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MATHEMATICAL MODELLING OF DISPUTE PROCEEDINGS BETWEEN INVESTORS AND THIRD PARTIES ON ALLEGEDLY VIOLATED THIRD-PARTY RIGHTS

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Abstract. The article analyses the possible influence of third-party rights infringed during construction planning on the implementation of an investment project. In a construction project, judicial disputes are an unwanted risk factor, which may disrupt the entire project. It is therefore necessary to plan and apply preventive measures for the mitigation of such risk in the initial planning stage of a construction project. The article, for that purpose, presents modelling a dispute between investors and third persons on allegedly violated third-party rights with the help of a tree that illustrates the possible actions of the dispute parties. A mathematical model for dynamic programming the dispute on allegedly violated third-party rights has been developed; it helps to determine the optimal investor's strategies for each situation that involves decision-making.

Keywords: construction investment process, defence of third-party rights, judicial defence of rights, decision tree, dynamic programming, recurrent equations, optimal behaviour strategy.

1. Introduction

In most of our cities, some parts undergo intensive transformations related to commercialisation, land use and the density of buildings (Kaklauskas *et al*. 2007; Bardauskienė 2007; Turskis *et al*. 2006; Zavadskas *et al.* 2004; Kaganova *et al.* 2008). Several examples in European cities show that development can embrace internal urban areas (Mcdonald *et al*. 2009; Kaklauskas *et al.* 2009; Miller *et al*. 2004). Currently, Lithuanian cities also witness concentrated development (Zavadskas *et al*. 2009; Viteikienė and Zavadskas 2007; Burinskienė 2009; Jakaitis *et al.* 2009). It allows using the existing infrastructure and abandoned urban territories. Such planning also reduces the amount of used land and creates a lasting environment, the immensely dense population of which is not always able to function properly (Burinskienė and Rudzkienė 2009; Lahdenperä 2009; Petrović *et al.* 2009; Greater London Authority 2003; Ribeiro 2008; Lindgren and Castell 2008). On one hand, it is a natural stage related to the renovation of neglected valuable urban areas. On the other hand, the course and outcomes at this stage reveal gaps within the renewal process. We are inclined to blame the drawbacks of laws regulating urban planning and protection of visual identity (investors cannot always be expected to abandon their self-centred ends for the sake of urban values, etc.) (Dringelis 2005; Vrubliauskas 2005; Jakaitis 2004; Mickaitytė *et al*. 2008; Banaitis and Banaitienė 2007; Majamaa *et al.* 2008). This is in a large part influenced by a confusing, non-effective system for the coordination of constructions with government institutions and the public. The regulation of constructions is confusing; builders breach the introduced requirements; officials are frequently provided with the right to easily choose the requirements necessary to be applied. An inappropriate distribution of functions among government institutions and private subjects raise a number of problems (Šostak and Kutut 2009). One of the outcomes of inappropriate legal regulation is the violation of the third-party rights (i.e. the parties not directly related to the investment construction process: the owners of neighbouring plots, users, communities of residential districts, etc.). The article analyses the influence of third-party rights infringed during construction planning on the implementation of an investment project.

The development of the national economy is impossible without construction: people use construction products – various buildings – to live, work and satisfy other social needs. Construction investment contributes to national economic growth and development extensively (Urbanavičienė *et al.* 2009; Zavadskas and Kaklauskas 2005, 2008). The investment process in construction is long and complicated; it requires enormous financial, intellectual and other resources. If judicial disputes occur during this process, the investor may incur huge loss, and project implementation may be postponed for an indefinite term. Litigation may continue for several years (The judgement of the Supreme Administrative Court of Lithuania of 19 January 2007 in the administrative case; The judgement of the Supreme Administrative Court of Lithuania of 26 January 2007 in the administrative case). Thus, investors are most concerned to avoid any legal

disputes and should pay considerable attention to their prevention.

Violations of third-party rights are of benefit neither to third parties, nor to the parties of the investment process, because, on one hand, such violations might wrongfully cause the deterioration of the conditions for life and other activities of third persons. On the other hand, violations of third-party rights at the stage of construction planning may affect the implementation of the investment project, because all solutions violating third-party rights also violate the provisions of legal acts and can be disputed as stipulated by the Law on Administrative Proceedings (hereinafter LAP 2000), the Law on Territorial Planning (2004) and other legal acts (Mitkus and Šostak 2009).

In a construction project, judicial disputes are an unwanted risk factor, which may disrupt the entire project. It is therefore necessary to plan and apply preventive measures for the mitigation of such risk at the initial planning stage of a construction project. To evaluate and eliminate these risk factors, state-of-the-art technologies for construction project planning and management must be integrated into each step of construction project planning and implementation. It is necessary to employ innovative methods for construction project planning and implementation when the conditions are indeterminate (Kahraman and Kaya 2010; Błaszczyk and Nowak 2009). Risk management strategies and the development of a risk management plan must be improved, risk analysis methods and technologies must be used, and the risk reporting mechanism must be implemented. For a successful construction project, it is worth to employ the functions of project management. It is necessary to analyse the risk using the knowledge of relevant experts and to properly evaluate the scope of possible negative effects and their outcomes to the construction project. The findings should influence the subsequent decision-making process. Risks must be monitored and decision-making must be analysed throughout the project lifecycle. Before launching a project, an investor must be ready for any "surprises". Forecasting is the most important part of any strategy, because the actions recommended for certain situations stem from the forecasts of possible outcomes. Thus, investors must be aware of the defence procedures taking place in administrative courts when third-party rights are violated during territorial planning – they must assess possible actions of third parties.

The process consists of the following main stages: 1) third parties learn about the violation of their rights (infringement determined); 2) a pretrial defence of infringed rights (advance instance). Before an administrative court is involved, separate legal acts or actions/ omissions of public administration entities foreseen by laws can be, and in cases established by laws must be, disputed by applying to an advance institution for out-of-court case hearing. The procedures for a pretrial defence of third-party rights are defined in Article 25 of The Law on Administrative Proceedings of the Republic of Lithuania (LAP 2000). Unless the laws foresee otherwise, administrative disputes may be heard out-of-court by public municipal commissions for administrative disputes and the Supreme Commission for Administrative Disputes (LAP 2000, Art. 26); 3) a judicial defence of violated rights. The Law on Administrative Proceedings of the Republic of Lithuania foresees that a decision of a respective commission for administrative disputes or another institution for advance out-of-court hearing of disputes made after hearing an administrative dispute out-of-court can be appealed against to an administrative court by the dispute party which is discontent with the decision of such commission for administrative disputes or another institution for advance out-of-court hearing of disputes. The appellation must be submitted to the administrative court within 20 days upon the announcement of the decision (LAP 2000, Art. 32); 4) the case proceedings at a court of first instance. Art. 68 of LAP (2000) foresees that the chairman of the court or the judge who made the decision to accepted the claim, if necessary, take care of the following important aspects of preparation for the trial: a) prepare claim guarantee measures; b) make a decision on the invitation of experts or inspection; c) perform other actions required for preparation for the trial; etc. It is not always possible to complete a trial fully and to make a judgment at the first and single court session; although the court attempts to complete a trial within one session if it does not impair proper settlement. However, it is rather difficult, and sometimes impossible, even if the proceedings are prepared properly, though it is the aim of such preparation to guarantee full completion of a trial already at the first session. Unforeseen obstacles are rather frequent; therefore, the proceedings continue for one, two, three and sometimes even ten or more sessions (Laužikas *et al.* 2005); 5) the case proceedings at a court of appeal. In order to guarantee the expedition of the process, to protect the interests of the winning party in the case and to guarantee definite relations between the parties, the law specifies a period for party discontent with the court decision or for another person participating in the case to exercise their right of appeal. Judgements of county administrative courts announced after a trial in the court of first instance can be appealed against to the Supreme Administrative Court of Lithuania within fourteen days after the announcement of the judgement (LAP 2000, Art. 127). The proceedings of an appeal are similar to proceedings at the court of first instance. A judgement, a resolution or a rule of the court of appeal comes into force on the day of its announcement and cannot be appealed against in cassation (LAP 2000).

A peace treaty can be signed at any stage. A compromise is achieved in such case and further litigation is avoided (Mitkus and Šostak 2008a).

If a judicial dispute occurs when the construction project is already launched, the investor must also consider all possible actions of judicial institutions. The lessons learned about risk management during the implementation of construction projects should be used in future projects (Zavadskas *et al.* 2010; Park *et al.* 2009; Yang *et al.* 2009; Antuchevičienė *et al*. 2010). Mathematical modelling of the problem in question and the selection of a proper method for optimisation help with

determining the optimal investor's behaviour strategy that would allow expecting a certain average profit irrespective of the strategies of third parties and decisions of judicial institutions. Our research employs the mathematical model for stochastic dynamic programming.

2. Mathematical Modelling of a Dispute between Investors and Third Parties on Allegedly Violated Third-party rights with the Help of Stochastic Dynamic Programming

The analysis of the procedure related to the defence of violated third-party rights in administrative courts leads to a conclusion that a judicial dispute may either ruin a construction investment project completely or to cut the expected profits considerably. Largely, it depends on the decisions of the interested communities (third persons) that object to the construction and on the decisions of judicial institutions hearing the disputes. Naturally, investors are most interested to avoid any legal disputes. A possible preventive measure to mitigate such risk is an assessment and proper analysis of all possible future events related to the occurrence of such risk before the investment project is launched. For that purpose, the investor must come up with the scenarios of actions in possible situations and to plan strategic options. The investor, which is most interested to avoid any legal disputes, should assess all possible risk factors that may affect the implementation of a construction project. To illustrate such assessment, we shall turn to mathematical modelling of a dispute between investors and third parties on allegedly violated third-party rights. The dispute between investors and third parties on possibly infringed third-party rights was modelled by creating a tree of the behaviour variants of dispute parties (Fig. 1).

Besides, the tree of variants helps in finding mistakes made afterwards and in correcting them (Mitkus and Šostak 2008b; Mitkus 2004; Nollke 2007; Ross Quinlan 1993). The tree of the behaviour variants of dispute parties in Fig. 1 models all possible actions of third persons, judicial institutions and the investor in a certain situation. The outcomes of their actions are assessed.

Dynamic programming will be used to find an optimal behaviour strategy for an investor. Dynamic programming is a method of calculation applied in a solution to the multi-stage problems of optimisation. It means that we need to break a complex problem of optimisation into a string of simpler problems. When these problems are

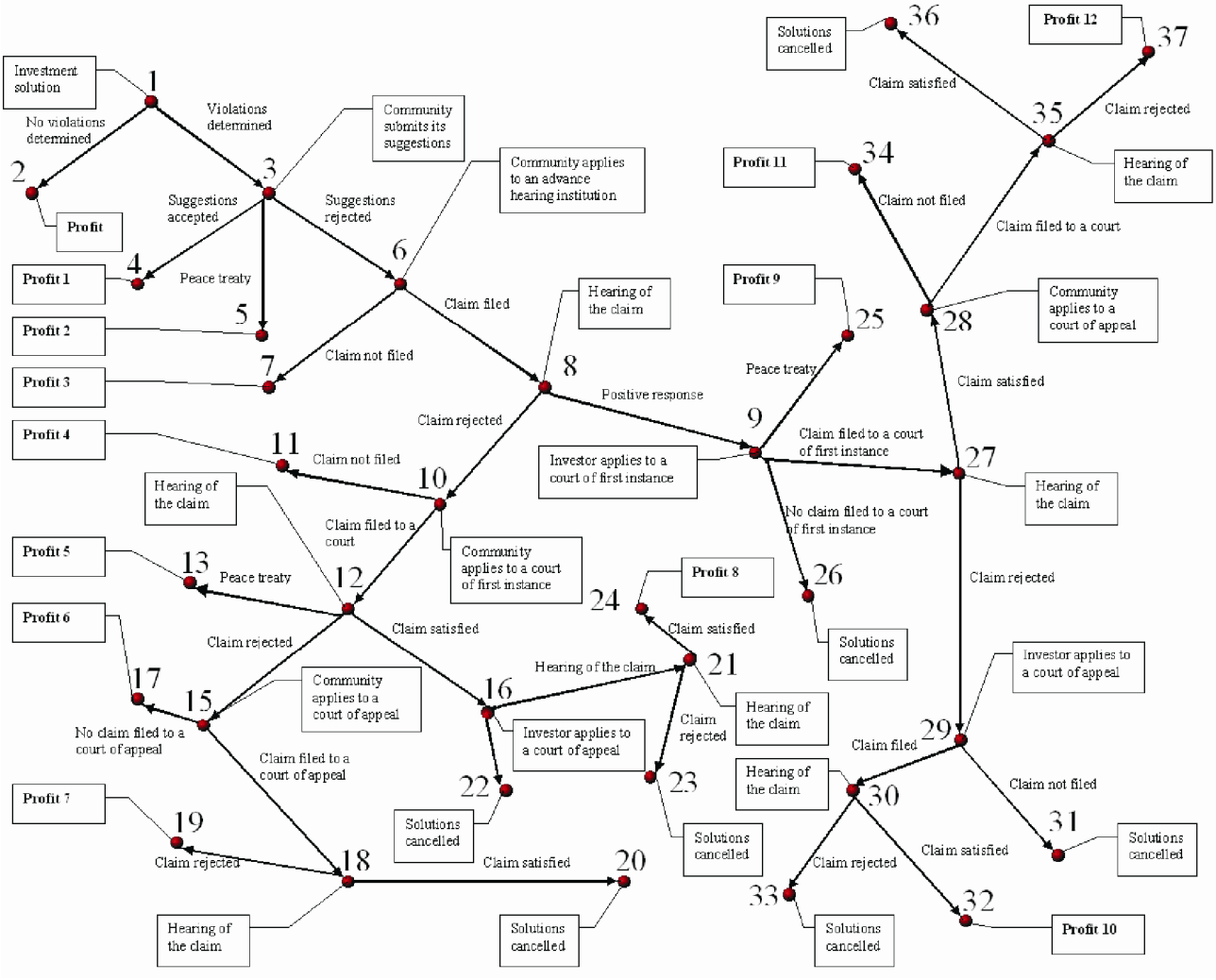

Fig. 1. The tree of the behaviour variants of dispute parties

solved, it is easy to find an answer to an original problem. Problems are divided following the Belman's Principle of Optimality: an optimal solution (management) has the property that whatever the initial state and initial solution are, the remaining solutions must constitute an optimal policy with regard to the state resulting from the first solutions. Note that by a dynamic problem we usually mean any process which depends on time (in our case, the court proceedings related to the defence of the infringed rights depend on time) (Čiočys and Jasilionis 1990; Taha 1997).

For further modelling, we shall look at the tree of the behaviour variants of dispute parties and make a tree of behaviour strategies for the investor (Fig. 2). If we want to solve the tree of behaviour strategies for the investor mathematically – to perform mathematical modelling – we need numerical values for our specific research case. The values are shown in Table 1. The numerical values are based on actual cases brought to Lithuanian courts (The judgement of the Supreme Administrative Court of Lithuania of 20 February 2006 in the administrative case; The judgement of the Supreme Administrative Court of Lithuania of 19 January 2007 in the administrative case; The judgement of the Supreme Administrative Court of Lithuania of 26 January 2007 in the administrative case). We base our research on a general (abstract) model. The analysis of specific dispute cases in the future, however, could use corrected values and assess all individual aspects related to the conflict.

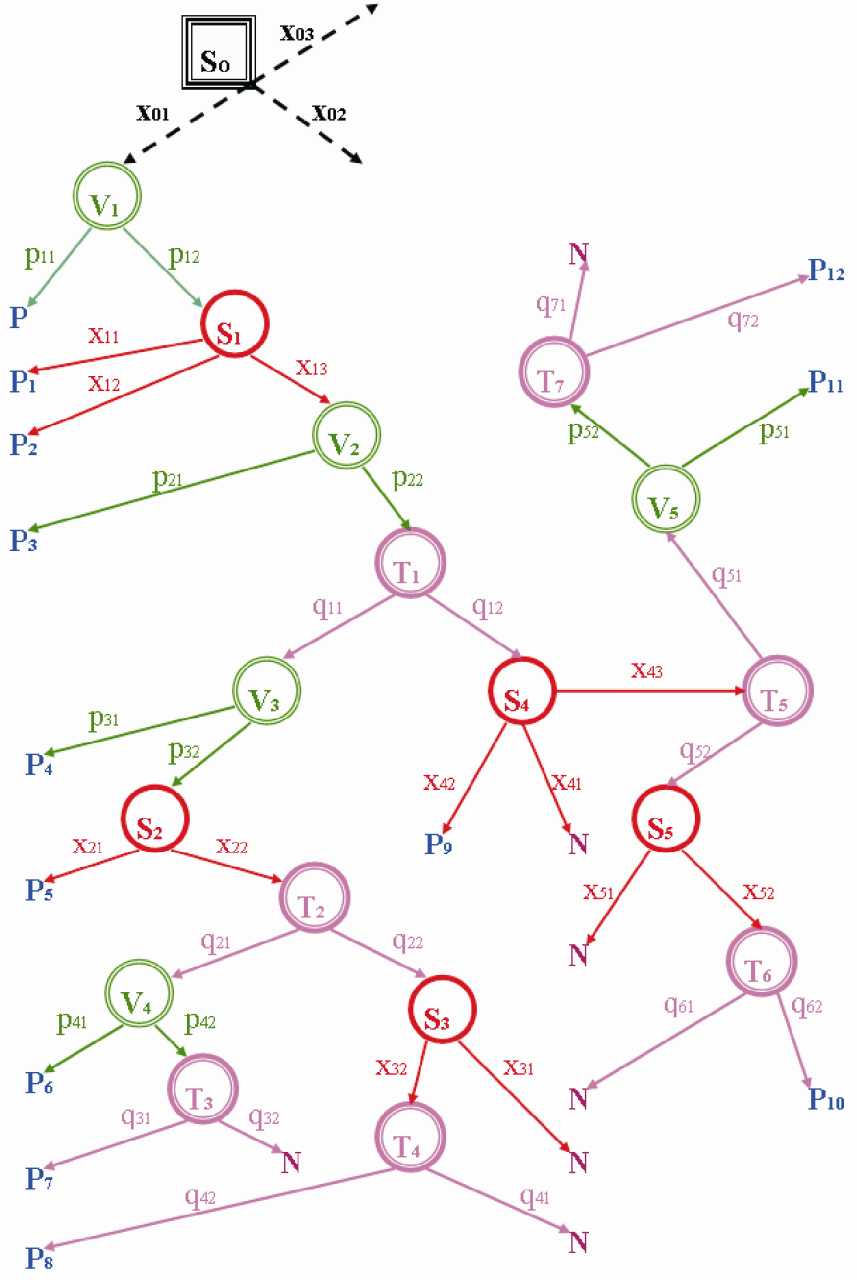

Fig. 2. The tree of behaviour strategies for the investor

Table 1. A numerical expression of behaviour strategies for the investor shown in the tree

No.	PROFIT	LTL	%
1	P = P3 = P4 =	LTL 1m *	100%
2	P1 =	LTL 500,000 **	50%
3	P2 = P5 = P9 =	LTL 950,000 ***	95%
4	P6 = P11= P7 =	LTL 980,000 ****	98%
5	P8 = P10 = P12 =	LTL 950,000 *****	95%
6	N =	–LTL 1m ******	–100%

* successful completion of the construction investment project;

** changed project solutions cut the profits by LTL 500,000;

*** a peace treaty is signed with the interested community, profit decreases by LTL 50,000;

**** the annual litigation expenditures make up LTL 10,000 (2 years), thus profit decreases by LTL 20,000;

***** the annual litigation expenditures make up LTL 10,000 (3 years), plus LTL 20,000 for forensic examinations; thus profit decreases by LTL 50,000;

****** the construction investment project is cancelled.

3. The Model for Stochastic Dynamic Programming

Let $f(S_i)$ be the likely (expected) average investor's profit ensured by state S_i and optimal strategy X_i selected from the set of possible strategies in this situation. The Belman's Principle of Optimality gives us recurrent equations for all situations S_i:

$$f(S_i) = \max_{X_i}\Big(\sum_{j\in J_{is}} x_{ij}\sum_{k=1}^{n_{ij}} p_{ijk} f(S_{ijk}) + \sum_{j\in J_{ib}} x_{ij} p_{ijb} P_{jb}\Big), \quad (1)$$

$X_i = (x_{i1}, x_{i2}, ..., x_{im_i})$, is the pool of investor's original strategies in the situation (state) S_i. Here $\sum_{j=1}^{m_i} x_{ij} = 1$, and $x_{ij} \ge 0$, $j = 1, 2, ..., m_i$.

When the number of possible strategies is m_i, breaking the set of strategies using Index 2 satisfies equation $J_{is} \cup J_{ib} = \{1, 2, ..., m_i\}$.

Generally, the intersection of index sets J_{is} and J_{ib} is a non-empty set, which means that the same strategy can lead to the final state or to a situation when the investor must chose a strategy again.

When $j \in J_{is}$, strategy x_{ij} may lead the investor to situation S_{ijk} (probability p_{ijk}). The number of situations enabled by the investor's choice of strategy x_{ij} is marked as n_{ij}.

When $j \in J_{ib}$, strategy x_{ij} leads the investor (probability p_{ijk}) to the final state with profit P_{jb}.

$f(S_{ijk})$ is the likely (expected) average profit ensured by state S_{ijk} and the optimal strategy selected from the pool of possible strategies in this state.

In our model for stochastic dynamic programming, probabilities p_{ijk} and p_{ijb} depend on the probability of decisions made by other institutions.

We shall proceed with the analysis of possible behaviour strategies for an investor that invests into a construction project, seeks maximum profits but faces the opposition of the community. We shall also look at the problem in which optimal strategies are determined using multi-stage optimisation – dynamic programming.

Here, probabilities p_{ijk} and p_{ijb} depend on the probability of certain decisions made by the community opposing the construction and judicial institutions hearing the disputes.

Let us define possible judicial situations.

Let T_k be possible judicial states, $k = \overline{1.7}$ (in our research, there are seven of these states).

In each state T_k, courts may make one of two decisions: A_k or B_k.

Let the probabilities of events A_k and B_k be $q_{k1} = P(A_k)$ and $q_{k2} = P(B_k)$, $q_{k1} + q_{k2} = 1$, $q_{k1} \ge 0$, $q_{k2} \ge 0$.

The first judicial state T_1 is possible if breaches are determined in planning and implementing construction investment projects and if the interested community applies with a claim to an advance institution for out-of-court case hearing. There are two possible events in such situation:

1) A_1: the advance hearing institution rejects the claim (determines that the solutions of the construction investment project do not violate rights of the interested community).
2) B_1: the advance hearing institution satisfies the claim.

Let us assess the probabilities of the events: $q_{11} = P(A_1) = 0.40$, $q_{12} = P(B_1) = 0.60$.

The second judicial state T_2 is possible if the advance hearing institution rejects the claim of the interested community and the interested community applies to a court of first instance. There are two possible events in such situation:

1) A_2: the claim of the interested community is rejected.
2) B_2: the claim of the interested community is satisfied.

Let us assess the probabilities of the events: $q_{21} = P(A_2) = 0.50$, $q_{22} = P(B_2) = 0.50$.

The third judicial state T_3 is possible if the court of first instance rejects the claim of the interested commu-

nity and the interested community applies to a court of appeal. There are two possible events in such situation:

1) A_3: the claim of the interested community is rejected and the investor makes profit P_7.
2) B_3: the claim of the interested community is satisfied and the cancellation of the solutions related to the construction investment project is initiated – the investor suffers loss *N*.

Let us assess the probabilities of the events: $q_{31} = P(A_3) = 0.50$, $q_{32} = P(B_3) = 0.50$.

The judicial state T_4 is possible if the court of first instance satisfies the claim of the interested community and the investor applies to a court of appeal. There are two possible events in such situation:

1) A_4: the investor's claim is rejected and the cancellation of the solutions is initiated – the investor suffers loss *N*.
2) B_4: the investor's claim is satisfied and the investor makes profit P_8.

Let us assess the probabilities of the events: $q_{41} = P(A_4) = 0.50$, $q_{42} = P(B_4) = 0.50$.

The fifth judicial state T_5 is possible if the advance institution for out-of-court case hearing satisfies the claim of the interested community and the investor applies to a court of first instance. There are two possible events in such situation:

1) A_5: the investor's claim is satisfied;
2) B_5: the investor's claim is rejected.

Let us assess the probabilities of the events: $q_{51} = P(A_5) = 0.50$, $q_{52} = P(B_5) = 0.50$.

The sixth judicial state T_6 is possible if the court of first instance rejects the investor's claim and the investor applies to a court of appeal. There are two possible events in such situation:

1) A_6: the investor's claim is rejected and the cancellation of the solutions is initiated – the investor suffers loss *N*.
2) B_6: the investor's claim is satisfied and the investor makes profit P_{10}.

Let us assess the probabilities of the events: $q_{61} = P(A_6) = 0.50$, $q_{62} = P(B_6) = 0.50$.

The seventh judicial state T_7 is possible if the court of first instance satisfies the investor's claim and the interested community applies to a court of appeal. There are two possible events in such situation:

1) A_7: the claim of the interested community is satisfied and the cancellation of the solutions is initiated – the investor suffers loss *N*.
2) B_7: the claim of the interested community is rejected and the investor makes profit P_{12}.

Let us assess the probabilities of the events: $q_{71} = P(A_7) = 0.50$, $q_{72} = P(B_7) = 0.50$.

Let V_j be the possible states of the interested community (situations when the community decides), j = $\overline{1,5}$ (in our research, there are five of these states).

The interested community may act in two different ways in each state: either to refrain from applying to a judicial institution (event C_j) or to apply (event D_j). There are respective probabilities p_{j1} and p_{j2}, where $p_{j1} + p_{j2} = 1, \quad p_{j1} \geq 0, p_{j2} \geq 0.$

The first state of interested community V_1 is possible if the investment solution violates rights. There are two possible events in such case:

1) C_1: the interested community fails to see the violations in the investment solution or fails to submit its suggestions or objections before the deadline, thus the investor makes profit *P*.
2) D_1: the interested community determines the violations in the investment solution and submits its suggestions and/or objections before the deadline.

Let us assess the probabilities of the events: $p_{11} = P(C_1) = 0.80$, $p_{12} = P(D_1) = 0.20$.

The second state of interested community V_2 is possible if the investor rejects the suggestions submitted by the interested community regarding the violations in the investment solution. There are two possible events in such case:

1) C_2: the interested community does not apply to an advance institution for out-of-court dispute hearing and the investor makes profit P_3.
2) D_2: the interested community applies to an advance institution for out-of-court dispute hearing.

Let us assess the probabilities of the events: $p_{21} = P(C_2) = 0.30$, $p_{22} = P(D_2) = 0.70$.

The third state of interested community V_3 is possible if the advance institution for out-of-court dispute hearing rejects the claim of the interested community. There are two possible events in such case:

1) C_3: the interested community does not apply to a court of first instance and the investor makes profit P_4.
2) D_3: the interested community applies to a court of first instance.

Let us assess the probabilities of the events: $p_{31} = P(C_3) = 0.25$, $p_{32} = P(D_3) = 0.75$.

The fourth state of interested community V_4 is possible if the court of first instance rejects the claim of the interested community. There are two possible events in such case:

1) C_4: the interested community does not apply to a court of appeal and the investor makes profit P_6.

2) D_4 : the interested community applies to the court of appeal.

Let us assess the probabilities of the events: $p_{41} = P(C_4) = 0.15$, $p_{42} = P(D_4) = 0.85$.

The fifth state of interested community V_5 is possible if the court of first instance satisfies the investor's claim. There are two possible events in such case:

1) C_5 : the interested community does not apply to a court of appeal and the investor makes profit P_{11}.
2) D_5 : the interested community applies to a court of appeal.

Let us assess the probabilities of the events: $p_{51} = P(C_5) = 0.45$, $p_{52} = P(D_5) = 0.55$.

Let S_i be the possible states of the investor—the situations when the investor decides, $i = \overline{0.5}$ (in our research, there are six of these states).

In each state, the investor can choose from either two or three behaviour strategies. Mixed behaviour strategies are also possible, when each original strategy has a probability assigned:

x_{i1} is the probability the first strategy s_{i1} will be selected; x_{i2} is the probability the second strategy s_{i2} will be selected; x_{i3} is the probability the third strategy s_{i3} will be selected. $x_{i1} + x_{i2} + x_{i3} = 1$, $x_{il} \geq 0, l = 1, 2, 3$.

S_0 is the zero state of the investor. In this state, the investor contemplates whether the investment project is worth launching.

S_1 is the first state of the investor. If violations are determined, the investor has three strategies to choose from:

x_{11} : to accept the suggestions of the interested community and to make profit P_1.

x_{12} : to sign a peace treaty and to make profit P_2.

x_{13} : to reject the suggestions of the interested community.

S_2 is the second state of the investor. If the interested community applies to a court of first instance, the investor has two strategies to choose from:

x_{21} : to sign a peace treaty with the interested community and to make profit P_5.

x_{22} : to reject the peace treaty.

S_3 is the third state of the investor. If the court of first instance satisfies the claim of the interested community, the investor has two strategies to choose from:

x_{31} : to refrain from an application to a court of appeal and to suffer loss *N*.

x_{32} : to apply to a court of appeal.

S_4 is the fourth state of the investor. If the advance institution for out-of-court dispute hearing satisfies the claim of the interested community after the hearing, the investor has three strategies to choose from:

x_{41} : to refrain from applying to a court of first instance and to suffer loss *N*.

x_{42} : to sign a peace treaty with the interested community and to make profit P_9.

x_{43} : to apply to a court of first instance.

S_5 is the fifth state of the investor. If the court of first instance rejects the investor's claim, the investor has two strategies to choose from:

x_{51} : to refrain from applying to a court of appeal and to suffer loss N.

x_{52} : to apply to a court of appeal.

We shall proceed with further mathematical modelling and, using the data from our graph (Fig. 2), shall come up with the recurrent equations (2):

$$
\begin{aligned}
f(S_5) &= \max_{X_5}[Nx_{51} + (Nq_{61} + P_{10}q_{62})x_{52}],\\
f(S_3) &= \max_{X_3}[Nx_{31} + (Nq_{41} + P_8q_{42})x_{32}],\\
f(S_4) &= \max_{X_4}[Nx_{41} + P_9x_{42} + ((P_{11}p_{51} + Np_{52}q_{71} + P_{12}p_{52}q_{72})q_{51} + f(S_5)q_{52})x_{43}],\\
f(S_2) &= \max_{X_2}[P_5x_{21} + ((P_6p_{41} + P_7p_{42}q_{31} + Np_{42}q_{32})q_{21} + f(S_3)q_{22})x_{22}],\\
f(S_1) &= \max_{X_1}[P_1x_{11} + P_2x_{12} + (P_3p_{21} + (P_4q_{11}p_{31} + f(S_2)q_{11}p_{32} + f(S_4)q_{12})p_{22})x_{13}].
\end{aligned}
\qquad (2)
$$

In each state, we need to solve the problem of linear optimisation:

$$\max(c_1x_{i1} + c_2x_{i2} + ... + c_{m_i}x_{im_i}),\ \sum_{j=1}^{m_i} x_{ij} = 1,\ x_{ij} \geq 0,$$

$j = 1, 2, ..., m_i$, in which one of the optimal plans is $x_{ik} = 1, x_{ij} = 0$, when $j \neq k$, if $c_k = \max\{c_1; c_2; ...; c_{m_i}\}$.

Thus, we can replace the recurrent equations with simplified versions (3):

$$
\begin{aligned}
f(S_5) &= \max\{N; (Nq_{61} + P_{10}q_{62})\},\\
f(S_3) &= \max\{N; (Nq_{41} + P_8q_{42})\},\\
f(S_4) &= \max\{N; P_9; (P_{11}p_{51} + Np_{52}q_{71} + P_{12}p_{52}q_{72})q_{51} + f(S_5)q_{52}\},\\
f(S_2) &= \max\{P_5; (P_6p_{41} + P_7p_{42}q_{31} + Np_{42}q_{32})q_{21} + f(S_3)q_{22}\},\\
f(S_1) &= \max\{P_1; P_2; P_3p_{21} + (P_4q_{11}p_{31} + f(S_2)q_{11}p_{32} + f(S_4)q_{12})p_{22}\}.
\end{aligned}
\qquad (3)
$$

In order to determine optimal behaviour strategies for the investor, a programme code for a solution to the recurrent equations (3) has been developed in the EXEL environment (see Table 2). Let us analyse calculations in question.

Table 2. Optimal investor's strategies calculated using the programme code developed in the EXEL environment

Situation	$f(S_5)$	x_5^*
S_5	–25	$x_{52}=1$
Situation	$f(S_3)$	x_3^*
S_3	-25	$x_{32}=1$
Situation	$f(S_4)$	x_4^*
S_4	950	$x_{42}=1$
Situation	$f(S_2)$	x_2^*
S_2	950	$x_{21}=1$
Situation	$f(S_1)$	x_1^*
S_1	968.5	$x_{13}=1$

We solve the recurrent equations to find the specific values of profit in the final state and to determine specific probabilities that the community and judicial institutions will take one or another action. These values are the expected average profit for each state (situation) $f(S_i)$ and the optimal situation management marked as x_i^*. Obviously, original strategies are optimal for each state; their probability is equal to one.

Optimal investor's strategies determined using our calculations are shown in Fig. 3. A broad analysis of determining the dependency of the solutions on the parameters is possible. If, for instance, the size of loss N in the final situation varies between 1 and 1000, the optimal investor's behaviour remains the same, only values $f(S_5)$ and $f(S_3)$ change (1,000 monetary units were used as a measuring unit throughout research).

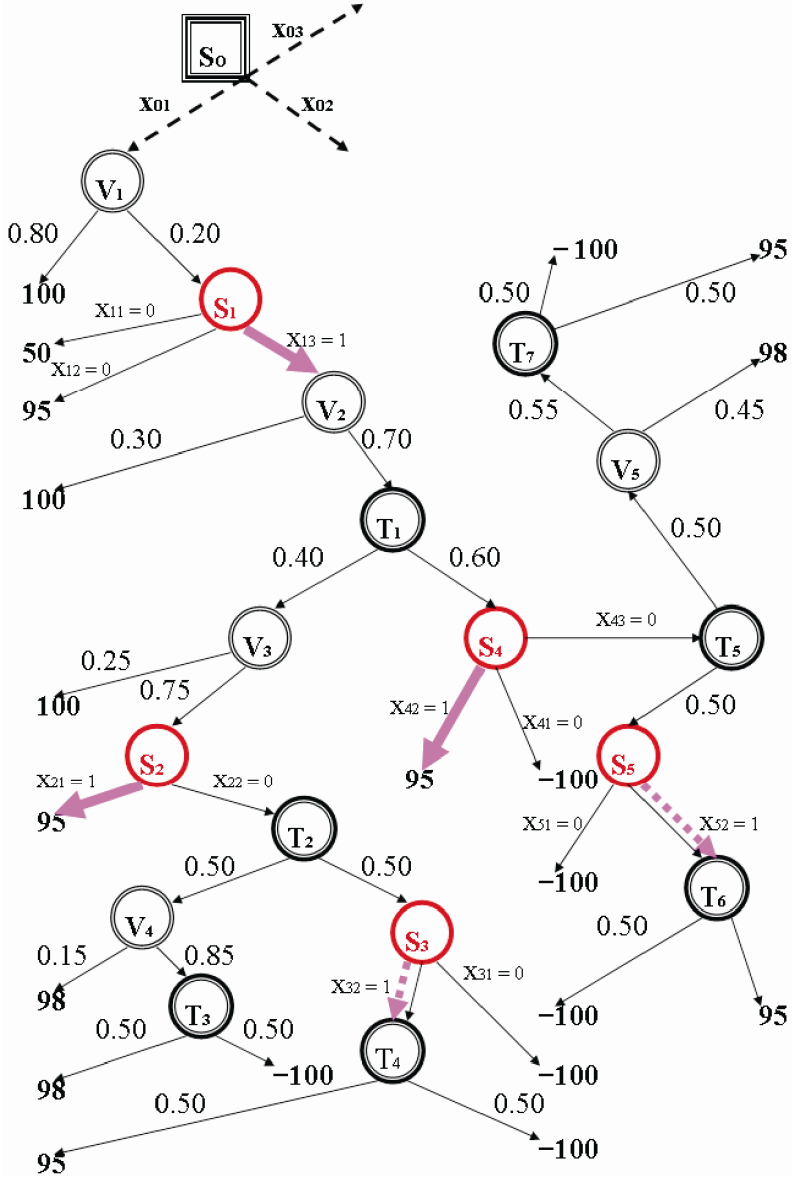

Fig. 3. Optimal investor's strategies

Further research should focus on the analysis of the investor's possibilities of choosing only the projects that would trigger the most positive reactions of third persons with increasing $f(S_1)$ values.

Therefore, future research should consider the inclusion of several trees of the behaviour variants of dispute parties with the same starting point *So* and equivalent to the tree used in this research. An investor, when in state *So*, could select an optimal project based on the same Belman's Principle (see Fig. 3).

4. Conclusions

1. Violations of third-party rights are of benefit neither to third persons, nor to the parties of the construction investment process, because, on one hand, such violations might wrongfully cause the deterioration of conditions for life and other activities of third persons. On the other hand, violations of third-party rights at the stage of construction planning may affect the implementation of the investment project, because all solutions violating third-party rights also violate the provisions of legal acts and can be disputed as stipulated by the Law on Administrative Proceedings (LAP), the Law on Territorial Planning and other legal acts.

2. Investors may incur, and do incur, huge losses when solving disputes on the infringement of third-party rights.

3. In order to make the relations between investors and third parties more rational, a mathematical model of a dispute on allegedly infringed third-party rights has been developed. It helps with determining optimal investor's strategies for each situation of decision-making and thus ensures a certain average profit to the investor irrespective of the strategies chosen by third persons if the probabilities of selecting these strategies are known.

4. The mathematical model for stochastic dynamic programming (EXEL programme code for recurrent equations (3) is used) enables a broad analysis of the dependencies between the optimal investor's strategy and the probabilities that third parties will select a certain strategy. It also helps in analyzing the possible numerical values of profit (or loss).

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GINČO PROCESO TARP INVESTUOTOJŲ IR TREČIŲJŲ ASMENŲ DĖL GALIMAI PAŽEISTŲ TREČIŲJŲ ASMENŲ TEISIŲ MATEMATINIS MODELIAVIMAS

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Santrauka

Nagrinėjama, kaip trečiųjų asmenų teisių pažeidimai, planuojant statybas, gali veikti investicinio projekto įgyvendinimą. Įgyvendinant statybos projektą, teisminio ginčo atsiradimas yra nepageidaujamas rizikos faktorius, galintis sužlugdyti visą projektą. Todėl vykdant statybos projektą jau pradiniame projekto planavimo etape būtina numatyti ir taikyti prevencines priemones tokios rizikos mažinimui. Siekiant šio tikslo straipsnyje atliktas ginčo tarp investuotojų ir trečiųjų asmenų dėl galbūt pažeistų trečiųjų asmenų teisių modeliavimas, sudarant ginčo šalių elgsenos variantų formavimo medį. Sudarytas ginčo proceso dėl galbūt pažeistų trečiųjų asmenų teisių dinaminio programavimo matematinis modelis, leidžiantis nustatyti optimalias investuotojo strategijas kiekvienoje situacijoje, kai reikia priimti sprendimus.

Reikšminiai žodžiai: investicinis statybos procesas, trečiųjų asmenų teisių gynimas, teisminis teisių gynimas, sprendimų medis, dinaminis programavimas, rekurentinės lygtys, optimali elgesio strategija.

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