influence of the level of the development of the population business initiative on the indicators of economic growth. In general, this task is not set in the process of the adoption of laws and statutory acts of federal and regional levels.

The formation of short-term and medium-term forecasts does not take into account the influence of small business on the consumer demand and the income of the population. The forecast of the consumer demand and income of the population is performed within the framework of the general forecasting process regulated by the resolution of the government of the Russian Federation of the 22 July, 2009 N 596 «On the procedure of elaboration of the forecast of socioeconomic development of the Russian Federation». This resolution affirms the rules of the elaboration of the forecast of socio-economic development of the Russian Federation defining the statute, the terms of agreement and the examination of the materials.

The forecasts of the consumer demand and the incomes of the national economy are based on the extrapolation of the dynamics of these indicators of socio-economic development and the comparison of the basic and forecasted periods. The complex simultaneous analysis of the state of the consumer market and the labour market in the whole country and in certain

regions is performed expertly and is not accompanied by a clear strategy.

The methodic recommendations of different levels note the influence of small business on the consumer demand and the income of the population. But it does not offer any quantitative coordination of these indices. As the result, there is a lack of coordination in the assessment of the development of small business in general in the country and in its regions.

The forecast data on the state of small business and the real disposable income of the population do not accord in the national forecast and the regional part of the forecast. The functioning methodic statute and recommendations do not take into consideration the quantitative influence of small business on the income of population as well.

It is necessary to develop and expand the existing practice of the medium-term forecasting with the procedures and methods that allow estimating the decisions taken by the authorities regarding small business from the position of their influence on the factors of the economic growth.

Using the methods of econometric simulation, these approaches and procedures will considerably facilitate the process of complex expert analysis of the state of consumer demand and income. They will contribute to the consistency of the measures and mechanisms developed by the federal agencies and executive bodies of the subjects of the Russian Federation to create the conditions of the steady growth and leveling the influence of the factors connected to the irrational correlation between small and large enterprises in the dynamics.

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## **CONCEPT OF FORMING THE MUNICIPAL MARKET OF ENGINEERING KNOWLEDGE**

**А.Н. Шичков, Н.А. Кремлёва, В.Д. Половинкина**

## **КОНЦЕПЦИЯ ФОРМИРОВАНИЯ МУНИЦИПАЛЬНОГО РЫНКА ИНЖЕНЕРНЫХ ЗНАНИЙ**

The regional market of Knowledge is the economic system, the infrastructure of which implements a function to enhance continuously the competent level of enterprises' manufacturing-technological systems. It provides the increase in sales of products and /or services that have market cost, in other words, competitive advantage on the market. Products of the market of Knowledge are educational bachelor's programs by the major «Innovation» and master's programs by the major «Innovation management», which is university's intellectual property and intangible assets. The mechanical-engineering enterprises of the municipal district have been offered to purchase these intangible assets in the form of «Rights to manage the study process under the Bachelor's Educational Program» and «Rights to manage the study process under the Master's Educational Program» adapted to the competent level of manufacturing-technological systems of each enterprise. These Educational Programs have been accredited in the Russian Federation and submitted for the ASIIN accreditation. The estimation of capitalizing the balance cost of intangible assets shows that managing amortization techniques allows adjusting the base for the tax on operating income. Besides, if we have a group of at least 10 students who pay for the course of 4 years – the study period of bachelor students –, it will result in the capitalization of 3.47. The main advantage of the concept of the municipal infrastructure of the Knowledge market is the formation of a market structure based on the purchase of intangible assets, which provides funding for accreditation of Educational Programs at the European accreditation agencies. The proposed methodology to assess the level of competence in manufacturing-technological systems provides reasonable investments into their competent level and functional capabilities. The methodology allows controlling the stability of consumer properties of products having a competitive advantage on the market.

COMPETENCE; COMPETENT-TECHNOLOGICAL COMPLEX; COMPETENCE LEVEL OF MANUFACTURING SYSTEM; MUNICIPAL MARKET OF KNOWLEDGE; INFRASTRUCTURE OF MARKET OF KNOWLEDGE; EDUCATIONAL PROGRAM; STUDY PROCESS; ACCREDITATION; INTELLECTUAL PROPERTY.

Региональный рынок знаний является экономической системой, инфраструктура которой реализует функцию непрерывного повышения компетентностного уровня производственно-технологических систем предприятий, обеспечивающего увеличение объема реализации продукции (услуг), имеющих рыночную стоимость (конкурентные преимущества). Продукцией рынка знаний являются образовательные программы подготовки бакалавров направления «Инноватика» и магистров направления «Инновационный менеджмент», являющиеся интеллектуальной собственностью (нематериальными активами) университета. Машиностроительным предприятиям муниципального округа предложено приобрести нематериальный актив в виде права управления образовательным процессом по программам, адаптированным к компетентностному уровню каждого предприятия. Программы аккредитованы в России и представлены к аккредитации в ASIIN. Оценка капитализации балансовой стоимости нематериального актива показала, что управление амортизационными технологиями при формировании налогооблагаемой базы налога на операционную прибыль предприятия и совместную (в пропорции 2 к 8) реализацию одного платного набора группы (10 человек) студентов, позволит за четыре года (срок обучения бакалавров) получить капитализацию 3,47. Основным достоинством разработанной концепции муниципальной инфраструктуры рынка знаний является формирование рыночного уклада на основе трансферта нематериальных активов, обеспечивающих инструмент финансового обеспечения процедуры аккредитации образовательных программ в Европейских аккредитационных агентствах. Предложена методология оценки уровня компетенций производственных систем, обеспечивающая формирование обоснованных пропорций инвестирования в компетентностную и функциональную составляющие производственно-технологических систем. Методология позволяет управлять стабильностью получения потребительских свойств продукции, имеющей конкурентные преимущества на рынке.

КОМПЕТЕНЦИЯ; КОМПЕТЕНТНО-ТЕХНОЛОГИЧЕСКИЙ КОМПЛЕКС; УРОВЕНЬ КОМПЕТЕНЦИИ ПРОИЗВОДСТВЕННОЙ СИСТЕМЫ; МУНИЦИПАЛЬНЫЙ РЫНОК ЗНАНИЙ; ИНФРАСТРУКТУРА РЫНКА ЗНАНИЙ; ОБРАЗОВАТЕЛЬНАЯ ПРОГРАММА; ОБРАЗОВАТЕЛЬНЫЙ ПРОЦЕСС; АККРЕДИТАЦИЯ; ИНТЕЛЛЕКТУАЛЬНАЯ СОБСТВЕННОСТЬ.



*Topicality.* The factor which determines a continuous increase in the gross municipal product (GMP) and the tax base of municipalities is the improvement of production at enterprises based on product, technology and allocation innovations.

In the innovative market economy enterprises continuously increase sales of products and services on the basis of constant changes of the product range. Therefore, their production systems are competent-technological complexes implementing consumer properties through the sequence of technological stages, the formation of consumer properties of products being their market cost.

The capitalization level of cash flow is the factor of efficiency for a competent-technological manufacturing organization in the engineering business. That is why the innovative market economy is sometimes called the economy of commercialization of intellect.

Net income from company's operating activities amounts to net operating profit, amortization and depreciation of intangible and tangible assets. The fact of the increase in sales with the simultaneous growth of net income indicates investments into the product and/or technological innovation. In accordance with the accounting standards, investments into modernization are funded from the depreciation fund. It results in the increase of fixed assets of entity. Amortization of intangible assets decreases the taxable base of operating profit in the developed countries. As a result, the increase in the net income due to the increase in the net operating profit needs additional analysis.

The efficiency of enterprise production systems is determined by the adequacy of competent and functional levels of technological machines. The ratio of sales  $V$ , rub/year to net income  $D_o$ , rub/year from operating activities is an information indicator of the competence level of the production system. This ratio is an indicator of the competence of  $k_q$  production system at the enterprise

$$V / D_o = k_q > 1.$$

The logic of assessing the competent component of a manufacturing-technological system in terms of competence shows that the lacking professionalism of the production staff leads to the decrease in sales due to the inconsistency of consumer properties of the output. The manufacturing-technological system has sufficient technological capabilities if it manufactures 90 or more percent of products with the required consumer properties.

In the market economy cash flows are realized on the basis of two natural processes – purchase and sale. These two interrelated tools of management implement the following business functions: monitoring of consumer properties, market assessment of cost and motivation of participants in the money exchange. Thus, the production structures and processes are based on the transfer of cash flows, forming the market cost of products and services.

In general, in the developed countries a competent technological manufacturing organization is realized on the basis of the management accounting (controlling) by the transfer of operating costs into consumer properties of products or services having the market cost. It takes place subsequently in zones of financial responsibility, which are stages of technology. If any single part of the technology has no market cost, a finished product cannot have a competitive advantage on the market.

The main criteria to evaluate the effectiveness of management accounting are:

1. The price of product or of technological conversion is greater than or equal to its market cost and higher than direct operating costs;
2. Production costs should approach direct operating costs;
3. Wages in the structure of direct operating costs is equal to the labour payment;
4. Labour productivity must be equal to the productivity of manufacturing- technological systems;
5. The indicator of competence  $k_q$  of the operational process must not change or can increase;
6. The cost of property complex, business and equity capital (tangible and intangible assets) of a company on the stock market continuously increases.

Moreover, management accounting certified by the international quality management system is instrumental to continuously increased tax payments at all budget levels and reduces the technogenic burden on the environment.

**Conclusion.** The manufacturing-technological system of an enterprise (MTS) is a competent-technological complex. Firstly, it is obvious that in order to enhance a manufacturing organization, it is necessary to invest separately into the competent and engineering components of MTS. Secondly, it is necessary to invest proportionally to the positive or negative balance of functionality of technological machines and to the competent level of the production staff.

### Management of competent-technological processes and systems

One of the processes regulated by the international quality management standard ISO 9000:2000 is developing the competent level of the production staff.

In order to ensure the enterprise's effective performance and to raise the competent level of the production personnel, this ISO suggests the procedure of regular professional upgrading for employees.

The Standard requires continuous education, training and re-training of the enterprise's production personnel and provides for drafting an array of company documents which are binding for management in all divisions of the enterprise.

The supervisors of divisions and other structural units at the enterprise realize situation analyses of excellence in production processes, namely: consistency of consumer properties of products at stages of the technological process and adequacy of operating costs to planning parameters. Based on the situation analysis, plans and programs are designed to foster competencies of the production personnel.

*Theory and practice of an engineering organization* consists of:

1. Competencies for designing and enhancement of scientific and methodological systems as well as technical principles of a manufacturing organization;
2. Creation and application of methods and tools for monitoring;
3. Research and analysis of various organizational, technological and technical solutions at all levels of the organization's production of goods and services with competitive advantages.

The solution to these issues is implemented with a wide use of information technologies, which qualitatively improve a manufacturing organization's processes in various industries and accelerate the scientific and technological progress.

The competencies of innovation processes determine the practical development of science, techniques and technologies of producing goods and services, development and implementation of technology innovations, investments and processes of innovative transformations.

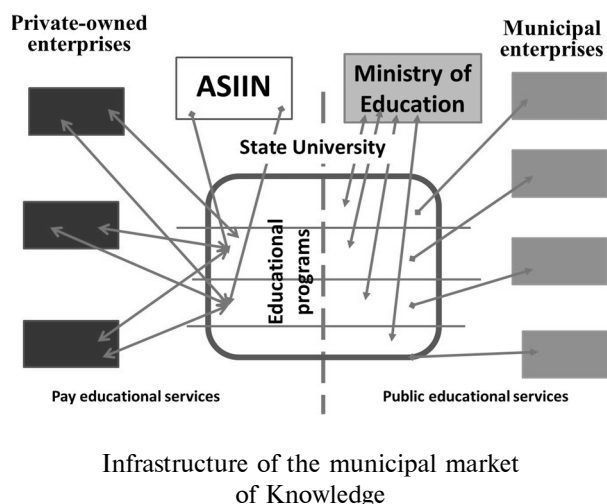
The innovators realize projects and predict processes of innovation development in the engineering business and adaptation of production systems to the innovation implementation.

The tasks of an innovative approach concerning the formation and development of the market structure are successfully solved by professional engineers. They master management functions in the state and municipal governments, implement the status of top managers at innovative production, create tangible and intangible assets that have the market cost. Any business created by a professional engineer generates income.

In relation to this, the Council of the Russian Federation (RF) has drafted a bill on the status of Professional Engineers and Engineering Interns. The underlying basis of the Law is the experience of the developed countries in this area which certifies professional engineers and engineering interns at self-regulatory organizations in the respective industry (e.g., the Union for mechanical engineers, the Union for building engineers, etc.). These are people who hold and apply for engineering positions in design, production and technological organizations.

**Conclusion. Engineering competence is the base of innovative market economy.**

The Federal Law on Education in the Russian Federation states organizational and financial aspects of high professional education in the market structure (Figure).





An employer is interested to hire graduates who are able to perform a number of professional tasks. Consequently, learning outcomes should assess competencies including the following:

- a) a necessary amount of background professional and theoretical knowledge;
- b) a set of methodologies and techniques to apply the knowledge in practical activities;
- c) professional experience during laboratory works, in job training, manufacturing, etc.

The competencies are divided into professional, i. e. specialization in certain production areas and universal, i. e. which require an educated person regardless of training. To do this, the modular design of educational programs is used.

The municipal market of Knowledge means a self-managing economic system, the infrastructure of which implements the balance of supply and demand on the competencies, having the market cost and adequate functionality at manufacturing-technological systems of enterprises.

A state university is a provider of competencies to the regional market of Knowledge. Under the Federal law on Education in the Russian Federation a higher educational institution may be either private and state, or municipal. The training of bachelors, masters and post-graduate students is based on the state licensing and accreditation of Educational Programs in compliance with the requirements of the State Educational Standards of the Russian Federation.

In the process of licensing and accreditation the Ministry of Education and Science of the Russian Federation applies the same standards to the regional and state universities regardless of their forms of ownership. These requirements are fair due to the fact that graduates are conferred the uniform state diploma on the entire territory of the Russian Federation.

Financing educational services for bachelors, masters and post-graduate students is carried out on the basis of the State Order for state authorities, self-government municipalities and enterprises which provide the support of population's life activities. The State Order for training is financed by the Ministry of Education and Science of the Russian Federation in accordance with the estimated direct costs.

Today, the estimated direct costs, depending on training, varies for universities from 80 to 120,000 rubles a year per student. This funding amounts to about 50% of the university budget. Under the current legislation a state university

has the right to render paid educational services to train bachelors, masters and post-graduates students and conclude contracts with individuals and legal entities (private-owned enterprises). The students who pay for their education must get the same educational services as their counterparts taught at the expense of the state budget. Therefore, student tuition fees shall be in no way lower than the price approved by the Ministry of Education and Science.

Higher school of the Russian Federation is moving towards the integration with the European concept of education.

In the developed countries Educational bachelor's and master's programs are drawn up by accumulating competencies (credits) that allow a postgraduate student to adapt to the specific business.

The fundamental difference between the educational system of the Russian Federation from the European systems results in the development of higher education in different economic systems. Therefore, there is some difference between bachelors and masters trained by those Educational programs accredited in the Russian Federation and the EU pertaining to different economical systems.

The leading engineering universities of the Russian Federation approach the challenge to integrate the educational systems from different points of view. For instance, the N.E. Bauman Moscow State Technical University set up the Department of Engineering Business & Management. The Department generates engineering solutions based on their cost. This Department and other engineering departments of this University award diplomas that are in great demand on the international market of Knowledge. The St. Petersburg State Polytechnic University accomplishes a double degree program with Lappeenranta University of Technology (Finland). Students of the first year study in Russia and they go to Finland for their second year. As a result, students gain a Master's degree in Innovation Management by the Educational program accredited in the Russian Federation and a diploma of the Educational Program on Global Innovation Management accredited by ASIIN.

Vologda State University has developed a similar methodology. The implementation of the double diploma program is very complicated and is not managed. Students should be financially supported for the course of one year in Finland

or Germany. Costs of accommodation and meals are more than 500 euros per month. Teaching is done in English. To be enrolled in Lappeenranta University of Technology (Finland), one must have the certificate to confirm a certain level of the English language with at least six points.

The price of the English examination for the certificate is 10,000 rubles in Moscow or St. Petersburg. Only three or five students agree to study in foreign universities to obtain a double diploma. The students usually do not return to Russia. As a matter of fact, regional industrial enterprises do not need those students who received a bachelor's degree or master's degree in engineering. It is explained by the difference in the content of engineering education.

In other regions there is no infrastructure for the market of Knowledge, which contributes to adaptation of bachelors and masters to engineering business upon graduation from university. Today large manufacturing companies are not ready to organize production and to form staff using the market of Knowledge at the level of bachelors. Bachelors are not ready psychologically to begin their production careers from the position of machine operator. There are also other reasons which prevent from training bachelors and masters for engineering business in accordance with the European requirements.

To solve this problem, Vologda State University has designed two Educational Programs for engineering and technological profiles of training bachelors and masters, having skills to cooperate with enterprises of the European Union. Their competencies, knowledge and practical skills allow them to work at an engineering enterprise and to develop products and technologies that have competitive advantages in foreign markets. These Educational Programs are the intellectual property of the University and are reflected in the balance sheet as intangible assets.

The University started the accreditation of Educational Programs in the European accreditation agency ASIIN. As a result of the accreditation, the University will receive a print of this Agency. The University graduates trained by these programs will be eligible to take engineering positions in Russia and the EU.

The price of the accreditation according to the agreement with the «Accreditation Agency for Study Programs in Engineering, Informatics, Natural Sciences and Mathematics» (ASIIN, Robert-Stolz-Str. 5, 40470 Düsseldorf) is 15,000 euros.

In order to implement the concept of continuous engineering education, the University has offered to its partners – enterprises to jointly tackle the task of training professional engineers and managers who will ensure the development of innovative production and will also implement product, technology and allocation innovations.

### **The Commercial Offer from the University to its partners-enterprises**

Below is the commercial offer to purchase the following intangible assets:

*«The Right of managing the educational process of Bachelor's and Master's Educational programs, the competencies of which should meet the accreditation requirements of ASIIN to professional engineers».*

*These Bachelor's and Master's Educational Programs are intangible assets.*

1. *«Innovation»* is the comprehensive educational program in engineering licensed and accredited by the Ministry of Education and Science of the Russian Federation. The content of the program is designed for the period of study of four years. Two degrees are awarded to each graduate: a bachelor's degree in «Innovation» (state-approved diploma of the first level of higher education) and that of a technician in «Technology of Mechanical Engineering» (state-approved diploma of secondary education) alongside with the machine operator certificate.

A bachelor having two state diplomas of the Russian Federation and a profession of a worker begins his production career with a position of manufacturing-technological system operator. His competences allow consistently adapting to the levels of technology and production management.

2. *«Innovative Management»* is the Educational Program of the second level of higher professional education licensed and accredited by the Ministry of Education and Science of the Russian Federation. The content of the Educational Program is designed for the period of study of two years combined with the industrial training. A master's degree in innovation management is awarded regardless of a bachelor's training profile.

*Master's competencies in innovative management* allow consistently adapting to the levels of production top management, aimed at organizing production based on innovative management tools, and launching innovative products with competitive advantages into foreign markets.





*Capitalization of investments will be implemented with the following tools:*

The previous logical research apparently shows that the post-industrial innovative economy is the economy of Knowledge. Namely, intellectual activity in the production sphere is converted into an intangible asset acquiring quantitative parameters, defining, and characterizing the cost of business on the stock market.

The market cost of the intangible assets purchased from the University is 5,000 euros.

1. The intangible assets purchased at a market cost by an enterprise will enter the balance sheet, and the management of amortization allows adjusting the base for the tax on operating profit.

2. The Rights of management over the educational process will be implemented through the selection of candidates for training. The use of planned educational programs for practical training to develop innovative technologies in production. As to Master's training, it is implemented in combination with the industrial activity.

3. Mastering proficient English will allow junior students to cooperate with foreign partners.

4. The framework of the contract for purchasing an intangible asset contains the following items:

4.1. The University will train five bachelors and two masters;

4.2. The University will advise on organizational and technological issues prior to the completion of training by bachelors and masters.

#### **Estimation of intangible asset capitalization**

$V$  – balance cost of intangible asset – 380 000 rub;  $\tau$  – time of useful life of intangible asset – 4 years;  $\Delta D_{am}$  – part of income from amortization of intangible asset:

$$0.25 \cdot 380000 = 95\,000 \text{ rub./year};$$

$N_{op}$  – 20 % – tax rate on operating profit;  $\Delta D_p$  – part of income from the decrease in the taxable base on operating profit:

$$0.2 \cdot 95\,000 = 19\,000 \text{ rub./year.}$$

$D_{tot}$  – total income over 4 years:

$$95 \cdot 4 + 19 \cdot 4 = 456\,000 \text{ rub.}$$

$n$  – 10 fee-paying students.

$\Delta D_s$  – income of enterprise from students:

$$(72\,870 + 34\,890) \cdot 4 \cdot 10 \cdot 0.2 = 862\,000 \text{ rub.}$$

Commercial capitalization from intangible assets:

$$K = D/V = (862\,000 + 456\,000)/380\,000 = 3.47.$$

*Conclusion.* The concept of economic tools and market infrastructure of educational services (market of Knowledge) requires that entities of infrastructure completely abandon the tools of the state system in training specialists for specific jobs. The market system of training bachelors and masters is fundamentally different from the state system of engineering training. However, there is a tendency to apply state organizational and educational tools to market conditions. For example, Educational programs are not recognized as intellectual property. Therefore, the motivation to update them from the point of view of scientific and applied significance is lost. In fact, credit-cumulative forms of competencies evaluation are not used. This fact causes serious problems in accreditation of educational programs at European agencies.

In the regions there are no documents to regulate the relationships between the market and consumers of universities' educational services. The Ministry of Education and Science should shape the market structure of engineering educational services.

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**A.R. Kankovskaya, S.A. Tsvetkova**

## **WAYS OF INCREASING COMPETITIVENESS OF THE RUSSIAN STEEL INDUSTRY**

**А.Р. Каньковская, С.А. Цветкова**

## **ПУТИ ПОВЫШЕНИЯ КОНКУРЕНТОСПОСОБНОСТИ РОССИЙСКОЙ ЧЕРНОЙ МЕТАЛЛУРГИИ**

The article analyzes the ways to improve the international competitiveness of the Russian steel industry, the basis of the Russian economy. The concept of sectoral competitiveness is discussed and the methods to evaluate competitiveness in terms of the outcome, i. e. the ability to sell products in certain markets and the quality of existing competitive advantages, are suggested. The application of the proposed methodology enabled us to indicate lower competitive position of the Russian metallurgical enterprises within the last ten years. Thus, the application of a systematic approach to the problem of improving sectoral competitiveness is quite up-to-date. According to this, the effective sectoral innovation system is to be established to provide interaction of economic agents. A key role in it is given to the system of higher metallurgical education as it is reflected in all stages of the innovation cycle, from training highly qualified personnel to the commercialization of research results. We focus on the development of the sectoral innovation system, which is to enable us to increase international competitiveness of Russian steel industry and to determine the direction of development of the Russian system of higher metallurgical education, consistent with the objectives of the sectoral innovation system. As a result, we have ensured the key role of higher education supported by the state in the development of the metallurgical industry innovation system. Due to the role of higher education in innovation and development of the industry we focus on motivation of metallurgical enterprises to build relationships with universities.

SECTORAL COMPETITIVENESS; SECTORAL INNOVATION SYSTEM; STEEL INDUSTRY; FUNCTIONAL CONNECTION; STATE SUPPORT.

Проводится анализ путей повышения международной конкурентоспособности российской черной металлургии — базовой отрасли российской экономики. Рассмотрено понятие «отраслевая конкурентоспособность», предложено оценивать ее с точки зрения достигнутого результата — способности продавать товары на определенных рынках, и с точки зрения имеющихся конкурентных преимуществ. Расчет показателей по предложенной методике позволил сделать вывод об ухудшении конкурентных позиций отечественных металлургических компаний за последние десять лет, несмотря на значительные инвестиции предприятий в модернизацию производства. Обоснована необходимость применения системного подхода к решению проблемы повышения конкурентоспособности отрасли, который предполагает построение эффективной отраслевой инновационной системы, обеспечивающей взаимодействие экономических агентов в ходе генерации, распространения и использования знаний. Ключевая роль в ней отводится системе высшего металлургического образования, активно задействованной на всех этапах инновационного цикла, начиная с подготовки высококвалифицированных кадров и заканчивая коммерциализацией результатов научных исследований. Проведена декомпозиция глобальной цели создания и развития отраслевой инновационной системы, заключающейся в повышении конкурентоспособности российской черной металлургии. Это позволило нам определить направления развития российской системы высшего металлургического образования, соответствующие целям развития отраслевой инновационной системы. Доказана ключевая роль государственной поддержки в развитии системы высшего металлургического образования как элемента отраслевой инновационной системы вследствие особой природы высшего образования и инноваций. Обоснована приоритетность использования инструментов государственного воздействия косвенного характера, ориентированных на побуждение металлургических предприятий к наращиванию связей с высшими учебными заведениями.

ОТРАСЛЕВАЯ КОНКУРЕНТОСПОСОБНОСТЬ; ОТРАСЛЕВАЯ ИННОВАЦИОННАЯ СИСТЕМА; ЧЕРНАЯ МЕТАЛЛУРГИЯ; ГОСУДАРСТВЕННАЯ ПОДДЕРЖКА; ФУНКЦИОНАЛЬНЫЕ СВЯЗИ.

Globalization and acceleration of scientific and technological progress contributed significantly to increased competition in world markets. In

this respect, the problem of gaining the competitive position of domestic producers, both within the country and abroad, is of particular



importance. The prerequisite for the international competitiveness of the national economy is the presence of competitive industries in its structure. Therefore, the development of competitive advantages of basic industries is a priority, with steel industry being one of the most important for the Russian economy.

The importance of steel industry in the modern economy is determined primarily by the fact that it is a major supplier of construction materials for engineering, construction and power complex. The contribution of steel industry into GDP of Russia is about 1.4 percent. It accounts for about 8 percent of the industrial production and 6 percent of the country's exports. The share of the Russian steel industry in tax payments in all levels of budget exceeds 5 percent. Moreover, as a consumer of goods and services of natural monopolies, steel industry uses 5.3 percent of total electricity consumption and more than 8 percent of total natural gas consumption, and its share in rail freight makes up about 15 percent. Around 3.5 percent of employees in the industrial sector of the Russian economy are employed by the enterprises of steel industry [16]. Changes in the metallurgical production lead to corresponding fluctuations in the index of the industrial production ahead one or two quarters. Thus, we can draw a conclusion that the development of steel industry affects the entire industrial production and, consequently, the economic situation in Russia [4].

Steel industry is one of Russia's key areas in the international division of labour. Today, Russia is the fifth largest steel producer after China, Japan, India and the United States: the share of the Russian steel industry amounts to 4.3 percent of the total global steel production [18, p. 9]. Russia takes the 4th place in net exports of steel products (17.1 million tons) after China (46.8 million tons), Japan (36.1 million tons) and Ukraine (23.0 million tons) [18, p. 25].

The importance of steel industry for the national economy makes it necessary to evaluate its competitiveness and the ways to improve it. However, it should be noted that today there is no single methodology for assessing the level of sectoral competitiveness.

M.I. Gelvanovsky, V.M. Zhukovsky, I.N. Trofimov suggest assessing the sectoral

competitiveness by using a set of indicators, such as labour productivity, specific wages, capital intensity, research intensity, the degree of export or import dependency in the industry, the expansion of the industry (the degree of use of the products of the industry in other sectors of economy) [2].

V. Petrov identifies the following indicators of sectoral competitiveness: the dynamics of the norm and the mass of the profit; the economic growth in the country; the balance of exports and imports of the analyzed industry in comparison with such balances in other countries [8].

A.V. Skubko and T.I. Vlasenko point out the need to analyze the competitiveness of the industry by two factors [1, 10]:

- the competitiveness in the global market, i. e. the ability of goods produced by the industry of the national economy to compete with similar products produced abroad;
- the competitiveness of the industry in the domestic market, i. e. the ability of goods produced by the industry of the national economy to compete with goods imported into the country.

According to I.V. Pungin and V.S. Pungina [9], the criteria for evaluating the competitiveness depend on the purpose of such assessment.

In our study, the increased competitiveness of a particular industry is considered to be the contribution to improving the competitiveness of the economy as a whole. The evaluation is initiated by the state, which aims to improve the living standards of the population. Living standards in the country are largely determined by the productive use of resources, since they depend on the amount of income of owners of these resources. Therefore, industry can be considered to be competitive if the volume of production and sales in it has been in accordance with the trends of the global and national economies for a long period of time.

We believe that the sectoral competitiveness should be assessed in the following way: 1) in terms of the outcome, by which we mean the ability to sell products in certain markets; 2) from the standpoint of the quality of existing competitive advantages. All figures should reflect the dynamics.

We suggest using two indicators to measure the competitiveness of steel industry, both in

domestic and foreign markets: 1) to assess the external competitiveness, the dynamics of exported steel products share in the total steel production should be analyzed; 2) to assess the internal competitiveness, the imported steel products share in the total steel consumption within the economy should be calculated. Based on the data of the World Steel Organization [17], we have calculated these indicators for ten largest steel-producing countries as of 2013 for 2003 and 2012 (Tab. 1).

As it can be seen from Tab. 1, the analyzed period is characterized by the deterioration of the competitive position of the Russian steel industry both in foreign and domestic markets, by 8 percent and 5 percent respectively. The leader of the world's steel production, China, was able to strengthen its export position twice during this period, while significantly reducing its dependence on imports of steel products – from 16.79 percent to 2.05 percent. At the same time, China is still a manufacturer of semi-finished products mainly, importing from abroad high-quality metal products. More than 60 percent of Russian steel exports also make up products with low added value [6]. The closest competitors to Russian steelmakers, in terms of external (about the third of production is exported) and internal competitiveness (the share of imported steel products in domestic consumption is about 13 percent), and export structure (predominance of products with low added value), are Brazilian steel corporations. The last ones continue to distinguish themselves through the world's lowest level of production costs and are able to compete with the world leaders on quality and technologies [6].

The Russian steel industry is increasing its raw specialization. The role of «raw material supplier» is enforced by the protectionist policies of a number of importers of the Russian metal and the availability of a large number of steel processing

facilities around the world (rolling, coating, etc.), loaded at only 75 percent. In the long term, global trends such as an increase in prices for raw materials and energy, increased competition in foreign markets, consolidation of steel companies, strengthening of protective measures, etc. may adversely affect the international competitiveness of the Russian steel producers. A gradual increase in export profitability of semi-finished products relative to the profitability of supply of finished products will entail technological backwardness of the Russian steel industry from the metallurgy of competing countries.

In contrast with the external markets, the share of consumption of low value added products in the Russian steel market is minimal, because the main buyers here are not steel mills, but machinery industry, construction, and energy sector. In the future, the growing rolled metal consumption in Russia, predicted at 4 percent per year [7], will encourage an increase in the production of high value added products [3].

Nowadays, the international competitiveness of the Russian steel industry is based on the following factors:

- properly developed iron ore, and fuel and energy base;
- modern facilities for melting pig iron and steel, and manufacturing metal products;
- vertically integrated structures, competitive in foreign markets.

It should be noted that Russian steelmakers' competitive advantage of lower production costs (tariffs for natural gas, electricity, rail transportation, wages), in comparison with their foreign competitors, with comparable product quality and technological level has actually been lost lately. As a result, compared to the level of 2005-2007, the profitability of sales of steel products in 2013 decreased almost threefold – from 25.3 percent to 9 percent [16].

Table 1

Year	Indicator	China	Japan	USA	India	Russia	South Korea	Germany	Turkey	Brazil	Ukraine
2003	Export. percent	3.71	30.52	8.25	15.95	45.96	30.43	55.06	60.89	41.55	71.96
	Import. percent	16.79	4.08	20.11	7.11	9.09	32.69	47.34	53.45	2.93	7.43
2012	Export. percent	7.50	38.67	15.29	10.65	37.89	43.74	60.46	51.99	28.13	73.16
	Import. percent	2.05	8.02	29.13	11.91	13.63	34.42	57.38	40.01	13.22	17.48



Russian steel companies are trying to regain its competitive position by expanding investment programs aimed at development of production facilities and transport infrastructure: thus, in 2012 they invested six times as much as in 2000 [7]. However, the technological backwardness of the Russian steel industry has not been overcome yet, and the competitive position of the Russian metallurgists has lowered. It indicates the need to apply a systematic approach to the problem of improving the sectoral competitiveness. Due to the important role of interactions throughout the innovation process, the increase in the competitiveness of Russian steel industry is impossible without building an effective sectoral innovation system, providing interaction of economic agents in the course of generation, dissemination and use of knowledge. Thus, the global goal of the development of the steel industry innovation system facilitates its international competitiveness.

One of the ways to improve the competitiveness is to reduce the production cost, by increasing productivity. If we compare the productivity of the leading Russian steel companies, such as MMK, Severstal, NLMK and others, with enterprises in Eastern Europe, for example, with the industrial group Arcelor Mittal, the productivity of the latter exceeds the productivity of domestic enterprises in about 1.5-2 times. As compared to the closest competitors of the Russian steelmakers – the Brazilian steel producers, domestic enterprises are lagging behind in 3–4 times in terms of productivity: the above mentioned foreign enterprises demonstrate the performance level of 1300–1500 tons of steel per person against the 300–500 tons of the Russian plants [11].

Improved competitiveness of domestic steel industry also implies higher quality of products manufactured in the country, as a result of increased expenses on research and development (R&D). Intense competition in steel markets forces the world's leading steelmakers to develop their own research centers, to cooperate closely with customers, universities and suppliers of metallurgical equipment on the development of breakthrough technologies that will facilitate the competitiveness of steel products in the world market in the medium and long term. In contrast with the world's leading steel companies, which spend 0.4-1.6 percent of their revenue on R&D

projects, the Russian companies invest ten times less for these purposes – only 0.01–0.02 percent [7].

The development of the innovative activity of metallurgical enterprises is another way to increase the competitiveness of Russian steel industry. Despite the fact that the level of innovative activity of the Russian steel companies is several times higher than the average for the country's economy (25.1 percent vs. 11.1 percent in 2012 [13, p. 55]), and is close to the average value of the Russian high-tech industries (31.3 percent [13, p. 54]), it is still significantly below the level of innovative activity of industrial enterprises in developed countries (55-70 percent) [14, p. 10].

The problems of the Russian steel industry revealed in our study are identical to the problems of the traditional industries of China stated in [5]. Recognizing the recommendations for the development of innovative industries formulated by A.V. Kozlov and Zhang Xia as relevant for Russia, we are going to supplement them with the reference to the very traditional industry.

At present, the institutions of the national innovation system and the state innovation policy virtually ignore the existence of outdated technologies and industries, as they are focused on finding and developing innovations in the breakthrough industries. Therefore, one of the urgent tasks of the national innovation system and its sectoral subsystems, including steel industry, is the transfer of production to a qualitatively new level and the transition to the knowledge economy. Thus, as described in detail in [12, p. 75–76], the partnership between businesses, government and universities on the basis of the triple helix, accompanied by the combination of their competences, is vitally important. It allows making an innovative breakthrough and providing the stable sectoral and national competitiveness.

In connection with this, there is an obvious need for the development of the Russian system of higher metallurgical education as a key element of the sectoral innovation system in conjunction with its other subsystems. The Russian system of higher metallurgical education should develop in three directions, consistent with the objectives of the sectoral innovation system:

1. Improving the labour productivity in steel industry by improving the quality of higher metallurgical education (educational and stimulating functions);

2. Improving the quality of steel products by strengthening the research component of higher metallurgical education (research and stimulating functions);

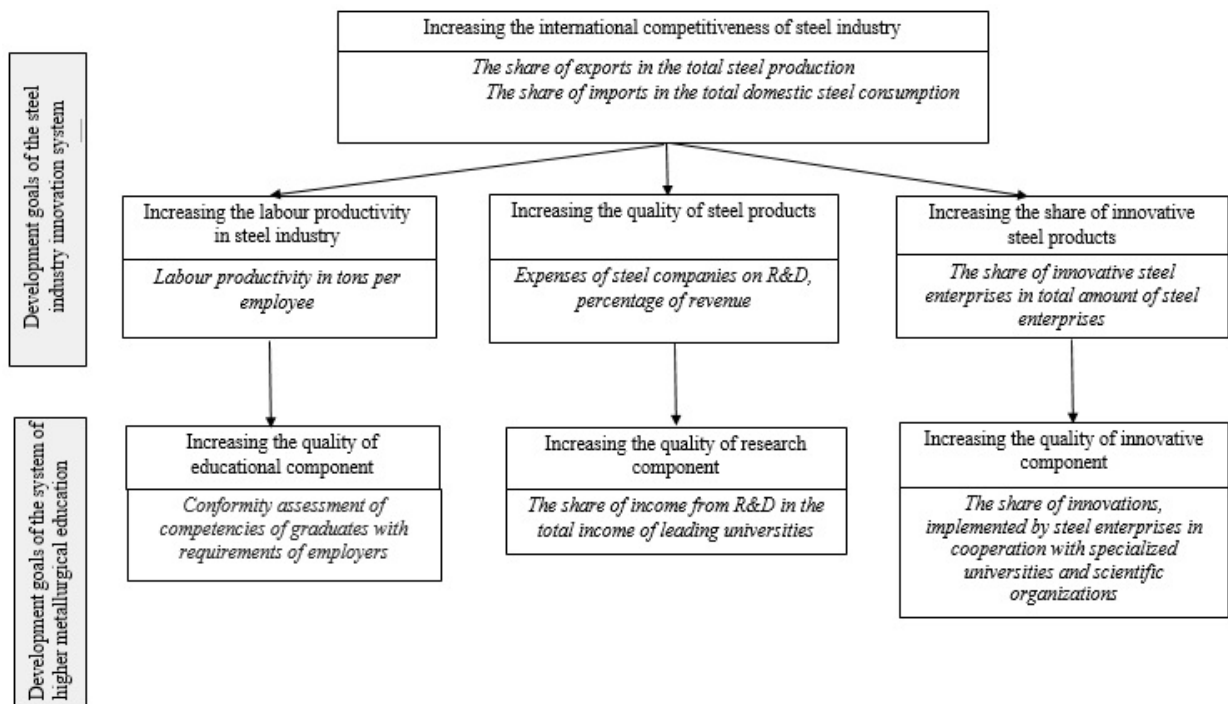
3. Increasing the share of innovative products in total steel production by increasing the innovative component of higher metallurgical education (innovative and stimulating functions).

The goals for the development of steel industry innovation system and the system of higher metallurgical education as an element of the sectoral innovation system are shown in Figure.

The higher education system is a key element of the national innovation system (NIS); and the system of higher metallurgical education plays a primary role in the steel industry innovation system. The higher educational system is unique in its ability to participate in all the subsystems of the NIS, realizing one or more of its functions within the NIS: educational, research, innovative, and stimulating ones. In contrast with other organizations, e.g. research institutes, innovative enterprises, innovation infrastructures, which are also elements of the NIS and are usually only

responsible for one of the stages in the innovation process (research, commercialization of research results, mass production of innovative products), universities are involved in the implementation of all phases in the innovation cycle, from training highly qualified personnel to commercialization of research results. Since the functions implemented by the higher education system in the NIS are closely linked with each other, the development of the system of higher metallurgical education in the steel industry innovation system should take place in all four functional areas.

We should emphasize a key role of the state support due to the special nature of higher education and innovation. Among the tools of such support, the indirect means of influence, such as tax incentives, development of innovation infrastructure and cooperation are the most effective ones. The reason for that is the fact that they contribute to the creation of the competitive environment, encouraging business entities to improve their performance through continuous innovation. Moreover, these tools boost the development of relationships between the participants of the innovation process.



The goals for the development of steel industry innovation system and the system of higher metallurgical education as an element of the sectoral innovation system





Table 2

Function	Object of support		
	Universities	Enterprises	Universities and enterprises
Educational + stimulating	Priority financing and development of the elite universities (research and federal universities) as educational and research centers (5,2)	Providing tax incentives to the innovative metallurgical enterprises (3,5)	Building technological platforms with participation of universities required (6,0).
Research	Involvement of leading scientists to the research activity of universities (3,2). Priority financing and development of the elite universities (research and federal universities) as educational and research centers (5,2). Priority financing and development of integration of university and academic science (7,4)	State co-financing of research projects, conducted by universities on request of metallurgical enterprises (2,1). Providing tax incentives to innovative metallurgical enterprises (3,5)	Building innovative clusters with participation of universities required (7,9)
Innovative	Establishment of small innovative enterprises at universities to commercialize the research results (4,3). Development of innovation infrastructure of universities (centers of excellence, technology parks, etc.) (5,5)	State co-financing of research projects, conducted by universities on request of metallurgical enterprises (2,1). Providing tax incentives to innovative metallurgical enterprises (3,5)	

In the course of our survey, experts in the field of metallurgy, including specialists and managers of Russian metallurgical enterprises (51 percent), specialized research organizations (37 percent), as well as university lecturers (12 percent), were asked to rank the indirect tools of the state influence, which we selected on the basis of the analysis of current state initiatives, according to the degree of their effectiveness. The opinions of the experts are concordant (the coefficient of concordance is equal to 0.72).

The distribution of the state influence instruments is presented in the decreasing order of their effectiveness in Tab. 2. The values of the average effectiveness within 1–3 correspond to the high level of effectiveness, 4–6 – average, 7–9 – low.

As it can be seen from Tab. 2, for all the functions, the greatest effect, according to experts in the field of metallurgy, is given to the government initiatives, focused on the support of metallurgical enterprises. Stimulating innovation

processes in such a way seems to reflect the needs of the Russian economy, which lacks the demand for innovations [15].

In our view, to develop sectoral innovation strategies and programs it is advisable to focus primarily on the development of the forms and tools of interaction and cooperation between enterprises and universities, which have already proved to be effective. Measures that have been evaluated by experts as less effective can also be used by the government in stimulating innovation activity through the integration of higher education into the innovation system as soon as the appropriate changes in the mechanism of their implementation are introduced. Therefore, these tools should be gradually put into practice, for example, in the form of pilot projects.

Thus, the development of the Russian system of higher metallurgical education is the key element in the development of the sectoral innovation system as it provides the sustainable increase in the international competitiveness of the Russian steel industry in the long run.

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**A.E. Erastov, O.V. Novikova**

**ON THE CONSISTENT TERMINOLOGY  
IN THE REGIONAL ENERGY SAVING MANAGEMENT SYSTEM**

**А.Е. Ерастов, О.В. Новикова**

**К ВОПРОСУ О ЕДИНОЙ ТЕРМИНОЛОГИИ  
В СИСТЕМЕ РЕГИОНАЛЬНОГО УПРАВЛЕНИЯ ЭНЕРГОСБЕРЕЖЕНИЕМ**

The paper presents the findings of a terminological analysis of the basic definitions related to the results-based method of energy saving management at the regional level. The authors highlighted the features of the regulatory framework for regional energy saving management. Ambiguity and incompleteness of the terminological system, lack of coherence in terminology of newly-introduced and earlier-accepted regulatory documents make the research important. The aim of the research is to synthesize and refine new terms on the basis of analysis of the existing terminology in the modern paradigm of the regulatory and methodological framework in terms of the regional policy of energy saving. The tasks of the research are: to define the main elements of the terminological system; identify the terms which definitions are absent from the terminological system, but used in the regulatory framework; carry out terminological analysis; link together the following terms: a subject of the Russian Federation, a region, state (regional government) energy saving and energy efficiency policy, a program related to energy saving and energy efficiency. In order to solve the tasks set, the authors' of the study applied the methodology of terminological analysis with an emphasis on an analytical approach. The scientific novelty of the findings of the phase of the research is to expand and clarify the modern terminological system related to the development and implementation of regional energy efficiency programs. The authors introduced explicit definitions of «regional policy in the field of energy saving and energy efficiency», «a program in the field of energy saving and energy efficiency». The authors stressed the importance of using a unified terminology system in energy saving management, including at the regional level, as an opportunity to reduce the uncertainty and subjectivity in making appropriate managerial decisions.

ADMINISTRATIVE DIVISION OF THE RUSSIAN FEDERATION; REGION; ENERGY SAVING MANAGEMENT; PROGRAM-TARGET MANAGEMENT METHOD; THE ENERGY SAVING POLICY; ENERGY SAVING AND IMPROVED ENERGY EFFICIENCY PROGRAM; TERMINOLOGY ANALYSIS.

Представлены результаты терминологического анализа основных определений, связанных с программно-целевым методом управления энергосбережением на региональном уровне. Выделены особенности нормативно-правовой базы в области регионального управления энергосбережением. Неоднозначность и неполнота терминологической системы, отсутствие согласованности в терминологии вновь вводимых и принятых ранее нормативных документов формируют актуальность исследования. Целью исследования являются синтез и уточнение терминов на основе анализа существующей терминологии в современной парадигме нормативно-методологической базы в области региональной политики энергосбережения. Задачами исследования являются: определение основных элементов терминологической системы; выявление терминов, определения которых отсутствуют в терминологической системе, но использованы в нормативно-правовой базе; проведение терминологического анализа; увязка между собой понятий «субъект РФ», «регион», «государственная (региональная государственная) политика в области энергосбережения и повышения энергетической эффективности», «программа в области энергосбережения и повышения энергетической эффективности». Для решения комплекса поставленных задач в рамках исследования применялась методология терминологического анализа с акцентом на аналитический подход. Научная новизна результатов этапа исследования заключается в расширении и уточнении современной терминологической системы, относящейся к разработке и реализации региональных программ энергосбережения. Введены эксплицированные определения терминов «государственная политика в области энергосбережения и повышения энергетической эффективности», «программа в области энергосбережения и повышения энергетической эффективности». Отмечена важность использования единой терминологической системы в управлении энергосбережением, в том числе на региональном уровне, как возможность снижения степени неопределенности и субъективности при принятии соответствующих управленческих решений.

СУБЪЕКТ РОССИЙСКОЙ ФЕДЕРАЦИИ; РЕГИОН; УПРАВЛЕНИЕ ЭНЕРГОСБЕРЕЖЕНИЕМ; ПРОГРАММНО-ЦЕЛЕВОЙ МЕТОД УПРАВЛЕНИЯ; ПРОГРАММА ЭНЕРГОСБЕРЕЖЕНИЯ И ПОВЫШЕНИЯ ЭНЕРГЕТИЧЕСКОЙ ЭФФЕКТИВНОСТИ; ТЕРМИНОЛОГИЧЕСКИЙ АНАЛИЗ.



*Introduction.* A target-oriented method in the regional administration has been used successfully used in various areas of government control for specific problem-solving. The task is regional energy-saving policy-making, development of management structure and regulatory framework.

However, analysis of the regulatory and methodological framework controlling development and implementation of energy saving and energy efficiency programs (energy efficiency programs), has revealed a number of features, such as ambiguity and incompleteness of the terminological base in this area, lack of coherence in terminology of newly introduced and earlier accepted regulatory documents. A consistent terminology system is an important aspect in energy saving management, including at the regional level, as it allows reducing the degree of uncertainty and subjectivity in making appropriate managerial decisions. The relevance of the research has been formed by the revealed features.

According to the great linguist A.A. Reformat'skiy, being a tool for forming scientific theories, laws, principles, regulations, terms and their complexes-terminologies are an important part of science and technology [15]. A common terminology creates conditions for identical presentation of information, ensures common understanding between experts and comparability of technical and economic information [10]. The importance of studying a scientific concept as a necessary element of a scientific theory in every branch of scientific knowledge is pointed out by many scientists in their research on the analysis of terminology (e. g., [18, 21, 22]).

*The goal and objectives of the research.* The goal of the research is to synthesize and refine terms by analysing the existing terminology in the modern paradigm of regulatory and methodological framework in terms of regional energy saving policy.

In order to achieve this aim the following objectives have been set:

- the essential elements of the terminological system in the field of regional energy saving policy have been defined;
- the terms without definitions have been identified, which are used in the regulatory and legal framework;
- terminological analysis has been conducted and the following terms have been dovetailed: subject of the Russian Federation, region, state (regional government) policy in the field of

energy saving and energy efficiency (hereinafter energy saving policy), energy saving and energy efficiency program .

*Research Methodology.* In order to solve the objectives set in terms of the research the authors applied the methodology of terminological analysis, in which the need to conduct systematic analysis of the elements of the existing terminological aggregate, assessment of the elements interrelation in such a system and their adjustment, if necessary, synthesis of new elements of the system. Analytical approach in the application of terminological analysis as a tool of research included the following stages of the analysis: detection of substantial evidence of the phenomenon (process, subject); comparison – identification of the similarities or differences in definitions by significant or insignificant indicators; abstraction – the emphasis on certain features of the phenomenon (process, subject) and distraction from others; synthesizing – association of individual elements in the generalized definition. In this study, by «term» we mean verbal definition of a concept included in the conceptual framework of a particular area of professional knowledge, by «terminology» we mean a set of terms (concepts and names) of a particular branch of knowledge [16]. In the context of the research we introduce the following definition to refer to «the uniform terminological system (uniform terminology)» – a rationally organized set of interrelated terms of a certain branch of knowledge that meets the same rules and requirements for all parties involved in making appropriate management decisions.

Terminological analysis initially originated in linguistics and subsequently became successfully used by researchers in many scientific fields. Interaction of the word and notion as a basis for the formation of a terminological system was generally studied in the works of such researchers as G.G. Shpet, A.A. Potebnya, A.F. Losev, V.V. Nalimov, L.S. Vygotskiy and others. The issues of formation and implementation of federal and regional energy efficiency programs were studied by Russian scientists such as I.A. Bashmakov, M.I. Yavorskiy, V.A. Koksharov, V.V. Bushuyev, N.I. Danilov, E.G. Gasho, E.A. Zenyutich, V.V. Litvak, Y.M. Shchelokov, E.P. Kuznetsov et al.

Now let's turn to *the findings of the study.*

Analysis of the regulatory and methodological basis revealed that one of the authorities of regional government bodies in the Russian Federation (RF) in the field of energy saving

according to [2] is to develop and implement energy efficiency programs in the region. At this stage it is necessary to introduce the term of «the administrative division of the Russian Federation» and «region». The RF consists of republics, territories, regions, cities with federal status, autonomous regions, autonomous areas – administrative divisions of the RF having the same rights [1]. Thus a subject of the RF is used to mean a republic, territory, region, city with federal status, autonomous regions, autonomous areas. At the moment, within the RF there 22 republics, 9 territories, 46 regions, 3 cities with federal status, 1 autonomous region, 4 autonomous areas. And according to [2], each subject of the RF must have an appropriate energy-saving program.

However, along with the term «subject of the Russian Federation» in the regulatory documents and other sources we often encounter the term «region» and terms that derive from it – regional programs, regional taxes, regional policy, regional government, etc. Terminological analysis of the term «region» has been done by many researchers, in particular, detailed work has been carried out by the authors in [19, 20, 24, 28]. The results of the studies indicate the polysemy of the term. However, in this study, the term «region» will be used according to [3] – part of the territory of the RF, which is characterized by common socioeconomic, natural, cultural, ethnic and other conditions. The region may coincide with the boundaries of the subject's territory or include the territory of several subjects. In terms of formation and implementation of public policies in energy saving a region acts a subject of law. In this case, «a region» is used to mean only a subject of the RF [5]. Thus, in this study the terms «subject of the Russian Federation» and «region» are used as synonyms. Consequently, in the framework of a regional energy saving program is understood as the program of a certain subject of the Russian Federation – that of a republic, territory, region, city with federal status, autonomous region, and autonomous area. Their programs, in their turn, will be called republican, territorial, regional ones, etc.

Regulatory documents governing development and implementation of energy saving programs contain requirements for such programs [2, 6-8], but do not include the term «energy saving and energy efficiency program». To compose such a term its constituent parts should be defined, such as «program», «energy saving» and «energy efficiency».

The definitions of the latter two are described in [2]:

«energy saving is implementation of organizational, legal, technical, technological, economic and other measures aimed at reducing the amount of energy resources used while maintaining the corresponding useful effect from their use (including the volume of produced goods, work done, services provided);

energy efficiency is characteristics reflecting the ratio of the useful effect from using energy resources to the cost of energy resources produced in order to obtain such an effect, with respect to products, processes, legal entity, individual entrepreneur».

Let us analyze the definitions of the term «program» and correlated terms: «complex program», «target program», «complex target program» (see definitions in Tab. 1) in relation to the requirements of the Federal Law 261-FZ.

The explicit definition of «energy saving and energy efficiency program» can be summarized as follows: a tool for program-target method of state regulation, which provides interconnection of tasks linked by resources (financial, material, labor, time, etc.), the venue and timing of a complex of legal, technical, organizational, economic, technological and other measures (actions) aimed at reducing the volume of the used fuel and energy resources while maintaining the corresponding positive effect with them being used with the goals and objectives, as well as ensuring consistency of decisions and actions in terms of the program. This definition is applied at all levels of development and implementation of programs – federal, regional, municipal, departmental ones.

The explicit definition of «public policy in the field of energy saving and energy efficiency» with due consideration of the definition «energy efficiency» can be summarized as follows: administrative, legal, financial and economic regulation at the appropriate level (federal, regional, municipal, departmental), aimed at creating the necessary conditions of organizational, material, financial and other nature used to reduce the amount of the used energy resources while maintaining the corresponding positive effect from their use. Regional policy structurally consists of the following main elements: goals, objectives, priorities, principles, policies, strategies, methods and tools [23]. All these elements are formalized, among other things, in energy saving programs.



Table 1

Definition
<b>complex program (target complex program)</b> – a method to coordinate actions with respect to independent organizations to achieve a common objective or solve a complicated problem that requires their joint coordinated interaction [17]
<b>target programs</b> – tailored to the tasks, resources and timing for doing a complex of R&D, development engineering, production, socioeconomic, organizational, economic and other actions to ensure effective solutions of systemic problems in the field of state, economic, ecological, social and cultural development of the Russian Federation, as well as innovative development of the economy [4]
<b>complex program, target complex program</b> – a system of interlinked in terms of contents, timing, resources and venues, actions aimed at achieving a common goal, common solution to a problem. A complex program includes the program objectives, ways and means of addressing the program problem [14]
<b>target complex program</b> – a set of hierarchically subordinate objectives, activities to achieve them, linked to resources, doers and terms of completion. A tool of the program-target method of state regulation [12]
<b>program</b> – budget planning tool for solving the existing problems of the state policy, i. e. they represent a set of tactics [13]
<b>target program</b> – a program tool of budget planning that ensures interrelation of financial, material and human resources with the goals and objectives of socioeconomic development and consistency of decisions and actions of state bodies at the federal and regional levels [13]
<b>programs</b> – documents that contain a complex of interconnected planned actions in terms of tasks, deadlines, resources, as well as public policy instruments to achieve the priorities and objectives of socioeconomic development of Russia and its regions [25]
<b>target complex program</b> – a key concept of program-target planning and management techniques, a set of measures aimed at achieving the defined outcomes and addressing specific scientific, technical, economic, and social problems. Usually it is a design project and targeted document which coordinates the activities of various organizations and individual associate contractors independently on their departmental affiliation in terms of the performance time and resources allocated [26]
<b>program</b> – a science-based representation about the status of an individual local object of control after a certain period of time (5, 10 years or more), based on the realization of the goal and a set of measures approved in terms of resources, deadlines and contractors [27]

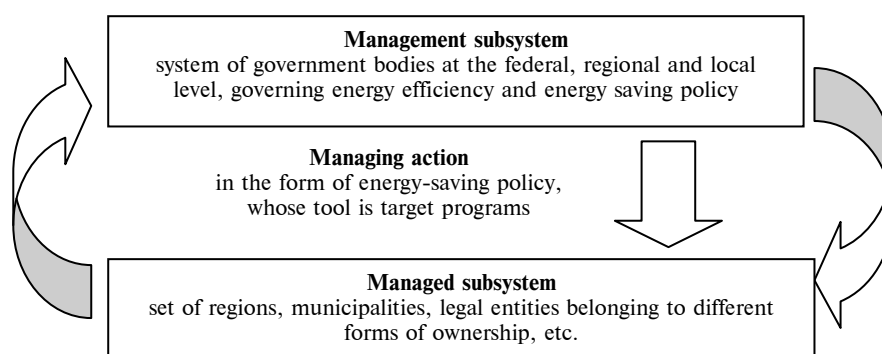
Table 2

Definition
<b>energy saving policy</b> – a complex system implementation at the state level, of a program of measures aimed at creating the necessary conditions of organizational, material, financial and other nature for the rational and economical use of energy resources [9]
<b>public policy</b> – a set of goals and objectives, practically implemented by the state, and the means used in this case [12]
<b>public policy</b> – the art of governing a nation, doing public affairs, the contents of government bodies' activities [12]
<b>public policy</b> – the main directions of internal and external activities of the state; is divided into economic, social, cultural, national, regional and other types; is linked to the interests and relations between social groups in society. The basis of the policy is to obtain, use, and retain state power [12]
state energy saving policy – administrative, legal, financial and economic regulation of the processes of extraction, processing, transportation, storage, production, distribution and use of energy resources in order to improve their rational use and economical expenditure [11]
<b>energy saving policy</b> – administrative, legal, financial and economic regulation of processes of efficient use and economical consumption of fuel and energy resources [11]

Also one of the powers of state government bodies of the RF in the field of energy saving and energy efficiency in accordance with [2] is formation and implementation of state energy saving policy. The definition of the term «public policy in the field of energy saving and energy efficiency» does not appear in the regulatory

documents governing the development and implementation of energy saving programs. There is a need to identify this notion.

Let's analyze the definitions of the correlated terms «public policy», «the energy-saving state policy», «the energy-saving policy» (see the definitions in Tab. 2).



Energy saving administration system

After widening and refinement of terminological system related to the development and implementation of regional energy efficiency programs, we should verify with a coherent and logical proof and interlink the terms «subject of the Russian Federation», «region», «energy saving and energy efficiency policy», «energy saving and energy efficiency program».

We represent the policy of energy saving and energy efficiency in the context of the system of state administration of energy saving and energy efficiency.

From the standpoint of cybernetics, public administration, as well as any other administration is a system consisting of an administrative subsystem (the subject of administration) and a subsystem being controlled (the object of administration), between which there is interaction. The interaction implies not only the information flow from the subject to the object of administration, but also in the reverse direction [12].

The managing subsystem in the system of state administration in terms of energy saving is a system of state government bodies at the federal, regional and local levels. In accordance with Article 6 of the 261-FZ the powers of such bodies include development and implementation of state energy saving policy [2].

The managed subsystem in the context of 261-FZ is a set of regions, municipalities, economic entities belonging to different forms of ownership, etc.

Managing action will be nothing but energy saving policy, whose tools are energy saving programs (see Figure).

**Conclusion.** According to the study based on the analysis of the existing terminological system of regional energy saving policy the authors revealed the lack of certain fundamental terms' definitions. Using the method of terminological analysis as a theoretical method of research aimed at identifying the semantic content of the phenomenon under investigation by detecting and clarifying the meaning of terms designating it, the authors conducted a terminological analysis and linked together the following terms: «subject of the Russian Federation», «region», «regional policy in the field of energy saving and energy efficiency», «energy saving and energy efficiency program». Scientific novelty of the findings of this phase of the study includes expansion and clarification of the contemporary terminological system related to development and implementation of regional energy saving programs. The authors introduced the explicit definitions of «regional policy in the field of energy saving and energy efficiency», «energy saving and energy efficiency program» given the current paradigm of regulatory and methodological basis in the field of energy saving. The single terminological system as a rationally organized set of interrelated terms, corresponding to the same rules and requirements for all those involved in making appropriate management decisions, allows lowering the degree of uncertainty and subjectivity, and consequently, improve management decision-making in the regional government system of energy saving.

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**Е.К. Khusainova, E.I. Reyshahrit**

**THE ENHANCEMENT OF APPROACH TO EFFICIENCY  
ESTIMATION OF ENERGY-SAVING PROJECTS  
IN THE PETROLEUM REFINING**

**Е.К. Хусаинова, Е.И. Рейшахрит**

**СОВЕРШЕНСТВОВАНИЕ ПОДХОДА К ОЦЕНКЕ ЭФФЕКТИВНОСТИ  
ЭНЕРГОСБЕРЕГАЮЩИХ ПРОЕКТОВ  
В НЕФТЕПЕРЕРАБАТЫВАЮЩЕЙ ОТРАСЛИ**

This article is concerned with the problem of energy saving and energy efficiency increase in Russia's petroleum refining industry. Power-intensive production is one of the petroleum refinery sector's characteristics. The costs of fuel and energy resources are influenced by the production cost. This type of costs is found after the raw material costs in the cost structure in petroleum refining. The article deals with typical development trends of the Russian petroleum refining industry. Attention is drawn to the special aspects of energy consumption at Russia's petroleum refineries. Lines of the energy saving and opportunities to increase energy efficiency are formulated. Different classifications of energy-saving measures are described in this text. The authors analyze the current approaches to the efficiency assessment of the resource and energy-saving projects for industrial enterprises. The authors of this article worked out a relative integrated index of the total effects due to the implementation of the energy-saving projects per 1 ruble of capital investments. In order to develop a portfolio of the energy-saving program, it is proposed to select a number of measures, ranking them according to the values of the worked out indicators. The best alternative of energy-saving measures implementation for the petroleum refinery is the decrease of energy consumption, reduction of the energy intensity of production, the potential increase in the yield of light petroleum products, fall of fees for the emissions into the environment and improving the financial and economic development level of the region as a result of an additional income to the regional budget. The original feature of the research is an enhancement of approach to the selection of the energy-saving projects to be implemented. This approach allows taking into account the particular characteristics of petroleum refining, which are energy saving, regional and environmental effects and the effect of quality.

PETROLEUM REFINERY; FUEL AND ENERGY RESOURCES (FER); ENERGY EFFICIENCY; ENERGY SAVING; RESOURCE SAVING; ENERGY INTENSITY; ENERGY-SAVING MEASURES; RANKING OF PROJECTS.

Статья посвящена актуальной на сегодняшний день проблеме энергосбережения и повышения энергоэффективности в отечественной нефтеперерабатывающей отрасли. Нефтеперерабатывающая отрасль характеризуется энергоемким производством. Затраты на ТЭР в нефтепереработке являются вторыми по величине в структуре расходов после затрат на сырье. Таким образом, затраты на энергоресурсы оказывают влияние на размер себестоимости нефтепродуктов. Описываются характерные тенденции развития российской нефтеперерабатывающей отрасли. Уделяется внимание особенности энергопотребления на отечественных нефтеперерабатывающих предприятиях. Определены направления энергосберегающей деятельности и возможности повышения энергоэффективности в нефтепереработке. Рассматриваются различные классификации энергосберегающих мероприятий. Приведен анализ существующих подходов к оценке эффективности ресурсо- и энергосберегающих проектов для промышленных предприятий. Разработан относительный интегральный показатель суммарной величины возникающих при реализации энергосберегающих проектов эффектов на 1 рубль капитальных вложений. Отбор мероприятий для формирования портфеля программы энергосбережения предлагается осуществлять с учетом процедуры ранжирования по значениям данного показателя. Для НПЗ оптимальный вариант реализации энергосберегающих мероприятий предполагает снижение энергопотребления, снижение энергоемкости производства, потенциальное увеличение выхода светлых нефтепродуктов, уменьшение платы за вредные выбросы в окружающую среду и повышение уровня финансово-экономического развития региона в результате дополнительных поступлений в региональный бюджет. Новизной исследования является усовершенствованный подход к отбору энергосберегающих проектов для реализации, который позволяет учесть особенности нефтепереработки, а именно: в рамках подхода предложено опираться на энергосберегающий, региональный, экологический эффекты и эффект в области качества.

НЕФТЕПЕРЕРАБАТЫВАЮЩИЙ ЗАВОД; ТОПЛИВНО-ЭНЕРГЕТИЧЕСКИЕ РЕСУРСЫ (ТЭР); ЭНЕРГОЭФФЕКТИВНОСТЬ; ЭНЕРГОСБЕРЕЖЕНИЕ; РЕСУРСОСБЕРЕЖЕНИЕ; ЭНЕРГОЕМКОСТЬ; ЭНЕРГОСБЕРЕГАЮЩИЕ МЕРОПРИЯТИЯ; РАНЖИРОВАНИЕ ПРОЕКТОВ.



Petroleum refining industry is characterized by energy-intensive production processes. According to the «VNIPIneft» data, Russia spends much more fuel and energy resources (FER) to produce 1000 tons of refined petroleum products than other European countries (Fig. 1). The costs of FER are located after the raw material costs position in the cost structure for petroleum refining. Energy costs accounted for more than fifty percent in the structure of operating costs of the average Russian petroleum refinery (Fig. 2).

Optimization of the energy consumption in these enterprises can decrease production costs by 20–40 %. Because of this decrease, competitiveness of the petroleum refining

industry sector will increase, and environmental pollution will be reduced.

Increasing energy efficiency and energy saving were included in the top five priority directions of the Russian economy modernization. Energy saving is the realization of organizational, legal, technical, technological, economic and other measures aimed at reducing the volume of the used energy resources, while maintaining the consequent benefits from their use (including the volume of production, works, services) [7]. Implementation of the energy saving programs in accordance with the Federal Law № 261 «On the energy saving and increasing energy efficiency» is mandatory for petroleum refineries (referred to below as «Federal Law № 261») [7].

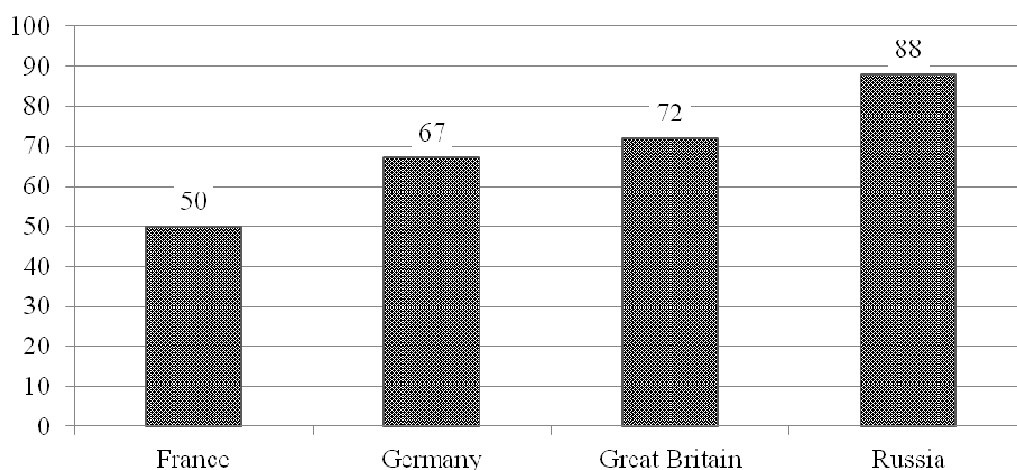


Fig. 1. Energy consumption for production of 1 thousand tons of petroleum products (tons of oil equivalents)

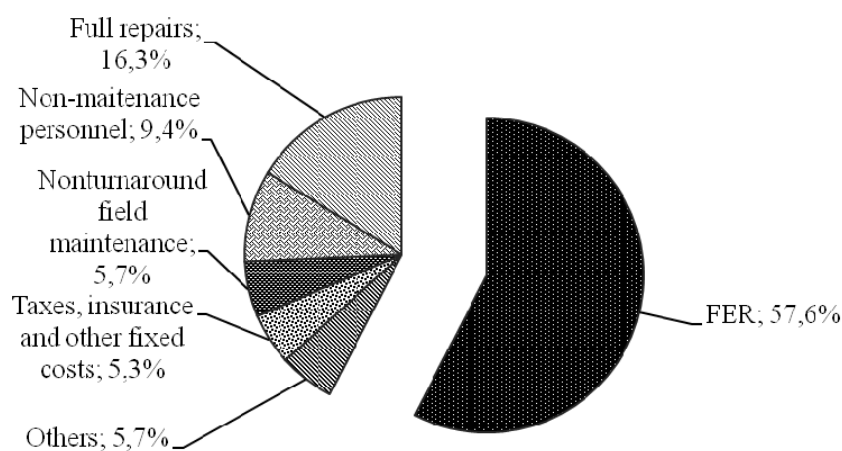
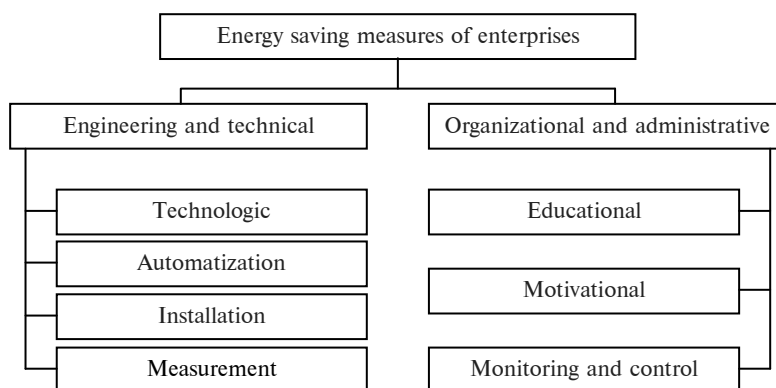


Fig. 2. Structure of the average Russian refinery operating costs [1]



**Fig. 3.** Classification of the energy-saving measures' types at enterprises

One of the major objectives for the oil industry in the «Energy Strategy 2035» project [12] is the balanced development of the petroleum refining in the direction of further increase in the oil refining the increase in the refined oil products quality. The solution to this problem must be linked to the needs of domestic and foreign markets, and must be based on the development of resources and energy saving and the reduction of losses at all process stages. «Energy Strategy 2035» project defines the following main areas of the energy saving in petroleum refining:

- Increasing the depth of refining;
- Better utilization of petroleum-refinery gas;
- Automation of the technological chain management.

Mainly, the problem of energy conservation is considered from the point of technological aspects view of the energy-saving projects implementation at the present day. The scientific study of organizational and economic components of the energy saving implementation is at an insufficient level.

In terms of costs and a payback period all the energy-saving measures can be divided into:

- Low cost group, with a payback period less than 2 years;
- Average cost group, with a payback period from 2 to 5 years;
- High cost group, requiring significant capital costs, with a payback period of more than 5 years.

Energy-saving measures are also grouped by their content: engineering and technical (aimed at improving of technologies, processes, equipment, etc.) and organizational and administrative (aimed

at improving the organization of energy management at an enterprise) (Fig. 3).

The complex of large-scale projects to modernize almost all the large and medium-sized petroleum refineries have been implemented in Russia in recent years. The goal is to increase the depth of oil refining and the production of modern petroleum products, primarily motor fuels that satisfy current standards of the Russian Federation and the European Union. Reconstruction leads to a sharp increase in the consumption of all types of FER at the refinery: fuel, electricity, water, moisture vapour [4, 5].

The following areas of FER efficiency at the petroleum refinery can be highlighted:

- Introduction of the automated process control and process management systems (for example, an automated system of technical accounting of boiler and furnace fuels consumption);
- Improvement of the waste heat utilization efficiency (for example, installation of waste heat boilers in the furnace);
- Increase in the furnaces efficiency;
- Improvement of heat pumps (for example, the replacement of positive displacement pumps to centrifugal pumping equipment with an electric motor);
- Reduction in the technological losses (for example, replacement and repair of pipelines insulation);
- Use of low-grade waste heat for the heat supply;
- Electricity saving lighting systems (for example, the automation of lighting systems, the use of the most efficient light sources);



– The use of secondary (thermal) energy resources (for example, saturated steam that is formed in a recovery boiler for neutralization of the hydrogen sulfide gas) and others.

The big problem for the petroleum refineries is fouling and plugging in the heat exchangers, which leads to an increase in FER consumption. Moreover, fouling and plugging in the heat exchangers is the cause of suspension of production and the financial losses for the company. The application of prediction tools for fouling in the heat exchanger will save about 2% of the total FER and improve the quality of the maintenance service. [14, 15].

The inefficient use of energy has also a negative impact on the Russian petroleum refineries. The poor insulation of the heat transport system, leaks in pipes, losses on power lines, etc. lead to FER losses. Losses in the processing industry can reach 40%, according to McKinsey & Company consulting company experts [8, 13].

The direct ways of FER saving in petroleum refining are the measures related to an increase in the overall efficiency of the fuel-using plant units. The goal can be achieved by modernization or replacement of such units. One of the indirect ways of FER saving is the closure of the energy cycle of the plant units for their own internal use of heat energy with the exception of low-grade heat emissions and secondary energy resources. Another indirect way of FER saving is the elimination of deficiencies in the steam supply systems, the use of steam and condensate from the exhaust heat exchange equipment, the development of heat transfer surfaces and the use of the modern heat-exchange equipment.

FER are mainly consumed by the process equipment and, above all, facilities for the primary crude oil processing. Therefore, it is necessary for them to develop energy saving and energy efficiency measures.

At a certain step, the company is faced with the problem of determining the rational composition and implementation's sequencing of the most important measures on the basis of the energy saving goals with accordance to financial constraints and comparison of the benefits of possible energy-saving measures and the implementation costs. Still it is possible to use various investment sources for energy-saving

measures i. e. owner's equity; equity; combination of both. Different financial constraints force a company to implement a combination of investment projects, which enable maximum total efficiency under the optimal volume of investments.

Usually the following basic indicators are used for the economic evaluation of investment projects:

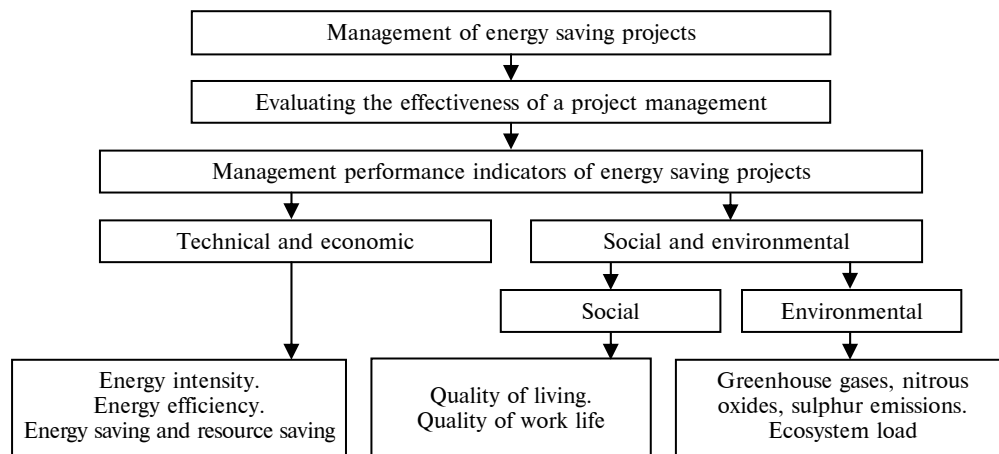
- Net profit;
- Net present value (NPV);
- Internal rate of return (IRR);
- The need for additional financing;
- Yield indices of costs and investments;
- Payback period;
- Group of indicators characterizing the financial standing of the company, participating in the project;
- Resource productivity.

A distinctive feature of energy-saving projects is that they are aimed at reducing energy intensity, energy efficiency and energy saving primarily. So their economic evaluation should allow for not only and not so much profitability and payback period, but namely economic result of energy efficiency, which is expressed in the reduction of production cost and gaining extra profit. Also it should be borne in mind that the most effective in terms of improving energy efficiency and saving projects can be economically unsound and have a long payback period and significantly lower internal rate of return compared with the investment projects of other areas.

The foregoing features of energy-saving investment projects cause the necessity of methods improvement for their effectiveness evaluating.

Some authors offer their own approaches to address this issue. So the author of the article [6] proposes to use a set of technical and economic, social and environmental indicators to evaluate the effectiveness of energy-saving projects. (Fig. 4)

The article [2], proves the necessity of the methodological approach to the selection of resource-saving projects in the situation of insufficient funding. The author proposes to consider not only the economic effects of implementation, but also its social effects. And the social effect is the effect that characterizes



**Fig. 4.** Evaluating the effectiveness of energy-saving projects

the process of the national welfare improvement (upturn and alleviation labor conditions, changes in its content, the development of creative functions, abilities and needs of the people, overcoming significant differences in labor, the development of community, conservation and improvement of the environment, etc.). The way of living and quality of life are a general indicator of the social effect. According to this methodical approach, if a resource-saving technology project meets the criteria of the economic effect, it can be implemented by a plant irrespective of the presence of a social effect. If the project has a negative or minor economic effect, its implementation might be considered in terms of improving the public welfare as a result of its realization.

Kryzhanovskaya G.S. [3] developed an approach to the selection of projects in the gas industry. The author suggests that the selection of projects for the formation of a resource-saving programs portfolio must be based on the complex of criteria, using the procedure of ranking and selection of the optimal combination of strategic alternatives with constraints on the required resources. The complex of criteria consists of economic indicators to assess the investment and index of potential resource saving's use. The author chose the following economic indicators: net present value (NPV), profitability index (PI), payback period (PP).

The main criterion for the formation of an alternatives' optimal combination is a generalized parameter that takes a probable decrease of

resource saving's potential ( $K_{RP}$ ) into account. The parameter is calculated using the formula:

$$K_{RP} = \frac{\sum_{i=1}^n RP_i}{RP_{i=1}} = \frac{RP_{A_1} + RP_{A_2} + \dots + RP_{A_{n-1}} + RP_n}{PR_{i=1}}, \quad (1)$$

$$0 < K_{RP} \leq 1,$$

where  $K_{RP}$  – coefficient of resource saving's potential use;  $PR_{i=1}$  – resource saving's potential before implementing resource-saving programs, tons fuel equivalent;  $RP_i$  – using resource saving's potential as a result of implementing the  $i$ -th alternatives' combination, tons fuel equivalent;  $RP_{A_i}$  – using resource saving's potential through the introduction of the  $i$ -th alternative, tons of fuel equivalent.

Sergeyev N.N. [9–11] proposes to use the ranking of energy-saving measures based on the coefficient of their efficiency ( $K_{em}$ ) in order to optimize the necessary costs allocation for the measures' realization. The coefficient is calculated by the formula:

$$K_{em} = R_{em} / C_{em}, \quad (2)$$

where  $R_{em}$  is the income gained from the measures implementation, 1000 rub.;  $C_{em}$  is the cost of the measures implementation, 1000 rub.

This coefficient shows the return of each ruble invested in the energy-saving measure of industrial enterprises. The smallest rank is assigned to the measure with the highest coefficient. A priority for the implementation of energy conservation measures determined by the smallest value of the rank (the highest value of the calculated index respectively).





All the approaches cannot take into account all the possible effects of the energy-saving measures implementation to the full. Besides, they do not allow for industry specifics of the petroleum refining.

From the point of view of the enterprise's interests, the value of the investment project implementation should be lower, and efficiency should be higher. But it is more important for the created industrial project to provide maximum resource saving in the operation. From the enterprise's perspective, an efficiency estimation of the energy-saving measures means defining the most rational combination of the consumable resources and the resulting effects. It is possible with the help of the summary index of efficiency.

According to the author of this article, the selection of measures for the energy saving program portfolio should be carried out with the procedure of ranking values of the worked out relative integrated indicator of the total value of the effects per 1 ruble of capital investments. The following factors have to be taken into account:

- Energy-saving effect;
- Regional effect;
- The effect of the quality;
- Environmental effect.

These effects are the most significant ones, because of the main trends of development analysis and the specific of the explored industry.

An energy-saving effect must be considered because the cost of the FER has a significant influence on the overall cost of petroleum products. This effect shows itself as the reducing energy intensity of production and expressed in saving the FER, which will be received after the project implementation.

The next effect that is taken into account in the calculation of the index is a regional effect. The share of the petroleum refining in the GRP is up to 6% depending on the Russia's region. The regional effect is an opportunity to increase the level of regional financial and economic development as a result of additional incomes to the regional budget from the energy-saving measures.

One of the key indicators of the petroleum refining condition is the yield of white petroleum products. The level of the yield of white petroleum products, which include gasoline, kerosene and diesel fuel, characterizes the

economic efficiency of petroleum refineries. More expensive white petroleum products make only approximately 56% of the Russian petroleum products. This situation needs to be changed. Thus, the third important effect is quality. The effect of quality is a potential growth of the revenue from the increase in the yield of white petroleum products after the project implementation.

Petroleum refinery is a source of environmental pollution. Obviously, it is important for a petroleum refinery to reduce the formation of harmful substances directly at their source. In this connection the fourth effect which is taken into account in the index is the environmental effect expressed in a fee decline because of the emission reduction.

The total amount of effects consists of FER saving, cost savings from the reduction of the energy intensity of production, increase of income to the regional budget, increase in the revenue from the growth in the yield of white petroleum products, economy of environmental fees by reducing harmful emissions into the atmosphere.

The index of the total value of the occurring effects for 1 ruble of capital investments is calculated according to the formula (3):

$$\Pi_{\text{eff. of project}} = \Sigma E_i / PC, \quad (3)$$

where  $E_i$  is the  $i$ -th effect that occurs as a result of the energy-saving projects implementation, rub.;  $i = 1...4$ ;  $PC$  – project cost, rub.

This criterion allows considering the main types of the effects arising from the implementation of the energy-saving projects, and their total value. The index is calculated for each project once.

The data source of potential measures to be included in the energy saving program of companies may be the results of energy inspection (energy audit), and the Bank of Ideas, organized within the enterprise. Energy-saving measures, taken from the results of the energy audit or the bank of ideas, must have a feasibility analysis.

Energy audit in accordance with the Federal Law № 261 [7] is a must for all petroleum refineries. Energy audit must be repeated at least once every 5 years. The main objectives of energy audits are:

- To obtain objective data on the volume of the used FER;
- To define energy efficiency index-numbers;
- To determine potential energy saving and energy efficiency;
- To develop a list of standards, open access energy-saving and energy-efficiency measures and to estimate their cost.

The Bank of Ideas is a database that stores all the projects focused on solving the important problems at the enterprise (for example, energy saving, increase of the energy efficiency) and proposed for implementation. The banks of energy-saving ideas for the system management of the energy saving measures' complex can be formed both autonomously and as a part of the bank of operational improvement ideas. Many of today's companies, including petroleum ones, develop and implement their own projects based on crowdsourcing technologies. Crowdsourcing means solving the problems of the enterprise by volunteers, whose activities are coordinated with the help of information technologies. For example, the automated IT-system «The Bank of Ideas and Innovations» was implemented in the «Lukoil» company. «Bank of Ideas and Innovations» allows organizing collection, processing and evaluation of the best practices and suggestions of employees, as well as the expert assessment of suggestions. The «Rosneft» company also applies crowdsourcing. There is a «Bank of innovation» and «Bank technologies» in «Rosneft». A crowdsourcing model of innovative development of «Tatneft» company is an «Auction of business ideas» automated system. It is used for the search of optimal decisions, formation and development of innovative ideas and identifying the key problems. Project participants are the employees of «Tatneft», scientific and industrial institutions and other registered users of the system, who are

ready to share ideas and discuss the proposals of others.

Ranking is used to make management decisions on implementing energy-saving measures. The criterion for ranking is the index of the total value of the occurring effects for 1 ruble of capital investments. It allows identifying the most actual measures for the petroleum refinery. If the measure has the greatest value of this index, it is assigned the highest rank. The largest value of the rank shows the priority of the energy-saving measure to be implemented.

*Conclusions.* Reconstruction and modernization of the petroleum refining industry leads to the increased consumption of FER.

Implementation of the measures aimed at improving energy efficiency and energy saving, should be based on the ranking procedure which allows for financial constraints and on the basis of the proposed integral index of a relative total value of the cumulative effect, which includes energy-saving, regional and environmental effects, and quality effect.

Ranking based on the elaborated indicators gives an opportunity to develop the alternative to the energy-saving measures. This alternative proposes a decrease of energy consumption, reduce the energy intensity of production, the potential increase in the yield of white petroleum products, reducing fees for harmful elements emissions into the environment and improving the level of region's financial and economic development as a result of the additional income to the regional budget.

The main results of implementing the energy-saving measures are saving of water, fuel, heat and electricity, and as a result, the reduction of the negative impact on the environment and the increase in profits by reducing the share of energy in the cost of final products.

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**A.A. Priemyshev, M.V. Arysheva, Z.I. Lavrova**

**ANALYSIS OF THE HUMAN DEVELOPMENT INDEX CALCULATION.  
COMPARISON OF THE OLD AND THE NEW METHODS**

**А.А. Приемышев, М.В. Арышева, З.И. Лаврова**

**АНАЛИЗ РАСЧЕТА ИНДЕКСА РАЗВИТИЯ ЧЕЛОВЕЧЕСКОГО ПОТЕНЦИАЛА.  
СРАВНЕНИЕ СТАРОЙ И ОБНОВЛЕННОЙ МЕТОДИК**

The article examines the population life quality as one of the most important indicators that reflect the level of development of any country, and its evaluation. The intricacy of the problem of life quality assessment is due to a large number of indicators on hand. The authors presented the basic theoretical concepts of life quality and methodological approaches to measuring and assessing life quality (objectivist and subjectivist). Particular attention is devoted to one of the main indicators of life quality – Human development index. Presented is the analysis of its calculation by the old technique, which was used until 2010, and by the new one, currently adopted. The main purpose of using the human development index is to draw up the inter-regional ranking of countries with a view to assess the population life quality dynamics and to compare it with other territories. 75 countries with high, average and low values of HDI were chosen for the analysis. The correlation coefficient is counted, proving the linear dependence between final values of the HDI, made by means of the old and the new methods for different countries. Calculation of the Russian Federation HDI is made using the Federal State Statistics Service data. The result differs from the RF HDI in the global HDI ranking presented by the UN report, which could be explained by using statistic data for calculating from different sources.

LIFE QUALITY; HUMAN DEVELOPMENT INDEX; THE OLD AND THE NEW CALCULATING METHODS; MAXIMUM AND MINIMUM VALUES OF INDICES; HDI COUNTRIES RANKING.

Рассматриваются вопросы качества жизни населения как одного из важнейших показателей, отражающих уровень развития любой страны, и его оценки. Сложность задачи оценки качества жизни связана с большим количеством существующих индикаторов. Приведены основные теоретические концепции качества жизни и методологические подходы к измерению и оценке качества жизни (объективистский и субъективистский). Особое внимание посвящено одному из основных показателей качества жизни населения – индексу развития человека. Понятие «индекс развития человеческого потенциала» (ИРЧП) формируется на международном уровне в конце 1980-х гг., а с 1990 г. данные о величине ИРЧП по странам, входящим в ООН появляются в публикациях. Проведен анализ расчета ИРЧП по старой методике, используемой до 2010 г., и новой, принятой в настоящее время. Основной целью использования индекса развития человеческого потенциала, или индекса человеческого развития, является составление межрегиональных рейтингов стран с целью оценки динамики качества жизни населения и сравнения показателей с другими территориями. Для анализа выбрано 75 стран с высоким, средним и низким значениями индекса развития человеческого потенциала. Определен коэффициент корреляции, подтверждающий линейную зависимость между итоговыми значениями ИРЧП, рассчитанными по старой и новой методикам для разных стран. Проведен расчет индекса развития человеческого потенциала России на основании данных Федеральной службы государственной статистики. Полученный результат отличается от значения данного показателя в общемировом рейтинге стран по ИРЧП, представленном в докладе ООН, что объясняется, вероятно, использованием для расчета статистических данных из других источников.

КАЧЕСТВО ЖИЗНИ НАСЕЛЕНИЯ; ИНДЕКС РАЗВИТИЯ ЧЕЛОВЕКА; СТАРАЯ И НОВАЯ МЕТОДИКИ РАСЧЕТА; МАКСИМАЛЬНЫЕ И МИНИМАЛЬНЫЕ ЗНАЧЕНИЯ ПОКАЗАТЕЛЕЙ; РЕЙТИНГ СТРАН ПО ИРЧП.

Quality of life is the level of satisfaction of the material, spiritual and social needs of the human being; the subjective assessment of the

level of material and spiritual need satisfaction [1]. Quality of life is one of the most important indicators adopted by the UN, which reflects the

level of the country development. Determining quality of life plays an important role in the process of socio-economic management and the country development. The relevance of this issue is emphasized by the fact, that with proper measurements, based on objective statistical indicators, we gain the ability to define a strategy of social development, the level of economic well-being of the population, as well as determine the human potential (capabilities), which is especially important during the transition to the post-industrial economics and society.

This period is characterized by significant changes: development of market economy, changes in the character of labor and the organization of the work process as a whole [2]. Such changes have a clear impact on quality of life: falling living standards, dramatically increasing income inequality. Economic situation characterized by crisis, caused by unresolved problems of the transition from planned economy to developed market economy, gives the special relevance to the analysis of methods to measure quality of life [3].

Measuring quality of life is a challenging task. Primarily, this is due to the fact that there are many indicators that can be used to assess quality of life. It is worth mentioning, that there are many theoretical concepts of quality of life that imply a different approach to the assessment of QoL (quality of life). The main theoretical concepts are called: the economic welfare theory, the utilitarian concept and the capabilities approach.

In addition to theoretical concepts there are two distinguished methodological approaches to measuring and evaluating quality of life: objectivist (based on the theory that the leading role in society is given to social structures) and subjective (based on the theory that the individual takes the main role. In this case, the assessment of QoL is reduced to the individual's assessment of his/her conditions). In this article the evaluation of quality of life is based on the objectivist approach and the analysis of statistical indicators and aggregate indicators that measure quality of life and characterize the population of the country as a whole. When speaking about the measurement of synthetic indicators of quality of life [4] it should be considered, that the measurement and interpretation methodology of aggregate indicators of quality of life must

comply with a certain type of tasks. In this work the authors are interested in the analysis of the Human Development Index calculation. The objective of such an index is to make inter-regional ranking of countries to assess the population life quality dynamics and compare it with other territories.

There are many indexes associated with the measurement of quality of life. These include the Gross National Happiness, the Happy Planet Index (HPI), the Quality-of-life, the Physical quality of life index, life satisfaction, the Genuine Progress Indicator (GPI).

One of the main indicators of quality of life is the Human Development Index (HDI). The Human Development Index (HDI) — is a measure of human development, a country's statistics in three dimensions: longevity and health, education and GNI per capita. The value of HDI is calculated as the geometric mean of all indices. This index was developed in the late XX century by a group of economists led by Mahbub ul Haq, a scientist from Pakistan. However, it should be noted that the conceptual framework of quality of life was created due to the works of Amartya Sen, who received a Nobel Prize in Economics in 1998. The investigation of this index was carried out within the UN Development Program and was first made public in 1990 in the Human Development Report of the United Nations [5].

The structure of the Human Development Index:

- GNI (gross national income per capita), adjusted in accordance with the purchasing power parity (PPP).
- Life expectancy at birth.
- *Expected years of schooling*.
- *Mean years of schooling*. The last two indicators form composite index of education.

#### **A comparison of the old and the new methods**

The first step in the HDI calculation is to create sub-indices for each measurement. To convert indicators into indices on a scale from 0 to 1. It is necessary to establish the minimum and maximum values.

The maximum values are assigned to the actually observed highest country indicators values of the time series, i. e. for the period 1980–2010. Minimum values will affect the



evaluation, that's why certain values are used as cost of living or «natural» zero [6].

$$\text{Index measurement} = \frac{D_{\text{fact}} - D_{\text{min}}}{D_{\text{max}} - D_{\text{min}}} \quad (1)$$

Shown below are the necessary for the calculation minimum and maximum values of the indicators.

Table 1

Values of indicators for the HDI, the old method, 2010

Measurement	Maximum value	Minimum value
Life expectancy at birth	85	25
Literacy	100	0
Percentage of students	100	0
GNI per capita (PPP US)	5448 (UAE, 1980)	100

The calculation method used until 2010 is different from the one currently in use. The resulting value was the average of the three indices (life expectancy at birth, Literacy Rate, Gross Enrollment ration, GNI per capita) [5] according to formula (2) [6].

$$\text{HDI} = \frac{I_{\text{life}} + I_{\text{education}} + I_{\text{income}}}{3} \quad (2)$$

Tab. 2 shows the extreme values for calculating the HDI, the new method.

Table 2

Values of indicators for the HDI, the new method, 2010

Measurement	Maximum value	Minimum value
Life expectancy at birth	83.2 (Japan, 2010)	20.0
Mean years of schooling	13.2	0
Expected years of schooling	20.6 (Australia, 2002)	0
The composite index of education	0.951 (New Zealand, 2010)	
GNI per capita (PPP US \$)	108211 (UAE, 2010)	163 (Zimbabwe, 2008)

Under the new methodology, developed and adopted by the UN in 2010, the total value is the geometric mean of three indices (life expectancy at birth, education index, income index). In addition to the changes in the formula to calculate the final result, there were made the changes in the education index calculation. Now it includes two components: the Expected Years of Schooling Index and the Mean Years of Schooling index. The maximum and minimum values used in the calculation of indicators were also changed in 2010. The income index is particularly interesting for the research [7].

The minimum value for this indicator – the GNI per capita. Some economists use the new value – \$ 163 for the calculation, referring to the fact, that this is the minimum value of the GNI per capita recorded in Zimbabwe in 2008 [8]. To us, the use of this amount seems unjustified, because if we consider Zimbabwe and calculate its income index, the actual value and the minimum one will be equal, hence the numerator and the income index as a whole will be zero. In this case, the calculations cannot be considered valid, as the human development index also takes a value of zero, and with such a result we cannot trace the dynamics of changes in the values of the indices included in the HDI calculation for the country where the minimum value of the GNI per capita was used for the annual calculation of the HDI. Thus, it seems appropriate to use the old minimum value, a constant value of \$ 100.

#### The differences in the calculation of the education index by the old and the new methods

The calculation of the Education Index (the old method):

- Percentage of students.
- Literacy Index.

$$I_{ed} = 1 / 3 \cdot i_{st} + 2 / 3 \cdot i_l \quad (3)$$

The calculation of the Education Index (the new method):

- Mean Years of Schooling Index.
- Expected Years of Schooling Index.

$$I = \frac{\sqrt{\text{mean\_years} + \text{expected\_years}} - D_{\text{min}}}{D_{\text{max}} - D_{\text{min}}} \quad (4)$$

The main difference in calculations using the old and the new methods is the final stage: according to the old methodology it was calculated by taking the arithmetic mean of all indicators [9]:

$$HDI = \frac{I_{life} + I_{education} + I_{income}}{3}. \quad (5)$$

The new method weights each component of the index differently, a weighting factor of 1/3 is assigned to the average life expectancy, per capita GDP has a coefficient of 1/3, Gross enrollment index – 1/9, Adult literacy Index is weighted as 2/9, so the formula will look like all the components have a weighting factor of 1/3, hence the formula will look like a geometric mean [10]:

$$HDI = \sqrt[3]{I_{life} I_{education} I_{income}}. \quad (6)$$

Whether or not those changes are justifiable can be viewed in different ways, but in general, the fact that proposed by the authors weights are

not reasonable can be seen as a major flaw, which casts doubt on the objectivity of the evaluation. There was the same disadvantage in the old calculation method. Though it is worth tracing the world dynamics on this issue, whatever insufficient the grounds.

In order to compare the old and the new method's results of calculating the Human Development index, we have compared the ranking of countries on the list of Human Development Index, made using this methods.

### Comparative analysis of HDI results using the old and the new methods

In this article, a comparative analysis of old and new methods of calculating the HDI was done. For the study purposes, there were 75 countries (15 countries from three groups in terms of HDI for low HDI – 30 countries) selected from the list. In Fig. 1–3 shown are the HDI values for the old and the new methods [10]. Based on the data a correlation analysis was performed.

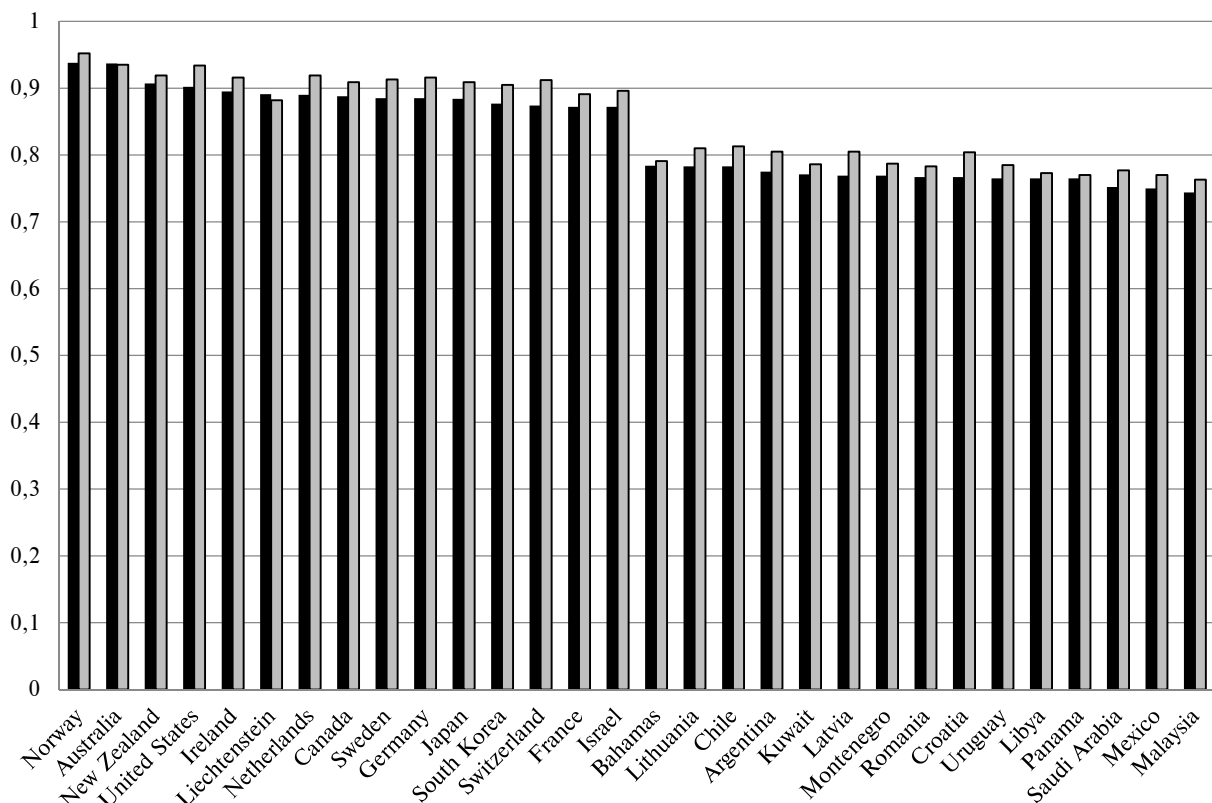
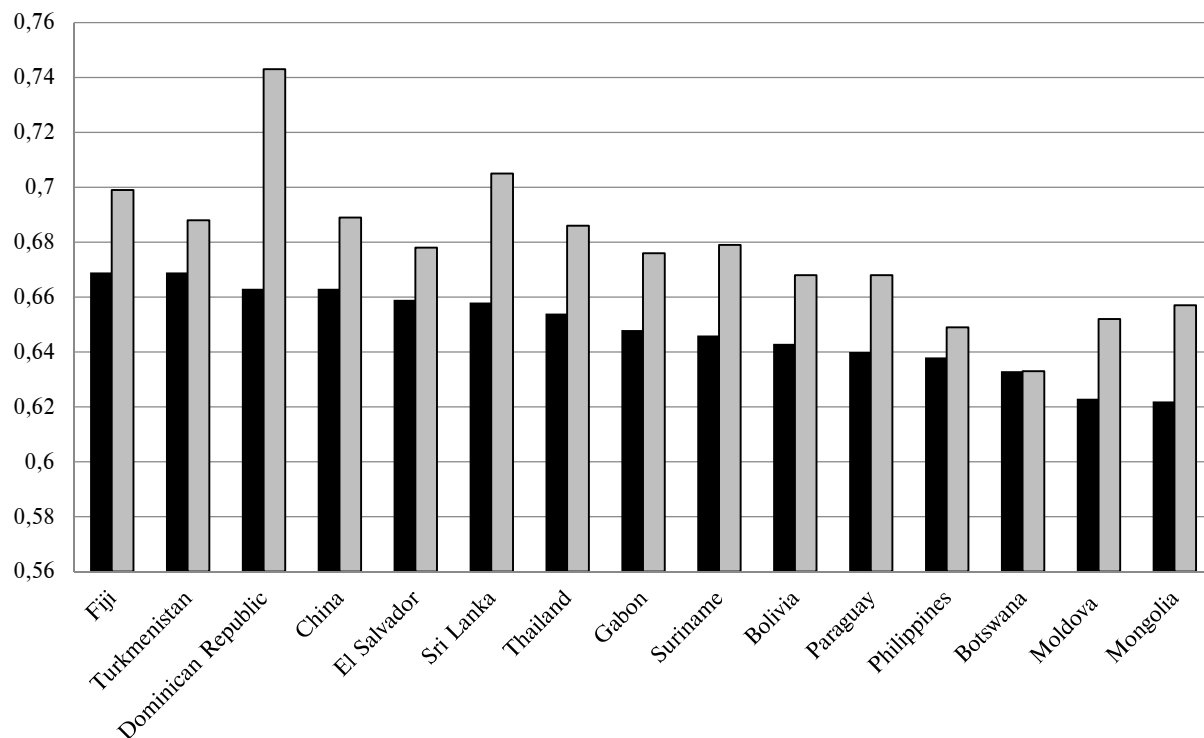
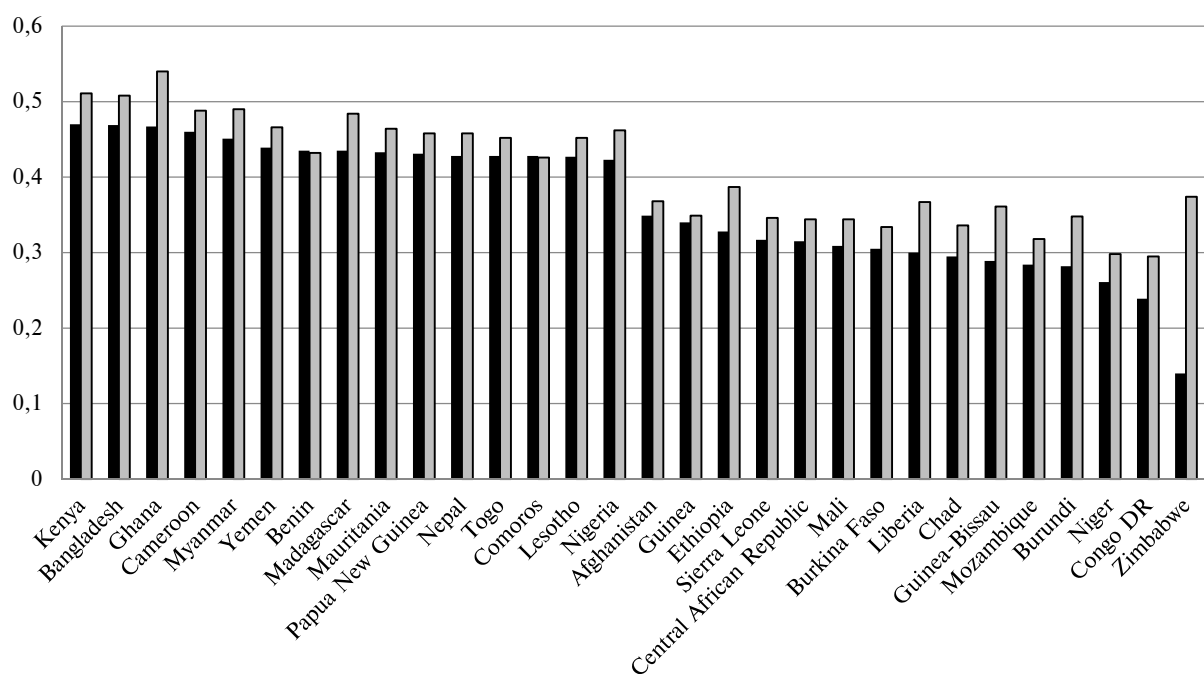


Fig. 1. HDI values for the countries with a very high and high development level of human potential (■) – new method; (□) – old method

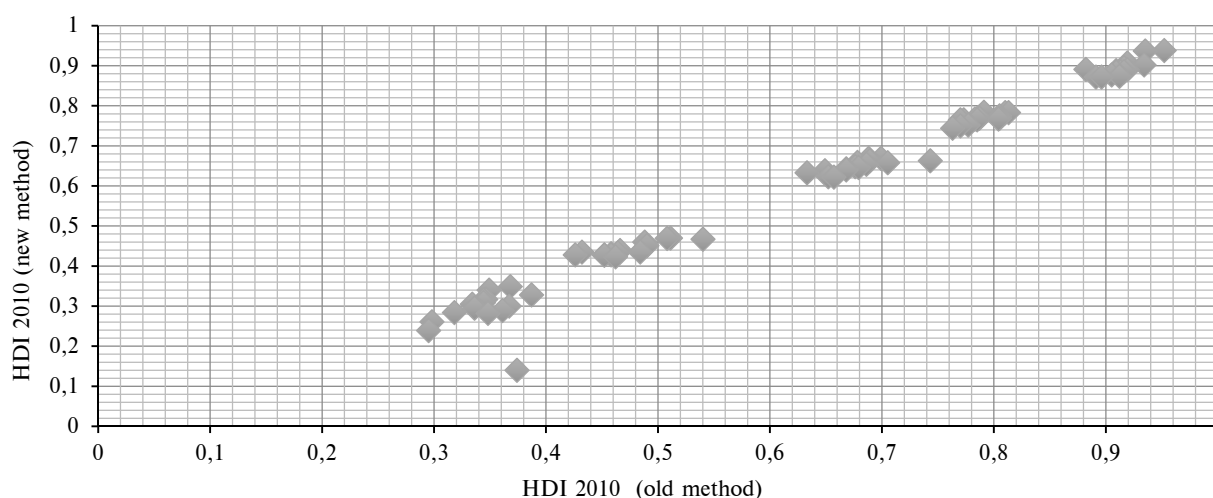




**Fig. 2.** HDI values for the countries with an average development level of human potential  
 (■) – new method; (□) – old method



**Fig. 3.** HDI values for the countries with a low development level of human potential  
 (■) – new method; (□) – old method



**Fig. 4.** The dependence between the values of the HDI for 2010, calculated according to the old and the new methods

Pearson's formula was used to calculate the correlation coefficient [11]:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}} = 0.99. \quad (7)$$

The calculation was made using the similar function in Excel.

The calculations show that the relationship is very close, as the correlation coefficient is in the range of 0.9–1. This suggests a direct relationship between the final values of HDI of the countries, calculated according to the old method and the values of the HDI calculated using the new method. The resulting value of the correlation coefficient suggests that the relationship

between these parameters is linear. This means, that by conducting the more detailed and wider study with a large enough sample, you can build a regression model and track how much the 1 point alteration in the HDI by using the old methodology will change the HDI calculated using the new method. The results of this computation are shown in the correlation field:

#### Position change in the global ranking of countries after application of the new method

Particularly interesting is the way the countries changed their position after the application of the new method. These data are presented in Tab. 3:

Table 3

Comparative analysis of the values of the HDI countries done by the old and the new methods

Rank	The old method		The new method		Changes	New rank
1	0.952	Norway	0.938	Norway	0	1
2	0.935	Australia	0.937	Australia	0	2
3	0.934	USA	0.907	New Zealand	+2	3
4	0.919	Netherlands	0.902	United States Of America	−1	4
5	0.919	New Zealand	0.895	Ireland	+2	5
6	0.916	Germany	0.891	Liechtenstein	+9	6
7	0.916	Ireland	0.89	Netherlands	−3	7
8	0.913	Sweden	0.888	Canada	+2	8
9	0.912	Switzerland	0.885	Sweden	−1	9
10	0.909	Canada	0.885	Germany	−4	10
11	0.909	Japan	0.884	Japan	0	11
12	0.905	South Korea	0.877	South Korea	0	12
13	0.896	Israel	0.874	Switzerland	−4	13
14	0.891	France	0.872	France	0	14
15	0.882	Liechtenstein	0.872	Israel	−2	15



For Example:

1) The HDI value of 0.952 in Norway under the old methodology (1st place) has changed in accordance with the new method to 0.938 (the first line in Tab. 1). Nevertheless, the position in the ranking has not changed and Norway remained at the first place.

2) The HDI value of 0.882 in Liechtenstein under the old methodology (15th place) has increased in accordance with the new method to 0.891. This allowed Liechtenstein to go 9 positions up (+9) and get the 6<sup>th</sup> place.

3) The HDI value of 0.919 in the Netherlands under the old methodology (4th place) dropped in accordance with the new method to 0.89. After changing the ranking position the Netherlands was on the 7<sup>th</sup> place (−3 position).

#### **Calculation of the Russian Federation HDI using the new method**

The authors calculated the human development index based on the data supplied by the Federal State Statistics Service [12]. This result does not correspond to the value of this indicator in the global ranking of countries by HDI presented in the UN report [13]. The results are presented in Tab. 4.

Table 4

**Comparison of the results of the HDI index calculation**

Method of calculating	Value	Place in the UN ranking
The old methodology	0.719	65
The new methodology	0.78	55
The author's calculations	0.809	44

The data presented in Tab. 4 show a discrepancy between the results of calculation and, accordingly, ranking of the UN. Primarily, this is due to the fact that the statistics cannot always be collatable due to the fact that the data used for the analysis are from different sources. It is worth noting that for the analysis of the life quality in a region that is inextricably linked with the level of quality of life of the country population, there are more commonly used indicators, such as the population change dynamics, indicators of the economically active population and unemployment, the structure of educational institutions, the number of hospital beds and the number of doctors, and the personal incomes [14].

Changes in the methodology for calculating the HDI and the introduction of new indicators have led to significant changes. By applying the geometric mean, we get the most accurate result of the averaging that allows us to find a value that would be qualitatively equidistant from both maximum and minimum values of the attribute, which is a positive moment. There is also a negative effect of using the geometric mean, associated with greater unpredictability of results than in the calculation using the arithmetic mean. It is also worth mentioning that the weights of the index components are a target for criticism by numerous Russian and European scientists, including S.A. Ayvazyan, who cites I. Numbler's criticisms [15]. B.V. Kornejchuk and N.G. Ivanova also subjected the index to the critical assessment, because it is difficult to use it as a full measure of human capital [16].

In addition to the adjustment of indices the new method is supposed to calculate several new indicators: the human development index, adjusted for socio-economic inequality, the gender inequality index, and the multidimensional poverty index. A wider range of indicators allows to analyze a wider range of indicators that affect quality of life of the population. In addition to the approved indicators, it would be appropriate to add indicators, influencing quality of life, that take into account:

- the environmental factor,
- the political system stability,
- the social tension in the society,
- the corruption level in the country.

In conclusion, it should be added, that in accordance with both the old and the new methodology, the main indicator of the population's income is the GNI per capita, which in its essence does not reflect the exact level of income, but it is highly weighted when calculating the HDI using the new method, which on the second thought shows certain reassessment of the importance of this criterion.

Thus, by analyzing the old and the new methodology for calculating the human development index it is worth mentioning that the new method has a number of positive aspects as well as some negative ones that have been criticized by economists and need some improvement. Nevertheless, the majority of

scientists recognize that the main task of the calculation of such index as the index of human development — development of the inter-regional system of countries ranking with the

aim to assess the population life quality dynamics and compare it with other areas — is performed quite well, while remaining understandable enough for the general public.

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**M.D. Mednikov, A.S. Sokolitsyn, N.A. Sokolitsyna**

## **CORPORATE BEHAVIOR MODELS OF ENTERPRISES IN A FINANCIAL AND INDUSTRIAL STRUCTURE**

**М.Д. Медников, А.С. Соколицын, Н.А. Соколицина**

## **МОДЕЛИ КОРПОРАТИВНОГО ПОВЕДЕНИЯ ПРЕДПРИЯТИЙ ФИНАНСОВО-ПРОМЫШЛЕННОЙ СТРУКТУРЫ**

This article is about modeling the corporate behavior of a financial and industrial structure under the present social and economic conditions in our country. Analyzing the publications related to the international and Russian practices in the sphere of forming, functioning and developing industrial corporations one can make a conclusion that they represent one of the ways to integrate financial, industrial and trade capitals by means of a complex participation system. On the basis of the undertaken analysis we have developed goal-setting concerning the congruence of interests in the enterprises of vertically-integrated financial and industrial structures based on the suggested interest congruence principles and taking into account the specifics of the present economic conditions in Russia. We have researched the congruence of economic interests of enterprises in vertically integrated structures on the basis of two economic and mathematical models. The support model describes the coordination of the economic interests of each enterprise in a vertically integrated structure in particular with decentralized money distribution. The central one shows the congruence of the economic interests of enterprises in a vertically integrated structure with centralized money. These models form the generalized chart of modeling the corporate behavior of enterprises with a vertically integrated structure. Putting the suggested models into practice allows increasing the effectiveness of these financial and industrial structures due to the synergetic effect from forming interest congruence mechanisms based on optimizing the enterprises' innovation plans in the corporate structure with decentralized and centralized money distribution. Introducing the developed economic and mathematical models and procedures into the corporate management system of financial and industrial structures boosts the effectiveness of their industrial and business operations, creates the necessary conditions for long-term sustainable development. The considered models can be structurally extended by means of including social and economic public interests and their realization within the framework of the public-private partnership system.

CORPORATION; MODEL; SYNERGETIC EFFECT; STRUCTURE; ENTERPRISE.

Применительно к современным социально-экономическим условиям развития нашей страны рассматривается моделирование корпоративного поведения финансово-промышленных структур. Анализ публикаций, касающихся современной практики в области формирования, функционирования и развития промышленных корпоративных структур, показывает, что они представляют собой одну из форм интеграции финансового, промышленного и торгового капитала путем разветвленной системы участия. На основе проведенного анализа разработана постановка задачи согласования интересов предприятий вертикально-интегрированных финансово-промышленных структур, базирующаяся на основе предложенных положений согласования интересов с учетом специфики современных экономических условий развития России. Проведено исследование согласования интересов предприятий вертикально-интегрированных структур на основе реализации двух экономико-математических моделей. Вспомогательная модель – согласование интересов каждого предприятия вертикально-интегрированной структуры в отдельности при децентрализованном распределении денежных средств. Центральная – согласование интересов предприятий вертикально-интегрированной структуры при централизации их денежных



средств. На основе этих моделей сформирована обобщенная блок-схема моделирования корпоративного поведения предприятий вертикально-интегрированной финансово-промышленной структуры. Реализация разработанных моделей позволяет повысить эффективность деятельности вертикально-интегрированных финансово-промышленных структур за счет получения синергетического эффекта посредством формирования механизма согласования экономических интересов, базирующегося на оптимизации инновационных планов предприятий корпоративной структуры при децентрализованном и централизованном распределении денежных средств. Внедрение разработанных экономико-математических моделей и процедур в систему корпоративного управления финансово-промышленными структурами повышает эффективность их производственно-хозяйственной деятельности, создает необходимые условия для устойчивого долговременного развития. Рассмотренные в статье модели могут быть структурно расширены за счет включения в них социально-экономических интересов государства и их реализации в системе государственно-частного партнерства.

КОРПОРАЦИЯ; МОДЕЛЬ; СИНЕРГЕТИЧЕСКИЙ ЭФФЕКТ; СТРУКТУРА; ПРЕДПРИЯТИЕ.

The timeliness and relevance of the present research consists in the fact that modern economy in each developed country is relies on big firms and companies which actively cooperate with small and medium enterprises, including big corporations, and in order to increase the effectiveness of their functioning and development it is necessary to model their corporate behavior by means of coordinating the economic interests of the enterprises, which in its turn allows obtaining a synergetic effect from uniting the available resources.

The analysis of the publications concerning the international and Russian practices in the field of forming corporations and their functioning shows that big industrial companies are one of the ways of integrating financial, industrial and trade capitals with a complex participation system. For example, [14] shows that the problem of managing large entrepreneurial structures functioning in several industries during a long period of time has been studied insufficiently. Under present day conditions the market model, in which each enterprise is a single independent unit, is economically impractical, as the special features of large companies allow them to adapt more flexibly to the changing economic conditions and toughening competition. The organizational aspects of managing corporate industrial structures are considered in [18]. The problems concerning the efficient implementation of M&A strategy are addressed as one of the main directions in which large corporate industrial structures develop. Economic and mathematical models of strategic development management for corporate industrial structures have been built in terms of short- and long-term lending. Studying the issues concerning forming, supporting and

developing competitive advantages in large corporate structures during economy recession and growth is of special interest [9]. The possible financial sources for the functioning and development of large corporations are given a detailed consideration in [19]. Besides that, [1, 2, 4–7, 12, 13, 19, 20] present detailed and original research concerning the corresponding aspects of the industrial and business operations of large corporate industrial structures.

Unlike other popular in modern market economy forms of integrating and organizing entrepreneurship (concern, trust, cartel, industrial holding), nowadays a special role belongs to large industrial firms or, in other terms, financial and industrial (industrial and financial) groups (FIGs). Under modern social and economic conditions FIGs are multiprofile and multifunctional structures formed as a result of uniting the capitals of different enterprises, investment, credit and financial institutions, as well as a range of other organizations in order to maximize profit, increase the effectiveness of the functioning and development of FIGs, increase the competitiveness in domestic and external markets, develop technological and cooperation links, boost the economic potential of their members. Legally autonomous firms and enterprises belonging to several branches of economy, banks and other credit bodies, industrial, trade and transport companies are united under the control of the head (Mother) company, i. e. the central company operates in the FIG as the business system center of the group. The central company coordinates the activities of the group members, provides unified accounting, forms a consolidated balance, provides financial statements and performs some banking operations, as well as a

range of other functions for the group members. So, the FIG members act autonomously in domestic and foreign markets, and the Mother company takes the functions of strategic management in the sphere of investments, production, sales and financial control.

Besides that, the analysis has shown that the basic aim of uniting enterprises into a corporation is cementing their positions in domestic and world markets, raising sustainability, effectiveness and compatibility. Forming corporations can ensure effective spillovers of technologies, qualified personnel and capitals, keeping and developing effective production and cooperation links while making a complex end product, increasing investment and export capacities. Therefore, in modern economy only large capital can normally provide the usage of cutting edge technology and maximum production effectiveness [6, 12, 13, 15].

The analysis of the international and Russian business practices shows that in these industrial firms enterprises often compete in the financial market.

There is usually a lack of finance not only for strategic development, but also for business activities. Despite that, the head (Mother) companies of industrial corporations implement a joint activity investment policy for all enterprises. For this purpose, they accumulate resources and invest them in new projects, as well as in reconstructing and modernizing the enterprises. Due to lack of finance the Head Company chooses the prioritized investment programs for its enterprises, which it will partly finance, and also guarantees getting investments from other sources.

It is a complex issue to select the prioritized investment programs, which actually serve as a plan of technical development and production organization.

Let us consider determining the optimization investment programs for vertically integrated financial and industrial structures.

A vertically integrated financial and industrial structure is a structure which unites a range of enterprises covering all stages of the production process ranging from extracting, manufacturing, assembling enterprises to the distribution network through which the mature product is sold to the end consumer. The organizational unity of all the production chain elements and establishing unified business discipline for all the enterprises and

organizations in a vertically integrated structure helps to optimize its industrial and business operations.

Analyzing the functioning and development practices of vertically integrated financial and industrial structures has enabled detecting their special features. For example, [8] considers the peculiarities of managing vertically integrated structures, the positive and negative aspects of their forming, functioning and development are determined. It is argued that they enable harmonizing the economic aims of business development with the social interests of the workforce, business partners and the society in general. Special attention is paid to their usage in petroleum industry. For example, [10] studies the organizational and economic benefits of vertically integrated petroleum companies, which emerged owing to a full-scale change in the management structure, and [3] analyzes the advantages and disadvantages of such companies taking into account the creation and implementation of a new form of business, i. e. a cluster within the framework of regional economic policy. Besides that, it is pointed out that vertically integrated structures are not only economic but also sociotechnical organizations [17].

*Background of setting the task concerning the congruence of interests of enterprises in a vertically integrated financial and industrial structure*

Increasing their functioning and development effectiveness usually requires equaling technical (production) capacities of storing, manufacturing and assembling enterprises. Upgrading the enterprises that are lagging behind in order to take them to the level of the average and top ones can be achieved by introducing innovations, which normally requires sufficient money that those enterprises generally lack. Therefore, the increase of the technical level of storing and manufacturing enterprises is usually carried out with the help of the money of the assembling enterprises and the mother company. In this case there arises a very important problem of determining each enterprise's role in the corporative result for profit redistribution between the enterprises and the mother company, which stimulates their effective business. Therefore, this is the problem of coordinating the interests of enterprises and the mother company in financial market.





*Setting the task of enterprises' interest congruence in a vertically integrated financial and industrial structure*

To coordinate the interests of the enterprises in such a structure we have developed a mechanism based on using the following two economic and mathematical models:

1) support model describing each enterprise's industrial and business operations in particular under the conditions of decentralized resources usage;

2) central model describing the enterprise's industrial and business operations under the conditions of centralized resources usage.

The support model describes the production and financial activities of each enterprise separately, i. e. under the conditions of decentralized resources usage. This model provides support while solving the basic problem, that is equaling the technical level of the corporate structure enterprises throughout the whole technological chain.

The central model describes the enterprise's production and financial activities under the conditions of centralized resources usage. Putting this model into practice allows equaling the technical level of the corporate structure enterprises, i. e. it is the basic model for the interest congruence of corporate structure enterprises.

Forming the centralized money fund of a corporate structure is based on the following general principles:

1. The principles concerning the allocation of financial resources for innovations by enterprises (enterprise reconstruction, equipment modernization), as well as their amount in the centralized fund of the company are considered in advance for the target period.

2. Centralized money fund is formed both by the firm enterprises and the Head Company, as well as other finance sources.

3. The principles of forming (redistributing) the profit from innovations among the firm enterprises and the Head Company are agreed upon beforehand by all those who invest in innovations.

4. The profit is distributed among the investors according to the profit obtained from innovations and the amounts of money invested.

There is no priority when distributing the profit from innovations.

The research into coordinating the interests of enterprises and the central company is based on realizing the following economic and mathematical models [15, 16, 18].

*Determining the interests of each enterprise in a vertically integrated financial and industrial structure in particular under the conditions of decentralized resources usage*

The support model describes each enterprise's production and financial activities separately, i. e. under the conditions of decentralized resources usage and it is as follows:

$$f(y) = \sum_{j=1}^n P_j y_j \rightarrow \max; \quad (1)$$

$$\sum_{j=1}^n C_j y_j \leq C; \quad (2)$$

$$P_\beta + \sum_{j=1}^n P_j y_j \leq P_\alpha; \quad (3)$$

$$\sum_{j=1}^n \Pi_j y_j / \sum_{j=1}^n C_j y_j \geq r; \quad (4)$$

$$y_j = \{1, 0\}, \quad (5)$$

where  $y_j$  is the figure meaning if innovation  $j$  exists in the enterprise's innovation plan ( $y_j = 1$  means planned innovation,  $y_j = 0$  – not planned);  $C_j$  is planned annual costs of innovation  $j$ ;  $C$  is the enterprise's planned innovation budget;  $P_j$  is the planned production capacity growth resulting from innovation  $j$  shown through the mature corporate product;  $P_\beta$  is actual production capacity shown through the mature corporate product at the beginning of the target period;  $P_\alpha$  is the limit of the production capacity shown through the mature corporate product at the end of the target period (this limit is not obligatory);  $r$  is acceptable return on costs (rate of return on capital) determined by bank interest rate or average rate of return on capital in the branch.

The economic and organizational meaning of the criteria and limitations is evident and there is no need for any additional comments. This problem is solved by each enterprise independently.

*Research into the congruence of interests of enterprises in vertically integrated financial and industrial structures under the conditions of centralized resources usage*

The central model describes the enterprise's production and financial activities under the conditions of centralized resources usage. This model is as follows:

$$f(x) = \min_{1 \leq i \leq m} (P_i + \sum_{j=1}^{n_i} P_{ij} x_{ij}) \rightarrow \max; \quad (6)$$

$$\sum_{i=1}^m \sum_{j=1}^{n_i} C_{ij} x_{ij} \leq C + M; \quad (7)$$

$$\sum_{i=1}^m \sum_{j=1}^{n_i} (\Pi_{ij} x_{ij}) / \sum_{i=1}^m \sum_{j=1}^{n_i} C_{ij} x_{ij} \geq r; \quad (8)$$

$$x_{ij} = \{1, 0\}, \quad (9)$$

where  $C_{ij}$  is planned annual costs of enterprise  $i$  on innovation  $j$ ;  $C$  is planned innovation budget of the enterprises;  $M$  is money spent by the mother company on the enterprises' innovations;  $P_{ij}$  is planned annual profit of enterprise  $i$  from innovation  $j$ ;  $C_{ij}$  is planned production capacity growth of enterprise  $i$  resulting from innovation  $j$  shown through the mature corporate product;  $C_f$  is actual production capacity of enterprise  $i$  shown through the mature corporate product at the beginning of the target period;  $r$  is acceptable return on costs (rate of return on capital).

Goal function (6) provides continuous equaling of the production capacities of all enterprises. The model is realized step-by-step according to the following chart that serves to determine the optimal plans of an enterprise in centralized resources usage.

Step 1. Determining the optimal plan for each enterprise with the help of the following model:

$$f(x) = P_i + \sum_{j=1}^{n_i} P_{ij} x_{ij} \rightarrow \max; \quad (10)$$

$$\sum_{i=1}^m \sum_{j=1}^{n_i} C_{ij} x_{ij} \leq C + M, \quad i = \overline{1, m}; \quad (11)$$

$$\sum_{i=1}^m \sum_{j=1}^{n_i} \Pi_{ij} C_{ij} x_{ij} / \sum_{i=1}^m \sum_{j=1}^{n_i} C_{ij} x_{ij} \geq r, \quad i = \overline{1, m}; \quad (12)$$

$$x_{ij} = \{0, 1\}, \quad i = \overline{1, m}. \quad (13)$$

Step 2. Results of (1)–(4) model allow choosing enterprise  $i^*$  corresponding to the condition

$$f(x_{i^*}) = \min_{1 \leq i \leq m} (P_i + \sum_{j=1}^{n_i} P_{ij} x_{ij}) \rightarrow \max. \quad (14)$$

Step 3. For this enterprise let us calculate the costs and subtract them from  $C + M$ , i. e. calculate the total budget for all the enterprises excluding  $i^*$

$$C' = C + M - \sum_{j=1}^{n_{i^*}} C_{i^*j} x_{i^*j}. \quad (15)$$

Step 4. For these enterprises let us calculate the following profit maximization model

$$f(x) = \sum_{i=1}^m \sum_{j=1}^{n_i} \Pi_{ij} x_{ij} \rightarrow \max; \quad (16)$$

$$\sum_{i=1}^m \sum_{j=1}^{n_i} C_{ij} x_{ij} \leq C + M - \sum_{j=1}^{n_{i^*}} C_{i^*j} x_{i^*j}; \quad (17)$$

$$\sum_{i=1}^m \sum_{j=1}^{n_i} \Pi_{ij} x_{ij} / \sum_{i=1}^m \sum_{j=1}^{n_i} C_{ij} x_{ij} \geq r; \quad (18)$$

$$x_{ij} = \{0, 1\}. \quad (19)$$

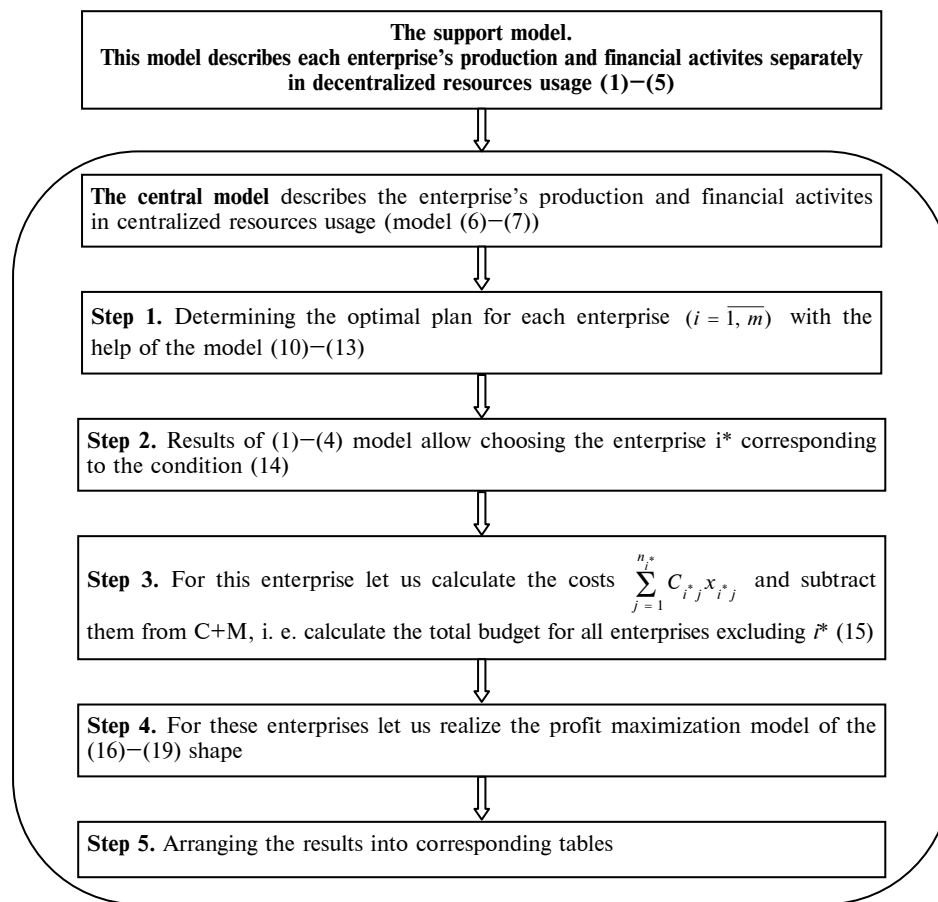
Step 5. Arranging the results into corresponding tables.

The generalized chart describing the process of modeling corporate behavior of the enterprises in a vertically integrated financial and industrial structure is shown in Figure.

This research has yielded the following results including the principally new ones:

1. The proposed mechanisms of coordinating the interests for the vertically-integrated firms are based on optimizing the enterprises' innovation plans with decentralized and centralized money distribution.

2. With decentralized money distribution the optimization model describes each enterprise's production and financial activities separately. With centralized money distribution the production and financial activities of the whole corporation are optimized, each enterprise and the Head Company contributing, which is the most important stimulating factor to increasing its effectiveness.



Generalized chart of modeling the corporate behavior of enterprises in a vertically integrated financial and industrial structure

3. It requires special attention that, when put into practice, the science-based approach proposed in the article, which helps to work out the direction and programs of developing the company activities, ensures complexity, coordination of managerial acts and valid economic forecasts.

Introducing the proposed economic and mathematical models, procedures and algorithms into the corporate management system of vertically integrated financial and industrial structures increases the effectiveness of their

industrial and business operations, creates the necessary conditions for long-term sustainable development.

The public-private partnership system combined with including social and economic public interests and their implementation can be considered as the main direction for further application of the model regarding the congruence of interests of enterprises in financial and industrial structures under the present day conditions of regional and national economy.

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**PROSPECTS AND SPECIFICS  
OF RESOURCE MANAGEMENT IN ENTERPRISES OPERATING  
IN DIFFERENT SECTORS OF THE RUSSIAN ECONOMY**

**Е.С. Балашова, Е.А. Громова**

**ПЕРСПЕКТИВЫ И СПЕЦИФИКА  
РЕСУРСНОГО УПРАВЛЕНИЯ ПРЕДПРИЯТИЯМИ  
РАЗНЫХ СЕКТОРОВ ЭКОНОМИКИ В РОССИИ**

The article analyzes the current economic situation in Russia. It considers the principle models of resource management, such as lean production, the theory of constraints, and the resource-based view. It also reveals how using one of the resource management models correlates with the present state of the Russian economy and examines the appearance of foreign automotive companies in the Russian market and its causes. The paper presents examples of adopting the modern organizational technology – lean production in the industrial enterprises, such as the Ural Automotive Plant (Chelyabinsk region), which is part of the GAZ Group, the KamAZ Automotive Plant, and the Signal Engels Instrument Making Association. These enterprises were the pioneers in implementing lean production principles in Russia. One more example is Tatneft, which has recently started applying the methods of this organizational technology as well. Another remarkable example in the service sector is Sberbank, the largest bank in Russia and Eastern Europe. The article considers the Sberbank Production System as part of Sberbank's Development Strategy and provides its interim results and new goals. The authors offer an explanation of why Russian companies often face difficulties when implementing lean production. Applying lean production principles is deemed to be one of the possible measures to overcome the current economic crisis in Russia.

RESOURCE MANAGEMENT; CONTEMPORARY ORGANIZATIONAL TECHNOLOGIES; LEAN PRODUCTION; ECONOMIC CRISIS; RUSSIA; SBERBANK.

Анализируется текущая экономическая ситуация в России. Рассматриваются основные модели ресурсного менеджмента, такие как бережливое производство (Lean Production), теория ограничений (Theory of constraints), ресурсная теория/ ресурсная концепция (Resource-based view). Выявляется зависимость между применением той или иной модели ресурсного менеджмента и сложившимся экономическим положением. Анализируется период прихода на российский рынок иностранных компаний. Приводятся основные причины захвата зарубежными автомобилестроительными заводами российского рынка. Рассматриваются примеры применения современной организационной технологии – бережливое производство (Lean Production) на промышленных предприятиях, таких как автомобильный завод «Урал» (Миасс), входящий в «Группу ГАЗ», автомобильный завод ОАО «КАМАЗ», Энгельсское приборостроительное объединение «Сигнал». Отмечается, что данные отечественные примеры внедрения принципов концепции Lean production венчали применение вышеуказанной современной организационной технологии в России. Приводится пример предприятия, начавшего использовать методы данной модели ресурсного менеджмента в последние годы (рознично-сбытовая сеть ОАО «Татнефть»). Отдельно отмечается отечественный пример внедрения принципов бережливого производства в сфере услуг в крупнейшем банке России и Восточной Европы – ОАО «Сбербанк». Рассматривается производственная система Сбербанка, как часть Стратегии развития Сбербанка, подводятся промежуточные итоги и обозначаются очередные цели. Делается попытка сформулировать основные причины сложного освоения и неудачных случаев внедрения концепции бережливого производства (Lean Production) в российских компаниях. Применение современной организационной технологии – Lean production рассматривается в качестве одной из возможных мер по выходу Российской Федерации из текущего экономического кризиса.

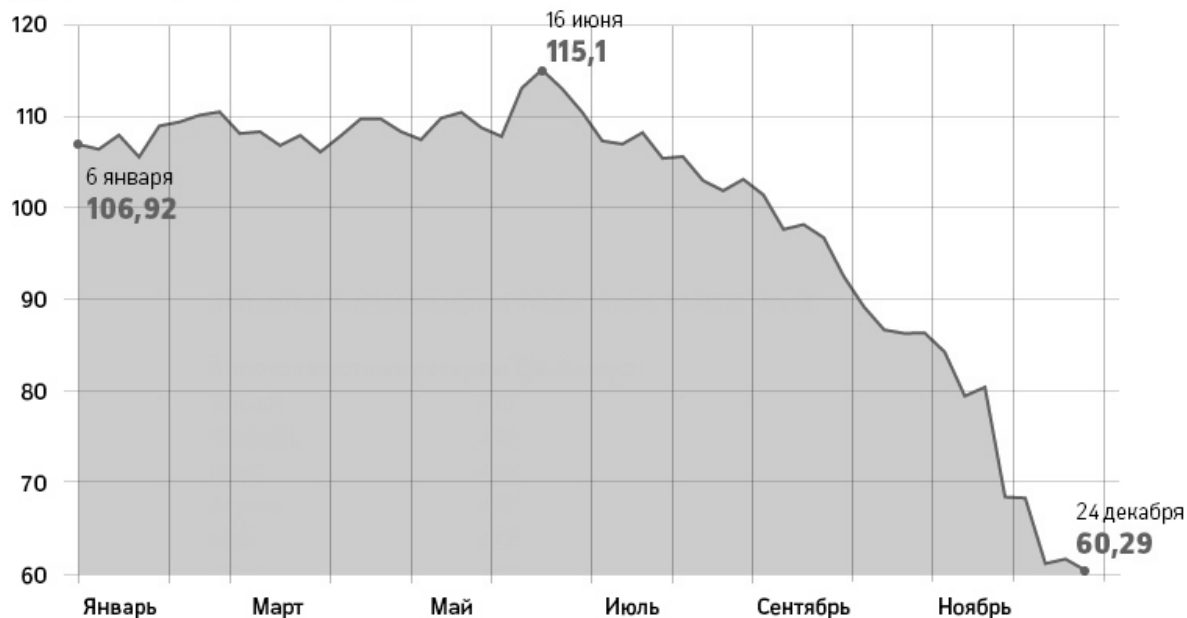
РЕСУРСНЫЙ МЕНЕДЖМЕНТ; СОВРЕМЕННЫЕ ОРГАНИЗАЦИОННЫЕ ТЕХНОЛОГИИ; БЕРЕЖЛИВОЕ ПРОИЗВОДСТВО (LEAN PRODUCTION); ЭКОНОМИЧЕСКИЙ КРИЗИС; РОССИЯ; СБЕРБАНК.

*Introduction.* Since the beginning of 2015, the Russian economy has been declining steadily, unable to cope with the deepening economic

crisis. The current crisis that was triggered last year by the tense geopolitical situation in the world caused the Russian economy, focused on

## Нефть подешевела на 44%

■ Цена на нефть марки Brent, \$/барр.



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Источники: Bloomberg

Brent oil prices in 2014

the export of oil, to start this year with weak prices per barrel. Oil prices dropped by almost half (Figure) [1]. At the present time, the prices for Russian oil show a downward trend.

As it is, amid the growing economic crisis, developing different sectors of the national economy by using internal resources appears as a rational solution. The representatives of the Central Bank consider the diversification of the economy to be an anti-crisis measure [2]. The diversification of the economy of such a large country is a challenging task of a revolutionary nature.

**Origin of resource management.** From time to time, different economies, such as the world economy or a national economy, are exposed to diverse fluctuations of various origins. The reasons for this can be multifold. Thus, in the context of an economic crisis, staying ahead of competition is vital for any company's survival. If the enterprise responds to the changes in the economic situation more quickly and effectively than its competitors, it will succeed. Consequently, the effective management of an industrial enterprise, based on a rational use of resources, comes to the fore.

Modern resource management is a field of science represented by different scientific schools that view the problem of efficiency from a variety of angles. However, the basic models share aims which take into account the following principles:

- total cost minimization;
- improving the efficiency of using the available resources;
- business profit maximization;
- maximizing the market value of the company [3].

There are three main up-to-date resource management models of an industrial enterprise, all of which are based on different scientific schools. As a result, each model has its own set of advantages and disadvantages. Lean production produces an overall impact on the value stream. It is based on continuous improvement in all the business processes. This framework mostly aims at a constant reduction of production costs. The theory of constraints is another common organizational change method which is based on focusing on the weakest link of the enterprise's chain and its subsequent elimination. For those

enterprises that use this business model, this process is cyclic. The next management system under consideration is the resource-based view. In contrast to the above models, it disregards the value stream and focuses instead on resource groups. So, each particular enterprise has a unique set of certain resources, – its competitive advantages. These are called core competencies. The resource-based view is the newest model of resource management among the above-mentioned models, and for this reason it is the least researched. The choice of the resource management model depends on the following factors: the internal state of the enterprise, market conditions, the strategy of development. Along with using one particular model, there can be employed a successful combination of several complimentary models. Nonetheless, lean production is a more holistic and fundamentally developed conception of management. This organizational technology is the most popular one in Russia because of government intervention at the initial stage of the model's development at the beginning of the 2000s as well as its vigorous promotion among the representatives of research and business communities.

**Main part.** A lot of foreign companies, especially automobile ones, came to the Russian market in the first decade of the 21st century. In the first half of 2005, the Government adopted a decree called «On Amendments to the Customs Tariff of the Russian Federation with Regard to Automotive Components Imported for Industrial Assembly». Next, the Government issued an order for realization of the decree called «On Changes in the Procedure Governing the Concept of «Industrial Assembly» of Motor Transport Components and Establishing the Use of This Concept for Importation into the Russian Federation of Auto Parts for the Production of Motor Transport Commodity Items 8701-8705 TN of the VED, Their Subassemblies and Aggregates». The main aim of these government bills was to attract foreign capital to develop the Russian automotive industry by gradually increasing local content in manufacturing automotive vehicles and auto parts, while reducing their imports. The mode of «industrial

assembly» benefited those investors who planned to start vehicle production in Russia by importing large quantities of automotive components free of duty or at reduced rates. Localizing the production of automotive components accounted for 30 % of the value of the vehicle when the investors brought in a complete production cycle. Then, they had to cut down on the number of imported parts. The Izhevsk Automobile Plant was the first manufacturer to start producing the KIA Spectra in the new customs mode. Thanks to concessionary terms, such top foreign companies as Volkswagen, GM, Nissan, Toyota, Suzuki, Peugeot-Citroen, Hyundai, Mitsubishi, Renault came to the Russian market within one year after the decree was adopted. The Ford Motor Company, which had already had manufacturing facilities in Vsevolozhsk, adopted the new mode too.

Lean production is thought of as an organizational system for industrial enterprises. This organizational technology is common to the Russian industry whose leading enterprises were the pioneers in implementing the principles of lean production in Russia, as they were the first to face different problem situations. Practicing lean production principles appeared to be the way to handle the crisis. For example, The Ural Automotive Plant (Miass, Chelyabinsk region), part of the GAZ Group, began to use lean production after the crisis of 2003. That crisis was caused by a twofold decrease in sales within two years. Using the modern organizational technology promptly produced a striking effect. The enterprise's performance indicators improved. The resulting cost savings amounted to approximately 300-400 million rubles per year [4]. Nowadays, the Ural plant continues to practice lean production methods, heavily relying on this concept. One more example is the KamAZ plant, another representative of the automotive industry. The company has been practicing lean production since 2005. This system was introduced step-by-step throughout all the departments of the concern. Soon, nine machines found in one of the plant shops were deemed superfluous and further dismantled, which, as a consequence, reduced the total unscheduled downtime nearly threefold [4]. Also, it was discovered that there were some





land plots among the capital assets that required constant financial support but yielded no profit. The problem was rectified by selling or renting the plots to gain some financial benefits. Now, KamAZ conducts a variety of conferences and seminars on lean production principles, organizes Doors Open events, demonstrating their current success in mastering Japanese methods of business organization. Another example of a Russian pioneer enterprise is the Signal Engels Instrument Making Association. It produces three types of products: aircraft and space equipment, general industrial equipment, gas and other kinds of heating equipment. The condition of the equipment was a major concern for the Association, so consultants were employed to implement the principles of lean production. Eventually, the employees of the Association were able to identify equipment malfunctions and develop a maintenance program aimed at keeping machines in operating condition [4]. The solution to the problem was found in understanding that not only staff from the maintenance department but also machine operators have to provide equipment upkeep. The named company has applied the principles of lean production quite widely. Recently, some Russian industrial enterprises have started to use a production system based on the concept of lean production more and more actively. In 2013, Tatneft began to master this modern organizational technology to increase its productivity. The introduction of new principles brought rapid results – the handover process at the petrol station was thoroughly analyzed and then optimized, which led to its reduction from 30 minutes to 4; and there were more to come. All in all, the economic effect of lean production measures amounted to 50 million rubles in the first year [5]. The ambitious aim of this enterprise is to achieve a business model based entirely on the principles of the above-described modern organizational technology by the end of 2016. Employee participation lies at the heart of this process.

Companies implementing the concept of lean production remain at odds on whether Russian enterprises are prepared to adopt this business model. However, they appear to have reached agreement on what makes its implementation so

difficult. They are of the opinion that the human factor is to blame. It is the human factor that exerts a significant impact on the application of the lean production ideology. According to experts, the human factor contributes, firstly, to misunderstanding, which induces rejection of the business model's principles among staff; secondly, to lack of awareness about a relevant organizational structure at all levels of the enterprise hierarchy; and, lastly, to allocating a small number of professional consultants to introducing the production system under consideration.

Sberbank serves as one of the most remarkable examples of a Russian company that implemented a model of resource management known as lean production. It is one of the largest banks in Russia and Eastern Europe. Overhauling its country-wide structure is a complex process. It is noteworthy that Herman Gref, CEO of Sberbank, said that they must prove that elephants can dance. This phrase reflected the complexity of the reform in mind. In 2008, the Supervisory Board of Sberbank unanimously approved Sberbank's Development Strategy until year 2014. The key elements of the Strategy included [7]:

- development of a client-oriented model to service individual and corporate clients of the Bank;
- technological upgrade of the Bank and processes industrialization;
- radical increase of the Bank's operational efficiency, based on up-to-date technologies, management and overall optimization through bank-wide implementation of Sberbank Production System/SPS based on Lean/Toyota Production System;
- development of international operations, primarily in the CIS countries.

The implementation of the Sberbank Production System (SPS) held a special place in the reform program. It was focused on the principles of lean production and oriented towards improving efficiency, raising motivation, increasing customer as well as staff satisfaction [8]. Establishing a work team and inviting an expert that had experience with this business model were the first steps in building the Sberbank Production System. The former system

of the Bank underwent dismantling, its flaws were identified with intent to turn them into advantages. Against this background, the goals were set in the framework of Sberbank's Development Strategy until year 2014. Overall, the results were regarded as positive. The primary growth of productivity was about 25 % and performance along the key business lines of the Bank improved by 30–50 % [9]. Later on, the growth of productivity continued to grow. The implementation of a number of large-scale projects resulted in such high performance indicators of the Bank as:

- The work of the retail network has been transformed: a new role-based work model was developed and introduced, flexible work schedules were established, and a brand new incentive system was created, the one that correlates employees' income with sales results and service quality.

- Work practices involving small businesses have been optimized: a new timing budget allows frontline managers to focus on providing good client service.

- The work of the accounting departments has been standardized and optimized: working standards for each operation were drawn up, a mechanism to manage staff workload and an incentive system correlating with labor efficiency and the quality of operations were adopted.

- The work of the IT department has been optimized: key software was developed and testing processes have been improved, including the introduction of the practice of integration releases.

- Work standards have been devised and implemented, they are also being continuously improved in cash and collection services. The SPS principles form the basis of a new approach to carrying out internal audits.

- A new method called «Do-it-Yourself, Step-by-Step» has been created.

Judging by an impressive list of completed projects, it is safe to assume that the implementation of the Sberbank Production System rested on a well-laid foundation. It is quite obvious that building a fully functioning

and a finely honed system in a large company, such as Sberbank, takes more than 5 years. Accordingly, the Bank approved Sberbank's Development Strategy until year 2018. The main aim of the current Strategy is to eliminate the shortcomings of the previous stage. The widespread implementation of the strategy has instilled confidence in the Sberbank Production System and increased awareness at all levels of the Bank's hierarchy. Sberbank's Development Strategy is a very comprehensive and ambitious reform program. It is to result in enhancing the Bank's competitiveness by organizing its productive processes and services more effectively in line with the concept of continuous improvement.

*Conclusions.* The primary focus of this article is on the contemporary model of resource management — lean production, and its application in the context of the current economic situation in Russia. Examples of the successful implementation of this management system in production and service are described. It is not deemed possible to make final conclusions as management development in the aforementioned companies is not quite up to par. There are also examples of the unsuccessful implementation of lean production in Russia, which can be accounted for by a huge area of Russia, lack of awareness in the business community, poor communication between management schools.

This model of resource management is not common in Russia because of how Russian business is conducted. However, the current economic crisis can induce widespread introduction of the organizational technology under consideration. This is quite a protracted and intensive process which requires hiring highly qualified specialists. They have to be result-oriented and regard Russia as a competitive and resilient country with a well-developed business culture. Nowadays, Russia is on the threshold of changes that will affect all spheres of life. But these changes are more than likely to influence economic sector, which, as a result, will propel Russia to a new level of development.



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Today's fast-changing market environment makes certain demands on the management system of modern companies. The management system, represented by the enterprise architecture, should have a balanced structure and be mature enough to promptly react to inner and outer business challenges. The system approach to enterprise management means that enterprise architecture components must be formed, reformed and developed taking into account their interdependency. As processes and projects are core components of business architecture, not only they seriously influence, but also define its maturity level. There are a number of existing process and project management maturity models, but no well-known research concerning their joint maturity and the maturity of business architecture. The balance between maturity levels of the mentioned components as a key factor of the balanced business architecture and its development is in the focus of the paper. Analysis of the existing processes and project maturity models has shown that there is a high correlation between maturity levels of these management approaches. Combination of process and project management maturity levels is a reliable diagnostic tool for estimating whether the business architecture is balanced or not. At the same time combination of the maturity levels of process and project management in the company is a way to determine the path of sustainable development of the company's management system. The paper is focused on exploring the ways to manage business architecture maturity via its key components' maturity management.

ENTERPRISE ARCHITECTURE; BUSINESS ARCHITECTURE; BUSINESS PROCESS MANAGEMENT; PROJECT MANAGEMENT; MATURITY; CMMI.

Быстро меняющиеся условия современных рынков накладывают определенные требования на систему управления предприятием. Система управления, представленная архитектурой предприятия, должна иметь сбалансированную структуру и быть достаточно зрелой для того, чтобы оперативно реагировать на внутренние и внешние бизнес-вызовы. Системный подход к управлению предприятием предполагает, что элементы архитектуры предприятия должны формироваться, реформироваться и развиваться с учетом их взаимозависимости. Поскольку бизнес-процессы и проекты являются основополагающими элементами бизнес-архитектуры предприятия, они не просто сильно влияют, но и определяют уровень зрелости последней. Существует ряд моделей отдельно по процессной и проектной зрелости, но нет известных исследований, посвященных совместной зрелости процессов и проектов и зрелости бизнес-архитектуры. Предмет исследования — баланс между уровнями зрелости упомянутых элементов как ключевой фактор сбалансированной бизнес-архитектуры и ее развития. Анализ существующих моделей зрелости процессного и проектного управления показал, что уровни их зрелости тесно связаны. Сочетание уровней зрелости процессного и проектного управления — это надежный инструмент для определения сбалансированности бизнес-архитектуры. Кроме того, сочетание уровней зрелости процессов и проектов позволяет определить пути устойчивого развития системы управления компанией. В статье исследуются способы управления зрелостью бизнес-архитектуры предприятия через управление зрелостью ее элементов.

АРХИТЕКТУРА ПРЕДПРИЯТИЯ; БИЗНЕС-АРХИТЕКТУРА; УПРАВЛЕНИЕ ПРОЦЕССАМИ; УПРАВЛЕНИЕ ПРОЕКТАМИ; ЗРЕЛОСТЬ; CMMI.

*Introduction.* Enterprise architecture is one of the mainstream concepts in scientific management nowadays. The term «enterprise architecture» originates from IT and was initially used to define the structure of tools of IT system

development. While it is true that modern enterprises cannot do without IT-systems supporting their processes, the key factor of successful management lies not only in the sphere of IT.

To achieve and sustain the desired market position modern enterprises have to be rather flexible and dynamic in order to introduce the relevant changes as soon as there is need for them. The more complicated the enterprise is, the more difficult the process of introducing changes into its management structure is and the more components of this structure should be involved in. Now the «enterprise architecture» is treated as a broader concept and traditionally means a series of different components of the management system and relationship between them (different definitions can be found in [1], [2], [3]).

Enterprise architecture in its current form has been developed as an answer to the problem of aligning business requirements and IT infrastructure (according to [4], [5]). So it is widely recognized that business process reengineering and transformation of IT infrastructure should be managed as a holistic, unified process. Thus, there are a lot of studies devoted to the analysis of alignment of business and IT architecture layers. In the meantime, it is crucially important to align the components within a single layer – it would form a backbone of the whole layer and provide reliable prerequisites for its development.

As business architecture is a foundation of the whole management system of a company, it seems vitally important to build a balanced business architecture and provide conditions for its further development. As any system is largely determined by the elements it consists of, the business architecture maturity level is determined by the maturity levels of its components. Nowadays there are some quite well-known approaches to estimating process and project management maturity but there is no complex research devoted to exploring their joint maturity or their contribution to the business architecture maturity. This paper is targeted on the analysis of the combination of the maturity levels of business architecture components – business process management and project management – as a key factor that forms a balanced business architecture and on determining the ways of its development. In other words, the paper is focused on the ways of business architecture maturity management via its components maturity management.

## Business architecture and its components

*Enterprise Architecture* is an interconnected whole of principles, methods and models that are used in designing and building organizational structure, business processes, information systems and infrastructure. [4]

Enterprise architecture is a complex management tool, which is designed to provide effective enterprise management solutions in response to the challenges of the business environment. Heterogeneous structure of enterprise architecture requires continuous alignment of all its components which are grouped into so called architecture layers. In the meantime, the need to follow the realities of today's business causes the need to reform and develop enterprise architecture.

Traditionally, the components of enterprise architecture can be represented as a set of layers comprising of several structural components. The number and names of layers varies in different sources (for example, [4–6]), but the concept is more or less the same. For example, [5] focuses on the following layers:

- Corporate mission and vision, strategic goals and objectives;
- Business architecture: business processes, organizational and staff structure, workflow system;
- System Architecture (IT architecture): applications, data, hardware.

Most of the researchers agree that business process system is a key element of business architecture. A business process is «a special process that intends at the implementation of the basic objectives of the enterprise (business objectives) and describes the central sphere of its activity» [7]. Business processes as «a stable (regularly repeated), targeted set of interrelated activities, which according to a certain technology transforms inputs into outputs which have value to the consumer (client)» is the definition of the organizational structure of an enterprise given by [8]. The organizational structure is a stable set of interrelated and inter-subordinate organizational units to coordinate human resources of a company. «The process approach to management is a construction of a system of processes, control over these processes aimed at achieving the best results, improved efficiency and customer satisfaction» [8]. In



modern enterprises process management involves description, regulation, updating, and improvement of business processes system and the organizational structure in order to ensure the stability and reproducibility of the results.

In the meantime every company faces business challenges which cannot be met effectively in terms of business-as-usual approaches. Such challenges include both realization of external customer orders and introduction of innovative initiatives within the company. In such situations an enterprise has to establish some temporary structures to meet a new challenge or achieve a new business goal.

Some researchers confess in a more or less explicit form (for example, Architecture Development Methods of [6] and [5] the need to include means in the enterprise architecture for dealing with changes and transformations. In [9] it is underlined that the enterprise architecture among other elements should include «transitional processes for implementing new technologies in response to the changing needs of the business». As the enterprise architecture is a dynamic management tool, it requires a build-in mechanism for managing changes that is different from the routine operational processes. These reasons prove the need to add a project viewpoint to the business architecture model.

A *project* is traditionally defined as «a temporary organization that is created for the purpose of delivering one or more business products» [10]. Project management as an area of management dealing with the need to implement changes or realize unique activities. A large number of companies in various fields of activity are faced with the need to solve business problems that cannot be settled through standard routine business processes. It causes the need for development and implementation of project-based solutions aimed at achieving business goals, which states the necessity of introducing the project approach to the enterprise architecture.

If project management is considered as one of the subsystems of the enterprise management system, such an updated model of the business architecture provides:

- a company with an effective tool for running projects;

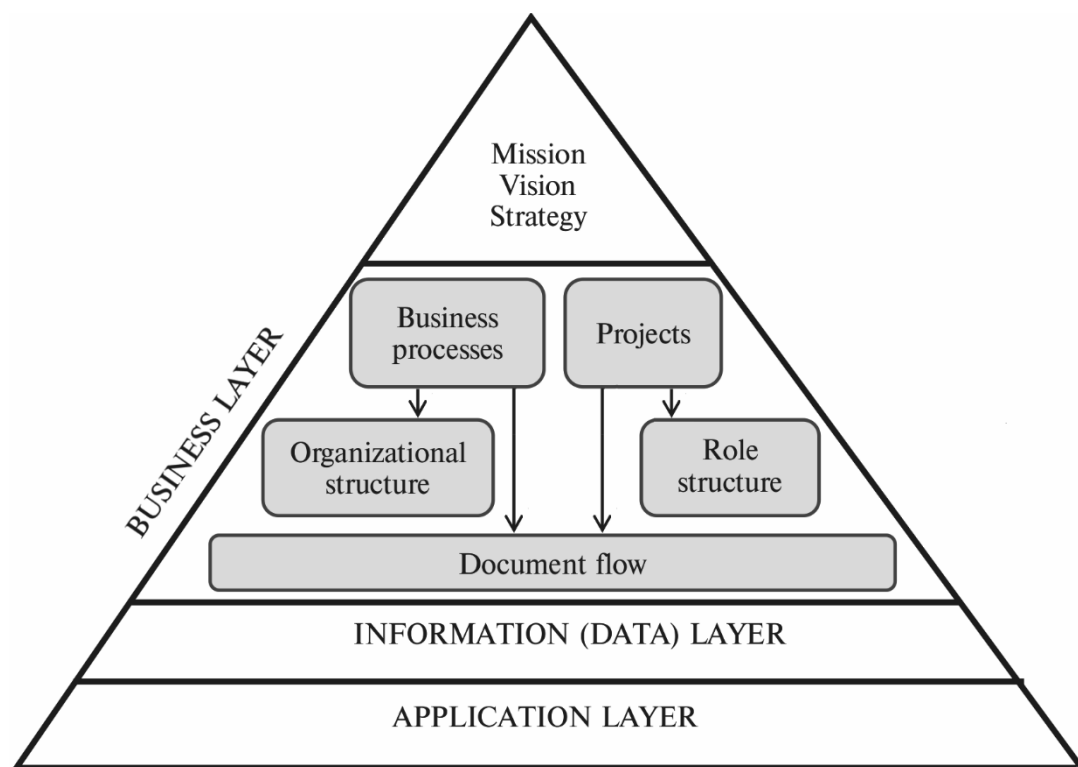
- an integration between project management processes and processes of the whole company management;

- an effective mechanism to balance the interests of the operating and innovation activities of the enterprise, i. e. coordination of the interests of process and project management approaches based on consistent strategic guidelines.

The model of enterprise architecture enriched with the project management approach within a business layer is presented in Fig. 1. Structural elements of the enterprise architecture are connected and determine each other. The way the company performs in a business environment depends on its strategic goals and objectives. Some objectives are achieved by means of processes, others via projects. The system of company's business processes defines the organizational structure of the company, while project activity requires a temporary role structure. Potential conflicts concerning scarce resources distribution between these two types of activities can be resolved depending on how important a certain process or project is for achieving the strategic goals of the company. Such an interpretation of the business architecture allows differentiating process-based activities for running business as usual from project-based activities for facing unique business challenges. At the same time such a model sets processes and projects as key elements of the business architecture. Application of the enterprise model as a coherent whole of business and IT elements (see Fig. 1) is demonstrated, for example, in [11].

#### **Maturity models of business process management**

There are a number of definitions of maturity and approaches to its estimating. The latter is beyond the scope of the current research. According to [12] «maturity levels characterize the overall state of an organization's processes» or according to [13] «a maturity level is a defined evolutionary plateau for organizational process improvement». Thus, the maturity concept always appears while talking about development of business: maturity is used to define the current state of a company or its elements and/or to evaluate the ways of a company's development. Before proceeding with enterprise architecture development it is necessary to find out the ways to define maturity levels of its components.



**Fig. 1.** Business processes and projects as components of the enterprise's architecture business layer

The majority of models of business process management maturity are based on the Capability Maturity Model (CMM) and its successor Capability Maturity Model Integration (CMMI) developed by the Software Engineering Institute at Carnegie Mellon University. CMMI introduced the concept of five maturity levels defined by cumulative requirements. A certain number of models have been developed by CMMI: Gartner's Process Maturity Model by [14], BPMM by [15], The Babson/Queensland University's Holistic BPM Maturity Model by [16], PEMM by [17].

According to [18] maturity levels are used to characterize organizational improvement relative to a set of process areas, and capability levels characterize organizational improvement relative to an individual process area (Fig. 2). As CMMI is a basement for a number of other well-known process maturity models, it has been chosen for further analysis.

Maturity Levels of CMMI Model are defined as follows:

- **Maturity Level 1: Initial.** At maturity level 1, processes are usually ad hoc and chaotic. The organization usually does not provide a stable

environment to support processes. Success in these organizations depends on the competence and heroics of the people in the organization and not on the use of tested and proven processes.

- **Maturity Level 2: Managed.** At maturity level 2, projects have ensured that processes are planned and executed in accordance with a policy; projects employ skilled people who have adequate resources to produce controlled outputs; involve relevant stakeholders; are monitored, controlled, and reviewed; and are evaluated for adherence to their process descriptions.

- **Maturity Level 3: Defined.** At maturity level 3, processes are well characterized and understood, and are described in standards, procedures, tools, and methods.

- **Maturity Level 4: Quantitatively Managed.** At maturity level 4, the organization and projects establish quantitative objectives for quality and process performance and use them as criteria in managing projects. Quantitative objectives are based on the needs of the customer, end users, organization, and process implementers. Quality and process performance is understood in statistical terms and is managed throughout the life of projects.



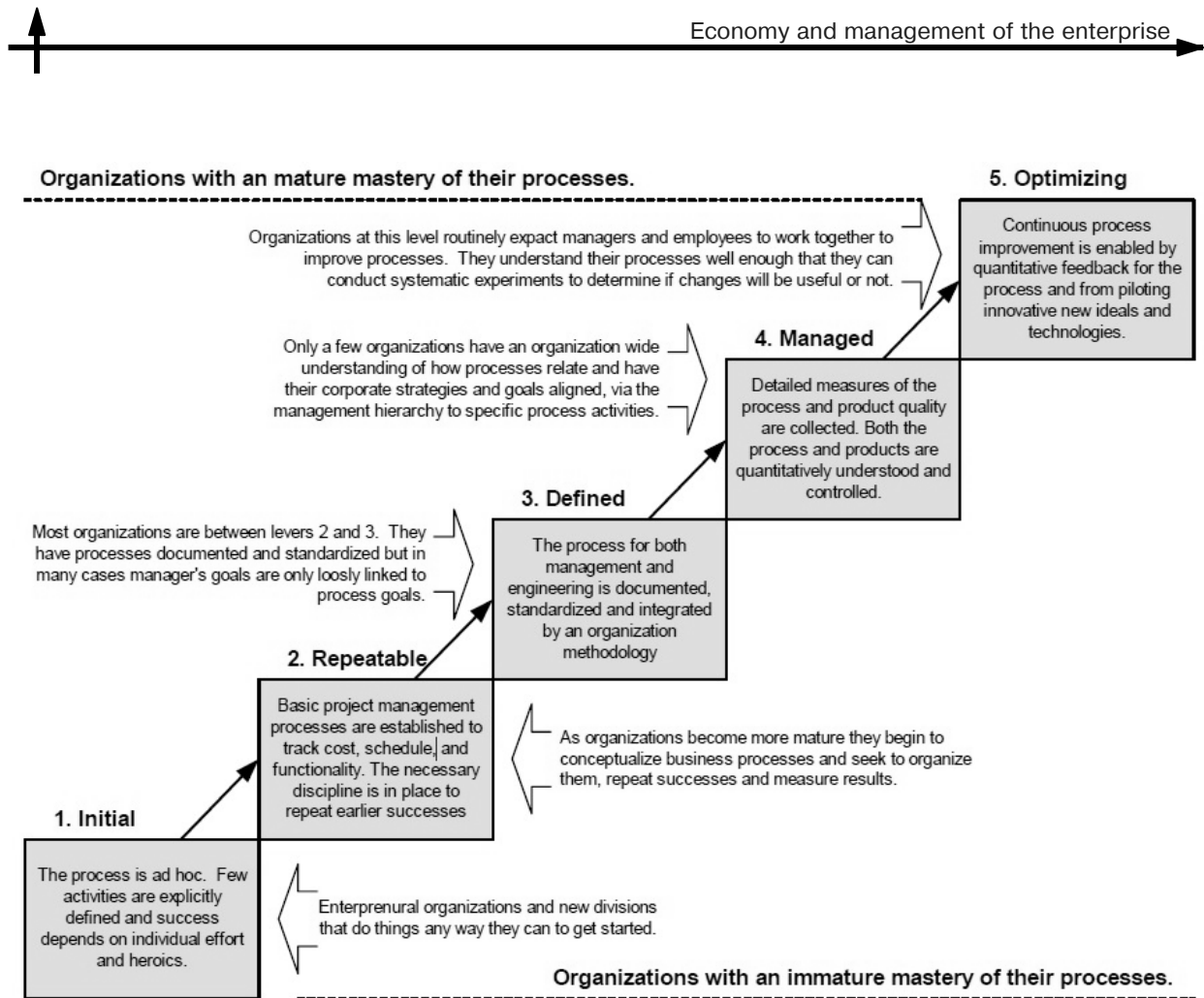


Fig. 2. Five Maturity Levels of CMMI Model [19]

- **Maturity Level 5: Optimizing.** At maturity level 5, an organization continually improves its processes based on a quantitative understanding of its business objectives and performance needs. The organization uses a quantitative approach to understand a variation inherent in the process and the causes of process outcomes. Maturity level 5 focuses on continually improving process performance through incremental and innovative process and technological improvements.

#### Maturity model of project management

In terms of project management there are a number of maturity estimating approaches: P3M3 and PjM3 by AXELOS, OPM3 by Project Management Institute, PMMM or PMS-PMMM by PM Solutions and others. One of the most well-known project maturity models is P3M3 (which stands for Portfolio, Program and Project Management Maturity Model) and its

version for project management PjM3 originally developed by Office of Government Commerce, UK. According to [20], P3M3 uses a five-level maturity framework and the five Maturity Levels are: Level 1 – awareness of process, Level 2 – repeatable process, Level 3 – defined process, Level 4 – managed process, Level 5 – optimized process. This maturity model allows for independent assessment in any of the specific disciplines – portfolio management, program management or project management – so it can be treated as 3 different models. The maturity of each discipline must be assessed according to 7 process perspectives: Management Control, Benefits Management, Financial Management, Stakeholder Engagement, Risk Management, Organizational Governance, and Resource Management. Most organizations have strengths in some areas but not in others. P3M3 is designed to acknowledge these strengths as well as highlight weaknesses. [21]

For project maturity assessment the levels of the P3M3 have the following meaning:

- Level 1 – awareness of the process: Does the organization recognize projects and run them differently from its ongoing business? (Projects may be run informally without any standard process or tracking system.)
- Level 2 – repeatable process: Does the organization ensure that each project is run with its own processes and procedures to a minimum specified standard? (There may be limited consistency or coordination between projects.)
- Level 3 – defined process: Does the organization have its own centrally controlled project processes and can individual projects flex within these processes to suit a particular project?
- Level 4 – managed process: Does the organization obtain and retain specific measurements on its project management performance and run a quality management organization to better predict future performance?
- Level 5 – optimized process: Does the organization undertake continuous process improvement with proactive problem and technology management for projects in order to improve its ability to depict performance over time and optimize processes?

It is easy to notice that:

- project management maturity depends significantly on the quality of process management,
- project maturity levels are high-correlated with CMMI levels.

It seems reasonable to take CMMI as a maturity model for both process and project management for further analysis of their joint behavior.

### **Business architecture maturity and its development**

According to the model proposed in [22] projects together with processes form the backbone of the business architecture. They define the organizational structure, role structure and document flow of the enterprise. Thus, the maturity level of the business architecture depends largely on the maturity of its key components.

In such a situation there cannot and should not be a significant gap between levels of development of these two components. Process and project maturity model analysis allows creating a 2-dimensional matrix of process and

project maturity that helps to define the maturity of the whole business architecture (Fig. 3). Thus, process and project management are important components of the enterprise management system, the relationship between maturities of these components is a key factor of the business architecture development. They can be considered as indicators that determine the business architecture maturity level, i. e. the combination of their levels is a diagnostic tool that shows:

1) whether the business architecture is optimally balanced, acceptably balanced or not balanced enough;

2) which is the maturity level of the business architecture;

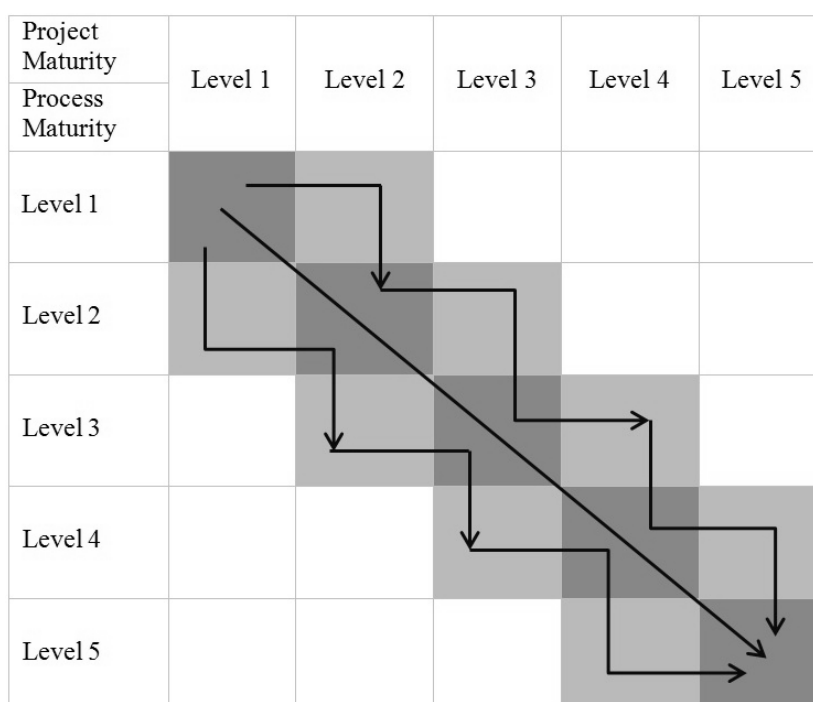
3) which is the next step of business architecture development (accumulating the level of the weaker component of the combination).

The business architecture can be considered as optimally balanced if processes and projects are managed at the same level (dark-grey cells on Fig. 3). It should be mentioned that optimally balanced architecture does not mean the highest maturity level, but the reasonable one for a particular company in the particular environment. Architecture balanced in a definite way at level 1 is different from that of level 5, but both situations mean that two core management approaches (process management and project management) are at the same level and can support each other's performance.

The business architecture can be called acceptably balanced in case of one-level difference between process and project management maturity levels (light-grey cells in Fig. 3). In such a case for further business architecture development it is reasonable to accumulate the capacity of the weaker component (in order to get into the dark-grey zone on Fig. 3).

The path of sustainable development of business architecture is depicted with arrows in Fig. 3. The development can follow any of the arrows shown in Fig. 3 or any can be composed of different pieces of these arrows. The important note is that the development path lies within the grey area of the matrix.

The difference of more than one level between process and project dimensions of the matrix means that an enterprise has an unbalanced business architecture maturity model which prevents it from further development. If an



**Fig. 3.** Process and Project Management Maturity Matrix

enterprise has a higher process maturity level and wants to keep on with process management implementation it will need to establish a process reengineering project. In its turn, it will require project management skills of a certain level in order to deliver a necessary result. Thus, the right way would be to raise the project capacity first which would provide more effective moving towards a new process maturity level. The reverse situation is a combination of higher project and lower process maturity levels. Project management is based on a certain system of processes and the more sophisticated the project approach adopted in the enterprise is, the more serious requirements for process management are.

Some combinations of maturity levels with a wide gap between them are not only undesirable but not even possible. For example, a company in reality cannot have level 1 of the process maturity and level 5 of the project maturity at the same time because it is impossible to reach such a high project management maturity without good enough process performance.

The analysis of each combination of the process and project maturity level within a business architecture is a subject of different research.

*Results and Discussions.* The competitiveness of a company depends on the maturity of its management system which is represented by the model of the enterprise architecture. A business architecture layer is a foundation that defines business performance of a company. Thus its maturity largely determines success and competitiveness of the business.

The paper focuses on understanding the role of maturity of business architecture core components – business process management and project management – and their contribution into the maturity level of business architecture. Analysis of correlation between maturity levels of business processes and projects delivered the following conclusions concerning enterprise architecture maturity:

- processes and projects are core components of the business architecture layer within the enterprise architecture;
- the maturity of the business architecture is defined by the joint maturity of its components, i. e. business architecture maturity management is represented via managing of process and project joint maturity;
- the combination of maturity levels of process and project management shows whether the business architecture is balanced or not: there

should not be a significant gap (more than one-level gap) between maturity levels of process and project management in order to provide the balanced business architecture;

– the relationship between business process management and project management maturity levels defines the path of sustainable development of the business architecture.

These items mentioned above are the elements of academic novelty of the research and are parts of the original methodology for analyzing enterprise architecture. The further steps of developing the methodology could be analysis of other architecture layers' maturity and defining the ways of complex enterprise architecture development.

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## SUCCESS FACTORS IN IMPLEMENTING MOBILE TECHNOLOGIES IN RUSSIAN ENTERPRISES

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## ФАКТОРЫ УСПЕХА ВНЕДРЕНИЯ МОБИЛЬНЫХ ТЕХНОЛОГИЙ НА РОССИЙСКИХ ПРЕДПРИЯТИЯХ

This work discusses the challenges of the mobilization process at enterprises in Russian industries. Mobile devices are characterized as necessary tools to perform any business action in the competitive market environment. In this context, mobile employees usually want to get access to data from any mobile devices, including their private ones. Because of high responsibility for a corporate IT department in terms of security and network scalability, an open access of users to all their applications and databases should be managed in a special order. This work outlines steps that need to be done to ensure success in implementing corporate mobility to improve efficiency of business processes and to reduce costs based on the conventionality of Russian enterprises.

MOBILE TECHNOLOGIES; CONSUMERIZATION OF IT; MDM; BYOD MODEL; COPE MODEL; CONCEPT OF ENTERPRISE MOBILITY; EMM; INFORMATION SECURITY MEASURES.

Рассматриваются проблемы осуществления мобилизации предприятий в условиях отраслей российской экономики. Мобильные устройства становятся необходимыми инструментами осуществления операционной деятельности предприятия в конкурентной рыночной среде. Мобильным сотрудникам необходим доступ к данным и приложениям с любых мобильных устройств, в том числе находящихся в их личном пользовании. Вследствие высокой ответственности подразделений ИТ за обеспечение безопасности и масштабируемости сетевой инфраструктуры проблема открытого доступа мобильных пользователей к корпоративным приложениям и базам данных должна решаться специальным образом. Описывается последовательность шагов, которые должны быть осуществлены для достижения успеха в реализации концепции корпоративной мобильности с учетом опыта российских предприятий.

МОБИЛЬНЫЕ ТЕХНОЛОГИИ; КОНСЬЮМЕРИЗАЦИЯ ИТ; РЕШЕНИЯ MDM; МОДЕЛЬ BYOD; COPE; КОНЦЕПЦИЯ КОРПОРАТИВНОЙ МОБИЛЬНОСТИ ПРЕДПРИЯТИЯ; EMM; СРЕДСТВА ИНФОРМАЦИОННОЙ БЕЗОПАСНОСТИ.

**Introduction. The challenges of developing corporate mobility at enterprises. Definition of needs in mobility.** The implementation of mobile solutions and the application of information technology belong to the major challenges of IT departments of Russian enterprises due to their demands for scalability, security, and visibility of applications.

To provide mobility is a priority task for today's organizations. Nowadays employees want to get access to data from any mobile devices, including their private ones. Moreover, now applications, needed for a job, are not limited to a mobile e-mail client. Applications for Windows and mobile operating systems, web-applications, which can be located both in the «cloud» and in

the data processing center are increasingly required. For IT-departments, open access of users to all their applications and data is a serious problem in terms of security and network scalability. Depending on the mobility concept, enterprises may apply systems for mobile device management (MDM) or enterprise mobile management (EMM) to ensure secure access in data and applications. However, these systems are not enough to guarantee the delivery of applications to users regardless of their location. The efficient use of these systems require a network infrastructure providing a secure delivery of applications to different kinds of mobile end devices. Simultaneously, challenges



and open issues in respect of the productivity, manageability and further spread-out need to be settled.

The high number of various mobile devices used in enterprises calls for a scalable infrastructure that may be supported by the corporate network. Thus, IT departments are required to set up an infrastructure for mobile applications capable to handle on the one hand queries that need broadband access and the large number of users with various kinds of mobile end devices. One of the major tasks is to satisfy the mentioned demands for scalability and productivity without the need of purchasing new equipment all the time. At the same time IT departments are required to guarantee absence of confidential documents and to ensure that they operate in accordance with the requirements set by regulating authorities to the industry and information security such as PCI-DSS and HIPAA requirements (a proprietary information security standard when handling plastic cards and transferring data about people's health insurance).

To summarize, the major challenges related to corporate mobility concept implementation are:

- security of devices, applications and data;
- scalability that allows managing a growing number of devices, applications and data;
- simplification of the network infrastructure due to its consolidation;
- visibility of users, devices and applications that helps to plan activities and eliminate problems; and
- configuration and deployment management.

**Enterprise Demands for Mobility.** Conservative pragmatism is a common strategy for corporate IT departments. The principle «never touch a running system» seems quite logical to them. However, this strategy is not advisable when an enterprise goes mobile. The number of queries from users reaches a certain critical point. That is a very common scenario for mobile devices. Initially the use of mobile technology in a corporate environment was limited in the executives of companies only. Subsequently the mobile by the employees started to use mobile technology. This process cannot be ignored. Together with other similar trends it is now called consumerization of IT (CoIT).

New devices are increasingly used as real mobile workstations. This is caused by two essential factors [1]:

**1. Capabilities and maturity of technology.** In terms of their capabilities in document processing, mobile devices such as tablets cannot be compared to the capabilities of conventional laptops or PCs. However, in most cases the functionality and ergonomics of tablets are enough for simple document processing if it does not imply any serious formatting tasks. Shortly, the major advantage of mobile devices is a chance to look through documents quickly and then make decisions.

**2. Need to work remotely.** To work remotely has a long tradition in business. However, for quite a while capabilities of technology could not satisfy this need. A survey of more than 150 managers of IT, IS and business departments, which has been conducted by the «Centre of Corporate Mobility of the Company «IT», has revealed that the use of smart phones and tablets is a sequence of real needs of those who work in businesses. Mobile technologies help to improve communication among and with remote workers (81 %). Moreover, new capacities of mobile technology may enhance current business processes (61 %) and trigger the development of new ones (50 %). The deferred demand for mobility that appeared due to the failure of the previous technology (PDA) is now streaming in the market.

These factors, which improve field work with information and, as a result, increase and improve the operative decision-making, have enabled the extensive use of mobile devices in the corporate environment. Consequently, tablet PCs pretend to become an widely accepted device in the briefcase of a business person replacing folders with paper documents and at the same time providing facilities for any time and any place business communication and enabling the access to up-to-date information. If they will they take this place (and to what extent) is too early to say, but the current situation cannot be ignored any longer by IT directors.

The Rational IT-management assets of a modern enterprise is one of the prerequisites for professional growth of its workers (which

positively influences development of enterprise knowledge database) and it results in lower operating costs for communication. Introduction of mobile technology into business processes of an enterprise becomes an important factor for its efficiency growth whereas search for rational technological solutions to mobilize the enterprise is a headache of its IT department. In order to take a reasoned decision it is necessary to develop a *concept of corporate mobility* strategy, which ensures the compliance with the company's security requirements in respect of data transfer and applications and ensures the successful integration of mobile devices into the existing IT environment of the enterprise.

The key advantage of mobile devices for enterprises is the higher labor productivity because of the shorter time for feedback quicker decision-making, and problem-solving. As corporate mobility is progressing, employees use more and more their personal smart phones for work and companies will be ready to stimulate the use of personal mobile devices.

The extension of user's experience related to different kinds of smart phones and tablets results not only in limited consumption of information, but also active «dialogue» reaction on the part of the users of mobile devices, which implies interaction with information resources and applicable systems. These mobile devices have actually consolidated into a new class of workstations – mobile ones.

Today entrepreneurs are ready to introduce mobile technology in order to offer new services for their employees and clients. However, uncontrolled process of developing corporate mobility entails a lot of hidden rocks and there are still no general routs or ways to avoid them.

According to the agency «Harris Interactive and Bank of the West»[2], the utmost barrier for the wider use of mobile technology in the small business is the lack of experience (33 % of respondents) and high costs (25 % of responds).. In the corporate segment, the picture is slightly different. The security issues are named as the most important factor. Big companies operate commonly with large amounts of information that need to be protected in accordance with the legally established procedures and the data that cannot end up in the hands of competitors. That

is why they need effective protection of mobile devices from different risks.

**MDM and BYOD Concepts While Introducing Corporate Mobility.** According to [3] most modern mobile device management systems (MDM) for enterprises have a complicated structure. it is necessary to attract considerable human and finance resources to introduce them. (Because of their complicated structure the introduction of modern mobile device management systems require remarkable human and financial resources.)According to IT specialists, decisions need to be made in line with the tasks the system has to perform according to the list of maintained equipment and according to the cost of ownership.

Implementation of a full scale MDM system at this stage of development of Russian corporate IT infrastructures is rather difficult and companies are waiting for suitable solutions. So-called «box» products in the field of mobile device management have to provide opportunities for companies to network mobile devices of employees – both corporate and personal ones – in an easy and secure way.

For instance, such an approach has been used in the company «Surgutneftegas». At the expense of the solution Microsoft System Center Mobile Device Manager 2008, the users have an access to the corporate infrastructure and can safely store information in a mobile device whereas IT administrators have a centralized mobile device management system with uniform safety policy, ability for remote initialization, switching off, locking out connections and even removal of data from a device e.g. if the device has been lost.

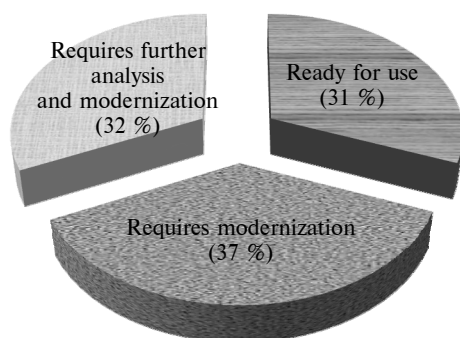
Mobile platforms are attractive for Russian credit organizations, too. In particular, a full scale mobile infrastructure has been introduced on the basis of the platform Symantec Mobile Management in Vneshekonombank of the Russian Federation. The strategy of the bank development for the next few years implies a considerable increase in the number of devices and provision of access from a mobile device to a large selection of bank services.

One of the urgent issues for many Russian companies is the use of mobile devices that are



brought by employees. It is referred to the BYOD concept (bring your own device). Employee's personal smart phones and tablets, of course, help companies to save money on purchase of equipment and at the same time ensure delicate handling of a device, since it is employees themselves who have paid to buy it. Nevertheless, BYOD creates serious problems in terms of infrastructure and safety management, which makes this concept unattractive for many companies.

According to the survey conducted by Russian company-system integrator «IT» in October 2013 [4], among Russian companies interested in mobility, 60 % of companies do not regulate in any way mobile access to corporate resources even though 56 % support BYOD. One third of organizations have not analyzed their structure yet to see if they are ready to introduce mobile technology. The half of companies that have had an audit realize that they need to modernize their IT infrastructure.



**Fig 1.** Readiness of Russian enterprises for mobilization.

Source: «IT» 2013

Basic communication resources are the most popular among mobile users. About 95 % of respondents plan to provide mobile access to corporate e-mail and 90 % of respondents plan to allow a mobile access to corporate file resources, such as shared Windows folders and Share Point document libraries, seen at same.

The next most common group of services includes decision-making tools. Introduction of mobile solutions to reflect the key business indicators is discussed in 58 % of companies whereas 18 % have already introduced such

solutions. One more category of services that is interesting in terms of mobilization comprises of advanced communication means such as IP telephony, instant messages and videoconferencing. The share of companies using such solutions is 13–16 percentage and by the end of 2014 it is expected to grow up to 30-40 percentage.

**Corporate Mobilization Models.** As mentioned above, the use of employees private mobile devices despite advantages and simultaneously entails new threats in terms of corporate data security. There are several ways to meet this problem.

**1. Prohibition to work by BYOD-model.** It is worth noting that to ban the use of private mobile devices does not mean turning down mobility. In this case the company provides the employees with protected corporate-owned mobile devices (COPE –corporate-owned personal equipment). Standardization of devices decreases maintenance costs and costs for support of employees who spend more than 20 % of their time away from their fixed workstations. This approach is spread in Japan, but it is not popular in Russia.

**2. Free use of any devices and applications,** with the IT department helping users to install the necessary applications. This approach is more common for companies belonging to the small and medium-sized business segments and for developing markets (China, India and others). In this case money is saved by the company as there is no need to buy mobile devices or licensed software or to develop mobile applications, but the security issues are affected. Additionally, compatibility problems between different platforms and applications may occur.

**3. Trade-off alternative:** the IT department of the company permits employees to use their private devices, but regulates which services can be used, develops mobile versions of specialized corporate systems, introduces means of remote management and protection of mobile devices owned by employees on the basis of the MDM concept.

This last alternative seems to be the most promising as it gives freedom of choice to the

workers and provides safety of the corporate information. However, in practice this way may prove to be more expensive than corporate purchase of devices. For BYOD it is typical to have a variety of both hardware platforms and software versions with different vulnerability characteristics. In a number of cases a lot of device protection schemes have to be developed according to the uniform procedures that are applied to corporate devices.

Purchase of mobile devices is widely used in Russia not only for the money-saving reasons, but due to the lack of well-established channels of work with suppliers of smart phones. It is because of difficulties in making contracts with producers of mobile devices and in maintaining this pool of device. Direct delivery of devices

from manufacturers is not common, which entails additional risks. Sometimes, there are exceptions for top-managers, who are supposed to have such a range of equipment owing to their status, and for employees who always travel or who need to be available 24 hours a day. Moreover, the package of paid devices does not include smart phones but tablets.

Policy of Russian companies in terms of mobile communication payment is more flexible. Many companies are ready to compensate communication expenses to a reasonable extent if their employees have to talk a lot over the mobile phone or use mobile Internet for work reasons. But with spreading mobile technologies there is a trend to turn down this practice.

Table 1

Statistics of Russian companies implementing corporate mobility strategy [5]

Company	Mobile services	Developer	BYOD or COPE	Number of users
Deutsche Bank, RF	n/d	n/d	BYOD	up to 30 000 users
Ford Sollers	Good Collaboration Suite (corporate e-mail, calendar, tasks, etc.), WebEx (videoconferences), corporate social network Yammer	Ready to use services	BYOD	n/d
Alfa-Capital	Corporate e-mail	In-house development	BYOD	n/d
Baltika	Corporate e-mail, CRM, file interchange GlobalSCAPE	Customized development	COPE (Galaxy S3 Mini Samsung on Android)	6000
Evrasia (drilling company)	«Mobile approval» on the basis of SAP Mobile Platform	Solution of the company «Innoway»	BYOD	n/d
SB Bank	Corporate e-mail, mobile application for service subdivisions (interacts with ABS and uses geolocation functions while in service. When workers maintain an ATM or a terminal, the application sends information to the bank about location, condition of the device, productivity of workers, which helps reflect the data in due time on the interactive map for clients of the bank and control its personnel)	In-house development	n/d	n/d
Finam	Corporate e-mail, SoftPhone (mobile device can be used as an office phone with corporate extension)	In-house development	n/d	n/d

Source: CNews Analytics, 2014.



### **Success Factors in Implementing Mobile Technology in Russian Enterprises**

1. Presence of clear and documented strategy of corporate mobility at the enterprise, which implies not only expansion of applied functionality of workstations but mainly improvement and development of business processes.

Quality extension of user experience in terms of a bigger range of available form-factors of mobile devices has created opportunities not only for selective consumption of information, but also active «dialogue» reaction on the part of mobile device users. This implies broad interaction with information resources and applied systems. As a result, mobile devices have actually turned into a new class of workstations – mobile workstation.

2. System approach to define limits of corporate mobilization coverage of workers at different levels of management of the enterprise, depending on importance of functions they perform and economic efficiency.

It implies:

1) Defining the number of mobile workers and providing them with corporate mobile devices or using their own gadgets to implement work processes at different levels of enterprise management;

2) Providing access for the mentioned workers to corporate resources and applications from mobile devices

3. Presence of actualized corporate standards at the enterprise for provided and supported by IT specialist mobile devices and mobile platforms («BYOD list»)

Standardization of mobile operating systems and mobile devices is one of the major tasks that have to be embraced in the concept and strategy of enterprise corporate mobility. This helps handle with the most common reason of its non-use, namely, diversity of mobile devices and platforms in the market. The concept of corporate mobility, its politics and regulations of use coordinate requirements of the information safety services and readiness of end-users and businesses to apply their own mobile devices more widely for the work purposes.

4. *Provision of information safety service of the enterprise with technological means to manage mobile devices and provide their secure measures*

Implementation of facilities to manage mobile devices into the IT infrastructure of the

company – the so-called Enterprise Mobility Management – EMM – is the most essential factor to provide legitimacy and transparency of control over mobile access to corporate information resources and systems in terms of information politics and regulations that are in force in the enterprise.

**Prospects of Corporate obility Implementation in Russian enterprises.** Even though there are obvious problems, corporate mobility is to develop. It is guaranteed by widely spread mobile technology at the consumer's level, its easiness for use and capability to increase efficiency of business. Among drivers of BYOD introduction that are common for Russian business, one can mention the geographic factor, because there are quite a lot of companies in the economy that operate in the immense territory. For such business it is important to create and maintain the effective communication environment that will help react to external and internal changes in due time.

Another factor in favor of mobility is the young and middle generation (from 16 to 35 years) who tend to use devices not only in their common lives, but also at work. Constant integration of life with social networks gives a certain momentum to develop BYOD concepts, since social networks have become not only an entertaining system, but also a good business tool, which gives rise to progress.

In the opinion of a number of analysts of the Russian IT market, there are three groups of industries that can get maximum advantages because of mobilization. First, these are industries with area-spread infrastructure and field visits: repairs, object check-ups, etc. For instance, this is railway transport and electric power industry. Second, these are all fields of activities where there is need for informing in a quick way about change of the situation or new orders. For example, courier and transport services, taxis, medical aid teams. Third, these are such industries that traditionally invest in IT, i. e. retailing, with mobile technology applied on shop floors, warehouses when accepting and inventorying goods and those who do this for customer attraction and retention.

Experts of the company «IT» believe that in Russia in all enterprises that have IT services in the corporate environment, the level of corporate mobility is comparatively high. The leaders are finance sector (including insurance), production, retailing, and energy industry [4].

At the same time it is necessary to provide means for safe access to data and devices. Many cautious executive, when thinking of developing corporate mobility, remember about cases of loss of electronic media. Development of mobility is retarded mainly because of the fear to lose data important for the company, risk of sensitive information seepage. In addition, provision of safe mobile work of executives and employees in Russian companies is at a low level for the present.

Russian companies gradually increase their accounts of the number of workers who need mobilization of their activities, as it has demonstrated in surveys and research done by the Centre of Corporate Mobility «IT» [6]. However, the share of companies that already use the relevant technological solutions is still low.

An average cycle for decisions to implement corporate mobility management systems takes from half a year to a year. Today executives are conscious about it because of their own

experience and set high priorities to mobilization projects for IT and IS departments. In combination with a large number of projects that are at the stage of implementation and piloting, one can say that there is an active growth in this field of business automation, which improves its labor productivity indices through increased personal productivity of employees and executives. Because of it, the distribution of corporate mobility is just a matter of time and efficiency of promotion of its advantages.

**Conclusion.** The successful introduction of mobile technologies in business is a challenging task. This paper analyzes challenges Russian enterprises face when mobilizing their business. The challenges are predominantly technical or organizational reasoned by user needs to get access to corporate data anywhere and anytime. The BYOD tendencies among users cause increasingly additional problems for company IT departments. Thus, a clear company policy and guidelines for mobilization are needed.

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**CHARACTERISTICS OF THE FORMATION  
OF WORKING CAPITAL MANAGEMENT POLICY  
PROVIDING PRODUCTION AND SALES PROCESS**

**М. Сюэ, З.А. Дикая**

**ОСОБЕННОСТИ И ИНСТРУМЕНТЫ УПРАВЛЕНИЯ  
ОБОРОТНЫМ КАПИТАЛОМ,  
ОБЕСПЕЧИВАЮЩИМ ПРОИЗВОДСТВЕННО-СБЫТОВОЙ ПРОЦЕСС**

Nowadays, the development of the domestic industry is the main task of an economic strategy of the country. The development of processing industries that include the enterprises of timber processing complex has to become the key issue. The improvement of the management of the working capital that serves the production and marketing process of the industrial enterprise is one of the essential problems of the modern production management. The article focuses on the peculiarities of the implementation of the production and marketing activities causing the necessity to develop a new mechanism of the performance management of limited reverse resources to receive the highest economic results from all financial and economic activities. The existing approaches to the development of the management policy are outlined. However, each individual enterprise has to form an individual technique (tools and methods) in the developing situation. The authors show that the previous methods of the working capital management of manufacturing enterprises (rationing) in a modern unstable and unpredictable economy do not work successfully. It is noted that the existing methods, used by western companies and economists, cannot be effectively implemented in the current business environment. Therefore, under present circumstances it is necessary to provide the enterprises with some operational adaptation ways of the regulation of ensuring production and marketing process with current assets. It is essential for each enterprise to develop the working capital management policy individually. Only its own resources and interests should guide it. The authors draw a conclusion that the duration of the turnover used for the working capital and the established profitability at every stage and in general for PSP should act as the performance criteria of an adopted policy of the working capital management.

AN ENTERPRISE; WORKING CAPITAL; WORKING CAPITAL MANAGEMENT; PRODUCTION AND SALES PROCESS; MANAGING THE PRODUCTION AND SALES PROCESS MANAGEMENT TOOLS.

Развитие отечественной промышленности — главная задача экономической стратегии страны. Наиболее важным первоочередным направлением должно стать развитие перерабатывающих отраслей промышленности, к которым относятся и предприятия лесопромышленного комплекса. Совершенствование управления оборотным капиталом, обсуживающим производственно-сбытовой процесс промышленного предприятия — одна из актуальных проблем современного производственного менеджмента. Делается акцент на особенности осуществления производственно-сбытовой деятельности, вызывающие необходимость выработки нового механизма управления эффективностью ограниченных оборотных ресурсов с целью получения наиболее высоких экономических результатов от всей финансово-хозяйственной деятельности. Существующие подходы к выработке политики управления приводятся как возможная отправная линия, однако каждое конкретное предприятие на этой базе должно формировать индивидуальную методику (инструменты и методы их применения) в складывающейся ситуации. Показано, что прежние методы управления оборотным капиталом производственных предприятий (нормирование) в современных условиях неустойчивости и непредсказуемости экономических процессов себя не оправдывают. Отмечено, что существующие методы, широко используемые западными экономистами и практиками в условиях российского предпринимательства, также не могут быть эффективно использованы. Поэтому в сложившихся реальных обстоятельствах предприятиям необходимы оперативные адаптационные способы регулирования обеспечения оборотными средствами производственно-сбытового процесса. Каждому предприятию необходимо индивидуально подходить к формированию инструментов управления оборотным капиталом, ориентируясь исключительно на собственные ресурсы и интересы. Сделан вывод, что критериями эффективности инструментов управления оборотным капиталом целесообразно выбирать длительность оборачиваемости используемых оборотных средств и задаваемую рентабельность на каждой стадии и в целом для ПСП.

ПРЕДПРИЯТИЕ; ОБОРОТНЫЙ КАПИТАЛ; УПРАВЛЕНИЕ ОБОРОТНЫМИ СРЕДСТВАМИ; ПРОИЗВОДСТВЕННО-СБЫТОВОЙ ПРОЦЕСС; УПРАВЛЕНИЕ ПРОИЗВОДСТВЕННО-СБЫТОВЫМ ПРОЦЕССОМ; ИНСТРУМЕНТЫ УПРАВЛЕНИЯ.



Industry development is based on the economic development of the country. The most important task is to develop processing industries that include the enterprises of forest sector.

The economic mechanism of the management efficiency of production and business operations has undergone numerous transformations in accordance with the new paradigm of management for twenty years of free entrepreneurship. Yet, there are still problems that need constant development. They include the improvement of the current asset management that ensure the implementation and the efficiency of the production and sales process or its operating activities. Whereas, an operating activity is the main source of profit for any enterprise.

The term «working capital» refers to the mobile assets of the enterprise. There is a constant transformation of separate components during the production activities. At first, enterprises purchase raw materials and supplies. Then, the first unfinished goods appear during the production process. After that, the finished products are produced. Then, as a rule, they are sold on credit. As a result, they form receivables that after while become money. This ensures a comprehensive continuous production and sales process (PSP) that considerably determines the efficiency of all activities. Figure shows this cycle.

Current assets can be characterized from different perspectives. However, their main properties are liquidity, volume and structure. Each of these properties requires a special consideration and makes working capital complex as an economic category and an important element in the business management system.

In terms of a command-administrative system, rationing of the most important elements was the main method of the current asset management. It means that rationing determines the standard inventory to provide an uninterrupted

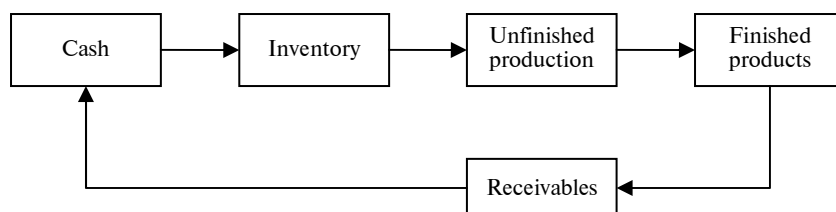
production process at their optimal size in terms of current costs. Nevertheless, even with a relatively stable and predictable economic situation, a lot of enterprises, as a rule, suffer from the lack of current assets and difficulties with its replenishment.

Volatile market conditions, unstable pricing and financial institution instability characterize the current situation. Thus, it puts forward new requirements for the current asset management. The problems of the current asset management typical for a command-administrative system not only exist in the market system but also have significantly complicated.

We have investigated the results of exiting methods of the current asset management in furniture production enterprises of Saint Petersburg and Leningrad Oblast. The presented technical and economic indicators show the absence of any system dependencies between all indicators and current assets (Tab. 1). It demonstrates the absence of any management policy aimed at current assets. Free entrepreneurship allows companies not to use previous instructions and guidance but it does not provide them with new tools and methods. As a result, a lot of enterprises face problems in their activities mainly due to the lack of current assets.

A lot of economists are concerned with the development of effective methods of the capital management in PSP. Some modern methods of management are used throughout the world. For example, the model of Baumol and the model of Miller-Orr are use for inventory management. They allow optimizing the sum of current assets. Using these models makes it possible to determine:

- the total sum of cash and cash equivalents;
- the amount of money reserved on the current account;
- when and what amount it is necessary to make transformation from cash to highly liquid securities.



Cycle of current assets in PSP

Table 1

Technical and economic indicators of furniture production enterprises in 2013

	Enterprises		A	B	C	D	E	F
1.	Revenue	th.rub	748925	39601				
2.	The number of employees	people	517	40	38	85	303	71
3.	The total cost	th.rub	628904					
4.	The cost of 1 ruble revenues	rub.	0.84	0.8	0.89	0.98	0.9	0.87
5.	Net profit	th.rub.	82807	5355	11550	1444	21009	19901
6.	Fixed assets	th.rub	86000	44557	15448	8449	33013	17605
7.	Current assets, total	th.rub	1145769.5	17619	13300	27264	117082	29553
8.	Including inventories	th.rub	229153	9018	4217	16915	69112	21015
9.	Receivables	th.rub	667461.4	7596	7911	8703	35404	7902
10.	Current assets turnover ratio		0.9	2.25	10.6	3.1	4.45	7.14
11.	The duration of one turnover	days	40.5	160	34	116	80.9	50.4
12.	The profitability of fixed assets	%	96	5.9	20	16	63.6	113
13.	The profitability of current assets	%	7.2	30.4	86	5.3	17.9	67.3
14.	The duration of PSP Stages:	days						
	I		25	17	10	7	15	18
	II		29	19	7	16	16	13
	III		351	124	17	93	49.9	19.4
15.	The profitability of sales	%	19	77.9	11.9	1.9	11.3	15.2

However, in Russia using these models is difficult due to a strong inflation, high interest rates and other factors of instability. Being the most regulatory organized the actual production process is the most manageable link in the chain.

The management of current assets in the sphere of sales is one of the biggest problems. The reasons are unsustainable and unreliable relations with customers, low financial solvency and payment discipline, etc. The duration of one turnover of current assets in days,  $T_{psp}$  (in days) is the main indicator defining the the effectiveness of the current asset management:

$$T_{psp} = T_{oz} + T_{prpr} + T_{deb},$$

$T_{psp}$  – the duration of production and sales process, days;  $T_{oz}$  – the duration of one turnover of inventories, days;  $T_{prpr}$  – the duration of one turnover of production process, days;  $T_{deb}$  – the duration of one turnover of receivables.

These calculations are based on data from financial statements that are related to PSP (from buying inventories until the date when the

money come to current account as a payment for finished goods).

The research shows that it is necessary to form a new policy for the current asset management that satisfies modern conditions. The main factors influencing on the the current asset management include the type of a company, the production development stage, working with contracts, information and competitiveness.

The most important feature of forest sector enterprises is a high material consumption for manufactured products. It shows that an effective management should include the optimization of the formation of inventories. The share of inventories in current assets amounts to 75–80 %. A high level of receivables is another factor to be taken into account.

Every enterprise during its development passes the following stages. They include an intensive development stage, a stable position in the market and the decline in sales. The volume and structure of currents assets depend on the current development stage of the company. The regulations





for current assets that are used in the period of a sustainable development cannot be used during its intensive development. For example, if a company is developing fast and trying to gain a foothold in the new market, current assets are quickly increasing. It is necessary for a company to give customers credits, to capture a market share and to have a big range of inventories to increase the speed of customer's service. In western companies about 80 % of bankruptcies occurs due to an ineffective current asset management in the intensive development of the company.

Inflation is one of the main factors that influence on the current asset management. For example, if a high growth in the prices for raw material is expected, it is possible to have overstated inventories. But only if an inflation level is higher than storage costs.

Seasonal fluctuations also influence on the current asset management. Wood-processing enterprises are subject to this factor, as forest

harvesting is seasonal. The inventories can be increased by 20–50 % due to this fact.

The ideologists of modern evolutionary Economics claim that nowadays it is not possible to develop the right policy for the current asset management. The data obtained from the six surveyed furniture enterprises confirm it (Tab. 1).

The policy of the current asset management should be established jointly by the heads of functional enterprise departments (the financial director, the planning director, the production director, the head of the sales department, etc.) and approved by the managing director. Taking into account the dynamism of the economy such work must be performed annually at the time of enterprise budget approval.

Nowadays, three approaches for the current asset management exist: conservative, hedging and aggressive. Tab. 2 shows the main approaches to the development of each type of the policy for the current asset management.

Table 2

Approaches for the current asset management

Approach	Implementation in practice	The ratio of risk and return
Inventories		
Conservative	The formation of the excessive volume of insurance premiums and reserves in case of interruption and the cases of emergency	Significant losses for inventory storage and the diversion of funds from circulation and as consequence, lower yields. The risk level connected with production stop is minimal
Hedging	The formation of reserves in case of typical failures	Average return. Average risk
Aggressive	The minimal level of inventories, just-in-time delivery	Maximum return, but even the slightest failures threaten to stop (delay) production
Receivables		
Conservative	A strict policy of credit provision and the collection of debts, the minimum payment periods, working only with reliable clients	Minimal loss from the formation of bad debts and late payments, but the level of sales and competitiveness is low
Hedging	Providing the average conditions of delivery and payment	Average return. Average risk
Aggressive	Big delay, flexible credit policy	A big volume of sales providing the prices higher than average market prices, but there is a big probability of the creation of overdue receivables
Cash		
Conservative	Keeping a large insurance cash balance.	The opportunity to make scheduled payments, even if temporary problems with collection money may lead to impairment
Hedging	The formation of relatively small insurance reserves, investing in the most reliable securities	Average return. Average risk
Aggressive	Storing the minimum cash balance, the investment of available funds in highly liquid securities	The enterprise has a risk not to have ability to pay for urgent liabilities or to receive losses due to receiving an unplanned short-term financing

The chosen current asset management policy may form only the basis to calculate the necessary amount of working capital. In practice, the need for working capital is mostly calculated based on the reporting data for the previous period as a percentage of sales adjusted for the percentage growth of sales. The ratio of the different types of assets (inventories, unfinished goods, finished goods, receivables) is based on the statistical information of the previous year. This method can be effectively used in the stable business environment. But it is not typical for the current situation.

The main task of the accepted current asset management policy is to ensure its efficiency and as a consequence the effectiveness of the whole PSP.

The profitability of assets and net current assets are used as the main criteria to estimate the efficiency. However, it is difficult to estimate the efficiency of the management based only on the amount and the structure of current assets. It is necessary to compare them with the financing sources. For this purpose, the indicator net working capital is calculated.

Net working capital is defined as the difference between current assets and short-term liabilities. The main task for management is to minimize the amount of net working capital. If net working capital more than zero, it means that enterprise's equity was used to finance current assets that are very often more expansive than borrowed funds. It is optimal condition when net working capital is equal to zero. It means that current assets are fully financed by borrowed funds. The indicator of the profitability of current assets is widely used in practice of western companies. It allows receiving the estimation of the effectiveness of current asset usage of any company. As a rule, the profitability of current assets is used as a key performance indicator of any company. The target value of the indicator is established. The calculations of the indicator are performed according to the formula:

The profitability of current assets (%) = the profitability of sales (%): the turnover of current assets = an operational profit: an average amount of current assets

This indicator allows estimating the effectiveness of current asset usage in any

company and defining the reasons of discrepancies between planned and actual data. It is necessary to make adjustments to the current asset management policy, if as a result of the performance evaluation of the planned volume of current assets, the value of net working capital is unsatisfactory and the profitability of current assets do not match the target value. For example, the company may revise credit terms for the customers, supplier relationship management, etc. After that, it can estimate the need for current assets and the efficiency of its plans again. Despite the apparent complexity of such calculations, it does not require from the company significant efforts, and the search for acceptable solutions can be implemented in Excel.

The chosen policy for the current asset management is effective. To control the effectiveness of the policy it is necessary to:

- to estimate the control indicators;
- to define clear responsibilities;
- to create a motivational system.

It should be carried out for all elements of current assets.

In practice, such indicators as turnover ratio, limits (for example, the minimum level of inventories) are used as control indicators. These indicators should be established for each group of assets. Depending on the speed of the turnover of current assets, the control for the selected indicators should include weekly and monthly monitoring. It will allow reacting on changes quickly and effectively. The financial department or the controlling department should provide the control function.

Another important aspect is the distribution of responsibilities to implement the standards included in the current asset management policy. The responsibilities among departments can be distributed as follows:

- the procurement department is responsible for such indicators as the turnover period of advance payments for suppliers, inventories and supplier debts;
- the production department is responsible for the turnover period of unfinished goods;
- the sales department is responsible for the turnover of finished goods, receivables and received advance payments.



Then, it is necessary to develop a motivation system. It should be focused to obtain the set tasks. As a rule, it is a system of fixed payments upon the achievement of the specified values of turnover indicators.

To implement developed standards and regulations of working capital management it is necessary to develop an appropriate documentation package to be accepted and carried out by the company.

Thus, the research shows that it is highly important to develop a special flexible mechanism in the management of PSP in small and medium-size enterprises with limited staff. It is based on not only on already existing tools, for example, the rates of turnover of current assets, but also on the methods and guidelines that allow manufacturers to achieve the desired results.

### Conclusions

1. The previous methods of the working capital management of manufacturing enterprises (rationing) in a modern unstable and unpredictable economy do not work successfully.

2. The exiting methods, used by western companies and economists, cannot be effectively implemented in the current business environment.

3. In practice, companies need rapid adaptive means of the regulation to provide a production-sales process with the working capital.

4. It is essential for each company to develop the working capital management policy individually.

5. The duration of the turnover used for the working capital and the established profitability at every stage and in general for PSP should act as the performance criteria of an adopted policy of the working capital management.

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**KNOWLEDGE DISSEMINATION PROCESS  
IN PARAMETRIZED NETWORKS OF ENTERPRISES**

**С.А. Баканова, Г.Ю. Силкина**

**ПРОЦЕССЫ РАСПРОСТРАНЕНИЯ ЗНАНИЙ  
В ПАРАМЕТРИЗОВАННОЙ СЕТИ ИНФОРМАЦИОННЫХ ОБМЕНОВ**

The article contains a mathematical model of parametrized network of knowledge exchange. It considers a process of knowledge spreading among a group of people united by common professional interests (a company or its sub-unit). A network is described by a fuzzy graph where vertices stand for individuals and edges – for contacts between them. A fuzzy set of edges defines the process quality characteristics that have direct influence on the result: coincidence of professional interests of individuals (in the model – cognitive potential of knowledge transfer) and evaluation of communication activity between them (how often they communicate – communication intensity). The first parameter is defined on the base of knowledge structure of individuals (for particular knowledge domain). The second one – communication intensity – is counted on information of communication occurrence (one-on-one communication, in groups, round tables and other ways of communication are taken into account). On the base of the quality parameters of relation between members of a group the model define clusters in a network (connected components in the graph theory) – subgroups of individuals that have strong productive communication among them. The model has a set of overall process characteristics of the process of knowledge spreading and may be used for analysis of network states in different timestamps and as consequence of all that – for knowledge management support. Information for analysis can be retrieved for corporate social networks. The model itself and its instruments can be added as an add-on to corporate networks to sustain knowledge management in organization. The article contains an example of the model use (calculation, analysis, illustration of fuzzy graphs). It defines the model's advantages and probable ways of improvement.

KNOWLEDGE SPREADING; ORGANIZATIONS; MODEL OF KNOWLEDGE SPREADING; GRAPH; CHARACTERISTICS OF KNOWLEDGE SPREADING PROCESS; CORPORATE SOCIAL NETWORKS.

В статье представлена разработанная авторами модель параметризованной сети информационных обменов. Рассматривается процесс распространения знаний внутри группы людей, объединенных профессиональными интересами (организации различных форм собственности, их структурные подразделения). Сеть описывается нечетким неориентированным графом первого рода, в котором вершины идентифицируют индивидов, а ребра – связи между ними. Нечеткое множество ребер графа задает качественные характеристики процесса распространения знаний, которые оказывают непосредственное влияние на результат рассматриваемого процесса: общность профессиональных интересов индивидов (когнитивный потенциал обмена знаниями) и оценка интенсивности их общения (как часто индивиды контактируют). Первый показатель строится на основе данных о структуре знаний индивидов в определенной области профессиональных знаний. Показатель интенсивности взаимодействия сотрудников определяется на основе информации о частоте их общения (общение один на один, общение в группах, на семинарах, круглых столах и т. д.). На основе введенных показателей качества связи между индивидами в сети выделяются кластеры (в теории графов – компоненты связности) – подгруппы индивидов, между которыми происходит особенно интенсивное общение. Модель включает набор обобщающих характеристик процессов распространения знаний, которые могут быть использованы для анализа текущего состояния сети. Информация, необходимая для вычислений может быть извлечена из корпоративных социальных сетей, поддерживающих организацию и хранение профилей сотрудников (их знаний и компетенций), электронные средства коммуникации и базы корпоративных знаний. Сам разработанный модельный инструмент может быть добавлен в качестве надстройки в корпоративную социальную сеть для сравнительного анализа и поддержки управленческих решений в сфере менеджмента знаний. Работа модели иллюстрируется расчетным примером (приведены результаты расчетов, их анализ и иллюстрации нечетких графов). Определены достоинства модели и направления ее доработки.

РАСПРОСТРАНЕНИЕ ЗНАНИЙ; ОРГАНИЗАЦИИ; МОДЕЛЬ РАСПРОСТРАНЕНИЯ ЗНАНИЙ; ГРАФ; ХАРАКТЕРИСТИКИ РАСПРОСТРАНЕНИЯ ЗНАНИЙ; КОРПОРАТИВНАЯ СОЦИАЛЬНАЯ СЕТЬ.

*Introduction.* In the modern world investment in human capital, on the one hand, and the development of infrastructure for knowledge

exchange, on the other hand, determine possibility of process of employees innovation creativity and, as a result, a company's success in

market. Validity of this assertion, set out in the report «The Global Innovation Index 2014», has been proved theoretically and repeatedly reaffirmed with real business practices [1]. Thereby, applied research in the area of knowledge management in enterprises becomes a subject of top interest. An increased number of domestic and foreign scientific and practical essays shows the value of this trend [2].

In a broad sense, knowledge management implies the process of creation, accumulation and distribution of it among people [3]. All the components of this process are fundamentally important for the success of modern companies, but are significantly different from the viewpoint of possibility of scientific formalization, justification and implementation of particular management decisions. In this sense, a creative process of knowledge production is the most difficult part; the problem of knowledge accumulation can be easily solved considering the current level of information technologies. And, finally, the knowledge dissemination, which involves not only using of modern communication tools, but, mainly, the interaction of knowledge carriers is, in the authors' opinion, the cornerstone of the knowledge management process and is of the greatest scientific interest for them.

The basic form of distribution of «working» knowledge (mainly, implicit) at all times have been an exchange of knowledge through the direct communication between people. Today, all the geographical, time and bureaucratic communication barriers and, consequently, knowledge sharing barriers are almost faded [4]. And this positive fact is one of the reasons for the increased involvement of employees of advanced technology industries, scientific and research organizations in the global knowledge exchange process. As a consequence, the interest of business and science communities for tools of analysis and optimization of processes occurring during this exchange greatly increased.

The existence and practical significance of a number of qualitative conditions of the productive knowledge exchange is a difficulty for formalization and simultaneously a great challenge to academic community. At the stage of searching for different approaches to the description of this process the authors can not ignore the various properties of knowledge (knowledge can be explicit or implicit, knowledge is inexhaustible in its

essence), exchange participants (each person has their own set of knowledge) and forms of the process (direct communication, attending conferences, participation in roundtables, etc.) [5].

*Analysis of the existing scientific and methodological initiatives.* The models presented in [6–8] can be distinguished as knowledge dissemination models. The selected models aim to justify and formalize the key factor in knowledge dissemination – cognitive distance between employees («remoteness» of individuals in knowledge aspect). However, these models have shortcomings, such as static character, lack of analytical justification and sufficient assessment of the qualitative aspects of the process. Simultaneously, these shortcomings determine the direction of their improvement.

Another group of models [9], used to represent knowledge exchange processes in organizations, is based on the mathematical tools for description and analysis of communication networks. In the models it simulates the space and time aspects of information exchange between the participants of social networks, which imposes certain limitations on possibility of using it for the formalization and analysis of knowledge exchange.

The endeavor to make a positive contribution to the critical remarks and to present own vision of knowledge distribution processes was the initial motive of writing this article. Moreover the existing mathematical apparatus provides opportunities to achieve the goal.

Commonality which unites the above mentioned models is that they are based on the ideology of graph theory, which is the most appropriate tool to reflect the relations between objects. In terms of this theory, objects are represented as graph with vertices  $v_i \in V$ , and relations (links) between them either undirected edges  $e_j \in E$  or directed arcs of the graph  $a_j \in A$ ; graph in general – a tuple  $G = \langle V, E \rangle$  or  $D = \langle V, A \rangle$ . Herewith, the nature and characteristics of the relations between objects in no way is taken into account: it is only important that the connection exists, and information about it is available.

In due time the development of classical graph theory was determined by networks – weighted graphs, which edges and arcs were credited with numerical parameters quantitatively characterizing the existing links: distance, time,



cost, etc. On this basis there were created and developed networking models of process, which are now widely used in transport planning, organization of project work, etc.

A key and at the same time a non-numerical nature aspects for knowledge exchange process are the characteristics of relations between people – the intensity of subject communication and matching of degree of professional interests (knowledge) in a particular area, defining the very possibility of knowledge exchange. For a quantitative image of these characteristics, we suggest to use apparatus of fuzzy graphs.

For development of the classic graphs theory positions the tuple  $\tilde{G} = \langle V, \tilde{E} \rangle$  is called as fuzzy undirected graph of the first kind, where  $V$  – conventional (clear) set of vertices,  $\tilde{E} = \langle \mu_E(v_i, v_j) / \{v_i, v_j\} \rangle$  – fuzzy set of edges, where  $v_i, v_j \in V$ ,  $\mu_E: E \rightarrow [0, 1]$  – membership function,  $\mu_E(v_i, v_j)$  – membership function value for the edge  $\{v_i, v_j\}$ , which characterize in one sense or another «quality» of connection between vertices  $v_i$  и  $v_j$ . There are no other formal imposed restrictions on  $\mu$ , so any function defined on the set of edges and taking values from the segment  $[0, 1]$  can be interpreted as the membership function [10].

The results of the implementation of the announced approach to modeling the propagation of knowledge are presented in this article.

**Parameterization of networks of knowledge exchange.** Let us consider a process of knowledge exchange among people united by professional interests (enterprises and their subdivisions). This process is defined by time and space measures. Employees and professional contacts between them represent a network of knowledge dissemination.

The network is modeled by a fuzzy graph:  $\tilde{G} = \langle V, \tilde{E} \rangle$  – is a set of vertices that identify employees and  $\tilde{E}$  – is a fuzzy set of edges that describes professional contacts between employees ( $E = \{e_{ij}\}$  – is a fuzzy set carrier – each element defines whether a professional communication between two people takes place).

As a membership function for the fuzzy set of the graph edges the model considers two parameters that define the possibility and the

result of knowledge dissemination process – density of communication between employees and cognitive potential of knowledge exchange.

The cognitive potential of knowledge sharing between two individuals defines to which extent their professional knowledge coincide. It is assumed that the exchange of knowledge between two employees is possible when the participants can easily speak the same «professional language» and can communicate on the same topic.

As it is shown in [7] graph vertices are determined by not just labels, but by a set of knowledge elements, formally expressed as a vector  $v_i = (((x_k)_l)_m)$  where  $x$  – is a component of a certain field of knowledge and takes value of 0 or 1 depending on whether an employee has this knowledge or not,  $m = 1, 2, \dots, M$  – subject groups of knowledge,  $l_m = 1, \dots, L_m$  – fields of knowledge,  $k_{lm} = 1, \dots, K_{lm}$  – components (elements) of knowledge.

Vector form of employee knowledge allows evaluating of cognitive potential for knowledge sharing between the two employees, numerically determining the «angle» between the vectors (disparity direction) of their knowledge.

Formally, the cognitive potential of knowledge sharing on the certain field of knowledge between the two network agents (employees)  $i$  and  $j$  we offer to calculate using the formula:

$$\alpha_{ij}^{l_m} = \frac{(v_i \cdot v_j)^{l_m}}{|v_i|^{l_m} \cdot |v_j|^{l_m}} = \frac{\sum_{k=1}^K x_k y_k}{\sqrt{\sum_{k=1}^K (x_k)^2} \cdot \sqrt{\sum_{k=1}^K (y_k)^2}}, \quad (1)$$

where  $v_i = (((x_k)_l)_m)$  and  $v_j = (((y_k)_l)_m)$  – knowledge vectors of employees with indexes  $i$  and  $j$ .

Here in the numerator – the amount of paired products of the coordinates (scalar product) and in the denominator – the product of the lengths of these vectors.

The reasons for the proposed approach are the following. In low-dimensional spaces, where the vector is directed segments, a similar formula calculates the cosine of the angle between the vectors. At full coincidence directions vectors cosine of the angle between them equals 1; divergence of directions reduces it down to a value of 0 (orthogonal vectors).

Extrapolation of this approach in a higher dimensional space allows meaningful interpretation of  $\alpha_{ij}^m$  as an indicator of the degree of closeness of knowledge of employees. The fact that the parameter takes values in the interval  $[0; 1]$  allows using it as a membership function in the fuzzy set determining the edges of the graph:  $\tilde{E} = \langle \alpha_{ij}(v_i, v_j) / \{v_i, v_j\} \rangle$ .

The second characteristic of the process of knowledge dissemination in the model is the intensity of communication which formally can be measured by the number of acts of communication for a certain time period. When describing the diffusion of knowledge it is reasonable not to limit it to only formal communication (trainings, round tables, etc.), but also include consideration of informal communication – as one of the key distribution channels of «working» tacit knowledge. As long as we are not limited by a form of knowledge transfer and talk about the impact of this communication in terms of knowledge dissemination, quantitative at first glance characteristic (how many times two employees talked) turns into qualitative one.

Given the latter, the authors propose to evaluate the relationship between the employees in terms of it to be «full-fledged» assuming that if the contact between individuals «full-fledged» the transfer of knowledge is considered to be working. Otherwise, communication between employees is considered partial.

In the model, this premise is expressed as follows:

Let  $\delta_{ij} = \frac{t_{ij}}{T}$  be the amount of communication over a communication channel between employees with indexes  $i$  and  $j$  (number of acts of intercourse between individuals over the time period,  $T$  – the length of the time period in days) and  $\bar{\delta} = \frac{1}{|E|} \sum_{i,j: \{v_i, v_j\} \in V} \delta_{ij}$  – average number of pairs of communication between employees in the network.

Then the characteristic of communication intensity between individuals is defined as follows:

$$\beta(e_{ij}) = \begin{cases} 1, & \delta_{ij} \geq \bar{\delta}, \\ \delta_{ij} / \bar{\delta}, & \delta_{ij} < \bar{\delta}. \end{cases} \quad (2)$$

The parameter  $\beta(e_{ij})$  also takes values in the interval  $[0; 1]$ , which allows us to interpret it as a membership function for the fuzzy defining of the edges of the graph:  $\tilde{E} = \langle \beta_{ij}(v_i, v_j) / \{v_i, v_j\} \rangle$ .

**Dissemination of knowledge in the parameterized network.** To describe the process of knowledge dissemination in professional networks the model uses the concept of parameterized routes. A route in a graph is determined by a set of alternating edges and vertices in which any two adjacent elements incident. Routes can be interpreted as ways in which knowledge disseminates from its original owner to probable recipients.

Based on figures parametrizing knowledge networks (the cognitive potential and the communication intensity), the model identifies the characteristics of routes that have their own meaningful interpretation.

The theory of fuzzy graphs uses various characteristics of routes between nodes and each of them can be interpreted in terms of knowledge propagation process. The model presented in this paper uses three kinds of routes strength – conjunctive, disjunctive and cumulative. Conjunctive and disjunctive strength define edges with the lowest or highest cognitive potentials, respectively (in cognitive units). These characteristics can be used to analyze the strength of the range of the route, to identify strong and weak links in the path.

For a route  $L(v_i, v_j)$  connecting vertices with numbers  $i$  and  $j$  conjunctive and disjunctive strength accordingly in the model defined as follows (examples of calculation formulas for cognitive units):

$$\eta_{\&}^{\alpha}(L(v_i, v_j)) = \bigwedge_{\langle v_e, v_m \rangle \in L(v_i, v_j)} \alpha \langle v_e, v_m \rangle, \quad (3)$$

$$\eta_{\vee}^{\alpha}(L(v_i, v_j)) = \bigvee_{\langle v_e, v_m \rangle \in L(v_i, v_j)} \alpha \langle v_e, v_m \rangle. \quad (4)$$

The cumulative strength of the route (in terms of cognitive and time units) characterizes the entire route as a whole, its overall «reliability» to transfer knowledge from one to another vertex. A need for such index occurs when a comparative characteristic of various knowledge flow directions from the initiator are required, as well as for construction of complex propagation characteristics in the knowledge



network. Formally, the cumulative strength of the route is defined as follows:

$$\eta_{\alpha}^{\alpha}(L(v_i, v_j)) = \prod_{(v_e, v_m) \in L(v_i, v_j)} \alpha(v_e, v_m). \quad (5)$$

In professional networks the cumulative maximum strength of the route can be interpreted as the most reliable direction of knowledge dissemination.

The parameter of maximum cumulative strength in the model is shown by a fuzzy reachability matrix of vertices (analog of reachability matrix in the classic graph theory), in which each element shows the most «strong» («reliable») route between the vertices.

Technically fuzzy reachability matrix is constructed in several stages as follows.

1. We construct a fuzzy adjacency matrix by the parameters of cognitive potential of knowledge for all pairs of vertices with specified level of intensity of their communication ( $\lambda^{\beta}$ ):

$$\tilde{S}_{\alpha} = (\alpha_{ij} \mid \beta_{ij} \geq \lambda^{\beta}).$$

By their meaning, elements of these matrices correspond to paths of length 1 in the parameterized network. Routes of greater lengths represented by corresponding degrees of adjacency matrix.

2. The model uses the following rule of matrix multiplication.

Each element of the result matrix is the maximum of element-wise product of a line to a column that is different from zero, if the number of the element in the line does not match the item in the column:

$$\begin{aligned} \tilde{S}_{\alpha} \cdot \tilde{S}_{\alpha} &= \tilde{S}_{\alpha}^2 = C; \\ c_{ij} &= \begin{cases} \max \{ \alpha_{ir} \cdot \alpha_{rj} \}, & r = 1, \dots, n, i \neq j, \\ 0, & i = j. \end{cases} \end{aligned}$$

Fuzzy adjacency matrix raised to the powers from 2 to  $n - 1$ . Each of the resulting matrix contains in fact the strongest possible routes of length  $k$  between two vertices:  $\tilde{S}_{\alpha}^2, \tilde{S}_{\alpha}^3, \dots, \tilde{S}_{\alpha}^{n-1}$ .

3. Final fuzzy reachability matrix by is defined element-wise comparison of matrices  $\tilde{S}_{\alpha}, \tilde{S}_{\alpha}^2, \tilde{S}_{\alpha}^3, \dots, \tilde{S}_{\alpha}^{n-1}$ :

$$d_{ij}^{\alpha} = \max \{ \alpha_{ij}^k \}, k = 2, \dots, n - 1.$$

The resulting matrix contains elements that characterize the maximum strength of the path

between two vertices in the graph in cognitive terms, taking into account the necessary intensity of communication between individuals.

**Clustering of parameterized knowledge dissemination network.** Characteristic feature of all communities (professional or interest) is the allocation of small subgroups in which there is the most intensive communication between their members. Companies and their subdivisions are not exception to this rule [11].

Theory of Graphs provides tools for searching connection components — sets of employees «united» with the same interests — vertices of a graph based on the relations between them. In the case of «simple» not parameterized network (as shown in [7]), the connection components will substantively mean disjoint classes with no connection in-between that is knowledge exchange is impossible. Network without any parameters allows only roughly estimate its internal division into isolated subgroups, limiting the ability of full analysis of its structure due to the fact that the factors of communication intensity and proximity of professional interests are not included.

Parameterized network based on coincidence of interests and intensity of employees' communication, through selection of connection components is divided into clusters — cohesive groups of information exchange with an intensive productive communication within, but at the same time with the links to external vertices and groups. In contrast to classes (defined in the network with no parameters), division into clusters in the graph occurs within the parameters of individuals' communication and enables structural analysis, evaluation of interest groups network coverage.

Interest groups of parameterized network are determined by introducing of minimum admissible strength coefficient —  $\lambda^{\alpha}$  ( $\lambda^{\beta}$ ), that fixes required intensity of communication or cognitive capacity among the employees. Based on the fuzzy adjacency matrix of vertices and the minimum allowable bond strength index, it is determined in the model by a binary matrix of elements' connection ( $T_{n \times n}^{\alpha}$ ), that is determinate analogue of fuzzy reachability matrix (for example, cognitive strength):

$$t_{ij}^{\alpha} = \begin{cases} 1, & d_{ij}^{\alpha} \geq \lambda^{\alpha}, \\ 0, & d_{ij}^{\alpha} < \lambda^{\alpha}, \end{cases}$$

where  $\lambda^\alpha$  – the minimum acceptable level of strength of the way between the vertices in cognitive units.

The final matrix  $T_{n \times n}$  ( $t_{ij} = t_{ij}^\alpha \cdot t_{ij}^\beta$ ) identifies substantively the «strong», «working» network links between agents considering cognitive potential and intensity of communication and it is interpreted by the authors as a connection matrix of an undirected graph vertices. According to the well-known in graph theory algorithm connection components are found on vertices connection matrix.

**Parametrized network characteristics.** Analysis and modeling of economic processes are focused on the development and justification of management decisions. The process of knowledge dissemination, covered in this article, and the suggested by the authors approach to its' analysis is not an exception in this respect. In this paper we offer a set of indicators by means of which it is possible to analyze knowledge dissemination networks and some practical recommendations for improving the conductivity of new knowledge in networks are given also.

Configuration network characteristics (characteristics of elements) and processes of knowledge distribution characteristics are defined in the model.

**Characteristics of vertices in the parameterized network of knowledge dissemination.** Each vertex in the graph (individual in a professional network) can be characterized in terms of cognitive and time «distance» from their nearest neighbors:

$$b_\alpha(v_i) = \bar{\alpha}_{ij} = \frac{\sum_j \alpha_{ij}}{|\Gamma(v_i)|}, \quad (7)$$

where  $\Gamma(v_i)$  – the set of vertices reachable from  $v_i$  by a single step. The indicator shows the average cognitive «distance» of the individuals from their neighbors. The time analog of the parameter (average «distance» in time units) is

$$\text{calculated by: } b_\beta(v_i) = \bar{\beta}_{ij} = \frac{\sum_j \beta_{ij}}{|\Gamma(v_i)|}.$$

The indicators can help to assess every employee involved in the process of knowledge sharing. Overall analysis of the individuals using time and cognitive «distance» parameters will identify active participants in the exchange of knowledge among the others and that need to be

motivated to get new knowledge and spread it on in the community (they can be sent to conferences, trainings etc).

**Characteristics of knowledge dissemination process.** For each field of knowledge used in professional community (enterprise), the model suggests the following characteristics of the process of knowledge sharing that can be used to analyze the process itself and to identify its probable sore points in the terms of knowledge sharing:

1. Potential scale of knowledge dissemination – amount of employees that able to «absorb» new knowledge from a particular field:

$$w_{l_m}^* = \{v_i \mid (x_{klm})_{l_m} > 0\}. \quad (9)$$

2. Average strength of the route in terms of cognitive units:

$$\bar{w}_{l_m}^\alpha = \frac{\sum_{i,j=1}^n d_{ij}^\alpha}{n^2}. \quad (10)$$

3. Average strength of the route in terms of time units:

$$\bar{w}_{l_m}^\beta = \frac{\sum_{i,j=1}^n d_{ij}^\beta}{n^2}. \quad (11)$$

4. The average number of interest groups (connected components):

$$\bar{V} = \frac{|V_p|}{p}, \quad (12)$$

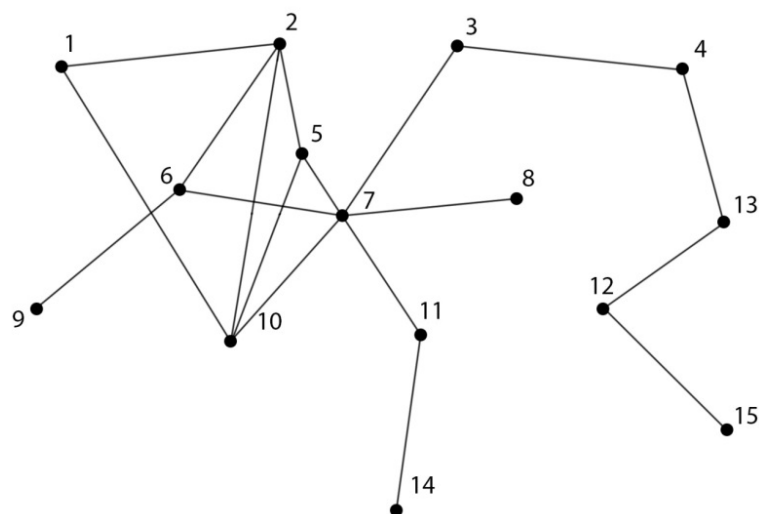
where  $|V_p|$  – the amount of elements in the set.

**Illustration of the model.** Let us illustrate with a calculation example how the model works.

Suppose there is a group of 15 colleagues (employees of organization or department), associated with professional contacts and interests in the same area of expertise.

Fig. 1 shows a graph, illustrating the information exchange between the network members, where the edges are defined by the existence of contact between the vertices. Such network (and its model illustration) provides a first idea of how connections are established between individuals in the group.

There is the structure of the professional knowledge of each member of the group (Tab. 1) and the frequency of their communication (Tab. 2) per unit of time taken for one month. Professional knowledge of the area, which is used in a hypothetical group, divided into five components.



**Fig. 1.** Non-parameterized network of information exchanges in a team (vertices identify employees, edges – contacts between them on the principle of «individuals know each other personally»)

Table 1

**The structure of the employees' knowledge**

$x_k \backslash v_i$	$v_1$	$v_2$	$v_3$	$v_4$	$v_5$	$v_6$	$v_7$	$v_8$	$v_9$	$v_{10}$	$v_{11}$	$v_{12}$	$v_{13}$	$v_{14}$	$v_{15}$
$x_1$	1	0	0	0	1	1	1	0	1	1	1	0	1	0	0
$x_2$	1	1	0	0	1	1	0	0	1	1	1	0	1	0	1
$x_3$	0	1	0	1	1	1	0	0	1	1	1	0	1	1	1
$x_4$	1	1	1	0	0	1	0	0	1	0	1	0	1	0	0
$x_5$	0	1	0	0	1	1	0	1	1	0	1	1	1	1	1

Table 2

**Amount of acts of communication between employees ( $t_{ij}$ )**

$v_i \backslash v_j$	$v_1$	$v_2$	$v_3$	$v_4$	$v_5$	$v_6$	$v_7$	$v_8$	$v_9$	$v_{10}$	$v_{11}$	$v_{12}$	$v_{13}$	$v_{14}$	$v_{15}$
$v_1$		1	0	0	0	0	0	0	0	2	0	0	0	0	0
$v_2$	1		0	0	6	4	0	0	0	3	0	0	0	0	0
$v_3$	0	0		1	0	0	11	0	0	0	0	0	0	0	0
$v_4$	0	0	1		0	0	0	0	0	0	0	0	1	0	0
$v_5$	0	6	0	0		0	1	0	0	15	0	0	0	0	0
$v_6$	0	4	0	0	0		3	0	18	0	0	0	0	0	0
$v_7$	0	0	11	0	1	3		4	0	9	1	0	0	0	0
$v_8$	0	0	0	0	0	0	4		0	0	0	0	0	0	0
$v_9$	0	0	0	0	0	18	0	0		0	0	0	0	0	0
$v_{10}$	2	3	0	0	15	0	9	0	0		0	0	0	0	0
$v_{11}$	0	0	0	0	0	0	1	0	0	0		0	0	1	0
$v_{12}$	0	0	0	0	0	0	0	0	0	0	0		24	0	11
$v_{13}$	0	0	0	1	0	0	0	0	0	0	0	24		0	0
$v_{14}$	0	0	0	0	0	0	0	0	0	0	1	0	0		0
$v_{15}$	0	0	0	0	0	0	0	0	0	0	0	11	0	0	

By the formulas (1) and (2) the network parameters are defined – the indicator of communication intensity and the cognitive potential of knowledge exchange between individuals. Tab. 3 shows the indicators for each pair of employees, and Fig. 2 illustrates a parameterized knowledge exchange network.

The graph shown in Fig. 2 is an illustration of the derived model calculations. Each edge of

the graph is painted in two colors – for the indicators of communication intensity and cognitive potential, respectively. For visualization of indicators we took gradation of colors, where the maximum intensity of the color corresponds to the highest value of indicator (each edge is marked with  $\alpha$  and  $\beta$  symbols to designate correspondence between a component of the edge and its' index).

Table 3

**Values of the communication intensity ( $\beta$ ) and cognitive potential ( $\alpha$ ) for the network**  
(each cell contains both ratings, the highlighted cells identify edges of the graph)

$v_i \backslash v_j$		$v_1$	$v_2$	$v_3$	$v_4$	$v_5$	$v_6$	$v_7$	$v_8$	$v_9$	$v_{10}$	$v_{11}$	$v_{12}$	$v_{13}$	$v_{14}$	$v_{15}$
$v_1$	$\alpha$		0.6	0.6	0	0.6	0.8	0.6	0	0.8	0.7	0.8	0	0.8	0	0.3
	$\beta$		0.2	0	0	0	0	0	0	0	0.3	0	0	0	0	0
$v_2$	$\alpha$	0.6		0.5	0.5	0.8	0.9	0	0.5	0.9	0.6	0.9	0.5	0.9	0.7	0.9
	$\beta$	0.2		0	0	0.9	0.6	0	0	0	0.5	0	0	0	0	0
$v_3$	$\alpha$	0.6	0.5		0	0	0.4	0	0	0.4	0	0.4	0	0.4	0	0
	$\beta$	0	0		0.2	0	0	1	0	0	0	0	0	0	0	0
$v_4$	$\alpha$	0	0.5	0		0.5	0.4	0	0	0.4	0.6	0.4	0	0.4	0.7	0.6
	$\beta$	0	0	0.2		0	0	0	0	0	0	0	0	0.2	0	0
$v_5$	$\alpha$	0.6	0.8	0	0.4		0.9	0.5	0.5	0.9	0.9	0.9	0.5	0.9	0.7	0.9
	$\beta$	0	0.9	0	0		0	0.2	0	0	1	0	0	0	0	0
$v_6$	$\alpha$	0.8	0.9	0.4	0.4	0.9		0.4	0.4	1	0.8	1	0.4	1	0.6	0.8
	$\beta$	0	0.6	0	0	0		0.5	0	1	0	0	0	0	0	0
$v_7$	$\alpha$	0.6	0	0	0	0.5	0.4		0	0.4	0.6	0.4	0	0.4	0	0
	$\beta$	0	0	1	0	0.2	0.5		0.6	0	1	0.2	0	0	0	0
$v_8$	$\alpha$	0	0.5	0	0	0.5	0.4	0		0.4	0	0.4	1	0.4	0.7	0.6
	$\beta$	0	0	0	0	0	0	0.6		0	0	0	0	0	0	0
$v_9$	$\alpha$	0.8	0.9	0.4	0.4	0.9	1	0.4	0.4		0.8	1	0.4	1	0.6	0.8
	$\beta$	0	0	0	0	0	1	0	0		0	0	0	0	0	0
$v_{10}$	$\alpha$	0.7	0.6	0	0.6	0.9	0.8	0.6	0	0.8		0.8	0	0.8	0.4	0.7
	$\beta$	0.3	0.5	0	0	1	0	1	0	0		0	0	0	0	0
$v_{11}$	$\alpha$	0.8	0.9	0.4	0.4	0.9	1	0.4	0.4	1	0.8		0.4	1	0.6	0.8
	$\beta$	0	0	0	0	0	0	0.2	0	0	0		0	0	0.2	0
$v_{12}$	$\alpha$	0	0.5	0	0	0.5	0.4	0	1	0.4	0	0.4		0.4	0.7	0.6
	$\beta$	0	0	0	0	0	0	0	0	0	0	0		1	0	1
$v_{13}$	$\alpha$	0.8	0.9	0.4	0.4	0.9	1	0.4	0.4	1	0.8	1	0.4		0.6	0.8
	$\beta$	0	0	0	0.2	0	0	0	0	0	0	0	1		0	0
$v_{14}$	$\alpha$	0	0.7	0	0.7	0.7	0.6	0	0.7	0.6	0.4	0.6	0.7	0.6		0.8
	$\beta$	0	0	0	0	0	0	0	0	0	0	0.2	0	0		0
$v_{15}$	$\alpha$	0.3	0.9	0	0.6	0.9	0.8	0	0.6	0.8	0.7	0.8	0.6	0.8	0.8	
	$\beta$	0	0	0	0	0	0	0	0	0	0	0	1	0	0	

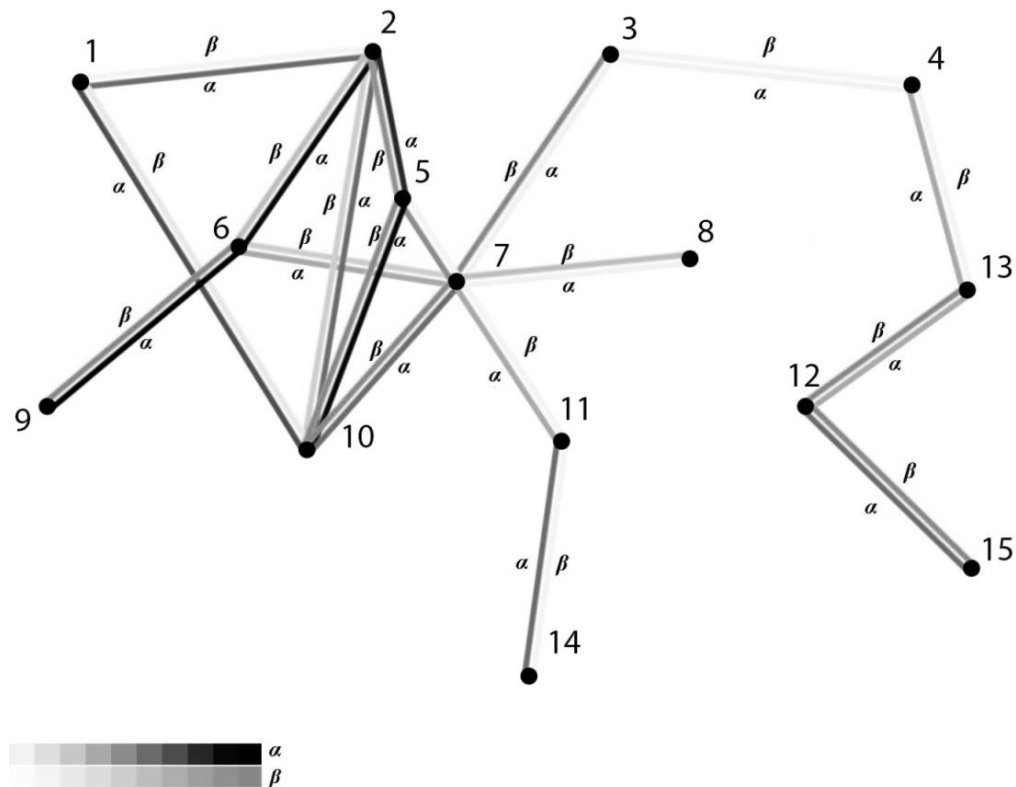


Fig. 2. Parameterized network of knowledge exchanges

Using the parameters of knowledge exchange in networks we can define routes and their characteristics that provide a value of each route and can be used to define conductivity properties of the network.

The presented approach to illustration of a parameterized network enables the primary analysis of the links in the network. Thus, for example, the edge between the vertices with the numbers 3 and 4 shows a very weak link for transfer of knowledge between the employees, in both cognitive and time units. In fact, this means that individuals do not have common interests and, moreover, communicate extremely seldom. In the model calculations parameters of the edge «3 – 4» are interpreted as conjunctive strength of routes passing through this edge. At the same time, exactly through this element knowledge exchange between a group of vertices with the numbers 12, 13, 15 and the rest of the members of the team is possible that makes this connection essentially important in terms of the whole network conduction. The most appropriate management decisions in this situation will be a redefinition of relations

between these two groups of employees (on one and on the other «side» of the «weak» in terms of knowledge exchange element).

Parameters of the edge lying between the vertices with the numbers 2 and 5 are defined as indicators of disjunctive strength for routes passing through this element. Substantially, this connection means a reliable knowledge dissemination channel, both in terms of time for distribution, and from the point of view of professional interests matching: individuals communicate frequently and use «the same language».

For each pair of connected vertices we calculated the cumulative strength of the routes, which are the elements of the fuzzy reachability matrix in cognitive and time units ( $\tilde{D}_{n \times n}^{\alpha}$  and  $\tilde{D}_{n \times n}^{\beta}$ ). These indicators allow a comprehensive analysis of the conductivity of knowledge within the network based on two parameters that determine the quality of the dissemination of knowledge. Tab. 4 contains the results of calculations of cumulative strengths routes in the network in question.

Table 4

The cumulative strength of routes between the vertexes in time and cognitive units

$v_i \backslash v_j$		$v_1$	$v_2$	$v_3$	$v_4$	$v_5$	$v_6$	$v_7$	$v_8$	$v_9$	$v_{10}$	$v_{11}$	$v_{12}$	$v_{13}$	$v_{14}$	$v_{15}$
$v_1$	$\alpha$		0.58	0	0	0.58	0.52	0.38	0	0.52	0.67	0.17	0	0	0.11	0
	$\beta$		0.29	0.31	0.05	0.31	0.18	0.31	0.19	0.18	0.31	0.05	0.01	0.01	0.01	0.01
$v_2$	$\alpha$	0.58		0	0	0.75	0.89	0.4	0	0.89	0.65	0.18	0	0	0.11	0
	$\beta$	0.29		0.93	0.14	0.93	0.62	0.93	0.58	0.62	0.93	0.14	0.02	0.02	0.02	0.02
$v_3$	$\alpha$	0	0		0	0	0	0	0	0	0	0	0	0	0	0
	$\beta$	0.31	0.93		0.16	1	0.58	1	0.62	0.58	1	0.16	0.02	0.02	0.02	0.02
$v_4$	$\alpha$	0	0	0		0	0	0	0	0	0	0	0.2	0.45	0	0.12
	$\beta$	0.05	0.14	0.16		0.16	0.09	0.16	0.1	0.09	0.16	0.02	0.16	0.16	0.004	0.16
$v_5$	$\alpha$	0.58	0.75	0	0		0.67	0.5	0	0.67	0.87	0.22	0	0	0.14	0
	$\beta$	0.31	0.93	1	0.16		0.58	1	0.62	0.58	1	0.16	0.02	0.02	0.2	0.02
$v_6$	$\alpha$	0.52	0.89	0	0	0.67		0.45	0	1	0.58	0.2	0	0	0.13	0
	$\beta$	0.18	0.62	0.58	0.09	0.58		0.58	0.36	1	0.58	0.09	0.01	0.01	0.01	0.01
$v_7$	$\alpha$	0.38	0.4	0	0	0.5	0.45		0	0.45	0.58	0.45	0	0	0.28	0
	$\beta$	0.31	0.93	1	0.16	1	0.58		0.62	0.58	1	0.16	0.02	0.02	0.02	0.02
$v_8$	$\alpha$	0	0	0	0	0	0	0		0	0	0	0	0	0	0
	$\beta$	0.19	0.58	0.62	0.1	0.62	0.36	0.62		0.36	0.62	0.1	0.01	0.01	0.01	0.01
$v_9$	$\alpha$	0.52	0.89	0	0	0.67	1	0.45	0		0.58	0.2	0	0	0.13	0
	$\beta$	0.18	0.62	0.58	0.09	0.58	1	0.58	0.36		0.58	0.09	0.01	0.01	0.01	0.01
$v_{10}$	$\alpha$	0.67	0.65	0	0	0.87	0.58	0.58	0	0.58		0.26	0	0	0.16	0
	$\beta$	0.31	0.93	1	0.16	1	0.58	1	0.62	0.58		0.16	0.02	0.02	0.02	0.02
$v_{11}$	$\alpha$	0.17	0.18	0	0	0.22	0.2	0.45	0	0.2	0.26		0	0	0.63	0
	$\beta$	0.05	0.14	0.16	0.02	0.16	0.09	0.16	0.1	0.09	0.16		0	0	0.16	0
$v_{12}$	$\alpha$	0	0	0	0.2	0	0	0	0	0	0	0		0.45	0	0.58
	$\beta$	0.01	0.02	0.02	0.16	0.02	0.01	0.02	0.01	0.01	0.02	0		1	0	1
$v_{13}$	$\alpha$	0	0	0	0.45	0	0	0	0	0	0	0	0.45		0	0.26
	$\beta$	0.01	0.02	0.02	0.16	0.02	0.01	0.02	0.01	0.01	0.02	0.004	1		0	1
$v_{14}$	$\alpha$	0.11	0.11	0	0	0.14	0.13	0.28	0	0.13	0.16	0.63	0	0		0
	$\beta$	0.01	0.02	0.02	0.004	0.02	0.01	0.02	0.01	0.01	0.02	0.16	0.0006	0		0
$v_{15}$	$\alpha$	0	0	0	0.12	0	0	0	0	0	0	0	0.56	0.26	0	
	$\beta$	0.01	0.02	0.02	0.16	0.02	0.01	0.02	0.01	0.01	0.02	0	1	1	0	

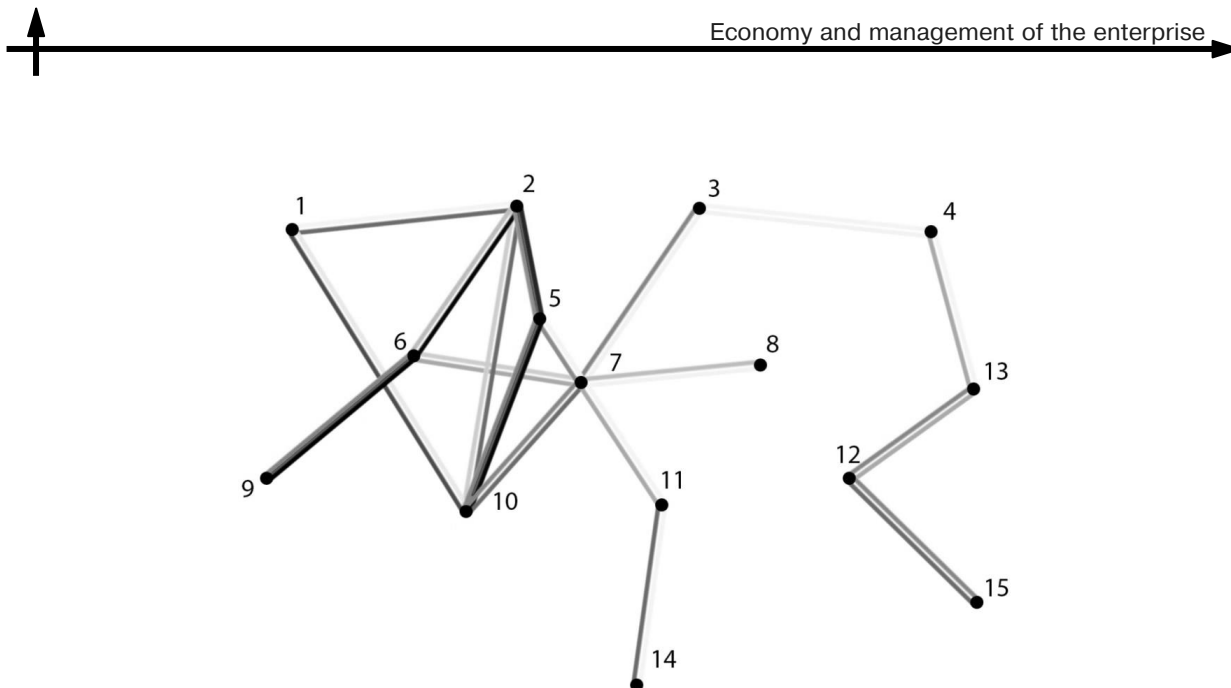


Fig. 3. Connected components in the parametrized network

At this phase of the knowledge conductivity analysis we can make a preliminary conclusion about the strength of the routes of the entire network. As seen from the table above, only a few routes have strengths exceeding the threshold  $\alpha = 0.5$  and  $\beta = 0.5$  (highlighted in color). There are only ten such routes of forty-two possible. Even now we can conclude uneven coverage of the network by «working» («strong») contacts, which makes the process of knowledge transfer chaotic and unorganized in the network in its current configuration.

On the basis of the cumulative strengths the model determines connected components that stand for groups of employees, in which there is the most intensive exchange of knowledge and competencies. In the example we settled the threshold levels of knowledge sharing to following values:  $\alpha = 0.7$  and  $\beta = 0.9$ . The following connected components appeared as a result of calculation:  $(v_2, v_5, v_{10})$  and  $(v_6, v_9)$ . Fig. 3 illustrates the results obtained.

The final stage of the analysis involves consideration of the general knowledge conductivity characteristics of the network. The developed model indicators help to assess the current state of the network and make a comparative analysis after application of reorganization measures, directly or indirectly affecting the throughput performance of the network.

For a comparative analysis different states of the network, in the example of we have simulated management actions to reorganize the connections

in the network in order to improve the conductivity of knowledge between employees. Based on the analysis of cognitive potential parameters of knowledge sharing between employees in the network we have partially established new contacts between those pairs of individuals for which the rate of cognitive potential of knowledge sharing exceeds 0.9. In fact, new edges were added to the initial graph (by indexes of the vertices): 1 – 9, 1 – 6, 2 – 11, 2 – 13, 2 – 15, 5 – 6, 6 – 10, 6 – 11, 9 – 10, 9 – 11, 11 – 13, 11 – 15, 13 – 15, 14 – 15. For each of the added links indicator of the intensity of communication was established at 0.9 (in practice it may be achieved by introducing regular round tables for the staff). Fig. 4 illustrates a new connection in the network (the values for the parameters are set only for «new» edges).

Tab. 5 contains the results of calculations of the knowledge conductivity main characteristics for both cases – the initial state and after the implementation of new connections between the employees.

As the table shows, the average strength indicators have improved markedly after the new routes determination between some pairs of employees. This gives grounds to conclude that the updated network communication channels between employees more reliable and stable. This in its turn makes it possible to assume that in the new network, there is an intense circulation of knowledge with greater reliability and, as a result, efficiency. An additional argument in favor of this

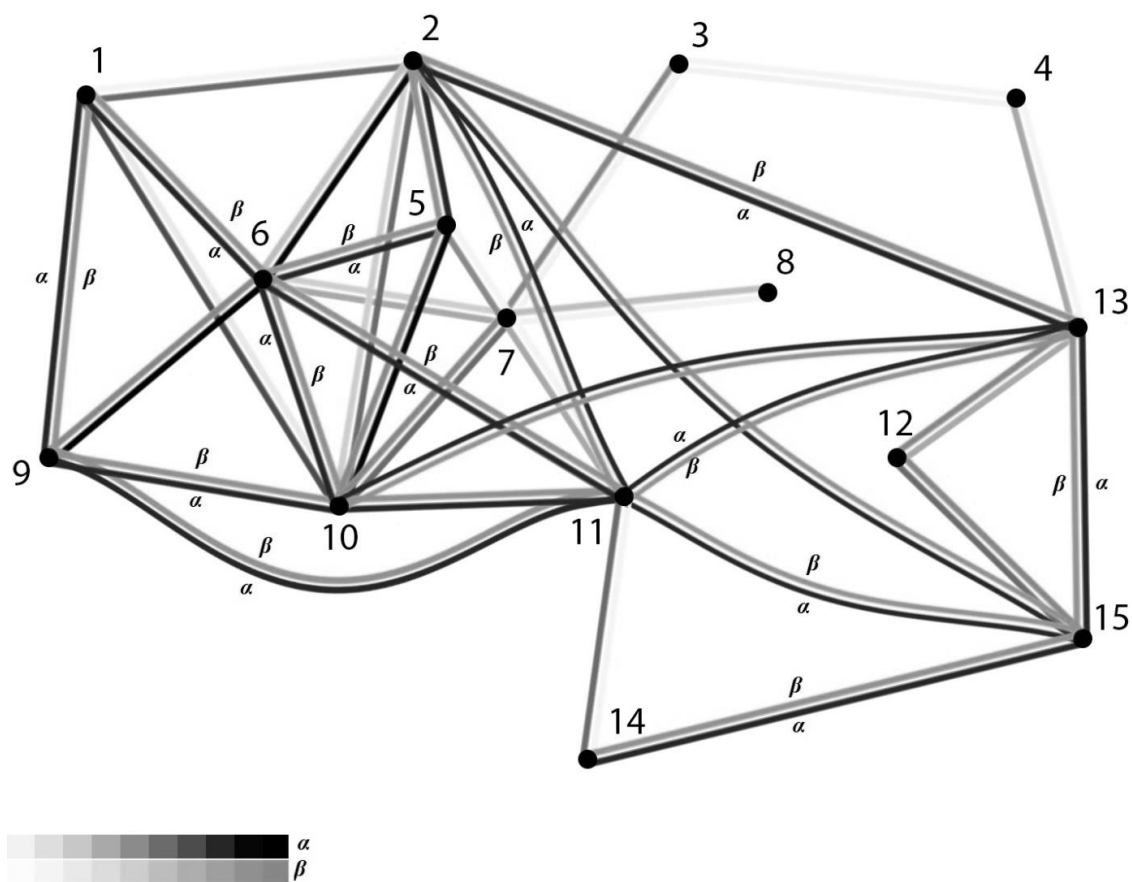


Fig. 4. Reorganized network of knowledge dissemination

Table 5  
Parameters of knowledge conductivity in the network  
for the initial state and after the reorganization  
of the network

Parameter	Initial network	After the reorganization
Average strength of the route in terms of cognitive units	0.23	0.5
Average strength of the route in terms of time units	0.32	0.75
The amount of interests group	2	1
The average number of interest groups (connected components)	2.5	10

conclusion is the indicators of the amount of interest groups and their average number. As soon as the model example considers one area of knowledge common to the entire group of 15 people, it is logically reasonable to assume that if there is a particularly cohesive internal team of ten people, in which there is active and productive

communication, knowledge will be intensively and effectively spread between the employees. In the reverse situation, when interest groups numerically small (2, 3 persons) and relatively few in the whole team, as shown in the example before the reorganization of relations, knowledge spreading will take a relatively long time and the knowledge itself will remain virtually inaccessible to other members of the team.

The provided example helps to evaluate the application and use of the model and to identify possible directions for its further development. Thus, for any enterprise in which the main production resource is knowledge, the model provides an opportunity to assess how the organization has established communication between its employees and how these relationships contribute to the spread of knowledge. The model uses qualitative characteristics of the diffusion of knowledge, which is an adequate reflection of the properties of such a complex and difficult process, as the dissemination of knowledge.





**Conclusion.** Scientific discoveries and innovations usually accumulate practices of several generations of scientists and researchers. Knowledge in this or the other area, reaching a certain critical mass, embodies in a new knowledge and moves to a new form. The ability to implement existing and newly created knowledge into economic products and operate knowledge as a product of modern economy is considered to be the key to success for organizations of different structures and sizes – from start-ups to international corporations and enterprises.

Nowadays, these facts are recognized at all levels of administrative management, in both the public and private sector.

As a result, analysis and development of applied tools for assessing and modeling processes of knowledge dissemination is an urgent scientific problem. The concept of numbers at all times has been the basis of decision-making.

Within the framework of this article the authors present a model, developed for the

analysis and evaluation of the knowledge dissemination process. The model can be used to support management decisions in important emerging stream of Management – Knowledge Management. Corporate social networks, which contain information about the knowledge and competencies of the employees and support electronic forms of communication, can serve as an information base for using the model in real companies. The authors see the following necessary directions for further research of this model:

- the introduction of fuzzy characteristics for describing the structure of the employees knowledge – this will bring a possibility to construct more precise assessment of staff knowledge and cognitive capacity among them;

- introduction of a time-dependent factor of knowledge assimilation by the individuals – this will allow to define the time characteristics of knowledge dissemination process, to consider dynamics of knowledge accumulation.

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# УСЛОВИЯ ПУБЛИКАЦИИ СТАТЕЙ

в журнале «Научно-технические ведомости Санкт-Петербургского государственного политехнического университета. Экономические науки»

## ОБЩИЕ ПОЛОЖЕНИЯ

Журнал «Научно-технические ведомости Санкт-Петербургского государственного политехнического университета. Экономические науки» является периодическим печатным научным рецензируемым изданием. Зарегистрировано Федеральной службой по надзору в сфере информационных технологий и массовых коммуникаций (Роскомнадзор). Свидетельство о регистрации ПИ № ФС77-52146 от 11.12.2012 г. С 2008 года выпускался в составе сериального периодического издания «Научно-технические ведомости СПбГПУ» (ISSN 1994-2354).

Издание с 2002 года входит в Перечень ведущих научных рецензируемых журналов и изданий (перечень ВАК) и принимается для печати материалы научных исследований, а также статьи для опубликования основных результатов диссертаций на соискание ученой степени доктора наук и кандидата наук по следующим основным научным направлениям: Менеджмент, Макроэкономика, Мировая экономика, Региональная экономика, Экономика и менеджмент предприятия, Маркетинг, Финансы, Бухгалтерский учет, Налогообложение, Управление инновациями и др. Научные направления журнала учитываются ВАК Минобрнауки РФ при защите докторских и кандидатских диссертаций в соответствии с Номенклатурой специальностей научных работников.

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