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The economic feasibility analysis of innovative megaprojects for the benefit of construction enterprises: the case of the Republic of Tatarstan

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The strategic development of the Republic of Tatarstan determines its development prospects for the coming 10–20 years. Its land zoning has shown that Kazan, Kama and Almetyevsk are the three fastest developing agglomerations in the republic. Nonetheless, many areas cannot benefit from the flow of goods and resources. A research on logistics allows to assume that the development of a road transportation network, including the construction of bridges, tunnels and the use of the river transport (as the cheapest means of transport) is a must. Along with the development of transport arteries, the republic needs advanced development points, the construction industry growth triggers, modernization and reconstruction of construction industry enterprises.

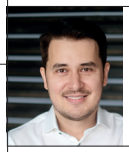
In the article, the co-authors analyze the natural resources, available in Tatarstan and the prospects for the establishment of enterprises for the production of construction materials in Tatarstan. The co-authors consider alternative cement delivery routes, key products needed for the development of housing and industrial construction to ensure the economic prosperity of Tatarstan.

The co-authors have also analyzed the economic efficiency of investment projects to be implemented in Tatarstan Republic, including the launch of a cement production facility that will take advantage of the mineral resources in the Ulyanovsk region minerals and the imported clinker to be delivered from Iran by water. The co-authors have also considered the potential construction of the toll highway “Shali (M-7) – Bavly (M-5)”.

Keywords: *construction enterprises, cement, air hardened binding materials, toll highway, total investment costs*



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INTRODUCTION

In May, 2011, within the framework of the cooperation plan, the Cooperation Agreement was signed between the Ministry of Transport and Road Facilities of the Republic of Tatarstan and the State Committee of the Republic of Tatarstan on transport and road economy. This agreement entailed the construction of the category 1A highway as a part of the Europe – Western China transport artery, passing through the territories of both republics (Fig. 1). The new international road, titled the Europe – Western China international transport corridor, to be constructed along the St. Petersburg – Kazan – Orenburg – Aktyubinsk – Almaty – Khorgos route, is an optimum way to connect Europe and China; it passes through the minimum number of countries and crosses the minimum number of borders (Fig. 2)[1, 2, 3, 4, 5].

As part of the Europe – Western China international transport corridor project, Tatarstan is implementing the investment project “Construction of the toll highway “Shali (M-7) – Bavly (M-5)” as part of new artery of the federal highway “Kazan – Orenburg”, within the framework of the project “Sviyazhsk interregional multimodal Logistics Centre (SMMLC)”, needed to accelerate the development of construction enterprises in Tatarstan. The total cost of the project is 18.3 billion rubles. The centre is located at the intersection of key primary railways, waterways, and highways, which can minimize transportation and intra-warehouse costs[3, 4, 5, 6, 7, 8, 9].

GENERAL PART

Cement is the most widely used resource on Earth after water, as its annual consumption equals to about one ton per person.

The Russian cement industry is gradually recovering from the crisis caused by COVID-19. A decline in

1 On the adoption of Strategy of socio-economic development of the Republic of Tatarstan till 2030 : Law of the Republic of Tatarstan dated June 17, 2015 No. 40-ZRT with changes for December 25, 2019 (in an edition. Laws RT of 05.04.2019 No. 31-ZRT, of 25.12.2019 No. 112-ZRT) it is accepted by the State Council of the Republic of Tatarstan on June 10, 2015.

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4 On approval of the State program “Transport system of Tatarstan development for the period 20142024” : The resolution dated December 20, 2013 No. 1012 (as amended on July 30, 2021).

5 On approval of the concept of import substitution in the construction industry for the period 2015–2016 in the Republic of Tatarstan : The instruction dated September 19, 2015 No. 2091-r.

6 On approval of the Concept of creating an industrial zone on the territory of the prospective development of the Sviyazhsk Interregional multimodal logistics Center : Resolution of the Cabinet of the Republic of Tatarstan of July 18, 2012 No. 613.

7 On approval of Transport complex of Tatarstan development Strategy for the period 2016–2021 with prospect till 2030 : The order dated July 24, 2017 No. 253 (amended as of February 27, 2020) (in an edition. Order of the Ministry of Transport and Road Facilities of RT of 27.02.2020 No. 72).

8 Methodology for calculating the fee amount for toll roads and road facilities. The procedure for its collection and revision. Assessment of consumer demand. Approved by Order of the Ministry of Transport of the Russian Federation dated 19.05.2003 No. OS-435-r: industry road methodological document

9 Industry Road Methodological document (ODM) 218.11.006-2021. Methodological recommendations for assessing the efficiency of the use of innovations and achievements of scientific and technological progress in the road sector: industry road methodological document.

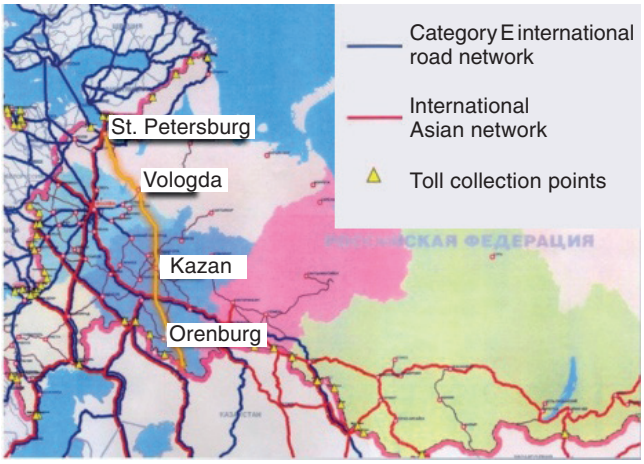


Fig. 1. Europe – Western China international corridor

demand was caused by the construction activity decrease in the country due to shutdowns of many infrastructure projects.

Cement is manufactured in 156 countries of the world. The major producers of cement are China, Russia, Japan and India.

The cement industry is of key importance for the economic development as it is main type of building materials for the construction of residential, industrial and infrastructure facilities. The rate of the cement industry development is 1.5–2 times higher than the global GDP growth rate [1].

In many regions of the Russian Federation, including Tatarstan, soil is composed of rock of sedimentary origin, including carbonate rock, like limestone and dolomites. Due to the features of the geological composition of the Earth crust, the territory of Tatarstan is not rich in carbonate raw materials, and their quality varies [1–3].

Carbonate raw materials are unevenly distributed over the territory of 43 districts of Tatarstan.

A consolidated analysis of mineral resources of the Tatarstan Republic has shown that the republic has 340 deposits of carbonate rock, 66 of them can be used for construction purposes. They include the saw stone, raw materials for the production of lime, magnesia binders and limestone flour. The amounts of raw materials usable for the production of non-combustible materials and hydraulic binders have not been determined.

According to the "Strategic concept for the capital construction development of the Tatarstan Republic until 2030", today the republic has the following reserves of carbonate mineral raw materials: crushed stone — 178,137.6 thousand m^3; saw stone — 15,039 thousand m^3; decorative and finishing stone — 823.5 thousand m^3; limestone binders — 68,532.5 thousand tons; magnesia binders — 3,647.5 thousand tons; ameliorants — 101,882.8 thousand tons [1].

The analysis of their application has shown that the republic does not produce raw materials used to make facing stone, dolomite lime and dolomite cement, hydraulic binders (Portland cement, hydraulic lime, roman cement), refractories and other materials not considered in this paper [4, 5].

In Tatarstan, there is practically no production of air binders made of local carbonate raw materials.

In the republic, limestones and dolomites, sandstones, are used in construction. In total, about 80 deposits of the building stone, widely used to produce crushed stone of the "200" brand, were taken into account.

There is one saw stone deposit within the republic, that is, the Karkalinskoye deposit, located in the Leninogorsk district. This saw stone is used in the construction of walls, ceilings and partitions.

Sand and gravel mixes (SGM) are the most popular mineral construction raw materials, widely used as concrete, reinforced concrete, and asphalt concrete fillers. They are also used to make plaster and masonry mortars and the ballast for foundations of highways. Tatarstan has about 60 SGM deposits. Building sand is concentrated in the water area of the Nizhnekamsk water reservoir near Kazan.

There are very few pure limestones in Tatarstan.

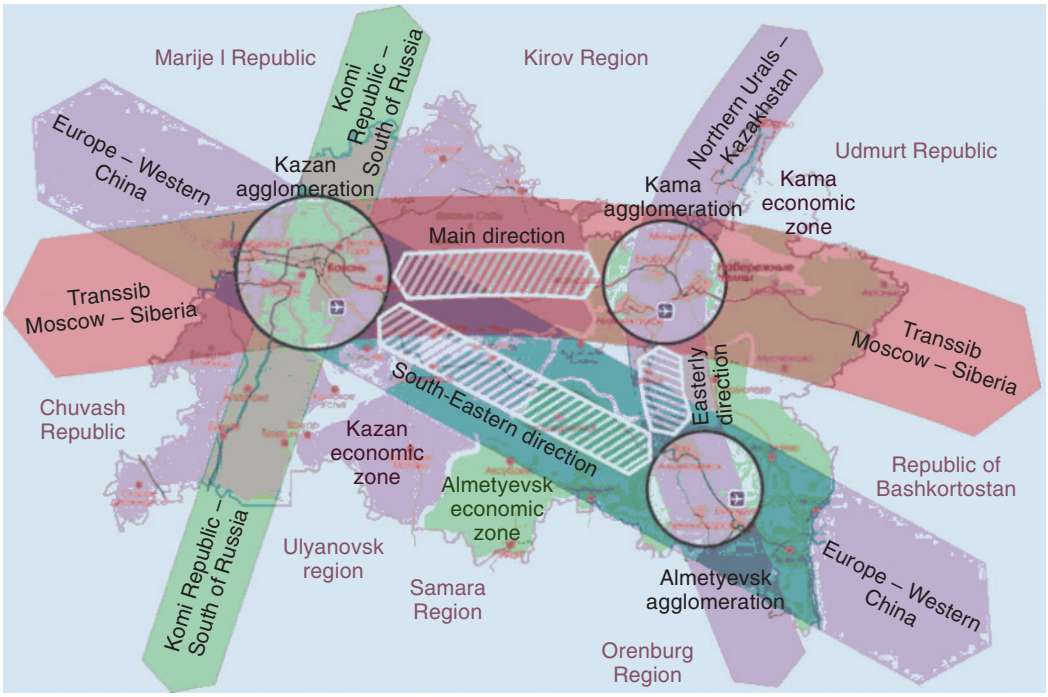


Fig. 2. The Republic of Tatarstan in the context of federal and cross-regional transport corridors

The development and application of resource- and energy-saving technologies for the production of building materials are feasible if local mineral raw materials are used. Their use must be based on the selective approach to raw materials; increasing the suitability of raw materials (for example, by switching to carbonate raw materials), the use of multi-level technologies to increase waste-free production; reducing energy consumption (reducing the temperature of heat treatment, duration of technological processes, etc.); using additives to expand the range of functional properties; optimizing properties and expanding the range of products.

However, the project of own cement production in the Republic of Tatarstan has a significant natural barrier. The point is that there are only three relatively large deposits of cement raw materials in the republic: Zelenodolskoye, Drozhzhanovskoye and Mendeleevskoye, and none of them are suitable for the organization of industrial production in terms of required volumes and quality [6–8].

Thus, at the moment, it is impossible to build a full-cycle cement plant with a capacity of more than 1 million tons of cement per year. To launch a plant of such capacity, deposits of low magnesium limestone having reserves of more than 50 million tons are needed, which are not available in the republic.

Therefore, the most competitive are the following options of providing the Republic of Tatarstan with cement:

- the purchase of finished cement from the Saratov region (OAO "Volskcement plant");
- the purchase of finished cement from the Mordovia region (OAO "Mordovcement");
- the purchase of finished cement from the Ulyanovsk region (OAO "Ulyanovskcement");
- a joint venture to be set up for the production of cement on the basis of the Ulyanovsk region deposits;
- logistics chains to ensure the purchase of the cement clinker from Iran to launch the manufacturing process [6].

If finished cement is to be purchased, the following suppliers can be considered:

Volsky sulphate-resistant cements are ideal for the manufacture of concretes that withstand the influence of corrosive media containing sulphates (when the concentration of sulfate ions exceeds 3000 mg-eq/l). A distinctive feature of Volsky sulphate-resistant cements is its lower heat release during hardening (2–3 times), which allows them to be successfully used in the construction of large cast-in-place structures (dams, port berths, etc.). Volsky cements are recommended for use in conditions of multiple freezing and thawing, moistening and drying of the cement stone (50–70 cycles).

Mordovian cement was used to make the dams of hydroelectric power plants on the Volga and Kama, hydraulic structures of the irrigation systems of Central Asian republics, ports in Murmansk, Tallinn, Nakhodka, Arkhangelsk; Nizhny Novgorod and St. Petersburg subways, Volga and Kama car factories, Cherepovets smelter, Cheboksary plant of industrial tractors, sports facilities of the 27th World Summer Universiade 2013 in Kazan, 22nd Winter Olympic Games 2014 in Sochi [6].

The raw materials supplied by JSC "Ulyanovsk Cement" allow for the early setting strength due to the high content of aluminum oxides. The plant isa smoothly operating facility; quality control is carried out at every stage of production from the supply of raw materials to the shipping of products to end consumers.

THE ECONOMIC FEASIBILITY ANALYSIS OF INNOVATIONS

A. The economic feasibility analysis of launching cement production

The per-ton cost of cement delivery to construction industry enterprises, with transportation charges included, is presented in Table 1.

Potential investors are willing to launch cement production and use imported clinker. The capacity of the cement production facility will reach 1 million tons per year.

Since the delivery of clinker by water transport is considered the cheapest alternative, it is assumed that two manufacturing facilities with the total capacity of about 2 million tons of cement per year will be launched in Kazan and Naberezhnye Chelny. Subsequently, it is

Table 1. Per-ton cement cost with transportation charges included

Breakdown of expenses	Total rubles per ton
Transportation by rail from Volsk (593 km)	
Per-ton price of cement	3,800
Transportation charges	1,323.61
Total cost with the transportation charges included	5,123.61
Transportation by rail from Mordovia Republic Railway station Nuya (593 km)	
Per-ton price of cement	3,600
Transportation charges	921.29
Total cost with the transportation charges included	4,521.29
Transportation by rail from Ulyanovsk (246 km)	
Per-ton price of cement	3,900
Transportation charges	820.67
Total cost with the transportation charges included	4,720.67

advisable to replace part of the imported semi-finished product with clinker made of local raw materials.

The final cost of clinker imported from Iran consists of the manufacturer's price and transportation charges and totals at 2,320 rubles per ton (Table 2).

Table 2. The per-ton cost of clinker transported by water from Iran with transportation charges included

Types of costs	Total rubles per ton/for 1,791 km
Per-ton price of clinker from Iran	1,980
Transportation charges	340
Total costs with transportation charges included	2,320 rub/ton

Hence, due to the favourable geographical position, it is possible to launch a joint venture in the Tatarstan Republic to be engaged in the manufacturing of cement based on Ulyanovsk region's minerals. The research calculations made using Alt-Invest-Construction software shows that the total amount of investments required for the construction of a joint venture equals to 20,008,774 thousand rubles, and the major part of the amount will be invested into buildings and structures.

Besides, it is economically feasible to produce cement from clinker imported by water from Iran.

The purchase of cement clinker from the Islamic Republic of Iran is designated for the production of cement from imported clinker on the territory of the Sviyazhsk Centre in the Republic of Tatarstan. Located at the crossroads of the international transport corridors "North-South" and "West-East", with access to the Federal railroad, water, and motor highways, Sviyazhsk logistics terminal can become the nucleus of the transportation and logistics system of the Volga region in the future [1].

The terminal is capable of becoming a major imported and exported cargo handling point that will serve all Volga regions, as well as a key river port for cargo transportation using international transport corridors.

The project implementation term is up to 4 years. The term is determined based on reaching the enterprise's full capacity, the term of repayment of borrowed funds. The total amount of investments to be made is 575,146 thousand rubles, the major portion of this amount will be invested in the construction of buildings and structures (Table 3).

The main research findings are presented in Fig. 3.

B. Economic justification of the toll highway construction megaproject

Highway parameters: length — 299 km; 1A technical category; 4 lanes with a median strip; no intersections at the same level; maximum speed — 150 km/h.

The construction of highway "Shali (M-7) – Bavly (M-5)" is conditionally divided into four sections: "Sorochy Gory – Shali (M-7)" — 40 km; "Bridge crossing over the Kama River at Sorochy Gory village" — 14 km; "Alekseevskoe – Almetyevsk" — 145 km; "Almetyevsk – Bavly (M-5)" — 100 km [6].

Let's consider the methodology used for calculating the fee charged for toll roads and road facilities in relation to the analyzed facility.

The fee must correspond to the number and quality of services provided to the user of a toll highway or a road facility, and take into account the need to fully or partially cover the costs of construction (reconstruction) of a highway or a road facility and the cost of their operation [8–10].

The benefits of toll roads and road facilities are:

- savings in operating costs (transportation costs) in the form lower fuel and lubricant consumption, tire wear, repair and other costs;
- shorter goods/passengers delivery time; higher comfort and traffic safety.

Table 3. Total investment cost efficiency

Indicators	Values	Measurement unit
A cement producing joint venture that will consume minerals from the Ulyanovsk region		
Required investment amount	20,008,774	thousand rubles
Cement price per ton	4,450.37	rub
Simple payback period	5.14	years
Net present value (NPV)	688,179	thousand rubles
Discounted payback period (DPP)	7.65	years
Internal rate of return (IRR)	27.6	%
Cement production from clinker imported by water from Iran		
Required investment amount	575,146	thousand rubles
Cement price per ton	3,800, 00	rub.
Simple payback period	3.57	years
Net present value (NPV)	8,987,319	thousand rubles
Discounted payback period (DPP)	3.61	years
Internal rate of return (IRR)	192.3	%

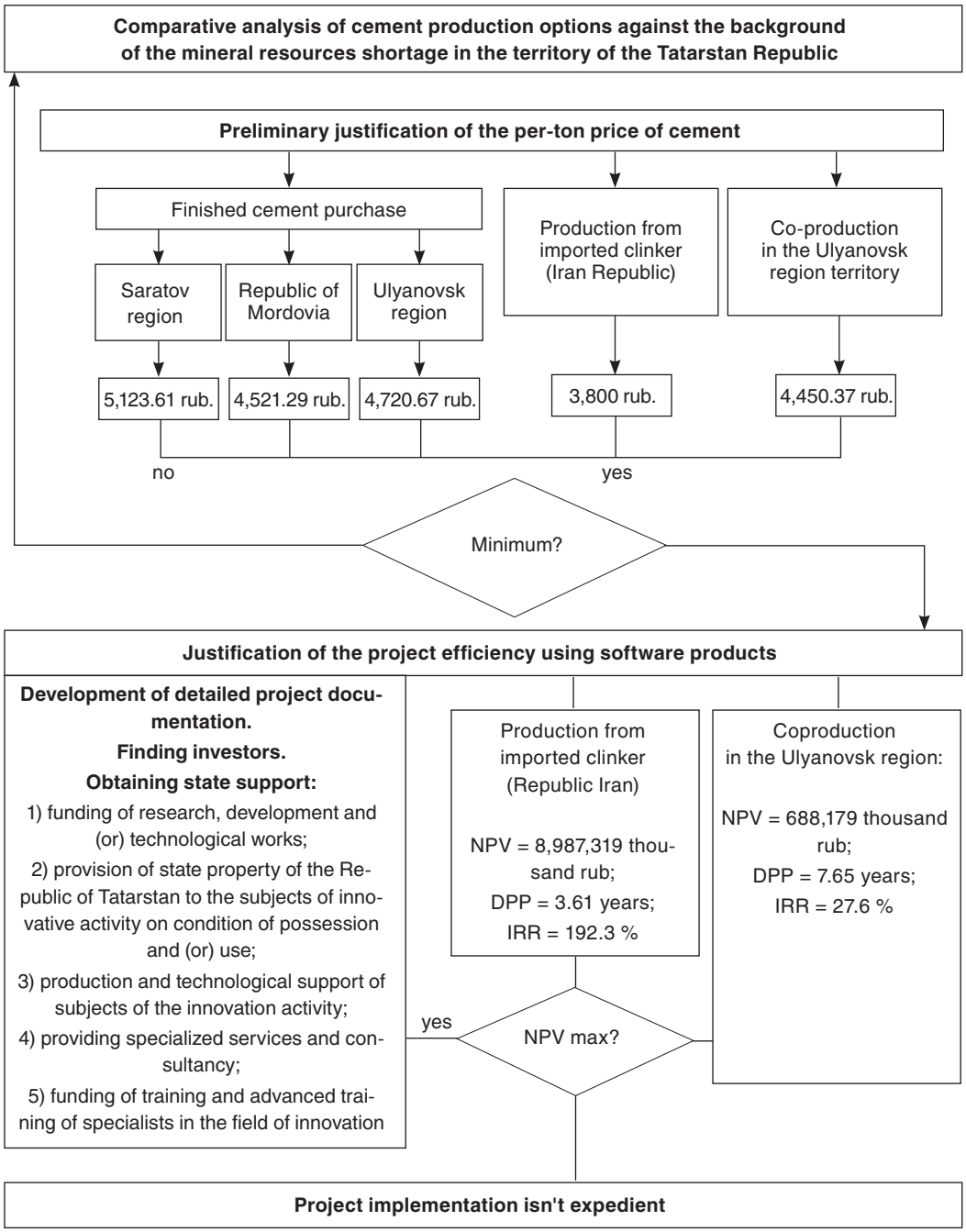


Fig. 3. Comparative analysis of cement production options against the background of mineral resources shortage in the Tatarstan Republic

The maximum toll amount must not exceed the ultimate (maximum) value of savings made by users of toll highways and roads.

Today, cargoes are delivered from Europe to Asia and back by sea through the Suez Canal. The delivery time via this route with a length of 21 thousand km is 30–40 days. An alternative option is the delivery by road using the Europe – Western China route, here, the delivery time is 14–18 days. The advantage of the road transport corridor Europe – Western China for cargo owners is its low cost and delivery time.

As part of the international project on building the transport corridor Europe – Western China, the Republic of Tatarstan is implementing an investment mega-project on construction of the toll highway "Shali (M-7) – Bavly (M-5)" as part of a new route for the Federal highway Kazan – Orenburg (Fig. 4) [6].

The Tatarstan Republic is one of the most developed regions of Russia in terms of the transportation infrastructure. In the coming years, promising megaprojects will be implemented in the region, attracting additional cargo flows to its territory and revenues to be generated by transit operations not only in Tatarstan, but also in Russia as a whole.

About 20 million tons of cargo is currently transported through the territory of the Russian Federation from Asia to Europe, and over a third of it passes through the territory of the Volga Federal District. The annual cargo flow across the border of the Republic of Kazakhstan and the Orenburg region is about 7 million tons. According to



Fig. 4. Situational plan of highway "Shali – Bavly"

the experts' forecasts, cargo transportation across Russia in the Asia–Europe direction may increase significantly in the next 15–20 years, reaching about 100–150 million tons a year [8, 9].

The toll charge is differentiated depending on the type and carrying capacity of vehicles. The classification of vehicles is presented in Table 4. [17, 18].

Each of these four groups has a characteristic vehicle: Vaz-2170 LADA Priora, GAZ-3310 Valdai, KamAZ-5520, Nefaz 3297. Amounts saved by these vehicles, if they take the toll route, are calculated and compared with the same vehicles taking alternative routes, and the resulting values are applied to the entire group.

The process of calculating the toll charge and compiling the toll charges list has the following stages: initial data collection and list drafting; calculating amounts saved by users of toll roads in comparison with alternative free routes; assessing the consumer demand for travel services on toll roads; determination of optimal toll charges; compiling the toll charges list.

The economic evaluation S_Σ of total savings (effect) made by the user of the toll road includes (Fig. 5):

$$S_\Sigma = S_{op} + S_d + S_t + S_a, \quad (1)$$

where S_{op} — costs saved due to the vehicle operation on a toll road facility compared to an alternative road; S_d — savings from

Table 4. Vehicle classification

Groups and types of vehicles	Identification	Classification	
		Weight, *t*	Axis number
Group I Motorcycles with and without a trailer (sidecar) Passenger cars with and without a trailer Vans, minibuses with up to 11 seats, trucks	G1	Below 3.5	Two
Group II Trucks Trailers Buses with 11 to 29 seats	G2	From 3.5 to 8.0	Less than three
Group III Trucks Trailers	G3	More than 8.0	More than three
Group IV Buses with 30 + seats Special large-sized vehicles	G4	More than 8.0	Is not used

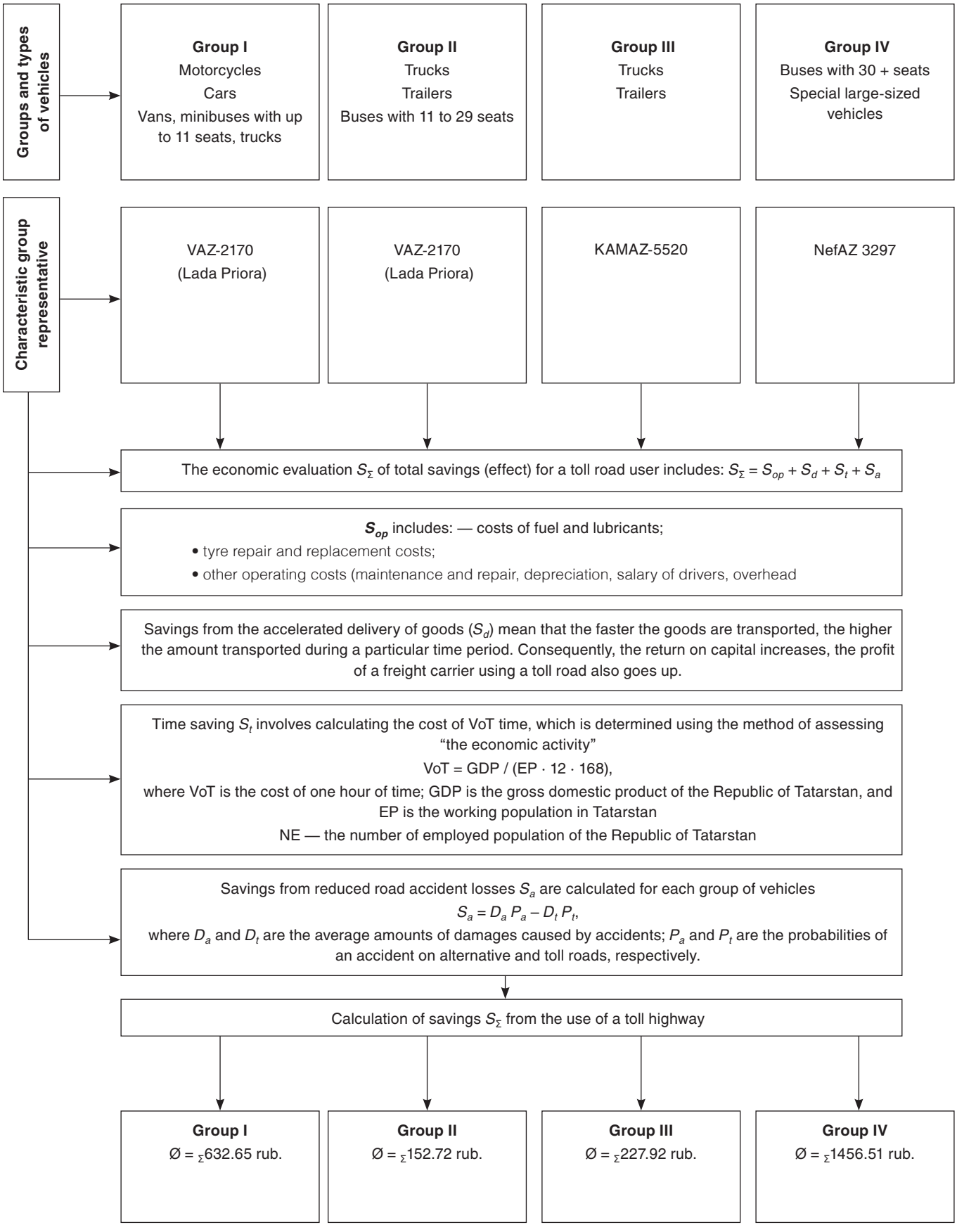


Fig. 5. Economic evaluation of total benefits (effect) obtained by the user of the toll road

speeding up the cargo delivery; S_t — savings from the reduced travel time; S_a — savings from reducing the risk of accidents.

The efficiency of the total investment costs in respect of the project on the construction of a toll highway is calculated using the Alt-Invest-Construction software (Table 5).

The discounted payback period (PP) is the minimum period required to achieve zero NPV. It is 6.66 years (see Fig. 6), given that the service life of the highway without major repairs is 15–19 years.

When calculating the performance indicators, project risks were taken into account at various project stages, including preparation, construction and operation (Table 6) [11, 12].

The discount rate, taking into account the risks of the project, is calculated according to formula (2):

$$d = d_i + \frac{R}{100\ \%}, \quad (2)$$

where d_i is a risk-free rate, is determined using formula (3); R — risk adjustment.

$$d_i = \frac{1 + \frac{r}{100\ \%}}{1 + \frac{i}{100\ \%}} - 1, \quad (3)$$

where r is the refinancing rate of the Central Bank of the Russian Federation; i is the officially announced rate of inflation for the current year.

Hence, the calculated value of the discount rate equals to:

$$d = 0.04 + \frac{8\ \%}{100\ \%} = 0.12 (12\ \%).$$

Table 5. Total investment efficiency

Indicators	Values	Measurement unit
Construction of toll highway “Shali-Bavly” having improved fast-track pavement		
Investment amount required	19,067,455	thousand rubles
Toll charge amount	1,062	rub.
Simple payback period	4.89	years
Net present value (NPV)	14,120,323	thousand rubles
Discounted payback period (DPP)	6.66	years
Internal rate of return (IRR)	25.1	%

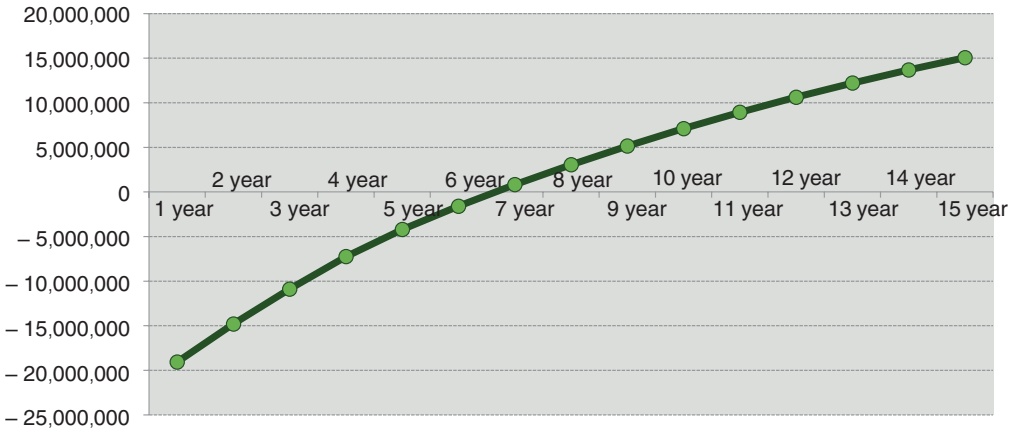


Fig. 6. Projected payback period for total investments

Table 6. Expert evaluation of project risks

No.	Simple risks	Wi (weight)	Pi (value of risk)
1	Preparatory stage (preparation)	0.12	1.00
2	Construction	0.2	2.00
3	Operation:	0.68	5
3.1	a) financial and economic	0.30	4.00
3.2	b) social	0.15	1.00
3.3	c) technical	0.15	0.00
3.4	d) ecological	0.08	0.00
Total project risk		R = 8.00	

We will simulate project risks on the basis of various initial indicators: the sale price, current (operating) costs, the discount rate, the required investment amount. The resulting value is the net present value of the project, or NPV (Fig. 7) [11].

Risk modeling has shown that NPV is most sensitive to the growth of project risks: an increase in the discount rate by 18 % will make the project will become ineffective. The safety margin is 40 %, since a 50 % reduction in the sale price makes the project ineffective. Performance indicators show little sensitivity to an increase in the investment amount and current costs.

CONCLUSION

Therefore, the toll highway project is financially feasible, cost-effective, and socially significant for the development of the Tatarstan Republic and the Russian Federation as a whole.

The following areas of development are set in the current "Strategy of the socio-economic development of the Republic of Tatarstan until 2030":

- renewal of transport and engineering systems, their intensive restoration and replication based on the development and implementation of effective social, scientific and technical programmes, federal and regional projects;
- increasing the investment attractiveness and innovative activity of industrial and construction enterprises, importation substitution and other actions.

These and many other tasks can be solved through the construction of transport arteries connecting the territories of advanced development, points of growth with all other municipalities, that need to boost their population and employment.



Fig. 7. Analysis of NPV sensitivity to changes in initial parameters

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Обоснование экономической эффективности реализации инновационных мегапроектов для нужд предприятий стройиндустрии (на примере Республики Татарстан)

Вектор стратегического развития Республики Татарстан (РТ) необходимо определить, чтобы сделать вывод: какой будет республика через 10–20 лет. Как показывает территориальное зонирование республики, основное развитие затрагивает три крупные агломерации: Казанскую, Камскую и Альметьевскую. При этом многие районы остаются в стороне от движения товаро- и ресурсопотоков. Рассмотрение логистики позволяет предположить, что необходимо развитие дорожной транспортной сети, в том числе строительство необходимых мостов, туннелей и использование возможностей речного транспорта (как самого дешевого). Одновременно с развитием транспортных артерий необходимо создание точек опережающего развития, точек роста строительной отрасли, проведение модернизации и реконструкции предприятий стройиндустрии и, как следствие, сопутствующих отраслей.

В данной статье проведен анализ состояния минерально-сырьевой базы РТ и перспективы создания на территории РТ предприятий по производству строительных материалов. Рассмотрены различные варианты обеспечения РТ цементом, имеющим ключевое значение для развития жилищного и промышленного строительства и в целом для экономического развития РТ.

Выполнено обоснование экономической эффективности реализации на территории РТ инвестиционных проектов по созданию предприятий по производству цемента на базе полезных ископаемых Ульяновской области и из привозного клинкера, доставляемого водным путем из Ирана, а также по строительству платной автомагистрали «Шали (М-7) – Бавлы (М-5)».

Ключевые слова: *предприятия стройиндустрии, цемент, воздушные вяжущие материалы, платная автомагистраль, полные инвестиционные затраты*

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