International Journal for Quality Research 9(3) 455–466
ISSN 1800-6450

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MANAGEMENT OF INTERNAL RISKS AND OPPORTUNITIES OF ENTERPRISES

Article info:
Received 17.05.2015
Accepted 12.08.2015

UDC – 54.061

Abstract: *The work reviews the approach to the management of an organization taking into account internal risks caused by management decisions. Quantitative evaluations of individual risks, integrated risks, and the algorithm of the internal risks management are also reviewed.*

Keywords: *Internal risks, risk model, stages of the risk analysis, normalized risks, integrated assessment of a risk set, management algorithm*

1. Introduction

Realization of a new version of the international ISO 9001 standard that is proposed to be put in practice in 2015 requires readiness of experts. In addition to the new structure this fact is caused by the important new section devoted to consideration of risks and opportunities during a decision-making, process management, and activities planning, etc. (Madera, 2013)

Creation of quality management system must be the strategic decision of the organization. The reliable quality management system can help the organization to improve the general indexes of the activities and to create an integrated element of settled initiatives of organization development.

The risk is an effect of uncertainty in relation to the expected outcome. The concept of the risk - informed thinking was always implied in ISO 9001.

The new international ISO 9001:2015 standard (ISO 9001/DIS 9001:2014) makes the risk-oriented thinking more pronounced and includes it in the requirements to development, implementation, support of functioning, and continuous improvement of the quality management system.

Not all processes of the organization have the same risk level from the point of view of their influence on ability of the organization to achieve the objectives, as well as consequences of mismatches within processes, production, services or system aren't identical to the different organizations. In some cases a consequence of delivery of inappropriate production or provision of inappropriate services can result only in insignificant inconveniences for a customer of organization, whereas in other cases a mismatch can lead to far-reaching consequences and even be fatal.

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Therefore the risk - informed thinking means a need of the quantitative (and qualitative, if necessary) risk review during a decision making on severity and depth of approach to planning and control as a quality management system, so the processes and types of activity.

The uncertainty is incompleteness or inaccuracy of information on conditions of implementation of the administrative decision or a project. Risk is directly connected to uncertainty.

2. Main part

2.1 Sources of the uncertainty

Human activity is interaction between a subject and an object in the context of environment (Madera, 2013). The subject, the object, the environment and components of the environment (natural, technogenic, economic, and social) are main points of activity.

The indefinite and unpredictable main points of activity cause uncertainty and unpredictability of the activity process which, in total, form sources of uncertainty and unpredictability of the future.

The uncertainty is incompleteness or inaccuracy of information on conditions of implementation of the administrative decision or a project. Risk is directly connected to uncertainty.

And still, we remind that activity of a person is impossible out of the context of the environment comprising of natural, technogenic, economic, and social components. Therefore it is difficult to analyze abilities and risks without understanding these components.

The natural environment is characterized, on the one hand, by the extremely long time intervals when there are no notable changes in the fundamental and natural links expressed through laws of the nature.

The technogenic environment includes artificial objects created by “hands and intelligence” of a human. It is known that any thing: a system, a device, an instrument is subject to the irreversible changes causing failures.

The main characteristic of economic and social environments is that the main actors within them are a human, social groups, communities, society, and mankind in general.

Such important component of the economic and social environments as a competitive environment within which any business exists, is a vivid example of a total uncertainty.

In the greater degree, the reason of uncertainty and unpredictability of results and consequences of the activity lies in the subject of activity. Uncertainty and unpredictability of the subject cause uncertainty of the acts, actions, decisions made, and a trajectory of activities process which is realized by this subject.

Uncertainty and unpredictability of the subject of activity or so-called human factor together with factors of uncertainties of object and environment are main sources of uncertainty and unpredictability of activity (Madera, 2013).

Activities shall proceed within a favorable for these activities set of environmental conditions and factors with all the components - natural, technogenic, economic, and social.

In the conditions of uncertainty any actions lead to events and consequences which can be "positive" potential opportunities as well as "threats" as to the organization, so to individual types of activity. Now risk management includes concepts of the positive (opportunity, chance) and negative (losses) risk aspects.

The risk usually arises on the stage of administrative decision-making and is reduced to a loss estimate under the aspiration for gain.

2.2 Opportunities and risks

The dialectics of relations between opportunities (also the term "chance" is used) and risks are that chances are an expression of motivation to purposeful activities improvement, and risks are possible hazard warnings on the way (Madera, 2013; Boholm and Corvellec, 2010).

All opportunities (chances) and risks can be both subjective and objective.

Methods that enable to remove, at least partially, the uncertainty and unpredictability of the future and also to change and reallocate risks and chances together with their occurrence probabilities, and by that to make the future more certain and predictable, are:

1) purposeful activities,
2) management of activities.

The choice of one of action strategies within any line can lead both to augmentation and to losses of invested funds. In conditions of the uncertainty there is always a set of alternative options to make a decision. The successful implementation of any of them depends on a great number of internal and external factors influencing the organization, and on quality of the administrative decision made (Arsovski and Lazić, 2010).

The main objective of risk management which is reducing to of risks identification and control is a contribution to a process of maximizing value of the organization. It means detection of all potential "negative" and "positive" factors influencing the organization, its activities, and its risks and opportunities. It increases probability of success and minimizes probability of a deviation and uncertainty while achieving objectives set by the organization.

In contrast to the so-called crisis management, the risk management is characterized by the emphatic focus on perspectives (focus on opportunities and chances). At many hi-tech enterprises the risk management is implemented in the form of "risks and opportunities management".

Due to taking active measures the effective risk management enables to avoid crisis situations or to decrease negative effects of the situations occurred.

"The good manager manages risks, the bad – manages crisis situations".

The enterprise has to take risks into account in order to use the opportunities. Thus, in the long term, understanding risks and ability to manage activities, and consequently also these risks is a necessary provision of success. An analysis, an assessment, and risk management are necessary to be implemented.

Enterprise management today is impossible without prediction and implementation of a development strategy, without support of stability of the enterprise, without application of effective scientific methods (Vasilkov and Gushchina, 2011; Schiller and Prpich, 2014). One of actual approaches to management is risk accounting.

The administrative decision-making at any level is almost invariably connected to allocation of the various resources: raw, time, human (for example, allocation of specialists according to types of operations), financial, information, and etc. Ability to execute a target plan, production quality, a negative impact on environment, occupational safety of staff, motivation of staff, and etc. depend severely on resources allocation.

Any administrative decision made always involves some uncertainty connected to incompleteness of information on a status of the equipment, availability of raw materials and also to the incorrect assessment of the situation by managers owing to their incompetence, and etc. All this leads to risks of management occurring within the enterprise owing to the activities in the conditions of uncertainty (Vasilkov and Gushchina, 2011; Boholm and Corvellec, 2010.). Such risks cause problems with ability to achieve the set operational and strategic objects, with costs of production, with controllability of processes, with stability of the enterprise development, and etc. Management efficiency depends on the level of internal risks, on the enterprise ability to identify these risks and to evaluate them according to the chosen model, and to eliminate them to the acceptable level.

If a result or an event in the future is interpreted by the subject as favorable, then we may talk about an opportunity, or a “chance event”. Otherwise when the event is estimated by the subject as unfavorable, then we talk about risk or a risk event. As each chance and risk events are forms of actualization of the indefinite future, then formation of a multitude of possible risks and chances, as well as their quantitative assessment are the task of prediction of the future. Such problem shall be solved taking into account as tendencies which were generated during the last periods, so those data and tendencies which are observed in the present.

For a comprehensive characteristic of risks and chances the following criteria are to use:

1. The “time horizon” - a period of time from the moment of risks / chances actualization during which the subject covered by this risk / chance will experience its aftereffect;
2. The ecological importance is relevant to the specific territory, and affects all aspects of environment, such as a spatial quantity, ecological conditions, a landscape, ecosystems, flora and fauna, a subsoil, and etc.
3. The importance to a person concerns as the certain individual, so human communities over this territory, whose interests (a health, a quality and a standard of living, a personal welfare, and etc.) are affected by a specific consequence of the chance or risk;
4. The economic importance is losses (risks) or gains (chances) in the sphere of economy and finance (interest rates, credits, investment portfolio, supply and demand, profits, losses, and so on) expressed in physical units (kilometers, tons, pieces, barrels, and so forth) or monetary units (rubles, dollars, euro, and so on);
5. The social importance concerns interests of both the certain subject and all people living on this territory from the point of view of the social and political - legal sphere of their life (all authority institutions at the different hierarchical levels of society, political parties and movements, judicial and investigating agencies, a law and order, a criminogenic situation, and etc.);
6. The moral significance means loss or, in contrast, acquisition of such qualitative and significant to society life and business characteristics as reputation, esteem, respect, ill fame, and so forth and concerns as to the certain individual so the groups of individuals (collectives, organizations, companies, and etc.).
7. The probability of actualization of risks and chances in the future is a quantitative assessment of how probable the actualization of a specific risk or chance in the future is.

Criteria (1) - (6) define risks / chances from the factual point of view and through the quantitative and qualitative aspects, while the criterion (7) defines a degree of a probable actualization of risks / chances in the future. Note that one part of criteria (1) - (6) is quantitative (the time horizon, the economic importance), another part of the criteria (the ecological importance, the importance to a person, the social importance, the moral importance) are qualitative. The quantitative criteria can be measured according to a numerical scale, but there is no quantitative scale or units to measure the qualitative criteria. At the same time for an assessment of risks / chances according to both the quantitative and qualitative criteria, a uniform and common ordinal scale can be designed. The complete characteristic of specific risk / chance evaluated from different points of view according to a set of criteria is a quantitative measure of risk / chance.

In addition to the quantitative measure characterizing the factual aspect of risks and chances from the point of view of different criteria 1 – 6, risks and chances are defined also by probability of the possible actualization (criterion 7) in the future. The concept of actualization probability in contrast to the classical, statistical concept of probability, defines the quantitative measure of possible occurrence of a future single unique event to which risks and chances belong. The cause is that the classical, statistical concept of probability is applicable only to events which are mass, homogeneous, and able to occur in completely reproduced conditions, and can be characterized by a stability of frequencies. It is obvious that risks and chances as two different forms of actualization and reflection of the real indefinite future may not be include with events of the last mentioned type and therefore can't be defined by the traditional concept of probability (classical or statistical). (Hu *et al.*, 2014)

2.3 Risk accounting methods

The main objectives of the internal risks accounting when managing business are reduced to development of:

- methods of the quantitative assessment of single risks parameters,
- methods of the quantitative assessment of a set of risks generated as a result of the administrative decision,
- methods of formation of risk reducing algorithms in case of the main type of administrative decision – a resources allocation.

When reviewing issues of the quantitative risks assessment the two-factor model defining risk as a combination of probability (p) of hazard occurrence and a severity level (Z) of effects (losses) which will happen if a threat is realized, is used most often. If both components are expressed quantitatively, the risk is defined by the product of (p) and (Z):

$$R=p*Z \tag{1}$$

Administrative decisions-making risks shall be assessed before making the decision, and if the risk is great, it must be reduced to the acceptable level at first (Vasilkov and Gushchina, 2011)

First of all it is necessary 1) to identify hazards (Ω) (the set (Ω) contains some elements (N), i.e. (N) number of hazards are identified) which can arise consequently upon implementation of the administrative decision, 2) to assess the occurrence probability (p) and possible effects severity (Z), and 3) also to design a normalized quantitative risks assessment model enabling to define limits of admissible risks.

We will consider solutions of the specified tasks.

2.3.1 Quantitative assessment of single risks parameters

The first objective is to develop a method of the quantitative assessment of single risks parameters. This objective can be solved in four steps. Matter of these stages and peculiarities of ways to implement them are reviewed more particularly in works (Vasilkov and Gushchina, 2011).

1) Hazards identification, i.e. detection of hazards. For this purpose we can use methods introduced in the work, for example such methods as Brainstorming, the structured or semi-structured interviews, the Delphi Method, Check Lists, the Process Hazard Analysis (PHA),

the cause-effect analysis, and some others. These are rather full-blown methods. They are supported methodically by a great number of references, for example (Akimov *et al.*,2008). The result of identification is a list of actual hazards which occurrence probability must be evaluated.

2) Assessment of hazard occurrence probability. There are different approaches to this problem. The statistical, expert, indicator-based approaches are necessary to be mentioned when we talk about economic systems management. (Vasilkov and Gushchina, 2013).

Statistical approach is based on theoretical definition of probability as a limit of ratio of unfavorable event outcomes to the total number of outcomes. Often in practice it is possible to take a form of a ratio without limit. As a result we have the rough estimate with a rather large amount of total number of outcomes. For example, by this approach a probability of making a wrong decision can be estimated as the ratio of number of error decisions to a total number of decisions made. The probability of equipment failure can be defined as the ration of number of failures to a total number of switching on this equipment or to a quantity of the production made. The ratio of the equipment down time in consequence of the failure to the total equipment operating time for a big period of time is possible to be used as a probability measure.

But these examples are true only if all conditions of implementation of analyzable activities are identical, i.e. the data set include identical events within identical environments. Otherwise this statistics doesn’t enable to get realistic results. This aspect of assessment of hazard occurrence probability also doesn't enable using such strict approach to a probability assessment in actual practice of administrative activities. Besides, such unfavorable events during enterprises and organizations activities which probability is to be evaluated happen rather seldom, and the ratio (without limit) has a random value. I.e. the probability is evaluated too roughly or essentially incorrect.

Statistical approach is efficient in case of a probability assessment not in respect of time aspect, but in respect of a sequence of actions, i.e. by assessing the deviations frequency when producing a large product batch. In particular, it is possible to use probability assessment in terms of amount of products per particular equipment (“2 spoilage units per 1000 products are admissible”, and etc.). The probability can be presented as an average interval of hazard occurrence (for example, “hazard is realized on average once a year” or “hazard is realized in every 500 products”, and etc.), as well as the amount of unfavorable outcomes for the specified period of time or per specified amount of products, accessories, and so forth.

Expert approach seems to be considerably without the mentioned shortcomings, and is rather popular. According to this approach the unfavorable event occurrence probability is assessed by the expert, as a rule, without reasoning for the decision, just on the basis of the experience, subjective feelings, intuition, etc.

On the one hand, this approach seems to have no shortcomings mentioned above, and on another hand this approach brings a lot of other problems related to personal perception of events, to peculiarities of collective decisions, and so forth. Nevertheless, the expert assessment of events occurrence frequency can be more effective than “strict” mathematical assessment.

Specialized methods can be also used. Among the following are to mention (ISO / IEC 31010): the "What if?" (SWIFT), the analysis of types and effects of potential failures, the analysis of a failure tree of, a decision tree, etc. However these methods quite effective within technical systems aren't always suitable for economic and organizational systems.

The approach based on indicators monitoring. One of the most important tasks of the hazard occurrence probability assessment and consequently also risk realization is monitoring of factors which can serve as indicators of risk development. Indicators are the information sources reflecting a probable succession of events. They shall provide as much as possible exact data on the direction and volume of the changes indicated by them. In addition, they shall enable to recognize as soon as possible the unforeseen events capable to obstruct achievement of strategic objectives. It enables to be prepared for elimination of negative effects in advance.

This area of hazard realization probability assessment deals with specific numerical indexes (values) which approximation to the preset threshold values (the upper and lower threshold) means peaking of a risks situation.

Monitoring of indicator values is made within every stage of activities and shall affect all enterprise. The most important tasks of monitoring of indicators are monitoring of achievement of objectives, and control of appropriateness and efficiency of risk analysis processes. It contributes to the earlier detection of the current and potential opportunities and risks, and to identification of their levels. The choice of indexes which can be used as indicators is made by each organization taking into account specifics of the activities and the available experience in the past.

3) Assessment of possible effects severity. It is better to get the assessment result in terms of money, with analysis of possible losses. It is also possible to assess losses in terms of objectives that are under the threat not to be achieved. In all these cases possible losses can be expressed in terms of money. Besides it is possible to use also the assessment based on expenses necessary for recovery of the broken system balance.

4) The quantitative risk assessments enabling to form limits of different risks categories (negligible, admissible, and so forth) are explicitly reviewed by different authors. Methods of risk normalization (risks reduction to the dimensionless form in the range from 0 to 1) and formation of limits of different levels using one of psychophysical scales are given in works.

Risk normalization (Table 1) is carried out considering ratios (2) and (3):

$$Z^{relative} = \frac{V_{toll}}{V_{overal}} \qquad (2)$$

Here in:

V_{toll} – the amount of resource losses of in case of hazard occurrence,

$V_{overall}$ – the total amount of resources used in activities which are exposed to risk,

$Z^{relative}$ – the relative resource losses in case of hazard realization. This attribute can vary in the range (0, 1).

$$R^{norm} = p^{norm} * Z^{relative} \qquad (3)$$

Here in:

p^{norm} – the assessment of the hazard occurrence normalized probability. This attribute can vary in range (0, 1).

Table 1. Normalized Risks Scale

VariationRange of the Attribute R^{norm}	Qualitative Assessment	Appropriate Risk Zone
0 – 0,2	Excellent	Negligible
0,2 – 0.37	Good	Admissible
0,37 – 0,63	Satisfactory	Dangerous
0,63 – 0,8	Bad	Very dangerous
0,8 – 1.0	Very bad	Disastrous

In addition to contribution to risks scaling the normalized risk implementation provides additional advantages of risk management which are clearly manifests themselves in possibility of economic justification of reducing risks actions.

2.3.2 Quantitative assessment of a set of risks generated

The second objective is to develop methods of the quantitative assessment of a set of risks generated as a result of the administrative decision. Solving this problem we have to take into account the integrated assessment of the most probable number of manifestation of hazards (which have an accidental character) for the specified period of time (or the size of a product batch). Please note that risk is a probabilistic characteristic (a multiplier is a hazardous event occurrence probability) (Gipich *et al.*, 2013).

Let's analyze potential losses in a case when occurrence of any hazard doesn't impede production and a new manifestation can happen at any indeterminate (random) time point (or the next spoilage product will appear anywhere within the batch). Let the expert probability assessment be expressed as average frequency of hazard occurrence in a unit of time or in one batch of a certain size (for example, once a month or once in 100 units of production). In this case we can assess losses connected to hazard realization for rather big period when specific moments of accidental hazard occurrence have no impact, and losses are integrated for the great period of time. Of course, in case of assessing risk the period of analysis shall be greater than the hazard occurrence period specified by an expert assessment. All this allow us to consider not only single accidental occurrences of hazardous situations, but also to acquire an integral loss assessment subject to occurrence of rather large number of hazards.

Let's assess a probability that the hazardous event can occur not once, but (k) times. Generally this problem can be solved using a binomial distribution. However if the probability of a single hazardous event is small then it is possible to use the Poisson distribution instead of binomial distribution for description of a consequence of occasional hazardous events.

Probability that (k) events have occurred during the period (T) is described by the Poisson distribution:

$$p_T(k) = \frac{(\lambda T)^k}{k!} e^{-\lambda T} \tag{4}$$

As (T) we can take any period interesting us for which a hazard will manifest several times and to acquire a hazard occurrence probability as once (k=1), two times (k=2), three times (k=3), etc. for this period.

Thus (λ) is a predetermined average frequency of hazard occurrence in a unit of time (for example, in a month, in a year, or in a batch of products). (λ) is a result of the expert assessment (p).

If λ is calculated not as frequency in a unit of time, but as occurrence frequency in the performed operations (for example, λ= 0,05 – 5 hazard realization occur per every 100 performed operations, thus λ= 5/100=0,05), then (T) can be taken not in units of time, but in number of the performed operations.

Let's assess a rather large interval of time (or number of operations) in which a sufficient number of hazards can be realized (the more, the better). This period shall be the same for all hazards to be analyzed (Ω_i) (i=1,…, m). For each of these hazards with the own occurrence frequency (λ_i) (i=1,… m) we can calculate the most probable number of the hazards realized (k_i) (i=1,…,m), i.e. calculate $\arg(\max\{p(k)\})$. These most probable values shall be within the same period (T) for all hazards.

In this case let's present the total losses in consequence of hazard occurrence as the weighed amount of each hazard effects severity (Z_j). Let the most probable number of the hazards realized (k_j) is a weight coefficient.

Thus, in the pessimistic option the most probable total losses for the range of time variation (or the range of a batch size variation) can be defined this way:

$$Z_{obob} = \sum_{j=1}^{m} k_j Z_j \qquad (5)$$

The optimistic option for the most probable total losses can be represented as:

$$Z_{obob} = \sum_{j=1}^{m} k_j p(k_j) Z_j \qquad (5a)$$

Herein:

$p(k_j)$ – is a probability of manifestation of every hazards realized.

Z_{obob} – characterizes the most probable total losses for a certain option of resources allocation resulting from the administrative decision causing specific hazards.

Using the proposed method of the quantitative assessment of risks set we can carry out a complex assessment of different administrative decisions related to resources allocation through the value of a complex integrated assessment of all identified risks – Z_{obob}.

2.3.3 Develop an algorithm of administrative decision-making

The third objective is to develop an algorithm of administrative decision-making with minimum potential losses (with minimum integrated risk, in essence). This objective can be achieved by using methods of mathematical programming. For this purpose let's formalize this task as follows.

It is obvious that resources allocation influences hazard occurrence probability and a severity of possible effects. For example, we can select the better equipment for production of goods which are effective from the economic point of view. The enhancement of quality of these goods expected from this decision can manifest not in full owing to, for example, reduction in funding for required professional development of staff. Resources are limited! Increased to one customer, reduced - to another. This hazard can lead to failure of the scheduled product quality objectives, or production volume objectives, and so forth; i.e. to risk of not achieving targets to which resources have been allocated.

Let a DM (a Decision Maker) holds (q) types of resources (ψ) which he/she allocates on to (L) types of activity (μ):

$$\Psi_k = \Sigma\psi_{jk}. \qquad (6)$$

Summation is made with respect to every type of a resource (ψ) and (k) varies from 1 to (q). In general case resources are allocated to each of (L) types of activity (μ) and (j) varies from 1 to (L). Within the limits (6) the resource share allocated to a specific type of activity doesn't matter. It can be even equal to zero.

Each resource has the impact on probability of hazard occurrence (p=p (Ψ)) and on possible effects severity (Z=Z (Ψ)) (Ψ is a vector of resource herein). Specific effects can be equal to zero.

In this case the general task of the administrative decision is reduced to such allocation of resources (ψ) when the minimum of the complex assessment of potential losses is achieved and at the same time there are balance contraints (6) and other targets achievement.

$$Z_{obob}\,(p(\psi),Z(\psi)) \rightarrow \min$$

Considering restraints:

$\Psi_k = \Sigma\psi_{jk}$ (k=1,..q) – balance constraints on present types of resources,

$G=G_{plan}$ – planned constraints on production schedule,

$Q=Q_{plan}$ – planned constraints on production quality,

$R_{safety}<R_{safety\_plan}$ – planned constraints on occupational safety risks,

$V_{emissions}<V_{emissions\_plan}$ – planned constraints on environmental emission.

Constraints on targets G_{plan}, G_{plan}, R_{safety_plan}, $V_{emissions\_plan}$ and etc. are caused by that resource allocation affects not only internal risks of the enterprise, but also performance of principal activities:

$G=G(\Psi)$, $Q=Q(\Psi)$, $R_{safety} = R_{safety}(\Psi)$, $V_{emissions} = V_{emissions}(\Psi)$

2.3.4 Example

The enterprise producing goods (A), (B), and (C) set an objective to increase the amount of released goods (A). According to experts in marketing these goods will be in a great demand in the next years that will provide to the enterprise the extra income of (Z) during period of implementation (T) of the project. This income can be directed on increase of salary of staff; on procurement of a new hi-tech equipment and etc. that, in turn, can provide resources for further development of the enterprise (in order to simplify the example, we will not consider the effect from these future investments). Of course, forecast of experts in marketing may be an error. This error can occur with probability (p_1) and lead to reduction in planned income for planning period (T) by (ΔZ_1).

New more efficient equipment is needed in order to implement this project. The cost of equipment is (q_1) and depends on a Producer Company. These expenses can result in a reduction of allocated resources for maintenance of production of goods (B) and (C). In turn, the reduction can law the amount of production of goods (B) and (C) with probability ($p_2(q_1)$) and also gained earlier "stable" income by (ΔZ_2) depending on (q_1), i.e. ($\Delta Z_2(q_1)$). To take up a new equipment purchase loan seems to be a problem owing to instability of the economic situation in the world. It is necessary to reallocate own resources which are limited.

Before there were no similar technologies at the enterprise and the staff isn't prepared both to actuate the new equipment on their own and to use it efficiently. Therefore, there is a need for expenses (q_2) for staff training which depends with a certain probability (p_3) on a training place that influence a level of competence after training completion, and can result in decline of overall productivity of the new equipment by (ΔZ_3) depending on (q_2), i.e. ($p_3(q_2)$) and ($\Delta Z_3(q_2)$).

It is already known that increase of the new equipment productivity is a consequence of busier work schedules through applying the imperfect technology. It causes a threat of unexpected failure of operation (expressing in occurrence emergency shut-downs in accidental unpredictable points of time, spoilage by a normal productivity, and so forth) with probability (p_4) (the probability in a certain measure depends on producer company and respectively on the equipment price, i.e. ($p_4(q_1)$), as well as on costs of necessary staff competences ($p_4(q_1,q_2)$) that cannot provide as a result the necessary (target) productivity. At the same time, the projected income (Z) with the specified probability (p_4) will be leveled down, on average, by ($\Delta Z_4(p_1)$), i.e. ($\Delta Z_4(q_1,q_2)$) during period of project implementation (T). In addition, negative environmental emissions of this equipment (Vemissions (q_1, q_2)) depend on the producer company and on efficiency of staff training, i.e. on costs of training. They can occur with a probability ($p_5(q_1, q_2)$. These emissions can lead to excess of admissible (target) emissions (Vemissions plan) and to the respective economic losses ($\Delta Z_5(q_1, q_2)$).

Specific values of probabilities and possible consequences need to be estimated in each individual case according to approaches described above. To assess hazard occurrence probabilities, it is possible to use statistical and expert estimates, and also monitoring of indicators. Severity of effects of hazard realization can be assessed through statistical analysis of production.

We will consider possible risks in case of implementation of this project.

1) The risk (R_1) connected to hazard of an error of experts in marketing in forecasting increase of release of goods (A). $R_1=p_1*\Delta Z_1$. It is a "single" risk for the entire period (T) of project implementation, i.e. it can be expressed by one numerical summary value.
2) The risk (R_2) connected to possible leveling down of the income from goods (B) and (C) due to resources reduction by ($\Delta Z_2(q_1)$). $R_2=p_2(q_1) * \Delta Z_2(q_1)$. It is also a "single" risk for the entire period (T) of project implementation.
3) The risk (R_3) connected to gaining necessary competences by staff training. $R_3=p_3(q_2) * \Delta Z_3(q_2)$. It is also "single" risk for the entire period of T projects.
4) The risk (R_4) connected to accidental failures of operation of the new equipment caused by intensification of its productivity. $R_4=p_4(q_1,q_2) * \Delta Z_4 (q_1, q_2)$. The appropriate hazard can manifest in unpredictable points of time repeatedly during the period (T) of project implementation.
5) The risk (R_5) connected to excess of negative environmental emissions. $R_5=p_5 (q_1, q_2) * \Delta Z_5 (q_1, q_2)$. Let this risk is a "single" for the entire period (T) of project implementation.

It is obvious that all components of risks and consequently, risks themselves (except R_1) depend on resources allocated for the equipment (q_1), for training of staff (q_2), i.e. all risks are interrelated because of common resources. Management of the risk (R_1) is excluded in thi work. The main emphasis shall be placed to the integrated assessment of risks of the repeated hazards when producing goods (A). It corresponds to the second main objective.

In the Figure 1, you can find examples of relation of several hazards occurrence probability to the number of hazards.

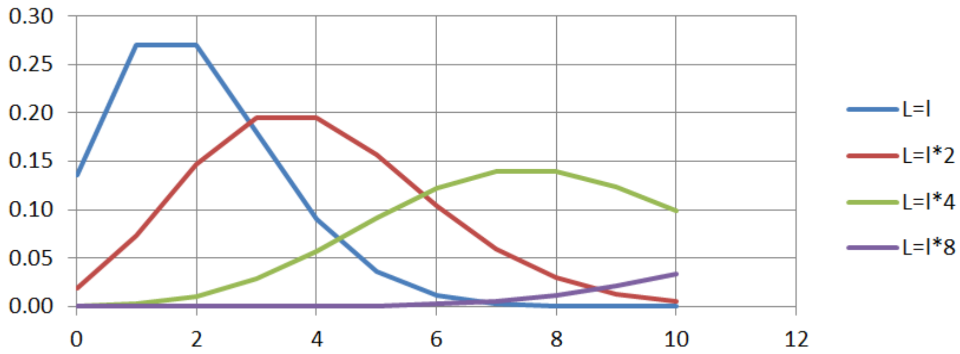

Figure 1. Relation of probability *p* of occurence of hazards (vertical axis) to the number of hazards *k* (horizontal axis)

In expressions (5) and (5a) the values (k) of number of hazards corresponding to a maximum of the given relation for different average frequencies of hazard occurrence (λ) are used to assess risks. Using ratios (5) and (5a) for specifically found parameters we can find generalized most probable losses resulted from realization of risks.

To achieve the set objective, it is necessary to make the administrative decision considering the limited total amount of resources ($Q_{\Sigma A}$), ($Q_{\Sigma A} = Q_{\Sigma} - Q_{\Sigma B} - Q_{\Sigma C}$) which the enterprise is able to allocate for development of production of goods A, it is necessary to allocate resources:

- for purchase of the new equipment (q_1),
- for training of staff (q_2)

with provision not to excess environmental emissions ($V_{emissions}$ $(q_1, q_2) \leq V_{emissions\_plan}$) in order to support a minimum of possible risk (R_4). At the same time, it is necessary to set limits of the admissible level of risks (R_2), (R_3), and (R_5).

3. Conclusions

The provided general concept of control of internal risks for different options of appearance of private dangers and risks allows to optimize risks in case of distribution control of limited resources.

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