Identification and Initial Risk Assessment of Construction Projects in Poland

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Abstract: This paper presents an analysis of the Polish construction market with examples of project risk assessment taking into consideration one of the biggest markets in Central Europe. The writer has conducted research in identification and quantification of construction risks based on the Polish market that has developed considerably since joining the European Union. The risk analysis consists of verbal and quantitative description. The specification of risk indicators is directly linked to the Polish construction market and the writer has provided examples for applying the risk assessment process in construction projects. A summary of the analysis is presented in the final part of the paper.

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Introduction

In May 2004 ten new countries joined the European Union, including Poland, a country with a population of approximately 40 million people. After many years of communist occupation, Poland now stands the chance of experiencing a steady economic growth. While the former political system collapsed 15 years ago, it has not been recently that one can observe the positive aspects that are conducive to economic growth. They include pro-investment changes in law and the economy, the availability of new technologies, a higher level of education, a desire of Polish people to become rich (an issue of changing social awareness resulting from a new role of the state in the social security system), and to satisfy their own increasing needs, as well as the accession to the European Union (EU). All these factors have contributed to the assessment of experts who consider Poland to be the country with the biggest growth potential in Central Europe (“ZAGAP” 2005).

Building projects are fundamental within the wide range of planned investments in Poland. This issue is determined by many factors. One of them is a marked tendency to relocate production from western European countries to Poland due to the substantially lower labor costs. This fact necessitates developing industrial and infrastructure capabilities including the building of new production halls and storehouses. The second factor that generates the need for investment projects is lack of suitable road and bridge infrastructure in Poland that requires development of new bridges, ring roads, and motorways. While several thousand kilometers of motorways are already in the planning stage of construction, thousands of kilometers of existing roads need to be modernized and reconstructed in the years to come. Another factor which creates the need for investments is the housing shortage in Poland, with an estimated need for a few million apartments. This situation is referred to as a “housing hunger.” Experts indicate that easier and easier access to mortgage loans will soon lead to a “housing boom,” which may become a major force for the development of the state economy, particularly in the construction industry.

It goes without saying that in order to complete those projects substantial financial support is required. However, the situation seems optimistic. It can be assumed that as far as industrial investments are concerned, the required building projects would be sponsored by the companies entering the Polish market, whereas in the case of transportation facilities both governmental and EU resources would need to be employed. Therefore, with these considerations and the easier access to mortgage loans, the building investment boom seems inevitable. Consequently, it is worthwhile to take a closer look at the construction market in Poland. However, it is important to note that the market is not risk free. The research described in this paper has been conducted to identify the areas of risk in a building project in Poland.

Understanding Risk

The term “risk” is derived from the Italian verb “risicare,” which means: “to have the cheek to do something.” Risk is a permanent element of each decision-making process, including design and planning decisions.

The notion of risk is interpreted and defined in a variety of ways. Risk has a different meaning and interpretation for economists (with a focus on financial aspects), engineers (relating the issue of risk to process disruption and cost), military (a risk of completing a task), police officers (treating risk as a threat to citizens), and even more differently by employees (a risk of being dismissed), etc. This fact makes it imperative to clearly specify the meaning of risk in a given project.

Risk is a well-known notion that is frequently used by practi-
tioners and theoreticians in various areas of human activity. As in the case of planning, the definition and understating of the descriptive considerations of risk are more common than its quantitative interpretation. Risk is defined (Willet 1951) as “a phenomenon objectively correlated with subjective uncertainty of an undesirable event occurring.” Kasprowicz (2002) has divided the overall risk in construction projects into three categories: (1) uncertainty of works—e.g., accidents and unforeseen events related to the type and size of the construction project; (2) uncertainty of resources—including technical, organizational, operational, system, etc., and (3) situational uncertainty including unforeseen events related to the system surroundings and environment in which a construction project is being carried out, whereas Holliswell (2001) has identified four categories of financial risk in construction, including contractor risk, financial risk, interest rate risk, and currency risk.

Risk management on the other hand is defined as a set of methods and activities designed to reduce the disturbances occurring during the realization of the project. The fundamental aim of risk management process is to ensure that all steps needed to achieve the project objectives will be taken. Those objectives normally include the delivery of a project on schedule, in accordance with the budget and in line with all quantitative and qualitative standards. In other words, a risk management system is aimed at identifying and analyzing all risk events which may occur during the realization of the project and subsequently allow undertaking of appropriate mitigating actions (Brown and Chong 2000; Skorupka 2003; Hastak et al. 1994).

A typical risk management process includes the following consecutive steps (Winegard and Warhoe 2003):

- Identification of risk;
- Risk assessment and analysis;
- Risk mitigation—development of risk reduction and reaction to threats;
- Implementation of risk management plan; and
- Review and correction of risk assessment.

The first two steps are fundamental because without their reliable analysis, the following steps may not be useful. Unfortunately, the lack of reliable tools for risk assessment at the preliminary stages of project planning and decision making allow risk conditions to develop. For example, a shopping, service, and office complex were recently constructed in a Polish city by a general construction company “D” (the name has not been disclosed due to reasons of confidentiality). This project faced a 12-day delay due to incorrect subsurface investigation, as a result earthwork and foundations were delayed on this 6-month long project (scheduled start date January 5, 2005 and expected completion for July 15, 2005). For a short duration project 12 days represents a significant delay resulting in a cost escalation of 60,000 PLN (i.e., approximately $20,000) over an estimated project cost of 1,988,600 PLN (1 U.S. dollar=3 PLN). Fig. 1 compares the scheduled costs (the business-financial schedule drawn up for the tendering procedure) to the actual ones (data developed upon completion of the project). The example presented is only one of numerous projects (the same issue pertained to many other projects) indicating the importance of thorough risk assessment. Therefore, it is important to develop a method for risk assessment that accounts for all potential sources of risk at different stages of a project. The research presented in this paper describes such a method for identifying risk in construction projects.

Description of Risk Indicators in Poland

Risk indicators are dependent on the type of project and its environment. Several of the indicators could repeat in a typical construction project. The research presented in this paper describes the major risk factors present in the Polish construction market. The data evaluated for this research and the projects analyzed for this research case study are described in the following sections. The research on the knowledge of experts has been divided into two categories: practical knowledge and theoretical knowledge (Kapliński 1997; Kasprowicz 2000; Marcinkowski 2002). The starting base was a comparison of risk indicators at the country, industry, and project levels, presented in the “ICRAM—Model for international construction risk assessment” (Hastak and Shaked 2000) method, and an analysis of risk indicators in the RAMP—Risk analysis and management for projects (Cocksaw et al. 2000), whereas the details concerning practical knowledge are presented under a case study discussed later.

Within the scope of the research into theoretical knowledge, the research was carried out at some of the most renowned technical universities in Poland such as the Wroclaw University of Technology, the Cracow University of Technology, the Warsaw University of Technology, the Poznan University of Technology, and the Gdansk University of Technology. The research made it possible to present the biggest threats (risk indicators) pertaining to construction investments in Poland.

Operational Risk

Operational risk is referred to as political risk in some publications. It has already been mentioned that after the collapse of communism in 1989, Poland changed its political system into capitalism. Liberals came to power, but already in 1993, due to social discontent, they lost power in favor of ex-communists (in name only, as it turned out) who had assumed the title of social democrats. Social democrats were in power in Poland, with a 3-year break (1997–2001), until the year 2005. In practice, these social democrats were more liberal than many right-wing parties. It sounds paradoxical, then, that under their rule unemployment
reached 20% of employable people. This did not result from their liberal policy but was due to the omnipresent corruption and numerous financial scandals in the ruling party.

In October 2005, parliamentary and presidential elections were held. Power was seized by a right-wing party having its origins in the solidarity movement, which is considered to be a socialist party (with approximately 27% of the vote) that was supported rather reluctantly by liberals (with 24% of the vote). This party also has the informal support of two peasant parties and a party that is considered to be an ultraright-wing and nationalist party. The presidential elections were won by Lech Kaczyński, a professor of law and a patriot. As is always the case, opinions concerning this election differ. Some foreign commentators are afraid of a rise in patriotic tendencies, or even nationalistic ones, which may adversely affect the possibility of winning contracts by foreign companies. Others claim, however, that the market of contracts will be more transparent and uncorrupted. Lech Kaczyński has a reputation of being determined and consistent in combating crime. Of course, elections always lead to some kind of anxiety in the financial markets. However, deviations of the currency from parity were relatively minor, which may be understood as a testimony to Poland’s financial stability.

While assessing the economy and finance through the criteria of monetary inflation and economic growth, one can draw on the data from the Polish Central Statistical office. According to this office, the growth in the Polish economy was 4.8% in 2005. With regard to inflation, it is systematically declining and at present it is running at approximately 1.5%. This trend should last for at least a few more years. One of the reasons is that it is necessary for Poland to keep inflation at a low level, as it is a criterion for joining the Euro zone. It is expected that the national currency will be converted to the Euro by the year 2010. Administration is the dark side of Polish reality. Rampant bureaucracy, delays in issuing planning permissions, and poor service are only some of its weaknesses. The situation, however, may improve as it is one of the priorities for the new government to rectify this state of affairs.

### Political Risk

The political structure in Poland is stable. The Parliament (Sejm and Senat) exercises legislative power, the government exercises executive power, and the President exercises supervisory power. There are no special abnormalities in these areas. One can say that they come up to world standards. Despite the difficult situation of part of the Polish society (20% unemployment), there are no symptoms of instability in Poland.

### Financial Risk

Legal aspects play an important role in determining financial risk. In 2004, Poland joined the European Union. In accordance with the decisions made by the European community, laws enacted in Brussels are superior to national laws (at the moment it concerns only a few areas of common activity, e.g., economy, environmental protection, etc.). This situation sometimes takes even sophisticated entrepreneurs by surprise. Consider, for example, the new laws on environmental protection, which in particular concern road investments. The changes made in these laws are so considerable that in consequence construction companies will take a loss (“Informacja dotycząca zmian w prawie inwestycyjnym” 2005) of 300–400 million Polish zloty (~$100–130 million). More specifically, the issue concerns the article that makes it necessary for investors to “prepare documentation for at least two variants for the preparation of the road, including documentation for the variant that will not be built. Each of the variants requires a complicated documentation of the assessment of the effects on the environment (“Informacja dotycząca zmian w prawie inwestycyjnym” 2005).

Furthermore, after Poland’s accession to the European Union, the value added tax (VAT) rate on construction products increased from 7 to 22%. As a result, thousands of small and hundreds of medium-sized construction companies went bankrupt. In many cases construction entrepreneurs had made decisions to terminate contracts and suffer financial consequences resulting from such action, the reason being that the losses the company would sustain were smaller. The writer will not comment on the question as to why the ex-government (having communist origins) agreed to adopt such high VAT rates so quickly.

An important part of financial risk is obviously the stability of the financial market, but this issue has been addressed while analyzing political risk and will also be touched upon while discussing exchange risk.

### Exchange and Inflation Risk

Exchange and inflation risk are changes in the relation of the Polish currency to other currencies. This risk needs to be examined in two aspects: the relation of the Euro to the United States dollar and the relation of the Polish zloty to other currencies. The former depends on world trends, widely described in periodicals devoted to economic matters, and thus will not be analyzed. The latter one (determining the level of risk) is dependent on the type of currency, i.e., the stability of a financial system of the country where it comes from and obviously on the financial stability in Poland. Polish companies bestow the greatest trust on the currencies in this particular order: Swiss franc, Euro, and United States dollar. Interestingly, the loans taken out in the Swiss currency are cheaper by ~10% than the loans taken out in zloty (Polish currency). The issue of the level of exchange risk is obviously strictly connected with the financial policy and the state of the economy in a given country. Commenting on this fact, it is necessary to stress that the present government in Poland (NOW 10 2005) attaches great significance to curbing the budget deficit and maintaining the economic growth.

With regard to inflation risk, it has recently been minimized (the level of inflation has been presented above). One has to bear in mind, though, that Poland is a young democracy and the economic situation may be subject to larger fluctuations than in the countries where free market economy has been in place for many years. Other important criteria for assessing risk include the budget deficit, which exceeds 3% of GDP, as well as the foreign debt exceeding 40 billion dollars. Poland has no gold reserves. It has, however, dollar reserves amounting to 20 billion dollars to secure the stability of the national currency.

### Corruption Risk

This risk is rapidly diminishing, as a result of political changes (described above), changes in law, and widespread, social condemnation. A few years ago corruption in the construction market was so common that it was almost taken for granted. Nowadays the situation has considerably improved, resulting from introducing legal regulations concerning, for instance, the mode of conducting tenders and toughening criminal sanctions.
Risk of Changes in Prices of Raw Materials and Construction Products

Changes in this area have recently been exceptionally dynamic, only because of a tremendous rise in the prices of oil and steel. However, the problem did not result from the specificity of the Polish market, but from worldwide trends. However, with regard to the Polish conditions, the risk of the change in the prices of construction products was determined by the VAT as mentioned earlier. The increase of the rate from 7 to 22% led to a price rise of a few percent (manufacturers included the remaining part in their expenses). There are no problems with obtaining products. The same holds true of skilled and unskilled workers. Labor costs in Poland are very low. For instance, an unskilled worker in the construction industry earns 9 PLN/h (approximately $3).

The risk indicator with respect to financing of the investment is dependent on the availability of the medium and long-term financing of construction investments and construction tax relief. Poland has a well-developed banking system that includes several international financial institutions such as City Bank or ING Bank. However, the system of tax relief is often subject to fluctuations and depends on the government. The present government declares strong support for the construction industry. The most important tax relief includes relief for housing construction, in which a 7% VAT rate on construction products and work was maintained, whereas a 22% VAT rate is generally compulsory in the construction industry. In general the cooperation between foreign managers and local contractors is good. However, a certain complication is posed by the language barrier, but this obstacle is gradually being overcome.

Tendering procedures as well as planning permissions are a serious problem in Poland because of the time required. However, at present one can hear promises of radical changes in these areas. It is important to add that with respect to risk indicators directly connected with the project in progress, the most important ones include faulty (imprecise) project planning, design, and estimating. Design errors impact the amount of calculated production resources such as the amount of steel or finishing materials.

Risk Analysis of Project—Case Studies

Each of the risk indicators mentioned above assumes a specific quantitative dimension depending on the type of project, its environment, and the time devoted to its delivery. Therefore the quantification of risk indicators has to be carried out for specific projects. In order to corroborate this thesis and to illustrate the specificity of the Polish market, the following case studies are presented.

Part I: General Risk Assumption

For the purpose of an overall assessment of the risk indicators described above, the writer has singled out three representative companies that play a significant role in the construction market in Poland. The names of the companies are secret.

The first company (A) is a global construction corporation committed to finding innovative solutions for its clients. The company offers a broad range of services from project development to construction and facilities management. The company has many employees with operations in nine markets (United States, Sweden, Finland, Norway, Denmark, Great Britain, Poland, the Czech Republic, and Latin America).

The second company (B) is a well-known company in Poland and abroad. As a result of political transformations in the 1990s, this firm gained a leading position in the construction market in Poland. In 1992 the company was privatized and 2 years later converted into a stock company. Since 1995 the company has been operating as a publicly traded company, listed on the Warsaw Stock Exchange.

The third company (C) is a large but relatively young (it has been in business since 1989) Polish construction company (with German capital) thriving in the domestic market. It has a significant list of national and international investors. Its scope of business includes the construction of public buildings (office buildings, shopping malls, cinemas, sports, administrative, and educational facilities), housing estates and apartment buildings, industrial, environmental protection, as well as engineering facilities (including roads, bridges, flyovers, airports, and underground structures), military, and special purpose facilities.

Research into the possible occurrence of individual risk indicators was conducted in the form of questionnaires in the first half of 2006. The questions asked the possible occurrence of the suggested risk indicators in Poland. Fifty questionnaires were sent to employees at those companies and 18 of them were returned. During the research, the following assessment scale was adopted: very low risk (0–20), low risk (21–40), moderate risk (41–60), high risk (61–80), and very high risk (81–100). Numerical values given in the responses were rounded off to single digits. Average results are presented in Table 1.

Analysis of Research Results

On the whole, the results obtained from individual companies do not differ fundamentally. It becomes evident that it is the risk of

Table 1. Level of Risk Assessment at Companies Analyzed

<table>
<thead>
<tr>
<th>Risk indicator</th>
<th>Companies analyzed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Operational risk</td>
<td>(43) moderate</td>
</tr>
<tr>
<td>Economic risk</td>
<td>(29) low</td>
</tr>
<tr>
<td>Financial risk</td>
<td>(28) low</td>
</tr>
<tr>
<td>Legal risk</td>
<td>(42) moderate</td>
</tr>
<tr>
<td>Currency and inflation risk</td>
<td>(44) moderate</td>
</tr>
<tr>
<td>Corruption risk</td>
<td>(34) low</td>
</tr>
<tr>
<td>Risk of change in prices of raw materials and construction products</td>
<td>(45) moderate</td>
</tr>
<tr>
<td>Tendering procedures as well as planning permissions</td>
<td>(73) high</td>
</tr>
<tr>
<td></td>
<td>(62) high</td>
</tr>
</tbody>
</table>
tendering procedures as well as planning permissions that managers rate high. Unfortunately, it is a typical investment problem in Poland. Paradoxically, one of the reasons is the law on combating corruption, which makes it possible for a company not awarded the contract to block the whole tendering procedure in order to check whether it has been conducted correctly. For this reason it is often the case where the commencement of an investment is delayed for 2, 3, or even several months. It is one of the major reasons for substantial delays in the construction of motorways in Poland. Another problem relating to the same risk indicator is purchasing land for investment from private owners. So far even one obstinate owner has been able to block a major investment, e.g., road construction. At the moment the government is trying intensively to work out solutions to the aforementioned problems.

It is notable that the risk of corruption is diminishing. Only one Polish company rates it high, but in the writer’s opinion it results from former negative experiences rather than from the current situation.

**Part II: Risk Dependent on Specificity of Projects**

Sometimes the project has its own unique risk indicators. In order to depict this phenomenon, two examples have been used.

**Example 1**

SKANSKA constructed a bridge (Fig. 2) in Wroclaw (a city in Poland with a population of 600,000) of the value of 140 million PLN (1 United States dollar = 3 PLN). It was a substantial investment for which 41,000 m³ of concrete was used, approximately 5,000 t of reinforced steel, and 670 t of prestressing steel. Its load-carrying structure was supported on 16 abutments (Winegard and Warhoe 2003).

At the stage of project preparation it turned out that environmental concerns might constitute a serious threat to completing the project on schedule (the risk of protests), the reason being that the bridge was being constructed on woodlands. In order to solve the problem during the project, SKANSKA pledged to take care of the natural environment. Therefore it promised to replant trees as well as the English ivy, which is under protection. Eventually, after the completion of the project, more than 700 trees, 27,000 shrubs, and 50,000 m³ of grass were planted on both banks of the Oder River. SKANSKA also built special passages under the road along with fences directing animals toward those passages. As a result, a diligent risk analysis allowed the company to avoid serious problems.

**Example 2**

A railroad engineering company, “E,” determined that the transportation of rails would constitute one of the most significant risks to influence the reconstruction schedule of an express railroad (the name of the company has not been disclosed due to reasons of confidentiality). The problem was that rails were transported in 200-m sections on special wagon platforms and along a specially selected route, because Polish railroads are quite winding. Prior to that, rails had to be transported from a steel mill to a welding department. The time allocated for their transportation was limited since the order could only be placed after awarding the contract. The company dealt with this problem by placing substantial emphasis on how the construction was organized. The managers had to make a special transportation schedule and maintain the schedule during the project.

**Part III: Risk Assessment of Project Completed by Medium-Sized Construction Company in Poland**

**Risk Assessment Model**

The method of construction risk assessment (MOCRA) is an original method that makes it possible to conduct a compre-
The next step in the method is the identification of risk factors. By analyzing the literature (Kasprowicz 2002; Kaplinski 1997; Marcinkowski 2002; Holliwell 2001), experts’ knowledge as well as their own experience with respect to construction projects, makes it possible to specify risk indicators. The starting point for the specification was a comparison of indicators suggested in the ICRM (Hastak and Shaked 2000) and RAMP (Cockshaw et al. 2000) methods. The fundamental difference, however, consists of taking into account the specificity of Polish companies and making the list of risk indicators at the level of a construction project more flexible. For instance, it is postulated that risk indicators are adjusted to the type of a construction project, i.e., that separate lists are compiled for general, road, railroad engineering, etc. Besides, the MOCRA method makes it possible to divide risk indicators into the ones that pose a risk to time and the ones that pose a risk to costs.

In order to quantify the identified risk indicators, the MOCRA method includes conducting an initial risk assessment, verifying risk indicators (risk reduction), matching risk indicators to specific activities in the schedule, and allocating them. An initial risk assessment of a construction project constitutes another element of the analysis. It makes use of the idea postulated in the ICRM method, consisting of assessing a project in three stages. The first stage is assessing risk at the macro level, which means analyzing a country (or domestic) risk. The next stage is an analysis at the construction market level and the last one at project level.

At this stage of the analysis it is possible to give up a construction project if the initially specified risk is unacceptable for potential contractors. If this is not the case, then the method makes it possible to reverify risk indicators and analyze the possibility of reducing their unfavorable influence on a construction project or eliminating it completely through the risk reduction module.

Another step is reassessment and matching risk indicators to specific activities in the schedule. It consists of a thorough analysis of which risk indicators may pose a risk to individual activities of the project.

Having done that, residue risk (this is the final list of risk indicators after mitigation of the general risk) in the business-financial schedule of a given construction project is allocated through the Monte Carlo method. On the basis of this information variants of a contingency budget and a contingency plan are drawn up.

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**Fig. 3.** Schematic diagram of MOCRA method

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**Table 1**

<table>
<thead>
<tr>
<th>Nazwa zadania</th>
<th>Cz. trw.</th>
<th>Rozp.</th>
<th>Zak.</th>
<th>Poprzedni</th>
<th>Koszt</th>
<th>Nazwy 1</th>
<th>Nazwy 2</th>
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<tbody>
<tr>
<td>1 Robocie zienné</td>
<td>21 dn</td>
<td>04-04-22</td>
<td>04-05-20</td>
<td>92 495,58 zł</td>
<td>Z1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Fundamenc</td>
<td>13 dn</td>
<td>04-04-22</td>
<td>04-05-10</td>
<td>98 398,04 zł</td>
<td>Z2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Ściany i ścianki</td>
<td>46 dn</td>
<td>04-05-11</td>
<td>07-13-2</td>
<td>192 534,76 zł</td>
<td>Z3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Tynki, sufity podwieszone</td>
<td>70 dn</td>
<td>04-06-01</td>
<td>11-15-32</td>
<td>91 926,74 zł</td>
<td>Z4</td>
<td></td>
<td></td>
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<tr>
<td>5 Poddźiani podłogi</td>
<td>61 dn</td>
<td>04-06-10</td>
<td>11-30-62</td>
<td>306 843,41 zł</td>
<td>Z5</td>
<td></td>
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<tr>
<td>6 Konstrukcje żelbetowe</td>
<td>52 dn</td>
<td>04-05-14</td>
<td>07-26-16</td>
<td>65 708,03 zł</td>
<td>Z6</td>
<td></td>
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<tr>
<td>7 Dach i pokrycie</td>
<td>55 dn</td>
<td>04-06-15</td>
<td>08-30-12</td>
<td>475 195,58 zł</td>
<td>Z7</td>
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<tr>
<td>8 Stalarnia cz 1</td>
<td>45 dn</td>
<td>04-06-18</td>
<td>10-15-11,2</td>
<td>207 520,36 zł</td>
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<td>9 Stalarnia cz 2</td>
<td>45 dn</td>
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<td>17 235,10 zł</td>
<td>Z9</td>
<td></td>
<td></td>
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<tr>
<td>10 Robocie zewnętrzne</td>
<td>33 dn</td>
<td>04-09-15</td>
<td>10-29-72</td>
<td>37 068,14 zł</td>
<td>Z10</td>
<td></td>
<td></td>
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<tr>
<td>11 Instalacje kotłowni</td>
<td>39 dn</td>
<td>04-06-22</td>
<td>04-06-15</td>
<td>54 273,58 zł</td>
<td>Z11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 4.** Finance plan and schedule of sport hall in Zarnowiec—deterministic
Example of Application of Method

Description of Construction Company Delivering Project.

Construction company “D” in Jędrzejów, Poland was established in 1990 resulting from the commercialization of the state-owned enterprise. The company constructs public buildings, apartment buildings, industrial and agricultural buildings, as well as construction projects that require environmental protection. In addition to this, the company renovates and modernizes monuments. It employs 200 well-qualified and experienced personnel, including 20 managers and engineers. The name of the company has not been disclosed due to reasons of confidentiality.

Description of Construction Project.

A gymnasium with an indoor swimming pool at a school complex—The Center for Continuous Education in Zarnowiec. The scope for the project included: constructing the main building—a gymnasium with back rooms, rebuilding part of the school building, rebuilding the workshop building into a central heating boiler house (in accordance with the boiler house technology design), building a connection to the water supply system, and building a sanitary connection. The start date for the project was April 22, 2004 with a completion date of December 5, 2004.

Details concerning the execution of the project can be found in the contract concluded between the investor and the contractor. The contract consists of eight pages and 25 articles.

Business-Financial Schedule. Fig. 4 presents an extract (due to its length) from the business-financial schedule drawn up by the contractor (construction company “D”) and approved by the investor (the owner of the school complex). The schedule is in Polish, because this is the original simulation result prepared for the “D” company, as well.

Table 2 compares the scheduled cost (the business-financial schedule), the actual cost of production (realization of the construction project), and the results of the simulation (a contingency construction budget). In order to illustrate the results of the research, they have been compared on the graph (Fig. 6).

Presenting risk in a quantitative manner made it possible to determine accurate time and cost contingencies. The amount of 146,000 PLN (resulting from rounding up the amount of 145,936 PLN), constituting 7.69% of the budget, was adopted as a cost contingency. That amount is the difference of the aggregate cost of individual operations with risk (Fig. 5 the Cost column) and the aggregate cost of the same operations conducted under deterministic conditions (Fig. 4 the Cost column).

Table 2. Scheduled, Simulated, and Actual Costs

<table>
<thead>
<tr>
<th>Month</th>
<th>Initial schedule</th>
<th>Completion of construction work</th>
<th>Simulation of influence of risk indicators on budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>58,495.77</td>
<td>165,234.00</td>
<td>62,888.80</td>
</tr>
<tr>
<td>5</td>
<td>329,394.20</td>
<td>345,666.00</td>
<td>356,895.06</td>
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<td>6</td>
<td>467,344.97</td>
<td>507,966.00</td>
<td>506,564.75</td>
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<td>7</td>
<td>858,134.18</td>
<td>840,186.00</td>
<td>928,617.10</td>
</tr>
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<td>1,148,434.11</td>
<td>1,190,186.00</td>
<td>1,243,593.39</td>
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<td>9</td>
<td>1,318,093.75</td>
<td>1,410,307.00</td>
<td>1,426,824.94</td>
</tr>
<tr>
<td>10</td>
<td>1,473,585.05</td>
<td>1,543,757.00</td>
<td>1,594,755.54</td>
</tr>
<tr>
<td>11</td>
<td>1,726,544.04</td>
<td>1,683,757.00</td>
<td>1,869,494.05</td>
</tr>
<tr>
<td>12</td>
<td>1,763,779.14</td>
<td>1,803,757.00</td>
<td>1,909,714.61</td>
</tr>
</tbody>
</table>

Cost contingency 1,909,714.61 – 1,763,779.14 = 145,935.47.

By using the MOCRA method algorithm (Fig. 3), risk indicators were identified, quantified, and verified. Next, they were correlated with individual operations of the construction project, specified in the business-financial schedule. Details of the analysis have been omitted due to their range and confidentiality of the research conducted.

In order to allocate risk (the consequences of the occurrence of risk indicators against the time and cost criteria), the Monte Carlo method was used (from software Risk 4.1. for project). The simulation (a parametric estimation) of the occurrence of individual risk indicators, conducted for each operation of a construction project, made it possible to determine how the values of the expected time and costs of individual operations would change. The data were used to draw up a contingency business-financial schedule for the project analyzed (Fig. 5). The schedule is in Polish, because this is the original simulation result prepared for the “D” company, as well.

Fig. 5. Finance plan and schedule of sport hall in Zarnowiec—probabilistic
investors from the necessity to carry out accurate analyses, including risky ones, prior to making a decision to enter the market.

References


Conclusion

The results of a risk analysis are not precise enough to exactly predict what unfavorable events will occur and to what extent they will influence a project. They have, however, a decisive impact on the size of the adopted time and cost contingency, which determines the amount of financial and time reserves. They also allow one to prepare a contingency strategy for some unfavorable events. A risk analysis conducted in a diligent manner may increase the profits on the investment completed.

It transpires from the research conducted by the writer that an overall level of risk of construction investments carried out in Poland is dwindling. Over the last 10 years Polish law as well as its enforcement have improved. As a result of the accession to the European Union, new opportunities for the economic growth in Poland have arisen and the Polish currency has gained strength. The present government has declared war on corruption, creating a special institution at government level. National and foreign economists claim that Poland stands a chance of experiencing a period of great prosperity. Five percent of the society, approximately 2 million people, is receiving higher education. The majority of them are determined to work hard and become a successful. This situation offers the chance of a sustainable and dynamic economic growth. It does not, however, exempt potential

Fig. 6. Graph of planning, real, and simulations cost