Chapter 2
Building LP-Risk Models of LP-Modeling Class

It may be a surprise for some mathematicians that the problem data ⇒ the model, explaining the data should be considered as the basic one for any area of science.

Kalman

Risk models of the *LP-modeling* class are fully described in the works concerning technical applications by I. Ryabinin and A. Mozhaev. We have already described *the LP-model* of this class for solving difficult economic problems. The procedure of building *the LP-model* of this class is the following: development of the risk scenario, writing down the *L-risk model* according to the scenario, transition from the *L-risk model* to the *P-risk model*.

The model of the *LP-modeling* class is used as the basis for building risk model of classes *LP-classification*, *LP-efficiency* and *LP-forecasting*, i.e. for the identification of the model of these classes by statistical data. Therefore the description of the issues concerning building the model of *LP-modeling* class is of greatest importance.

The Swiss mathematician and the author of the so called Kalman filter determined the requirements to a model in science [30]. He wrote that it may be a surprise for some mathematicians that the problem *data ⇒ the model*, *explaining the data* should be considered as the basic one for any area of science. It has deep mathematical content and close links with Kolmogorov's theory of probabilities.

We believe that another important requirement to a mathematical model is that of the possibility of detailed and transparent analysis of the model, results and data for management purposes. Neither scoring techniques, nor neural networks meet this requirement. The uniqueness principle places an emphasis on the undeniable fact that science results should be obtained from objective data analysis, and not from random self-assertive manipulations with model.

The LP-model of *LP-modeling* class conform to Kalman's rule, as well as *the LP-model* of derivative classes *LP-classification*, *LP-efficiency* and *LP-forecasting*.

The independent use of *the LP-model* of *LP-modeling* class has been considered for the following tasks:

E.D. Solozhentsev, *Risk Management Technologies*,
Topics in Safety, Risk, Reliability and Quality 20,
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- I^3*-technologies* of solving difficult problems (Sect. 1.1, Chaps. 10 and 21);
- *LP-management* of a transport company efficiency (Chap. 11);
- *the LP-model* of the company management failure risk (Chap. 15);
- *the LP-model* of a bank's operation risk (Chap. 16);
- *LP-analysis and management* of the processes non-validity risk (Chap. 18);
- *the LP-model* of fire-hazardous objects insurance risk (Chap. 20).

2.1 Perfect Disjunctive Normal Form

In economy and engineering the possible system states (complete set) can be always written down as a perfect disjunctive normal form (PDNF) taking into account the two states of each event-parameter (in engineering) [57] or taking into account GIE for each event-parameter (in economy) [85]. The total number of different system events-states is determined by expression (1.7). All these states can be written down in matrix form. The state appearance probability in statistical data is calculated by probabilities of events $Z_1, Z_2, \ldots, Z_n$ (to be more precise—their corresponding gradations) appearing in statistical data.

Orthogonality of system states in a KB. *L-function* for all possible system states is given by

$$Y = Y_1 \vee Y_2 \vee \cdots \vee Y_k \vee \cdots \vee Y_N, \tag{2.1}$$

where the state is determined by the *L-function* with all L-variables:

$$Y_k = Z_1 \wedge \cdots \wedge Z_j \wedge \cdots \wedge Z_n. \tag{2.2}$$

Each L-derivative takes a lot of values according to the number of gradations or intervals, into which the parameter is divided. L-functions for two different states (objects), for example

$$\begin{aligned} Y_k &= Z_1 \wedge \cdots \wedge Z_{jr} \wedge \cdots \wedge Z_n; \\ Y_{k+1} &= Z_1 \wedge \cdots \wedge Z_{jr+1} \wedge \cdots \wedge Z_n, \end{aligned} \tag{2.3}$$

are orthogonal, as Z_{jr} and Z_{jr+1} belong to the same GIE: $Z_{jr} \wedge Z_{jr+1} = 0$. The orthogonality property of the addends of the system states risk L-function allows passing over from L-functions to algebraic expressions for probabilities (risk), analysis the state risk according to the contribution of events-gradations, calculating transition probabilities, as well as overcoming exponential computational complexity of the algorithm.

2.2 The Shortest Paths of Successful Operation

Building *the LP-risk model* on the shortest paths of successful operation (SPSO) is widely spread in engineering [57], when electric, water gas or any other scheme of a

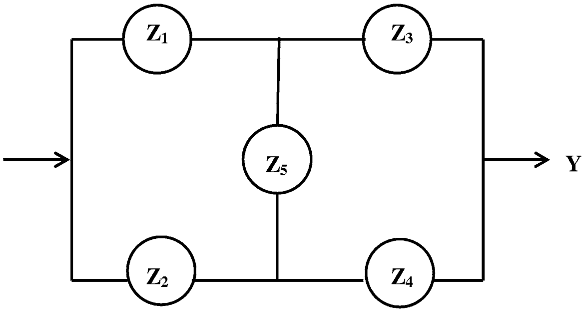

Fig. 2.1 Structural model of the "bridge"

system, device, etc. exists. In economy the *LP-model* of the system state failure risk is built according to the risk scenario or the failure risk graph model, which connect elements $Z_1, \ldots, Z_n$.

The L-function of risk is written down as minimal failure cross-sections or the shortest paths of successful operation [51, 57]. However, now one needs orthogonalization of *L-functions* in order to obtain *P-function* of risk, but this procedure is not a real problem when one has special *Software* and modern computers.

Example Electric circuit of the "bridge" type (Fig. 2.1) will be written down in disjunctive normal form (DNF) as a logical sum of the shortest paths of successful operation [57]:

$$Y = Z_1 Z_3 \vee Z_2 Z_4 \vee Z_1 Z_5 Z_4 \vee Z_2 Z_5 Z_3. \tag{2.4}$$

After orthogonalization (2.4) we obtain *P-model* of risk:

$$P_i = p_2 p_4 + p_1 p_3 + q_1 p_2 p_3 q_4 p_5 + p_1 q_2 q_3 p_4 p_5 - p_1 p_2 p_3 p_4. \tag{2.5}$$

2.3 Minimal Failure Cross-Sections

It does not matter if we write down the *L-function* for success or failure, as the failure probability $q = 1 - p$, where p is success probability. It is often important to analyze failure risk itself. Then it is more convenient to write down instead (2.4) the *s*ystem failure L-function as minimal cross-sections of elements failure [57]

$$\overline{Y} = \overline{Z_1 Z_2} \vee \overline{Z_3 Z_4} \vee \overline{Z_1 Z_5 Z_3} \vee \overline{Z_3 Z_5 Z_4} \tag{2.6}$$

and then perform orthogonalization of this functions and write down the *P-polynomial* of risk.

2.4 Associative *LP-Risk Models*

The system states failure risk scenario can be associative [85]. For example, a failure causes one, two, ... or all initiating events from $Z_1, Z_2, \ldots, Z_n$. *L-failure risk model* is written down according to this scenario (which is a PDNF subset). Here we also need orthogonalization of *L-functions* in order to obtain *P-function* of risk.

Example *L-function* of the associative model failure risk:

$$Y = Z_1 \vee Z_2 \vee \cdots \vee Z_j \vee \cdots \vee Z_n, \tag{2.7}$$

where $Z_1, \ldots, Z_n$ are logical variables for the state parameters.

Logical function of failure risk after the orthogonalization of the associative risk model (2.7):

$$Y = Z_1 \vee Z_2 \overline{Z_1} \vee Z_3 \overline{Z_1 Z_2} \vee \cdots. \tag{2.8}$$

From (2.8) *P-function* of the associative model failure risk:

$$P(Y_1 = 0) = P_1 + P_2 \cdot (1 - P_1) + P_3 \cdot (1 - P_2) \cdot (1 - P_1) + \cdots, \tag{2.9}$$

where $P_j = P\{Z_j\}$ is the probability of independent events Z_j leading to failure Y_1.

A limited set of events. As A. A. Losev demonstrated PDNF allows building associative *the LP-model* for a limited set of events [85], For example, when one or any two events occur *L-risk model* will be written down as

$$\begin{aligned} Y_1 = Z_1 \overline{Z_2 Z_3 Z_4} \vee Z_2 \overline{Z_1 Z_3 Z_4} \vee Z_3 \overline{Z_1 Z_2 Z_4} \\ \vee Z_4 \overline{Z_1 Z_2 Z_3} \vee Z_1 Z_2 \overline{Z_3 Z_4} \\ \vee Z_1 Z_3 \overline{Z_2 Z_4} \vee Z_1 Z_4 \overline{Z_2 Z_3} \vee Z_2 Z_3 \overline{Z_1 Z_4} \\ \vee Z_2 Z_4 \overline{Z_1 Z_3} \vee Z_3 Z_4 \overline{Z_1 Z_2}. \end{aligned} \tag{2.10}$$

In this L-model all L-items are mutually orthogonal, which allows writing failure risk P-model (polynomial) at once on the assumption of the independence of events Z_1, Z_2, Z_3, Z_4:

$$\begin{aligned} P(Y_1 = 0) = p_1 q_2 q_3 q_4 + p_2 q_1 q_3 q_4 + p_3 q_1 q_2 q_4 + p_4 q_1 q_2 q_3 + p_1 p_2 q_3 q_4 \\ + p_1 p_3 q_2 q_4 + p_1 p_4 q_2 q_3 + p_2 p_3 q_1 q_4 + p_2 p_4 q_1 q_3 + p_3 p_4 q_1 q_2. \end{aligned} \tag{2.11}$$

2.5 Tabular Form of *the LP-Risk Model*

Let's describe the building of *the LP-risk model* in a tabular form on the example of the "bridge" which was already analyzed (Fig. 2.1). The system has four paths (events) of successful functioning: S_1, S_2, S_3, S_4.

S_1—is given by events Z_1, Z_3,
S_2—is given by events Z_2, Z_4,

Table 2.1 Tabular form of the bridge logical model

States	Initiating events				
	Z_1	Z_2	Z_3	Z_4	Z_5
S_1	1	0	1	0	0
S_2	0	1	0	1	0
S_3	1	0	0	1	1
S_4	0	1	1	0	1

S_3—is given by events Z_1, Z_4, Z_5,
S_4—is given by events Z_2, Z_3, Z_5.

Let's represent links of events S_1, S_2, S_3, S_4 and initiating events Z_1, Z_2, Z_3, Z_4, Z_5 as a link Table 2.1.

Note 1—presence of the link, 0—absence of the link.

Let's write out L-functions for events S_1, S_2, S_3, S_4 according to Table 2.1:

$$\begin{aligned} S_1 &= Z_1 Z_3, \\ S_2 &= Z_2 Z_4, \\ S_3 &= Z_1 Z_4 Z_5, \\ S_4 &= Z_2 Z_3 Z_5. \end{aligned} \tag{2.12}$$

L-function of the system successful operation is presented as a disjunctive normal form (DNF):

$$Y = S_1 \vee S_2 \vee S_3 \vee S_4. \tag{2.13}$$

As a result we obtained the same *L-function* of the system successful operation (2.4).

Some L-variables are repeatedly (several times) included in the derivatives of *L-functions*. For example Z_1 is included in S_1 and S_3, Z_5—in S_3 and S_4, etc. As a result *L-function* for the final event is an Y L-functions with repeated elements. In order to pass from the L-function of risk to the P-function of risk one has to transform Y into a logical non-repetitive orthogonal form.

Using Table 2.1, let us build the functional integrity scheme according to A. Mozhaev (Fig. 2.2), is one of the forms of representing a risk model [51].

2.6 Risk and Efficiency Model for Several Aims

The *LP-system risk model* is built as follows: a scenario is formulated, a structural model is built, an *L-model* is written down, the orthogonalization of the L-model is performed and the P-model (polynomial) is obtained.

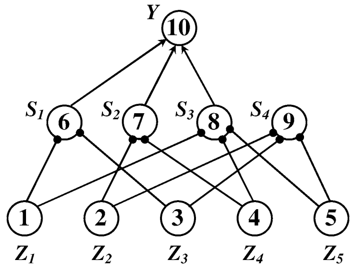

Fig. 2.2 Functional integrity scheme for the bridge

The LP-risk model can be made up for an arbitrary risk scenario. Scenario development begins from the top to the bottom: at first the final event is determined, then—the events which caused it, etc. Several edges are joined into one juncture (arbitrary event). Only one edge with from L-link comes out of each juncture *AND, OR, NOT*.

At the lowest level the events are called initiating, and their probabilities are given. The remaining events are called derivative events, and their probabilities are calculated, including those of the final event.

If two different system criteria are analyzed by the logical modeling method, one can study the following complex events:

(1) L-function for the realization of at least one criterion ($Y_1 \vee Y_2$),
(2) L-function for non-realization of no criteria ($\overline{Y}_1 \wedge \overline{Y}_2$),
(3) L-function for the realization of both criteria ($Y_1 \wedge Y_2$),
(4) L-function for the realization of only the first criterion ($Y_1 \wedge \overline{Y}_2$),
(5) L-function for the realization of only the second criterion ($\overline{Y}_4 \wedge Y_5$).

If there are two and more risk scenarios and correspondingly *L-risk model* or two different outcomes of one scenario, one can logically unite them into one *the LP-risk model*. For example, if there are two outcomes (Y_1 and Y_2) from two different model, then complex risk model might look as follows:

$$Y_1 \vee Y_2; \quad Y_1 \wedge Y_2; \quad Y_1 \wedge \overline{Y_2};$$
$$\overline{Y_1} \wedge Y_2; \quad \overline{Y_1} \wedge \overline{Y_2}. \tag{2.14}$$

Several different risk scenarios can be logically united into one LP-model, using operation *OR*. If different model or aims have efficiency parameters $E_1, E_2, \ldots, E_m$ of the same content and degree, then the risk of the complex model is calculated from the expression of (2.9) type, and efficiency as a scalar from the expression

$$E = P_1 E_1 + P_2 E_2 + \cdots + P_m E_m, \tag{2.15}$$

where $P_1, P_2, \ldots, P_m$ are risks (probabilities) of separate model failure. If different model or aims have efficiency parameters $E_1, \ldots, E_m$ of different content and degree, then the efficiency of the complex model should be viewed as a vector

$$E = (E_1, E_2, \ldots, E_m). \tag{2.16}$$

2.7 Scenarios and *LP-Risk Models* in Students' Projects

Scenarios and risk model, developed by the fifth-year economy students of St. Petersburg State University of Aerospace Tool Engineering are good examples of building and analysis of model of *LP-modeling* class, containing up to 30 events:

(1) failure risk of the Russian economics recovery;
(2) failure risk of the company development;
(3) EURO exchange rate fall risk;
(4) president's activity and election failure risk;
(5) risk of the enterprise profit reduction;
(6) risk of the world crisis;
(7) risk of the political instability in the country;
(8) risk of social unrest in the Russian Federation;
(9) risk of crisis in the Russian Federation;
(10) failure risk of the marketing strategy of a company;
(11) risk of oil prices reduction;
(12) failure risk of solving difficult economic problems;
(13) risk of bribery and corruption in an office;
(14) risk of officials' fraud;
(15) bribery risk during service;
(16) failure risk of small and medium-sized business development.

2.8 Building Composite *LP-Risk Models*

The problem of building the elaborate *LP-risk model* of the failure of composite structurally complex economic systems is not a trivial one. We suggest several rules of building such a *LP-failure risk model*.

An *LP-risk model* can be a composite one with a separate risk model joined by *AND, OR, NOT* operations and cycles. Integrated structurally complex economic systems include several subsystems, which may have several shared or repeated elements (events), which have to be registered.

A composite *LP-risk model* can be so complex that L- and P-risk functions do not fit in the computer RAM memory or the items in P-functions contain a big number of multipliers (with probabilities from 0 to 1) and risk assessment becomes inaccurate. In this case the model decomposition should be used and initiating events should be folded in junctures *AND and OR*.

The composite structurally complex economic system includes several subsystems. If the subsystems have no shared elements (events), then each subsystem failure can be considered independently, and the whole system failure can be obtained by joining events for subsystems by logical operations *AND, OR, NOT*.

If systems have several shared elements (events), the *LP-risk failure model* is built, taking into account repeated elements. Integrated *the LP-risk model* with repeated elements are of the greatest practical and theoretical value, because economic processes are interconnected and interdependent. However, there are no methods and techniques of building *the LP-risk model* with repeated elements.

Various terms and concepts can be used in various particular scenarios for the same events, and it is not easy to find repeated elements among dozens and hundreds of events. We propose the following rules of building a composite *LP-risk model* in economy:

1. Building an *LP-failure risk model*, if a risk scenario has only *AND* or only *OR* logical links is quite easy, and all calculations can be made in mind or using a calculator.
2. Indicating the risk of external, internal and repeated initiating events in scenarios.
3. Folding of the initiating events, if there is a problem of fitting *the L-risk model* into the computer memory.
4. Choosing the parameters of the *L-risk model* transformation algorithm (maximum number of logical items and maximum number of logical multipliers in L-items) by way of trial calculations.
5. Decomposition of the complex risk model into a number of simple model, if in a *P-risk model*, built after the orthogonalization of the L-risk function, the items of the P-function (P-polynomial) have a big number of multipliers (more than 30). As the initiating events probabilities have values in the interval $\{0, 1\}$, the accuracy of calculating derived acts probabilities is lost. After the calculations on each simple model these model and results should be joined by logical links *AND* or *OR*.

2.9 Complex *LP-Risk Models*

Examples are as instructive as rules. Let's give an example of building a complex *LP-failure risk model* with repeated elements, using the algorithm of L-functions orthogonalization.

If the subsystems of a composite structurally complex economic system have no shared elements (events), then the failure of each one can be viewed independently, and the failure of the whole system happens when events for subsystems are linked by L-operations *AND, OR, NOT*. If subsystems have several shared elements (events), then an *LP-failure risk model* is built, taking into account repeated elements.

Composite *the LP-risk model* with repeated elements are of the greatest practical and theoretical value, as economic processes are interconnected and interdependent. However, there are no methods and techniques of building *the LP-risk model* with repeated elements. In various particular scenarios for the same events different terms and concepts can be used, and it is practically impossible to find repeated elements among dozens and hundreds of events.

Discrimination of external connected events. The rule consists in discriminating external initiating events. For any particular scenario of economic process risk external and internal initiating events are considered separately. Then separate external initiating events can turn out to be shared (repeated) for several *the LP-risk model* of particular scenarios concerning the risk of economic processes. Examples of external initiating events.

1. A company—events in the economics of the country and world economics.
2. Departments of a factory—events in managing a factory: management, planning and financial departments, supply sales department, personnel training department, etc.
3. Natural disasters, flu epidemic, etc.

Folding of initiating events. A *LP-risk model* can be so complex, that logical and probabilistic functions of risk do not fit into the computer RAM memory. For example, in the non-commercial software complex ACM these functions should have not more than 600 items. Software packages *Arbiter, Risk Spectrum, Risk and Criss* have similar limitations.

One has to simplify the writing down procedure of the composite model in order to build a structural, logical and a probabilistic model of the composite model failure risk. In order to do that we propose to fold (join) initiating events in junctures *AND and OR*. Let's introduce the symbols: Y—junction event; $(Y_1, Y_2, \ldots, Y_k)$—events, influencing the success of the juncture event; $P\{Y = 0\} = P$—juncture event failure probability Y; $P\{Y_1 = 0\} = P_1, \ldots, P\{Y_k = 0\} = P_k$—the probabilities of influencing events $Y_1, Y_2, \ldots, Y_k$ leading to the event failure in juncture Y; $P\{Y_1 = 1\} = 1 - P_1 = Q_1, \ldots, P\{Y_k = 1\} = 1 - P_k = Q_k$—probabilities of events $Y_1, Y_2, \ldots, Y_k$ leading to a successful event Y.

Node OR (Fig. 1.4). The failure risk logical model:

$$Y = Y_1 \vee Y_2 \vee \cdots \vee Y_k. \tag{2.17}$$

The failure risk probabilistic model:

$$P\{Y = 0\} = 1 - Q_1 Q_2 \cdots Q_k. \tag{2.18}$$

Node AND (Fig. 1.3). The failure risk logical model:

$$Y = Y_1 \wedge Y_2 \wedge \cdots \wedge Y_k. \tag{2.19}$$

The failure risk probabilistic model:

$$P\{Y = 0\} = P_1 P_2 P_3 \cdots P_k. \tag{2.20}$$

Thus, using formulae (2.17–2.20), initiating events for junctures *AND* and *OR* are replaced by one initiating event with an easily calculated probability. It allows reducing the number of initiating events substantially, building L- and P-functions for composite *the LP-risk model* and studying failure risk of complex economic systems.

Repeated events are not included into folded initiating events. Folding can be conducted by V. Alexeev's bundled software, A. Mozhaev's non-commercial bundled software even by manual calculation. The problem of assessing the contributions of folded initiating events on the basis of the structure of Eqs. (2.17) and (2.20) presents no difficulties.

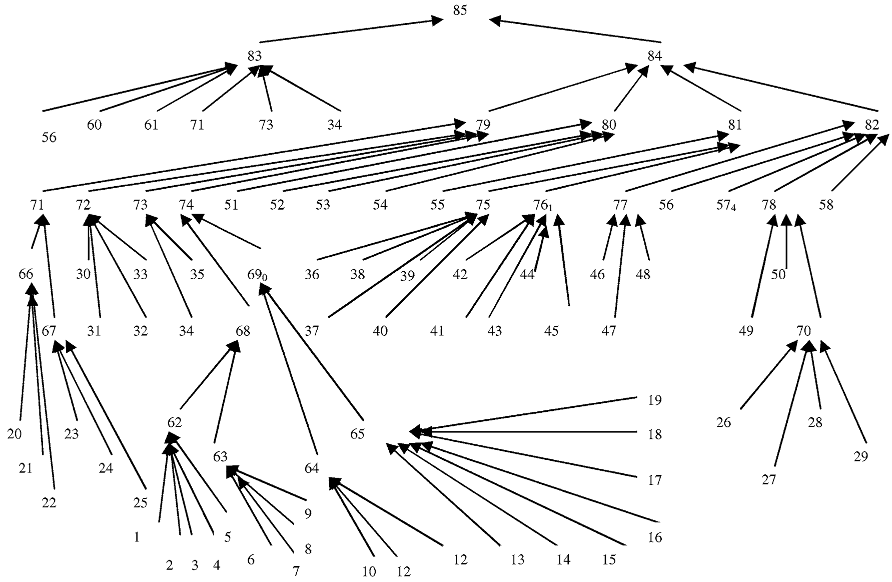

Fig. 2.3 Structural model of risk with repeated elements

Studies of the LP-risk model. The modeling was conducted by PC ACM 2001 bundled software, which allows performing structural-logical modeling of complex systems.

The maximum possible number of items in the L-risk functions in the transformation process is given. The final value of this parameter will be smaller, but the transformations will finish, if during the transformation process the number of items will exceed this value. The maximum number of logical multipliers in the L-function item is also given. The possible values of the mentioned parameters are assessed by rapid calculation on the bundled software.

The registration of repeated elements. The graph-model of the complex event failure risk has been built (Fig. 2.3). External initiating events are represented by a group of 6 events, belonging to Y_{11}—influence of external factors. 61 initiating events belong to group Y_{12}—influence of internal factors. Events Y_{31}, Y_{33}, Y_{47} are shared (repeated) elements in the risk model scheme. They belong to derived acts Y_{11}, Y_{12}, which are joined by a logical link *AND*.

Identifier *y* is draw down in designating logical variables, and only the index—number is left. The variables designation according to the graph (Fig. 2.3) has been replaced for the machine representation of the formed logical risk model. The content of events in the risk scenario according to Fig. 2.3 can be found in Table 2.2. Computational research was done for the final event equal to $Y_{85} = Y_{84} \wedge Y_{83}$.

The data are input into the files *Gb.dat, Harel.dat*. At first *Gb.dat* is filled. In the first line the total number of peaks N_1 is given, as well as the maximum number of semicircular arcs for one peak N_2, the number of initiating peaks N_3, the maximum number of items N_4 and the maximum number of multipliers in one item of the

Table 2.2 Initiating and derived events of the LP-risk model

Number	Title	Number	Title
1	2	3	4
85	complex event	66	lack of constant clients
83	external factors	67	lack of extra services
84	internal factors	30	incorrectly set tasks
59	bad economic situation in the country	31	lack of knowledgeable management
60	disagreement between managers and the owners of the company	33	lack of qualified employees
61	insufficient data concerning market research	32	high costs
79	lack of the company mission of	34	fall of the demand for the service
80	lack of the definite marketing strategy	35	bad image of the company
81	lack of the strategy choice and market analysis	68	net profit decrease
82	no marketing process within the collective	69	rise of expenses
71	no potential consumers	36	wrong choice of addressing customers
72	incorrectly set goals of the company	37	wrong choice of advertising period
73	fall of the demand for the product	38	unprofessional advertisement
74	efficiency fall	40	unprofessional text of advertisement
51	lack of economic activity analysis	39	wrong choice of advertising positioning
52	lack of main resources	41	decrease of additional benefits for the consumer
53	equipment failure	42	marketologists incompetence
54	decrease of the number of employees	43	insufficient work with consumers
55	pricing errors	44	lack of the consumer's precise concept
75	merchandising errors	45	wrong choice of target sales markets
76	drop of advertising efficiency	46	drop in meeting employees' basic demands
77	personnel turnover increase	47	lack of precise evaluation of work results
56	lack of qualified employees	48	lack of correspondence between work and salary
57	personal manager's incompetence	49	employees' dissatisfaction with working conditions

Table 2.2 (*continued*)

Number	Title	Number	Title
1	2	3	4
78	decrease of employees' work motivation	50	salary decrease
58	difficulties of choosing personnel	70	conflicts in the collective
20	out-of-date techniques of marketing research	1	high barriers of entering the market
21	out-of-date marketing strategies	2	introduction of substitute product techniques
22	out-of-date production technology	3	increase of competition
23	out-of-date type of services	4	fall of the brand reputation
24	out-of-date product	5	decrease of the people's welfare
25	inability to satisfy customers' requests	6	lack of similar materials
62	production ramp-down	7	lack of human resources
63	fall of the demand for the product	8	planning errors
64	increase of indirect expenses	9	fixed assets failure
65	increase of direct expenses	10	increase of household running costs
26	lack of corporate culture	11	increase of labor costs
27	lack of the system of clearly formulated job duties	12	increase of the delivery product price
28	lack of the clear system of demands to employees	13	increase of staff recruitment costs
29	different values of employees	14	increase of personnel training costs
	71, 73 and 34 belong to external and internal factors	15	increase of management costs
19	increase of costs for purchasing new equipment	16	increase of costs for production maintenance
18	increase of costs for fixed assets maintenance	17	increase of costs for fixed assets operation

automatically formed calculation logical function N_5. Then follow the description lines of all peaks. The peak number goes into the first column. The sign of the peak view (initiating—1 and derived—2)—in the second column. The third column is an auxiliary one, and then in the line come N_2 of pairs of parameters values, describing the peaks. Then the file *Harel.dat* for the probabilities of initiating peaks is filled.

Folding of initiating peaks. The initial graph-model (Fig. 2.3) had: $N_1 = 85$ peaks, with initiating peaks $N_3 = 61$. We failed to obtain a correct solution with parameter $N_4 = 600$ (the maximum number of items in the logical risk function).

When $N_4 < 500$ the logical and probabilistic functions are built only incompletely. It is seen from the fact that the transformations remain incomplete and the number of items for logical and probabilistic functions is equal to the given value of $K_1 = K_2 = N_4$.

Therefore we conducted the folding of initiating events groups with the aim of reducing their number. The following groups of initiating events were selected for folding:

group $Y_1 - Y_5$ and $Y_6 - Y_9$ was folded into derived act Y_{68};
group Y_{10}, Y_{11}, Y_{12} and $Y_{13}, Y_{14}, Y_{15}, Y_{16}, Y_{17}, Y_{18}, Y_{19}$ was folded into derived act Y_{69}. With the probabilities of mentioned initiating events 0.02, during the folding of probabilities events we obtained $P\{Y_{68} = 0\} = 0.1662$ and $P\{Y_{69} = 0\} = 0.1829$. Then we built a newer compact *the LP-risk model* excluding folded initiating events and using new events Y_{68} and Y_{69}, already described as initiating events, and not derived acts. We used probabilities events Y_{68} and Y_{69}, obtained after folding initiating events.

As it is seen from simulation results, the decrease of the model by folding initiating events allows decreasing significantly the dimensions of the *L-risk model*. Let's describe calculation research.

Initiating events from 1 to 19 are folded into events 68 and 69. Now the graph-model has $N_1 = 62$ peaks with $N_3 = 44$ being initiating ones.

Calculation research was also conducted for the final event equal $Y_{85} = Y_{84} \wedge Y_{83}$. When $N_4 < 400$ logical and probabilistic functions are built incompletely. It is seen from the fact that the transformations remain incomplete and the number of items for logical and probabilistic functions equals the given value of $K_1 = K_2 = N_4$. When $N_4 > 400$ the number of items for logical and probabilistic functions equals $K_1 = K_2 = 104$. When the parameter value $N_4 = 400$ (the maximum number of items in the L-risk function) the correct solution was obtained. When initiating events are folded and $N_4 = 400$ the final event probability $P\{Y_{85} = 0\} = 0.1806$.

The basic results of calculation research:

1. Without folding initiating events the value $P\{Y_{85} = 0\}$ differs from the real value $N_4 = 200$ ($P_{85} = 0.0613$), $N_4 = 400$ ($P_{85} = 0.1037$), $N_4 = 500$ ($P_{85} = 0.1197$) correspondingly. If we extrapolate the results, without folding initiating events the real value of probability P_{85} may be obtained when N_4 is more than 1000. Repeated events were taken into account and they were denoted by the same identifiers.
2. With the initiating events folded and without taking into account repeated events the following results were obtained with $N_4 = 400$—the number of items in L- and P-risk functions equals $K_1 = K_2 = 240$. The final event probability equals $P\{Y_{85} = 0\} = 0.078$ and is very different from the probability of this event when repeated events are taken into account.
3. The number of multipliers in the item of P-risk function reaches 42. As values of multipliers as probabilities are within the interval {0, 1}, it is not easy to calculate the items accurately. Calculation accuracy depends both on the number of multipliers, and the values of probabilities themselves. Thus, the best way out is to

decompose the complex composite the LP-risk model into several simple model, joined by logical operations *AND* and *OR*.

2.10 Dynamic *LP-Risk Model*

There are three types of dynamic *the LP-risk model* [85]. In the first type the change of probabilities parameters, gradations and states or objects in time is considered. In the second type time is viewed as an event-parameter. In the third type *the LP-model* is systematically retrained by monitoring statistical data.

In *the LP-risk model* of classes *LP-classification, LP-efficiency and LP-forecasting* time is taken into account as follows.

1. Events probabilities in a system change with time, and they may be given in the time function. Probabilities of elements failure change due to wear, corrosion, aging, repair works, details substitution, personnel training, etc. On the basis of the technical condition of the system one obtains information about its actual condition, evaluates its operation risk and takes a corresponding decision. As time goes the probabilities of elementary events also change in economic and social systems.
2. *LP-risk model* can be built as dynamic one, when, for example, one inputs as a parameter the date of getting a credit and gradations of this parameter. Thus, the problem of getting rid of out-of-date statistical data is solved. The research of the real data of the bank with 3000 credits showed that the parameter "the date of getting the credit" is practically as important for risk as parameters "sum", "period" and "aim" in credit provision. In the DB economic factors are usually given by days and months, for example, restaurant sales, i.e. time are input into an L-model as an event-parameter.
3. Systematic retraining of *the LP-model* by monitoring data makes *the LP-model* dynamic. Identification (retraining) of the *LP-assets portfolio risk model* can be performed daily according to the data about stock prices, *LP-credit risk model*—after the reports about next 10 credits have been submitted. Systematic retraining of *the LP-model* with the further analysis of the system risk and efficiency can identify the beginning of a crisis, as the trend of contributions of initiating events-gradations into the system failure risk and its efficiency becomes clear.

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