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The Risk of Misinforming for Competing Messages

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Abstract

This paper extends previous studies on quantifying the risk of misinforming by introducing models, which allow measuring the risk of misinforming in case of competing messages. These models are realistic representation of the market situation, where purchasing decisions are made based on the assessment of all available offers and selecting the one that meets at most the buyer's needs. The paper emphasizes the case of two competing products offered to a group of potential clients and studies the risk of misinforming and its effect on the purchase decisions. In addition, models for the evaluation of the risk of sellers are also proposed.

Keywords: information asymmetry, misinforming, warranty, risk, competition.

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Introduction

This paper is an extension of previous findings presented in Christozov, Chukova, and Mateev (2006, 2007, 2008). We consider the marketplace as a place where messages, describing different products suitable for solving one and the same set of clients' problems, are competing. The earlier studies, mentioned above, address the risk of misinforming in the case of a single message distributed to a group of potential clients and its effect on their purchase decision. Here, these models are extended to allow evaluation of the risk for multiple competing offers.

The misinforming is due to the existence of information asymmetry between the two parties – the sender and receiver. This asymmetry is actually two-fold, because the sender knows very well the meaning of the "information" s/he is providing, but his/her knowledge regarding the receiver's objectives on the use of this information is limited. From this viewpoint an assessment of the risk of misinforming provides learning opportunity to both parties and offers some ideas on how to improve the informing process.

The phenomenon of information asymmetry between two parties occurs when one of the parties has better understanding and is better informed on the subject of communication than the other one. There are several aspects of information asymmetry that have attracted the interest of researchers. The concept of information imbalance originates in Arrow (1963/2001). His ideas were further developed by Akerlof (1970) in his paper "The Market for 'Lemon's", where the term "information asymmetry" was firstly introduced. Akerlof investigated the influence of asymmetric information on the market value of a commodity and his ideas initiated studies on the impact and usage of the information asymmetry to improve the influence in business relationships. Slovac (1993) studied the asymmetric impact of negative and positive information on the social trust, known as principle of Information Asymmetry or Trust Asymmetry. White and Eiser (2005) continue this line of research. The role of information asymmetry as a source of misinterpretation, which results in misinforming and/or misleading in a sales/purchase process and might lead to wrong purchase decisions has never been studied at the level it deserves. Some authors (Hseih, Lai, & Shi, 2006) consider the impact of information asymmetry on the success in business transactions, but they do not go beyond recommendations on how to improve the information process. Christozov, Chukova, and Mateev (2006, 2007, 2008) developed a model to quantify the risk of misinforming, caused by information asymmetry and the current paper extends this study.

The outline of this paper is as follows. The next section summarizes the background of the problem. The following two sections describe the notations and provide a summary of the models studied earlier and present the new model for two competing messages. This model is then generalized to the case of *n* competing messages. The final section consists of conclusions and future research directions.

Background

A Successful Informing Process

Definition 1: We consider "a success" in an informing process in several levels, where the higher level "success" implies "success" in all lower levels:

Level 1: An informing process is successful if the message created by the sender is successfully transmitted to the receiver.

Level 2: The process is successful, if the receiver is able to read and understand the transmitted message.

Level 3: The process is successful, if the receiver does not ignore the information included in the message, but rather accepts and adopts the information encoded in it, i.e., the receiver acquires new knowledge.

Level 4: The process is successful, if the acquired knowledge coincides with the information the sender intended to provide to the receiver. Also this level of success implies that the objectives of the receiver in acquiring this information meet the intention (purpose) of the sender in providing it.

The risks associated with these levels of success are as follows:

At level 1 the risks are associated with any technical problems in the communication channel, e.g., a technical failure or noise. In this case there is no informing at all. At level 2 the risks are related to any encoding-decoding problems, linguistic problems and problems caused by insufficient or complete comprehensive domain expertise of the receiver (the message does not bring any new information to the receiver). These two extremes are well described by Michael Buckland (see Buckland, 1991, p. 173). As a result, in most of these cases, the communication will not generate any new knowledge. At level 3 the failures are caused mostly by the trust/credibility problems. If the receiver does not accept the information, s/he will not use it and, of course, will not create or utilize the knowledge associated with this information. As a result s/he will not be informed. Lastly, at level 4 the risks are the risks of misinforming. The obtained knowledge differs from the knowledge the sender intended to form and may mislead the receiver in her/his decision-making.

Categories of Information Processes

Our objectives are to evaluate the risk of misinforming in different realistic settings. Christozov, Chukova, and Mateev (2005, 2006, 2008) have addressed the evaluation of the risk of misinforming in two cases – the risk of misinforming in offering a single product to a single buyer (“one-to-one” case) as well as the risk of misinforming in offering a single product to many buyers (“one-to-many” case). Here we extend these models by proposing a new model to cover the case “many-to-many”. In our new model, we firstly deal with the case of offering two competing products to one and the same group of buyers and afterwards extend it to the case of offering n competing products to one and the same group of buyers.

Difficulties in Evaluating the Success in Informing

One of the main difficulties encountered in our attempts to quantify the risk of misinforming, is the subjectivity in the interpretation and the acceptance of the message sent by the sender. One and the same message may inform correctly some receivers and misinform others. The misinforming could be of different degrees and consequences for the individual receiver within a given group, and the affect may vary between different groups of receivers.

Additional difficulty in developing models for measuring the risks of misinforming is caused by the complexity of the message. A portion of the message may inform the clients correctly regarding particular properties of the object of informing and another part of the same message may misinform them regarding other properties of the object.

For the receiver the risk of misinforming is very personal. On the other hand, as in commercial activities, the sender is also affected by failures in informing. The sender’s risk is associated with the composition and the content of the message and how this message meets its objectives. The risk is measured by the percentage of misinformed receivers, and also by the nature of the incorrect actions caused by the message.

To evaluate the risk of misinforming for a group of receivers, we have to consider each and every personal reaction caused by the message, i.e., the individual’s risk, and to aggregate these risks over the whole group. The attitude of an individual receiver towards the message will allow us to divide the group of receivers into sub-groups (clusters). We study the risk of these subgroups to obtain a better insight on the nature of the failures, causes and effects in the informing process.

Quantitative Measures of the Risks of Misinforming

Notations and Assumptions

In order to present the model for quantifying the risk of misinforming we need to introduce and comment on the following notations. Let us assume that there is a **group of clients of information,** say $B = \{b_j\},\ j = 1, 2, \dots, J$, which need to solve a given set of tasks by using it. Each client has his/her own **set of tasks** denoted by $A_j = \{a_{ij}\}, i = 1, 2, \dots I_j$, so that each task belongs to a given **category of tasks** $A = \{A_i^*\}, i = 1, 2, \dots, I$. For example, using the Internet is a category of tasks, whereas using the Internet for downloading large files, such as movies or music, or using the Internet to e-mail or shopping or just surfing the Internet are particular tasks that a given user needs to solve for. On the other hand, all of these particular tasks belong to the category of tasks "using the Internet". Every client of information b_j has a particular **need** n_{ij} to solve his task from category A_i^*. If a client doesn't need to solve a task from a given category, then the corresponding need is set to be equal to zero, i.e., $n_{ij} = 0$.

All members of the group of clients receive the same message D from the sender. For example, an advertisement regarding a particular product, e.g., a personal computer, which clients may use for solving their tasks including the task of using the Internet. Let us assume that the sender's goal is to inform the clients as best as possible by composing a message, that reflects correctly and precisely his expertise, aiming to help clients in solving their tasks. Every client, as a party of the informing process, understands and interprets the message D according to his/her own expertise. Here under "expertise" we understand a whole set of factors, including personal background, preliminary knowledge, beliefs, culture, bias, etc. This set of factors influences not only the client's decision making, but more generally, his/her behavior, personal needs to solve tasks and his/her subjective understanding on what is the useful information in the message that will assist him/her in solving these tasks.

There are two aspects of acceptance of the message – the first one reflects the trust toward the source and content of information, and the second one – to what extend the obtained information allows for solving the clients' tasks. Here we will not consider the first one of these aspects. We will concentrate on the second aspect and more specifically on the following:

- the content, which the sender aims to transmit via the message;
- how this content, is understood, interpreted, accepted and used by the client;
- how this content could be a source for misinforming the clients.

Let's denote by $C = \{c_l\}, l = 1, 2, \ldots L$ the properties, attribute, parts, etc. of the message. Here we must note that $\{c_l\}$ are described in terms of the problems' domain. The personal **levels of acceptance** (thresholds) for the client b_j to solve her/his task a_{ij} from the category A_i^*, denoted by $\{q_{jil}\}, l = 1, 2, \ldots L$, are also defined in terms of the problems' domain. The level of acceptance is a threshold of the given property of the information, so that bellow this threshold the obtained information is unusable for this client. To make these levels of acceptance useful measures in our modeling, we have to normalize them $\tilde{q}_{jil} = norm(q_{jil})$ in a way to allow their interpretation as probability for acceptance $0 \le \tilde{q}_{jil} \le 1$. Such normalization can be done in many different ways, specific for every particular case. Onwards, we assume that these are already normalized and we will use further q_{jil} instead of $\tilde{q}_{jil}$. Moreover, ignoring the case when only a part of the message is useful and adopted by the client, we define the acceptance level of a message as follows:

Definition 2. The acceptance level of message D for solving the task a_{ij} is $q_{ij} = \min_l (q_{jil}), l = 1, 2, \cdots, L$.

Usually the message is composed in a way that it provides information allowing making decision regarding particular tasks. Let us denote by p_i the objective probability that the provided information solves tasks form category A_i^*. Also, let us denote by $\hat{p}_{ij}$ the subjective probability assessed by client b_j that the provided information is capable to solve his/her task a_{ij}.

The Risk of Misinforming

Let us denote by r_{ji} the risk of the client in using the provided information for solving the task a_{ij}. If the client b_j does not use the information for solving his task a_{ij}, despite of the fact that the information in the message is useful and can solve the task, then we have $r_{ji} = 1$. In addition, we will have $r_{ji} = 1$, if the client b_j will use the information, although the information in the message does not provide a solution for this task. In general, $r_{ji} = 1$ if the client makes wrong decision on whether or not to use the information in the message. With $r_{ji} = 0$ we label the correct decision regarding the use of information.

There are six possible cases, depending on the objective, subjective assessment of the information and related acceptance level that will identify the value of r_{ji}:

$p_i < \hat{p}_{ij} < q_{ij}$ - the product is not suitable to solve for task a_{ij}, the customer's estimation of the suitability of the product is **optimistic** and **below the degree of acceptance,** thus the decision is **negative** and **correct** and $r_{ij}=0$;

$p_i < q_{ij} < \hat{p}_{ij}$ - the product is not suitable to solve for task a_{ij}, the customer's estimation of the suitability of the product is **optimistic** and **above the threshold of acceptance,** thus the decision is **positive** and **wrong,** and $r_{ij}=1$;

$q_{ij} < p_i < \hat{p}_{ij}$ - the product is suitable to solve for task a_{ij}, the customer's estimation of the suitability of the product is **optimistic** and **above the threshold of acceptance** , thus the decision is **positive** and **correct,** and $r_{ij}=0$;

$\hat{p}_{ij} < p_i < q_{ij}$ - the product is not suitable to solve for task a_{ij}, the customer's estimation of the suitability of the product is **pessimistic** and **below the threshold of acceptance,** thus the decision is again **negative** and **correct,** and $r_{ij}=0$;

$\hat{p}_{ij} < q_{ij} < p_i$ - the product is suitable to solve for task a_{ij}, the customer's estimation of the suitability of the product is **pessimistic** and **below the threshold of acceptance**, thus the decision is **negative** and **wrong,** and $r_{ij}=1$;

$q_{ij} < \hat{p}_{ij} < p_i$ - the product is suitable to solve for task a_{ij}, the customer's estimation of the suitability of the product is **pessimistic** and **above the threshold of acceptance**, thus the decision is **positive** and **correct,** and $r_{ij}=0$.

Definition 3. The level of error, caused by the information asymmetry, is the difference between the real capability of the message and how the client assesses it. We call it degree of information asymmetry and denote it by $ia_{ij} = abs(p_i - \hat{p}_{ij})$.

In Table 1 we summarize all components needed for further modeling of the risk of misinforming.

Table 1. Information components of the model

Category of tasks / Client	A_1^* $\{p_1\}$	A_2^* $\{p_2\}$	$\dots$	A_I^* $\{p_I\}$
b_1	$\{a_{11},n_{11},q_{11},\hat{p}_{11},r_{11}\}$	$\{a_{21},n_{21},q_{21},\hat{p}_{21},r_{21}\}$	$\dots$	$\{a_{I1},n_{I1},q_{I1},\hat{p}_{I1},r_{I1}\}$
b_2	$\{a_{12},n_{12},q_{12},\hat{p}_{12},r_{12}\}$	$\{a_{22},n_{22},q_{22},\hat{p}_{22},r_{22}\}$	$\dots$	$\{a_{I2},n_{I2},q_{I2},\hat{p}_{I2},r_{I2}\}$
$\dots$	$\dots$	$\dots$	$\dots$	$\dots$
b_J	$\{a_{1J},n_{1J},q_{1j},\hat{p}_{1J},r_{1J}\}$	$\{a_{2J},n_{2J},q_{2J},\hat{p}_{2J},r_{2J}\}$	$\dots$	$\{a_{IJ},n_{IJ},q_{IJ},\hat{p}_{IJ},r_{IJ}\}$

"One-to-one" Informing Process: The Risk of a Receiver

Next, we will propose several measurements on how to evaluate the overall risk of a client b_j with respect of all of his/her tasks A_j. This risk is based on received information and on client's understanding of this information. The difference in these measurement models is associated with the availability of different information components: the needs n_{ij}; the risk of a wrong decision regarding a given task - r_{ij} and the degree of information asymmetry - ia_{ij}. Based on the availability of these information components we propose the following three measures:

Simple model, accounting for the risks of wrong decisions r_{ij}. It is not difficult to collect data for the evaluation of r_{ij}. For example, in commercial activities, one needs to count only the claims of the unsatisfied clients. The proposed measure is:

$$r_j^s = \frac{1}{I}\sum_{i=1}^{I} r_{ij} \ . \tag{1}$$

Model, accounting for the clients needs n_{ij}. We assume that if a client b_j doesn't need to solve tasks from given category A_i^* then $n_{ij} = 0$, and s/he doesn't need to know and interpret the message regarding these tasks. In general, it is easy to see that there is a simple relationship between the level of needs and the risk of misinforming, i.e., the higher the need of a client to solve for a given task is, the higher corresponding risk of misinforming is. Therefore, we propose:

$$r_j^n = \frac{1}{I}\frac{1}{\sum_{i=1}^{I} n_{ij}}\sum_{i=1}^{I} n_{ij} r_{ij} \ . \tag{2}$$

Model, accounting for the needs and for the degree of information asymmetry ia_{ij}. In this model, we collect and use feedback data to evaluate the degree of error in understanding the message. The proposed measure of the risk is more complex than in the previous cases, but at the same time, it is most precise:

$$r_j^a = \frac{1}{I} \frac{1}{\sum_{i=1}^{I} n_{ij}} \sum_{i=1}^{I} n_{ij} r_{ij} ia_{ij} . \tag{3}$$

The level of complexity in collecting feedback data for these models is quite different. The assessment whether a decision is correct or incorrect is trivial in the case of clients-optimists and quite difficult for clients – pessimists (see Christozov, Chukova, & Mateev, 2007). In the first case, the client adopts and uses the received information, and makes an error, which can be recorded. In the second case – the client does not use the information and there is no data, whether the related potential decision would be incorrect or correct.

"One-to-Many" Informing Process

In generalizing the risk for a whole group of clients, we propose measures of the risk of misinforming from the viewpoint of the sender of information. This risk is a measure of the informing quality of the message, i.e., it measures how the content or meaning the sender intends to convey to the clients is described and presented in the message.

Here, we also propose three quantifying models accounting for the three information components:

A simple model:

$$R^s = \frac{1}{I\,J} \sum_{j=1}^{J} \sum_{i=1}^{I} r_{ij} . \tag{4}$$

A model accounting for the clients' needs:

$$R^n = \frac{1}{I\,J} \sum_{j=1}^{J} \left(\frac{1}{\sum_{i=1}^{I} n_{ij}} \sum_{i=1}^{I} n_{ij} r_{ij} \right). \tag{5}$$

A model accounting for the needs and degree of information asymmetry:

$$R^a = \frac{1}{I\,J} \sum_{j=1}^{J} \left(\frac{1}{\sum_{i=1}^{I} n_{ij}} \sum_{i=1}^{I} n_{ij} r_{ij} ia_{ij} \right). \tag{6}$$

The Case of Two Competing Messages

Description of the Model

In this case, the client b_j receives two competing messages ${}^1D$ and ${}^2D$ from two competing sources of information and s/he has to choose the knowledge acquired only by one of them to solve her/his tasks or to ignore both. We will not discuss the case of two complementing messages. The client has the following options in making her/his decision:

1. choose ${}^1D$: this message is useful, the client solves her/his task a_{ij}, the decision is correct and the risk is ${}^1r_{ij} = 0$.

2. choose ${}^{1}D$: this message is not useful, the client doesn't solve her/his task a_{ij}, the decision is wrong and the risk is ${}^{1}r_{ij} = 1$.
3. choose ${}^{2}D$: this message is useful, the client solves her/his task a_{ij}, the decision is correct and the risk is ${}^{2}r_{ij} = 0$.
4. choose ${}^{2}D$: this message is not useful, the client doesn't solve her/his task a_{ij}, the decision is correct and the risk ${}^{2}r_{ij} = 1$
5. ignore both messages, but ${}^{1}D$ is useful and client could have solved his task a_{ij} if s/he has used the information from this message; while the message ${}^{2}D$ doesn't bring any useful information. The decision is wrong and the risks are ${}^{1}r_{ij} = 1$ and ${}^{2}r_{ij} = 0$.
6. ignore both messages, but ${}^{1}D$ is useful and the client could have solved his/her task a_{ij} if s/he has used the information from this message; the message ${}^{2}D$ also contains useful information. The decision is wrong and the risks are ${}^{1}r_{ij} = 1$ and ${}^{2}r_{ij} = 1$.
7. ignore both messages, but ${}^{2}D$ is useful and client could have solved his/her task a_{ij} if s/he has used the information from this message; while the message ${}^{1}D$ doesn't bring any useful information. The decision is wrong and the risks are ${}^{1}r_{ij} = 0$ and ${}^{2}r_{ij} = 1$.
8. ignore both messages, and both message do not bring any useful information. The decision is correct and the risks are ${}^{1}r_{ij} = 0$ and ${}^{2}r_{ij} = 0$.

In all of the above cases, the client b_j interprets each of the two messages according to her/his need and level of acceptance for a given task and according to her/his own assessment of how useful is the information received. Now, we have ${}^{1}p_i$ and ${}^{2}p_i$ as the objective probabilities that each of the two messages is capable to solve tasks from category A_i^*. Moreover, we have ${}^{1}\hat{p}_{ij}$ and ${}^{2}\hat{p}_{ij}$ the subjective probabilities, as assessed by the client b_j, regarding the capabilities of each of the two messages to solve her/his task a_{ij}. As before, regarding the task a_{ij}, the client b_j has level of acceptance q_{ij} and need n_{ij}. In the case of two competing messages, there 120 different cases to consider in order to identify the risks ${}^{1}r_{ij}$ and ${}^{2}r_{ij}$, compared to only 6 cases for a single message as given in section 2. We assume that the client chooses to use the information from the message with higher ${}^{*}\hat{p}_{ij}$, i.e., if ${}^{1}\hat{p}_{ij} > {}^{1}\hat{p}_{ij}$ s/he chooses to use ${}^{1}D$ and vice versa.

In the case of two competing messages, the risks for the three models, introduced in section 2, are proposed to be evaluated as follows:

$$r_j^s = \frac{1}{I}\sum_{i=1}^{I} \max({}^{1}r_{ij}, {}^{2}r_{ij}) \ , \qquad (7)$$

$$r_j^n = \frac{1}{\sum_i n_{ij}} \sum_{i=1}^{I} n_{ij} \max({}^1r_{ij}, {}^2r_{ij}) \quad, \tag{8}$$

$$r_j^a = \frac{1}{\sum_i n_{ij}} \sum_{i=1}^{I} n_{ij} \max({}^1r_{ij}, {}^2r_{ij})(abs(\max_{m=1,2}({}^m\hat{p}_{ij}) - {}^{\arg\max_m({}^m\hat{p}_{ij})}p_i)). \tag{9}$$

Similarly, we suggest measures for the risk of misinforming by any of the two messages with respect to a given category of tasks, as well as for the whole set of tasks. We propose:

A simple model: the risks regarding A_i^* to be measured by:

$${}^kR_i^s = \frac{1}{J} \sum_{j=1}^{J} {}^kr_{ij}, \quad k = 1,2. \tag{10}$$

A simple model: the overall risk to be measured by:

$${}^kR^s = \frac{1}{IJ} \sum_{j=1}^{J} (\sum_{i=1}^{I} {}^kr_{ij}), \quad k = 1,2. \tag{11}$$

A model accounting for the needs: the risks regarding A_i^* to be measured by:

$${}^kR_i^n = \frac{1}{J} \sum_{j=1}^{J} n_{ij} \, {}^kr_{ij}, \quad k = 1,2. \tag{12}$$

A model accounting for the needs: the overall risks to be measured by:

$${}^kR^n = \frac{1}{J} \sum_{j=1}^{J} (\frac{1}{\sum_i n_{ij}} \sum_{i=1}^{I} n_{ij} \, {}^kr_{ij}), \quad k = 1,2. \tag{13}$$

A model, accounting for the needs and the degree of information asymmetry: the risk regarding A_i^* to be measured by:

$${}^kR_i^a = \frac{1}{\sum_j n_{ij}} \sum_{j=1}^{J} n_{ij} \, {}^kr_{ij} \, (abs({}^k\hat{p}_{ij} - {}^kp_i)), \quad k=1,2. \tag{14}$$

A model, accounting for the needs and degree of information asymmetry, the overall risk to be measured by:

$${}^kR^a = \frac{1}{I} \sum_{i=1}^{I} (\frac{1}{\sum_j n_{ij}} \sum_{j=1}^{J} n_{ij} \, {}^kr_{ij} \, (abs({}^k\hat{p}_{ij} - {}^kp_i))), \quad k=1,2. \tag{15}$$

Discussion on Empirical Study

The experiment conducted for the case of two competing messages follows and extends the approach presented in Christozov, Chukova, and Mateev (2008). In this experiment the respondents are divided into two groups placed in two different market situations. In the first market situation they make their purchase decision having a direct comparison between the products, like in a departmental store. In the second market situation the respondents make their purchase decisions for each of the products independently, which is like shopping on the Internet.

The respondents – first year students in disciplines related to Information Technologies, but not technical in nature – were split into two groups. The first group was surveyed by a two-step questionnaire, while the second group had to fill in a questionnaire consisting of three steps. The first step in the questionnaires of the first group and the first and second steps of the questionnaire of the second group follow exactly the approach described in Christozov, Chukova, and Mateev (2008) for collecting data regarding the respondents needs.

In the second step, the fist group of respondents had to compare directly the two PC configurations (see Figure 1). The proposed PC configurations were designed so that the first PC is appropriate mostly for scientific usage while the second one has high quality components suitable for entertainment. The respondents had to compare directly the two PCs by filling in the form (Figure 2), and specify which of the two is their preferred purchase option. In addition, they had to specify, which of the three warranty policies, as in Christozov, Chukova, and Mateev (2007, 2008), they will prefer.

PC 1	PC 2
AMD 64: AMD Athlon 64 4800+ Quad Core **Hardware** • 107S 17" Flat Screen Beige or Black • PowerColour X300SE 64MB PCI Express Video Card • 2 GB DDR 400 RAM • Seagate 500 GB Serial ATA Hard Drive • Samsung Internal IDE 52/24/52 CDRW • 3.5" Floppy Drive • 56 kbps V92 PCI Fax Modem • Integrated 10/100 Network Card • Microsoft 101 Keyboard • Microsoft Optical Wheel Mouse **Software** • Microsoft Windows XP Professional • Open Office ver. 2 • AVG Antivirus	**AMD 64: AMD Athlon 64 4800** **Hardware** • 107S 21" Flat Screen • PowerColour X300SE 512MB PCI Express Video Card • 2 GB DDR 400 RAM • Seagate 160GB Serial ATA Hard Drive • Samsung Internal IDE 52/24/52 DVDRW • 256 kbps V92 PCI Fax Modem • Integrated 100/1000 Network Card • Microsoft Multimedia Keyboard • Microsoft Optical Wheel Mouse **Software** • Microsoft Windows XP Home • MS Office Professional • AVG Antivirus

Figure 1. The PCs configurations

The second group of respondents was surveyed twice, with one-week break between the surveys. Each time the respondents had to evaluate the level of satisfaction of their needs by one of the two PC configurations, i.e., the needs were determined by sequential comparison of the PC's. The form of this questionnaire is similar the one used in Christozov, Chukova, and Mateev (2007, 2008).

The results regarding the respondents needs agree with the results obtained previously. This was expected, because the group of respondents is very similar to the one used in the previous studies of Christozov, Chukova, and Mateev (2007, 2008).

The level of the risk of misinforming in its three forms was significantly lower for the group, which directly compared the two PCs (see Table 2), which was also expected.

Applicatione	**Degree to which the given PC satisfies your needs**					**Degree to which the given PC satisfies your needs**				
	low				**High**	**Low**				**High**
	0	1	2	3	4	0	1	2	3	4
Word processing										
Spreadsheets, (Excel)										
e-mail										
Internet										
Complex computational problems										
Games										
Movies										
Music										

Figure 2. Form for direct comparison of the two PCs.

Table 2. Risks of the two groups of respondents

	Direct comparison	**Sequential comparison**
$R^s =$	0.350	0.441
$R^u =$	0.336	0.442
$R^a =$	0.120	0.232

The major difficulty in this empirical study was related to the decision on how to match the two or the three-step survey responses. Initially we were reluctant to inquire the respondents to identify themselves, because we were concern with their anonymity. On the other hand, we realized that the model requires mapping the needs with preferences and the identification of the respondents becomes unavoidable. After collecting the data, we realize that only a small percentage of the respondents participated in all of the steps of the surveys - namely twelve out of 53 in the group with the two-step questionnaire and seven out of 46 in the group of the three-step questionnaire. The small sample size makes the results on the risk of misinforming highly unreliable.

Generalization: N Competing Messages

The above formulae for the risk of misinforming can be easily extended for the case of N competing messages. We propose the following for:

The individual risks:

$$r_j^s = \frac{1}{I}\sum_{i=1}^{I} \max_{m=1,2,\ldots N} \left({}^m r_{ij}\right) , \tag{16}$$

$$r_j^n = \frac{1}{\sum_i n_{ij}} \sum_{i=1}^{I} n_{ij} \max_{m=1,2,\ldots,N} \left({}^m r_{ij}\right) , \tag{17}$$

$$r_j^a = \frac{1}{\sum_i n_{ij}} \sum_{i=1}^{I} n_{ij} \max_{m=1,2,\ldots,N} ({}^m r_{ij})(abs(\max_{m=1,2,\ldots,N} {}^m \hat{p}_{ij} - {}^{\arg\max_m ({}^m \hat{p}_{ij})} p_i)). \quad (18)$$

The formulae for the risks of the sender regarding the category of tasks A_i^*

$${}^m R_i^s = \frac{1}{J} \sum_{j=1}^{J} {}^m r_{ij}, \quad m = 1, 2, \ldots, N, \quad (19)$$

$${}^m R_i^n = \frac{1}{J} \sum_{j=1}^{J} n_{ij} \, {}^m r_{ij}, \quad m = 1, 2, \ldots, N, \quad (20)$$

$${}^m R_i^a = \frac{1}{\sum_j n_{ij}} \sum_{j=1}^{J} n_{ij} \, {}^m r_{ij} (abs({}^m \hat{p}_{ij} - {}^m p_i), \quad m = 1, 2, \ldots, N. \quad (21)$$

The overall risks:

$${}^m R^s = \frac{1}{I J} \sum_{j=1}^{J} (\sum_{i=1}^{I} {}^m r_{ij}), \quad m = 1, 2, \ldots N, \quad (22)$$

$${}^m R^n = \frac{1}{I} \sum_{i=1}^{I} (\frac{1}{\sum_j n_{ij}} \sum_{j=1}^{J} n_{ij} \, {}^m r_{ij}), \quad m = 1, 2, \ldots, N, \quad (23)$$

$${}^m R^a = \frac{1}{I} \sum_{i=1}^{I} (\frac{1}{\sum_j n_{ij}} \sum_{j=1}^{J} n_{ij} \, {}^m r_{ij} (abs({}^m \hat{p}_{ij} - {}^m p_i))), \quad m = 1, 2, \ldots, N. \quad (24)$$

Conclusion

In this study, the model for quantifying the risk of misinforming is extended to the case of N competing messages sent to a group of buyer, i.e., to the case "many-to-many". This model is more realistic than our previous models and describes better the real situation in the market place. We designed an experiment to collect feedback data needed for the evaluation of the risk of misinforming for two competing products. The summary of the results of this experiment led to the following conclusion: the successful utilization of the "many-to-many" model needs a significant improvement of the questionnaires and the procedure for collecting feedback data and their further analysis.

The sample size of the feedback data collected in the empirical study is too small and does not allow for the development of the ideas of clustering within the population of respondents (such as optimists, pessimists and realists), as it was done in our previous studies. Also, due to the limited sample size, we are not in a position to make any practical recommendations to the seller (or the manufacturer of the PC's) on determining the best warranty policy for their product. Therefore, our next step in extending this research is to provide guidelines for a successful empirical study in quantifying the risk of misinforming in the case of “many-to-many” model.

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