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# Risk in transport projekts

**Abstract:** The paper discusses the issue of risk in transport projects. The first part includes the analysis of definitions developed to describe the notion of risk. Based on the studies of the literature on the subject, the author discusses the ways the scholars dealing with this subject-matter perceive risk. The second part includes the discussion of risk sources and factors in transport projects, depending on individual project implementation stages. The third part consists in the author's analysis of risk sources together with the presentation of basic risk factors assigned to such sources which affect the possibility of reaching the set objectives as part of a transport project being implemented.

**Keywords:** Risk; Source of risks; Risk factor

## Introduction - definitions

Risk is a common phenomenon in all areas of human life and activity. The word "risk" comes from Latin, where the verb "risicare" means to avoid something. This word can also be associated with the Greek rhize, which refers to "around the cape", i.e., a bold act [8, 12]. In other languages, the word sounds similar (risk, French risque, German risiko, Italian rischio), but it is an ambiguous concept, not easy to interpret, having many definitions depending on the field it refers to [1, 4, 8, 14, 22].

The risk was defined in the most concise way in the ISO 9000:2015 standard, where it was defined as the "impact of uncertainty," also pointing out that uncertainty is also the lack of information [19].

The Dictionary of Foreign Words and the Dictionary of the Polish Language define risk in a similar way as "an undertaking whose result is unknown, dependent on chance, uncertain, or whose risk is the possibility that something will fail" [15, 24].

Creating one universal definition is impossible, but in a general way, it can be said that risk is a measure of a condition or event that can lead to losses. This measure is proportional to the probability of the event and to the amount of loss that the event may cause. Using the concept of probability, risk (R) can therefore be defined as the product of the probability of an event occurring and the consequences of its occurrence (this measure can be expressed, for example, in the form of the value of costs or losses), i.e.:

$$R(A) = p(A) * m(a)$$

where:
R(A) – risk of the event A
p(A) – probability of the event A
m(A) – consequences of the event A

In the work on the development of the definition of risk, economists and mathematicians were the leaders. One of the first concepts of risk theory, formulated for the needs of economists, was presented in 1901 by A.H. Willett [27]. According to him, "risk" is the objectified uncertainty of the occurrence of an undesirable event. The risk will change with the uncertainty, not with the degree of probability. Willett assumed that "risk" is a term with different meanings commonly used in everyday life. Combining the concept of risk with uncertainty and using philosophical determinism, he decided that one should only talk about the impression or illusion of randomness, which is the result of imperfect knowledge of the

laws governing reality. Other researchers formulated their thoughts in a similar spirit. J. F. Sinkey [23] defined "risk" as uncertainty related to some future event or income. Uncertainty, according to him, was reflected in unexpected changes in events. W.A. Rowe [21] stated that risk is the possibility of the realization of something undesirable, a negative consequence of a certain event. According to L.N. Tepman [26], the risk is the possibility of an unfavorable situation during the implementation of plans and budgets for the enterprise. This author emphasized that risk is a category that should be understood as a potential probability of losing resources or not earning income in comparison with the variant taking into account the rational use of resources in a given period of economic activity. In this case, the risk is understood as the danger that the investor will suffer losses in resources or that his income will be lower than expected. The next concept of the economic theory of risk, known in the literature as the concept of measurable or immeasurable uncertainty, was proposed in 1921 by F. Knight [10]. According to the concept proposed by him, the risk is a measurable uncertainty, while the uncertainty that cannot be measured is called immeasurable uncertainty. Another definition, developed for the use of insurance business, was a concept prepared in 1996 by the Insurance Terminology Commission of the United States [25]. The committee's work resulted in two definitions of risk. The first of them defined risk as the uncertainty about a specific event under the conditions of two or more possibilities. In this case, the risk is a measurable uncertainty that answers the question: will the intended goal of the action be achieved? The second definition, on the other hand, concerned the insurance practice, defining the risk as the insured person or the insured entity.

Extensive considerations on the types of risk definitions found in the literature can be found in the paper by P. Niedziółka [17] devoted to interest rate risk management in a bank.

In technical literature, the word "risk" has many meanings. As mentioned earlier, the risk is commonly associated only with a threat or with both a threat and an opportunity at the same time. This term, in this approach, means a state or a set of conditions in the environment in which decisions are made, implying consequences unknown at the time of making these decisions. This term is commonly used to describe situations such as: accidents, unforeseen events, the possibility of loss, and the possibility that the result obtained will be different from the expected [27]. In particular, these can be dangerous events with catastrophic consequences, such as explosions in nuclear power plants or chemical plants, dam failures, accidents in the transport of dangerous goods, accidents in the construction of tunnels, and others. In the case of technical situations, the concept of probability is often used and then risk can be defined as [6,7]:

- the probability of a negatively assessed event,
- the degree of probability of occurrence of events beyond the control of the acting entity, which he cannot accurately predict and which cannot be fully prevented, but which - by reducing useful results and/or by increasing costs - would completely or partially deprive the action of the feature of effectiveness, advantage, and economy,
- the probability of incurring a loss related to making a specific economic decision, e.g. risk is a measure of the uncertainty of income expected in the future as a result of a specific capital investment,
- risk is the probability of not achieving the set goals.

Some definitions refer generally to the possibility of events of a different nature, i.e., positive or negative. The materials of the Ministry of Regional Development define "project risk" as "the probability of occurrence of a phenomenon or activity outside the project team's sphere of influence, which may have positive or negative effects on the course of the entire project or/and its particular parts" [2].

In engineering practice, the definition of risk has been adopted as the possibility of the occurrence of only undesirable events that affect the course of project implementation by

increasing the implementation costs, extending the implementation deadline, or changing the scope of work related to the project implementation.

Therefore, a feature of the projects is the prevalence of risk and its inevitability. The larger the project, the more sources of risk can be distinguished and the higher the probability that adverse events will occur.

When they occur, these undesirable events are referred to as "materialized risks."
Risk classification is also an important issue. In the literature on the subject, you can find many different classifications taking into account political, technical, or economic aspects [16]. And so:

- L.N. Tepman [26] made a classification according to the basic causes (sources) of risk, i.e., transport, natural, ecological, or commercial.
- M. Księżyk [13] classified the risk according to the sources of entrepreneurs' profits (e.g., innovations and entrepreneurship).
- H. Peumans [18] divided the risk according to the author's feelings (objective or subjective).
- L. Korzeniowski [12] introduced a classification that takes into account such aspects as: technical conditions of project implementation, future market conditions, owners' lack of interest in the company's activities, the quality of cooperation with a partner, or moral attitudes of partners' behavior.
- According to T. Kaczmarek [9], in the case of economic activity, risk classification should take into account: legal aspects, contractual conditions, the so-called force majeure, organizational aspects, transport problems (in the case of transport over long distances), changes in currency quotations, and, consequently, the value of the contract during its implementation, inflation.
- C. Prichard [20] proposes a classification system based on five levels: technical, program, service, cost, and schedule.

Many eminent scientists contributed to the development of the area of knowledge related to risk. In the 17th century, the French scientist B. Pascal became interested in the theory of probability, and together with P. de Fermat, he developed a method of analyzing future events. This procedure made it possible to determine the probabilities of possible outcomes, assuming that these outcomes were mathematically measurable. The beginning of the 18th century brought research by the brothers J. and J. Bernoulli in the field of utility theory. This theory defined the requirements for measuring utility in all circumstances and allowed choices and decisions to be made according to this measure of utility. Jacob Bernoulli led reflections on a new risk philosophy and decision-making process. He showed that, according to utility theory, a fair game is an unwinnable game. This fact allows many people to avoid risk by running a game or a business. Together with G.W. Leibniz, he discussed the relationship between probability and the quality and quantity of information and defined the conditions that should be met in order to be able to determine the probability of certain events with a limited amount of information. He gave a solution requiring only one assumption. It should be assumed that under similar conditions, the occurrence or non-occurrence of a certain event in the future will correspond to the same regularities that have been observed in the past. He also formulated in 1713 a law known as Bernoulli's theorem, or the law of large numbers, which states that with a probability arbitrarily close to 1, given a sufficiently large number of trials, the frequency of a given random event may be expected to differ arbitrarily little from its probability. Further work in this direction, related to the issue of cause and effect, was carried out, among others, by P.S. Laplace (1749–1827) or J.H. Poincare (1854–1912). In 1926, J. von Neumann (1903-1957), an outstanding physicist and mathematician, presented his theory of strategic games at the Mathematical Society in Göttingen, which later

became the basis of game theory and its application in the decision-making process in the entire economy.

Research conducted at the end of the 20th century and the beginning of the 21st century on risk and methods of its estimation is characterized by an increasingly intensive combination of risk with environmental issues, especially in the relationship between man and the environment, and the need to conduct interdisciplinary research. Despite this awareness, a single research concept of risk and its universal definition has not been developed so far.

**Sources of risk in transport projects**

A transportation project is a special type of project. Sources of risk in projects can be divided depending on the stage of their occurrence [2] :

a) Project definition stage:
- unavailability of expert knowledge,
- insufficient definition of the project,
- no feasibility study,
- unclear goals of the project,
- errors in tender procedures.

b) Planning stage:
- no risk management plan,
- -hasty planning
- insufficient specification of project products,
- unclear division of roles in the project,
- lack of experience in the project team.

c) Implementation stage:
- insufficient qualifications of employees,
- availability of resources,
- weather,
- changes in the scope of projects,
- changes in the work schedule,
- lack of monitoring and control,
- disruption of financial liquidity.

d) Completion stage:
- insufficient quality of the project,
- lack of acceptance by the end customer,
- project evaluation and audit,
- formal and legal requirements.

The listed sources of risk are mainly related to the internal aspects of project implementation, e.g. lack of appropriate qualifications or experience of people preparing the project, changes in the project scope, lack of appropriate resources, incorrect cost calculation or procedural errors.

The second very important group of sources are external sources over which the investor and contractors have no influence. These are primarily:
- legal and procedural changes,
- economic events,
- political events,
- social events.

The transport project belongs to a group of projects of a complex nature, primarily due to its scope and scale, the diversity of stakeholders, and the financial outlay involved. It is a

complex undertaking of a multidisciplinary nature. The implementation of the project concerns solving problems in the field of cases:

- social,
- historical,
- natural environment,
- economic,
- financial,
- technical and technological,
- urban and architectural,
- legal,
- security.

In transport projects (especially linear ones), the above-mentioned problem areas may occur in different forms and intensity depending on the location of a specific element of the project. There is also an interaction between individual areas of implementation and expectations related to meeting the needs arising from the mentioned areas, which often leads to mutually exclusive solutions and ideas. The complexity of the issues causes transport projects to be characterized by great difficulties in meeting the parameters assumed at the beginning, such as the deadline and cost of implementation.

Projects, and in particular transport projects, are activities carried out in an identifiable environment that surrounds them. Recognition of the environment and the factors that characterize it is important for the success of the preparation process and the achievement of the goals set for the project in the future.

There are no standard procedures on the market of domestic transport projects, established and issued in the form of standards or regulations, which would describe the risk areas for transport projects and the conditions for the project that are generated by a given area.

One possible way to define areas and the risk elements present in them is presented in the Guide published in 2010 by the Public Procurement Office. It presents 14 risk categories with appropriate assigned risk elements for each of them (Table **1**).

The featured categories are [11]:

- risks associated with construction,
- availability risks,
- risks related to the demand,
- risks related to the preparation of the project,
- market risks related to the availability of inputs for the implementation of the project,
- political risk,
- legislative risk,
- macroeconomic risk,
- regulatory/tariff risk,
- risk related to the revenues of the venture,
- risk related to the occurrence of force majeure,
- risk related to dispute resolution,
- risk related to the state of the natural environment,
- risk related to the location of the project,
- risk related to the transfer of assets.

**Tab. 1**. Risk categories

| Risk category | Risk elements |
|---|---|
| Construction risks | • delay in the completion of construction works<br>• non-compliance with the conditions concerning the established standards of works performance<br>• costs increase<br>• occurrence of inaccuracies in the specification of partner selection in the implementation of the project<br>• risks related to the influence of external factors<br>• occurrence of solutions inadequate to the project's purpose in the design documentation<br>• risks related to the emergence or application of new technologies for the implementation of the project<br>• occurrence of physical or legal defects reducing the value or rendering the asset useless |
| Risks related to the availability of services | • inability to provide a certain number of services<br>• non-compliance with safety or other industry standards<br>• costs increase<br>• the manner and quality of the work performed to deliver the services<br>• inadequate qualifications of employees<br>• occurrence of technological changes |
| Risks related to the demand | • emergence of competition<br>• cyclicality of demand<br>• price changes<br>• use of outdated technologies<br>• emergence of new market trends |
| Risks related to the preparation of the project | • availability of information on the planned implementation of the project<br>• introducing changes to the partner selection specification<br>• the manner and quality of the partner selection procedure<br>• resignation from the implementation of the project |
| Market risks related to the availability of inputs for the implementation of the project | • inability to obtain inputs of a certain quality<br>• impossibility of obtaining outlays of a certain amount<br>• inability to obtain expenditures within a specified period<br>• price change<br>• emergence of competition<br>• logistic problems<br>• maladjusted labor market |
| Political risk | • a risk of changes in the policy sphere that relate to the implementation of the project |
| Legislative risks | • a risk of changes in legal regulations affecting the implementation of the project |

**Tab.1.** Risk categories continued

| Risk category | Risk elements |
|---|---|
| Macroeconomic risks | • inflation<br>• change in interest rates<br>• exchange rate risk<br>• demographic changes<br>• changes related to the rate of economic growth |
| Regulatory/tariff risk | • a risk of changes in the regulations regarding payment systems within a given field of public utility services that affect the costs of project implementation or as a result of which the scope of rights and obligations of the parties under the project will change |
| Risk related to the revenues of the venture | • related to the method of remuneration of the partner under the project<br>• change in the applicable pricing mechanism<br>• changes in the implementation of the project-related fee collection mechanism |
| Risk related to the occurrence of force majeure | • leading to many consequences, including the inability to implement the project |
| Dispute Resolution Risk | • risks, the occurrence of which affects the method and effectiveness of resolving a dispute arising from the performance of the contract |
| Risk related to the condition of the natural environment | • risks related to the location of activities aimed at improving the condition of the natural environment before the commencement of the project<br>• a risk of deterioration of the natural environment as a result of the project implementation |
| Risk related to the location of the project | • legal status of the property<br>• archaeological or other cultural heritage discoveries<br>• property of existing infrastructure<br>• availability of manpower or other resources necessary to implement the project |
| Risk related to the transfer of assets | • the condition of the assets before their transfer<br>• flow of information regarding the assets involved in the project;<br>• performance of obligations and enforcement of rights related to the transfer<br>• receivables or other rights related to a given asset<br>• the need to transfer the workforce |

*Source: Own study based on B. Korbus (ed.) Public-Private Partnership UZP 2010 [11]*

Research in the form of interviews among representatives of companies implementing infrastructure projects in Poland was also conducted at the University of Gdańsk. As a result, the authors of the study defined key risk areas and assigned threats to them, i.e., elements affecting risk (Table **2**). The indicated risk areas are: environment, variability of ground

conditions and geological conditions, technical design, terrain, third parties, financing, political sphere, management, contract, market, employees, construction works, weather, and random.

**Tab. 2.** Elements affecting risk

| Area | Element affecting the risk/description of the hazard |
|---|---|
| **Environment** | • impact on biodiversity<br>• passages for animals, flows for fish<br>• problems related to the protests of pro-ecological circles<br>• occurrence of archaeological monuments in the area of works, archaeological discoveries<br>• hazardous materials used in construction<br>• risk of soil, water, and air contamination during the works<br>• violation of rare plant/animal habitats<br>• impact of the structure on drainage (rural areas) and sewage systems (urban areas)<br>• noise emission |
| **Variability of ground conditions and geological conditions** | • the need to redesign the structure<br>• introducing changes to performance standards in the project<br>• execution of additional earthworks, construction, and securing works |
| **Technical project** | • changes in the construction design (earthworks, slopes, structural elements)<br>• changes in the location of facilities (e.g. reconstruction of the roadside, change of entry point, exit from the motorway, location of the intersection)<br>• project coordination (changes forced by the implementation of other projects in a given area, e.g., construction of a road with a tram line)<br>• change of traffic organization devices (e.g. arrangement of lights, markings)<br>• changes resulting from operational conditions (change of overhaul schedule, an extension of periods between renewals, forcing the use of better materials) |
| **Terrain** | • changing spatial development plans<br>• the need to adapt to the future requirements of the development plan<br>• purchase of land |
| **Third parties** | • requests from individual third parties (e.g., in terms of design, additional elements, e.g., additional exits or entrances, soundproofing)<br>• requests from institutions (e.g., communes, cities, government agencies) |

**Tab. 2**. Elements affecting risk continued

| Area | Element affecting the risk/description of the hazard |
|---|---|
| **Financing** | • delays in transferring funds |
| **Political sphere** | • regulations<br>• changeability of regulations<br>• changes in taxation<br>• influence of the authorities on macroeconomic factors |
| **Management** | • change of contract management<br>• late decisions<br>• bad information flow |
| **Contract** | • change in the way the project is implemented<br>• unclear provisions (interpretations, lack of a common language of the contract, guarantees, insurance, compensation)<br>• delays in the process of settling tender procedures<br>• appeals against tender decisions<br>• non-competitive tenders (setting criteria favoring one contractor) |
| **Market** | • price changes<br>• no materials |
| **Employees** | • lack of suitably qualified employees<br>• employee errors |
| **Construction work** | • organization of traffic during works<br>• restrictions in the construction law (the need to apply for permits, e.g., to occupy a right-of-way)<br>• unrealistic schedule<br>• deterioration of transport accessibility during the works |
| **Weather** | • variability of conditions |
| **Random** | • employee accidents |

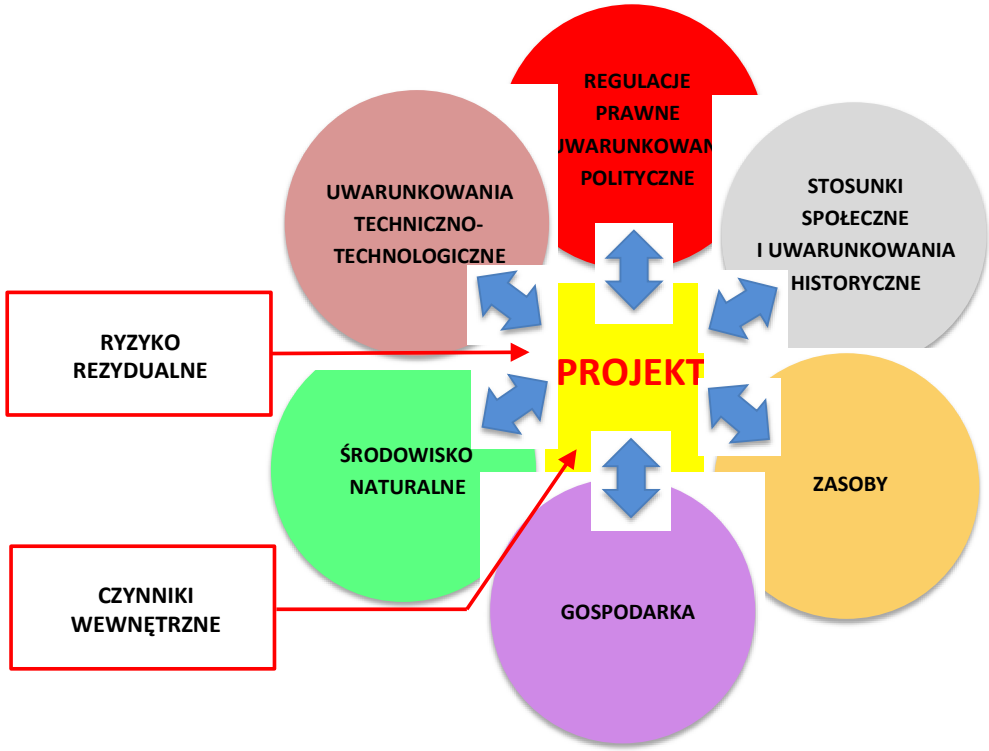
*Source: P. Borkowski Methods of objectifying risk assessment in infrastructure investments in transport University of Gdańsk 2013 [3]*

An interesting division from the point of view of the subject of the work was presented by S. Eksen et al. [5], who, discussing the problem of threats that may occur in the case of the construction of the metro, identified about 40 types of threats and grouped them into the following items:

- contractual disputes,
- insolvency and institutional problems,
- government interference
- interference by third parties,
- labor disputes,
- accidents,

– unforeseen unfavorable project implementation conditions,
– inappropriate (incorrect) designs, specifications, and procedures,
– failure of the main equipment,
– execution of works below standards or too slowly.

The experience of the author of the following work in the field of preparation, management, and supervision of infrastructural transport projects indicates that the parameters characterizing the conditions of the project environment should be ordered by creating sets, called risk sources, of a homogeneous thematic nature. It is also important to take into account the residual risk, which is commonly overlooked in the analysis of infrastructure transport projects (Fig. **2**).




**2**. Sources of risk
*Source: Own study*

There is a mutual relationship between the source of the risk and the project. This means that the factors contained in a specific source of risk affect the project, e.g. by causing the need to change assumptions or detailed solutions, and at the same time the project may cause changes in the outlined sources of risk, e.g. for improving the human resources situation, which will also be important for future projects.

The sources of risk can be divided into:
– social relations and historical conditions,
– legal regulations and political conditions,
– resources,
– economy,
– natural environment,
– technical and technological conditions.

Detailed risk factors can be assigned to each of the distinguished groups.

**Social relations and historical conditions**
This group includes risks related to historical conditions resulting from events that have taken place or are taking place in the areas where the project is located, as well as attitudes and positions presented by communities and authorities.

Examples of risk factors in this group include::

- residents' protests,
- negative impact on cultural heritage,
- archaeological finds at the construction site.

**Legal regulations and political conditions**
This group of sources includes current regulations and rules of conduct in all legislative processes necessary for the implementation of the project and

Examples of risk factors in this group include:

- lack of existing legal regulations in selected areas of investment implementation,
- changes in legal regulations affecting the course of the investment, in particular cases preventing its completion in the assumed scope,
- changes in regulations regarding the functioning of the completed investment (infrastructure elements), e.g., changes in fees,
- changes in spatial development plans,
- unregulated legal status of real estate,
- lengthy and complicated procedures related to obtaining permits required to carry out the investment,
- political pressures related to the course of the investment.

**Resources**
Risk factors in this group are related to the availability of resources necessary to implement the project and enabling the use of planned techniques and technologies, as well as methods of project management and supervision.

Examples of risk factors in this group include::

- lack of access to qualified human resources,
- non-compliance with the assumed standards of works,
- lack of access or limited access to the required tangible and intangible resources or service providers,
- physical defects in the acquired tangible assets,
- lack of scientific background enabling the use of the selected technology.

**Economy**
Risk factors in this group include broadly understood economic parameters of the country and region, which translate, on the one hand, into the demand for transport infrastructure and, on the other hand, into the costs of investment implementation.

Examples of risk factors in this group include:

- deterioration of economic indicators such as inflation, exchange rates, GDP, national income, interest rates, household disposable income, investment ratio, etc.
- lack of stability and predictability of funding sources,
- increase in investment costs resulting from changes in market prices,
- too low demand for services provided as a result of the completed investment,
- decrease in revenues generated by the investment,
- too low executive potential available on the market,
- no available business infrastructure.

**Natural environment**

This group of sources includes conditions related to the protection of environmental parameters and the condition of the natural environment.

Examples of risk factors in this group include:

- difficult or unknown ground and water conditions,
- deterioration of the natural environment as a result of the project, e.g., negative impact on biodiversity, soil, water, or air pollution as a result of the investment,
- excessive noise emission in connection with the investment,
- protests of representatives of pro-ecological circles,
- unfavorable weather conditions hindering the investment,
- the possibility of natural disasters.

**Technical and technological conditions**

Risk factors in this group are related to the use of investment implementation technology and the technical condition of buildings, structures, civil engineering facilities, and other infrastructure at the investment site.

Examples of risk factors in this group include:

- poor or unknown technical condition of buildings and structures in the project impact zone,
- the presence of non-inventoried infrastructure elements at the construction site,
- the need to introduce changes to the design in connection with other investments in the vicinity of the construction site,
- lack of access to modern techniques and technologies,
- the dilemma of implementing "innovative" solutions,
- technological changes that will occur after the completion of the design documentation and the commencement of the tender procedure,
- the poor capacity of the functioning infrastructure,
- logistic conditions hindering the technical service of the investment.

**Residual risks**

An important category in the analysis of risk sources is the residual risk, i.e., the risk remaining after applying the actions specified in risk management (PN-ISO 31000:2012), which cannot be eliminated. This means that even in a situation where actions are taken to minimize risk, eliminate risk or prevent risk, the implementation of the project is still subject to risk.

**Internal factors**

The sources of risk factors described above include only external factors. In addition to external factors, the proper course of the transport project is also influenced by internal factors related to the preparation of the investment.

Internal sources of risk include::

- inadequate preparation of the tender procedure,
- lack of suitably qualified employees to efficiently carry out the investment,
- the incomplete flow of information between the parties to the investment (investor, contractor, project manager),
- changes in the design resulting from inadequate preparation of the investment, e.g., due to insufficient soil testing,
- failure to comply with health and safety regulations on the construction site,

- incorrect, unclear, or incomplete regulation of the parties' obligations in contracts for the performance of works.

**Summary and Conclusions**

The article deals with the subject of risk in infrastructure transport projects. The complexity of this type of investment means that in the process of their implementation, there are significant problems with meeting the previously agreed conditions, i.e., deadlines and costs of project implementation.

It is extremely important to use, at the preparation stage, risk analysis methods that enable a multi-faceted assessment of the impact of risk on the possibility of achieving the assumed utility and financial goals of investments, i.e. methods that take into account not only technical and technological risks in the study, but above all organizational, environmental, and social risks.

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