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ALIGNING THE EWS METHODOLOGY TO THE IMPROVEMENT OF DECISION MAKING PROCESS IN MANAGEMENT

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Abstract
The authors' intention was to correlate the traditional body of knowledge in decision making associated to data gathering and problem solving in order to help the decision makers in their to prioritize scarced resources with the attempt to provide a more systematic and improve Early Warning System (EWS) methodology.
In order to mitigate the risks in business decision making, different approaches are possible, enlisting here uncertainty assessment and various forecasting techniques. Early Warning Systems are represented by a measure of a certain indicator meant to signal the increasing degree of confidence that a certain event could cause damages or bring negative impacts.
The idea is to identify the EWS as a new tool used to increase the effect of corrective actions in a system under stress or under turbulent influence form the outside context. Best practices of designing early warning systems in fields as monitoring natural hazards (such as flood or earthquakes) or in supervising banking performance in the current crisis are reported as a starting point in improving and then enlarging the body of knowledge in decision analysis. The interest in connecting EWS methodology to decision science leads to empowering knowledgeable individuals to make more reliable decisions, to acknowledge the increased complexity in the actual business climate and to recognize how the systems under study are threatened by hazards/unexpected/unforeseen situations. This may enable the individuals/groups in charge with management decisions to act under sufficient time and in an appropriate manner to reduce the possibility of personal injury, loss of life and damage to property and the environment.

Keywords*:* Early Warning System (EWS), decision making, problem solving risk assessment.

1. INTRODUCTION

The impetuous need for innovation, the technological progress aiming green or clean production, globalization, digitalization and the financial unstable business climate of the last years have posed to making decision making process more complex and potentially riskier than ever. This has presented new challenges to the management field, both to the theoreticians and practicians, with respect to the need to base their decision on more flexible and sophisticated instruments. Much attention is called to a better forecasting (meaning a more successful prediccting and managing) in the search for lowering the costs of unexpected developments of some economic processes. Foresight and lon-term planning methods, risk management, business intelligence and analytical decision techniques are component parts in a stretegic early awareness approach.

The paper's idea is based on recognizing some weaknesses of the dominant approach in the managerial decisions' literature of being oriented exclusively on fast results, on highly formalized instruments, focusing on decisions within a short or medium time frame. It has originated from the unexpected development of the prospective and foresight exercises brought into practice by the theoreticians of decision making disciplines meant to better management skills necessary in a turbulent environment as one can find worldwide today in the business climate. Even, at the company strategy's level, the need to faster investigate the future in respect to make possible early interventions may be related to the creation of new kind of competitive advantages: early awareness's state signals the incipient relevant business changes, the organization may shape some market trends in the sense of creating „trend setter" vectors; better anticipation and identification of market opportunities may save scarce resources and collect some time advantages (exploiting the first mover benefits).

The main goal of early warning systems is to take action to protect or reduce loss of wealth/performance/success/life or to mitigate damage and economic/societal loss, before the harmful event occurs. A key element of an EWS is a better understanding of the parameters thay play role in uncertainty reduction and of the manner to adrress the quality of the predictions made upon the variables of interest. The Early Warning System allows decision making in oriented selections and in scanning for signals in some specific areas (such as logistics); it does that by allowing the researcher/interested party to detect and to rectify potential problems at an early stage.

The concept of *Early warning* is derived from the political science representing a pro-active political process whereby networks of organizations conduct analysis to prevent likely events from occurring and producing damages. FEWER (Forum for Early Warning and Early Response) defines early warning as the systematic collection and analysis of information coming from areas of crises for the purposes of anticipating the escalation of a conflict, development of a strategic response to these crises and the presentation of options to critical actors for the purposes of decision making (FEWER, 1999).

Nowadays, early warning appears as major element of risk mitigation, especially when is associated to naturad hazards (such as seisms) or to economic effects of the liquidity crisis in the international financial markets. It helps identifying the possible harmful events and preventing loss of lifes, by drawing attention on the time frame of interventions. To be effective, early warning systems call for societal and political support , they need to actively involve the communities/populations/actors at risk, facilitate public education towards risk, effectively communicate the warnings and ensure there is constant state of preparedness (King, 2007). Effective early warning systems embrace all aspects of management, such as: data gathering and desidning action plans, risk assessment analysis (one of early warning system's design requirements), monitoring and predicting manifestation, location and degree of intensity of the negative chain of events waiting to occur;

communicating warning to authorities and to potentially affected society' segments; and responding to the effects of the harm/disaster happened.

The main goal of EWS is the reduction of losses or negative consequences derived from unexpected or uncontrollable events and mitigation of risks or exposure to economic losses. Under specific decision-making context, the EWS impact or effectiveness is strictly dependent on the warning time available and the quality of the information provided that influences and constrains the utilization of the information. Obviously, the timeliness and the reliability are contradictory design requirements (Grasso, 2006).

2. GENERAL FRAMEWORK FOR EWS

Early warning (EW) is "the provision of timely and effective information, through identified institutions, that allows individuals exposed to hazard to take action to avoid or reduce their risk and prepare for effective response" (from International Strategy for Disaster Reduction (ISDR), United Nations (UN); UN ISDR, 2006).

A distinction should be made toward the delimitations of EWS from other correlated terms. Firstly, formally the distinction from risk management, risk is expressed by a mixed value indicating the product between probability and the magnitude of the negative consequence. Risk assessment provides policy with relevant insights about the future as forecasting involves making judgments about the likelihood that an event will happen. Forecasting has traditionally referred to the estimation of the probability that some event will occur while the associated term „magnitude/gravity/severity" is used to describe the events' expected consequences. It is a prescriptive exercise and takes the form of a conditional generalization. Risk assessment precedes and complements early warning by them; it cannot be expected to provide precise points at which specific events are likely to occur.

As making a terminology clarification between EWS and Competitive Intelligence (CI), one should regard CI as the endeavour in which the starting point is observing the upcoming events and then investigating for trends and driving factors and the early awareness approach as the opposite – focusing on the structural drivers and trends to anticipate the upcoming events (Nick, 2006).

The early warning process is composed of four main stages: risk assessment, monitoring and predicting, disseminating and communicating warnings, and response phase. In this framework, the first phase of stating the short- and long-term actions plans, the institutions and and political actors interfer in designing the process of data gathering and analysis. Afterwards, the EW evolves in a technical dimension in the monitoring and predicting phase, while in the communication phase, EW borrows along to the technical aspect another one – of institutional responsibility. Finally, the response phase calls for massive implications from the national and local institutions, non-governmental organizations, communities, and individuals and so on.

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The basic elements used to design the early warning system consist of:

1. *Risk Knowledge*: Risk assessment provides essential information in setting priorities for mitigation and prevention strategies and designing the basic variables in the early warning systems. By addressing the risk knowledge, the aim is to establish a systematic, standardized process to collect, assess and share data, maps and trends on instable dynamics, on some hazards and insecured states or vulnerabilities.
2. *Monitoring and Predicting*: Those systems with monitoring and predicting capabilities provide timely estimates of the potential risks faced by populations/communities, state economies and the environment; in this stage, one organization/actor would establish an effective harmful events' monitoring and institute signal (or alarm) service with a sound logistic and technological basis.
3. *Disseminating Information*: Communication systems are needed for delivering signal messages to the potentially affected population segments to raise the alert for convenient and appropriate interventions.. It is necessary to develop rapid communication and dissemination schema in order to ensure that those affected are warned in advance of impending negative events and facilitate proper coordination and information exchange. The messages need to be reliable, synthetic and simple to be understood by personnel and/or public.
4. *Response*: Coordination, good governance and appropriate action plans are a key point in effective early warning. Likewise, „public" awareness and education are critical aspects of loss mitigation. One should strengthen the ability of communities to respond to hazards, crises or disasters through enhanced education of risks, awareness and solid capability to intervene.

Monitoring and predicting is only one part of the early warning process. This step provides the input information for the early warning process that needs to be disseminated to those whose responsibility is to respond. The scientific community and policy-makers should outline the strategy for effective and timely decision-making by indicating what information is needed by decision-makers, how predictions will be used, how reliable the prediction must be to produce an effective response, and how to communicate this information and the tolerable prediction uncertainty so that the information can be received and understood by authorities and public.

Some EWS applied in current practice

As a reference to existing EWS for real-time seismology, some examples are quoted from Grasso's works: in Japan, Mexic, Taiwan and Turkey (Grasso, 2006). Relating to a EWS used for a seismic study in Bucharest, Romania (being in operation officially since 2005), the system was developed for the protection from seismic hazards coming from Vrancea area (the epicentrer distance of approx. 130 km from the capital city). As even recent history reveals, earthquakes do represent a serious threat for Bucharest, the newly functional system allows a warning time of half a minute for Vrancea events (a similar case corresponds to EWS' s Mexico City having a known epicentral area at a significant distance from the urbanized area and having an estimated warning time of about 25-30 seconds).

In a totally different direction, in the last decades, the design and use of statistical models for predicting future bank health has been a significant development. In the search for an effective early system for recurrent currency, (Lin, 2008) describes a predictive model to assess the possibility of a crisis consisting of a combination of neural network capability for learning process with a fuzzy logic mechanism. The article enlists several directions to design a EWS for traiting the currency crises as derived from the previously accumulated work: stuides trageting mainly the changes in a scpecific indicators before the manifestation of crisis; papers focusing on the differences in values of the variables between the crisis period and the pre-crisis period; papers predicting the probability of the crisis according to given theoretical model (such as the noise-to-signal ratio model) and papers proposing indicators for benchmarking EWS variables.

Due to the last decades' prevalence of the financial crisis, a vast body of literature has been developed with the aim of understanding the determinants and the patterns of currency and liquidity crises. In (Beckmann, 2006), there are identified some recent trends inspired by EWS methods using approaches such as: multinomial logit, extreme value theory and even regional studies. Some considerations are offered as lessons to be taught by the policy makers: EWS have a certified forecasting power and may anticipate some crisis's simptoms; the EWS are subject to political influence.

The EWS models are extensively data-driven and use advanced quantitative techniques that attempt to translate various indicators of banks strengths and performance into an estimate of risk. In (Sahajwala, 2000), some statistical EWS models (for example: failure / survival prediction model, expected loss model, models estimating rankings and rankings downgrades) are used to assess the failure risk in operating banks, and calling for attention from bank supervisors to put in place more formal structural and risk-focused procedures in ongoing banking supervision.

As used in business and finance application, several examples of EWS application (based on two modes: *signal-based approach* and *limited dependent variable – logit multinomial)* can be addressed in anticipating crises in the Romanian central banking system, by studying the probability of entering the financial crisis (Racaru, 2006).

3. NEW APPROACHES IN DECISION ANALYSIS COMING FROM COGNITIVE SCIENCES

Literature in operation research and in statistics often refers to unexpected events as <*low probability, high impact*> situations without imposing the remark that that the event is purely unforeseeable or unknown (Geraldi, 2010).

Yet, in assessing the two factors of the risk expression, one may found a real intricacy upfront - it is reported by in scientific literature that approximately 60% – 80% of the efforts during a management process of a specific project is directed to the incipient stages of a decision making process: gathering the data, administrating the data and its manipulation (Franks, 2009).

Recent research has highlighted the crucial aspect of paying attention: managers concentrating on some specific features of the environment and relatively excluding others form the open window of focused thinking. In general, they learn to concentrate on what is critical in their experience with the confronted domain and disregard any other events or unexpected future. Reasons for the lack of attention are manifold but the cognitive exclusion of these possible events creates the effect of a surprise. For example, despite being knowledgeable about the risks in a project, they elect to shelve some under the rationale, 'it will not happen to me'.

Although the probabilistic, normative '*management by planning'* approaches such as risk management suggest that uncertainty can be well planned in advance, as regular individuals, we have incomplete knowledge about how things may grow and develop in time (Pender et al., 2001). It is inevitable that unanticipated events will occur in managing activities in projects, requiring a time-pressured response (Hällgren and Wilson, 2008; Loosemore and Tan, 2000) and calling for special „organizing" function of management (Williams, 2005). As responding to unexpected events is a fundamental function in project management, participants in this study were asked to think of examples of 'significant unforeseeable events' which took the project manager and his team 'by surprise', whether these were effectively unknown, unpredicted or merely residual risks that materialized.

4. IMPROVING THE QUALITY OF DECISIONS BASED ON EWS

A decision maker, facing a decision process in a hazard situation, has to decide between the two options: send a signal (raise the alarm) or do nothing. The decision problem may be approached by the theory of hypothesis testing (Wald, 1947). The sequential method of testing an hypothesis involves a rule to make selection from the following alternatives:

- Accept the hypothesis
- Reject the hypothesis

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- Continue and make an additional observation.

Accepting or rejecting the hypothesis means emitting a signal or doing nothing. The decision is made based on the observation on the variable of interest (called predictor). In making any decision for intervention under critical circumstance, two kinds of errors may be committed due to the uncertainty associated to the predictor on which the decision is based:

- Type I error: the alarm is not activated when it should have been.
- Type II error: the alarm is activated when it should not have been.

The type I errors are *missed alarms* and type II errors are *false alarms (*Grasso, 2006); the probability of each of these wrong decisions can be expressed as:

P_{ma}= probability of missed alarm, that is the probability of having the value of threshold excedeed but not followed by signal sent (no alarm activation);

P_{fa} = probability of false alarm, that is the probability of having the indicator value under the threshold but associated with signal emission (alarm activation).

The tolerance of a type I or II error is related to a trade-off between the benefits of a correct decision and the costs of a wrong decision and it could vary substantially, depending on the relative consequences of possible missed and false alarms. The likelihood of a wrong decision is due to having only partial knowledge of the phenomenon and so any prediction, as a consequence, is affected by uncertainty.

A rule for making one of the three decisions consists in defining the critical region (defined by the threshold, due to the EWS' s user specification). For each observation the hypothesis will be accepted or rejected if the observation lies in the critical region or not. The principles of a proper choice of the critical region are based on the study of the consequences of any decision.

The feasibility and reliability are main aspects involved in EWS application - the amount of spare time till the event appears and the attempt to decrease the likelihood of making wrong decisions (false alarms and missed alarms), impose conflicting requirements of the configuration of EWS. Obviously, examining the feasibility of a certain draw the need for a control mechanism upon the probabilities of false and missed signals. Since the decision to emit the alrm signal is based on predictor value, $\hat{S}$, the eventual signal proved to be false alarm can be caused by the predictor exceeding the warning threshold (a) even though the actual intensity measure, *S,* does not reach the milestone value. Similarly, missed alarms can be caused by the predictor value beiing under the warning threshold even though the actual intensity measure reaches its critical value.

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For a given case, the critical threshold, noted with *a*, of *S (the predictor)* may be chosen by the EWS's user as the value of *S* for which negative consequence (high amount of economic losses) is expected to occur with a high likelihood. However, to control the probability of wrong decisions, the warning threshold is chosen as the product of the critical threshold *a* and a parameter, *c*, to be specified during the design process. The critical value for the threshold (*a*) is contextual, it depends on the expected damage on the system/facility to be protected, but the warning threshold ($c \cdot a$) depends on the designed process chosen by the actors/ political agents to optimize the signal system. The parameter *c* provides a mechanism to control the probablity of occurrence of false and missed alarms (Table 1). The design parameter *c* provides a mechanism to control the incidence of false and missed alarms. The coefficient *c* is a parameter that will be defined in the design process, based on consequence based approach.

TABLE 1 - BASIC CONCEPTS IN DESIGNING A EWS

CRITICAL THRESHOLD (*A*):	A IS DEFINED BY A PARAMETER *A* THAT REPRESENTS THE VALUE OF THE PREDICTOR RELATED TO THE OCCURRENCE OF LARGE DAMAGE AND/OR ECONOMIC LOSSES. FOR STRUCTURAL APPLICATIONS OF EWS. THE CRITICAL THRESHOLD MAY BE REPRESENTED BY OCCURRENCE OF STRUCTURAL DAMAGE OR COLLAPSE, DEPENDING ON THE DAMAGE LEVEL OF INTEREST, THE VALUE OF THE THRESHOLD IS DEFINED BY VULNERABILITY ASSESSMENT.
WARNING OR ALARM THRESHOLD ($c \cdot a$):	IT REPRESENTS THE VALUE OF THE PREDICTOR FOR WHICH THE SIGNAL IS ACTIVATED... THE ($c \cdot a$) VALUE DEPENDS ON THE DESIGN PROCESS CHOSEN TO OPTIMIZE THE AUTOMATED ALARM ACTIVATION SYSTEM..

Specifying the reasonable level of the probability of deciding wrong is based on a cost-benefit analysis; mailnly, the decision rule may be taken to be the minimization of the expected consequences (Grasso, 2006). Afterwards, the acceptable levels of probability of the false signal (*β*) or for the missed alarm (*α*) can be accepted depending on the their consequences (the incidence of either false or missed alarm), expressed in monetary costs or loss of lives etc. Specifying tolerable values of these probabilities of chosing wrong, is often seen as a difficult endeavor, subject to organization inputs (such as preferences toward risk, loss avoidance). In the cost benefit reasoning, the previously subjective design constraint may be now easily linked to the cost of the effects that could derive from the any decision taken, raising the signal / alarm or doing nothing (instead of specifying tolerable probabilities of making wrong decisions).

A false alarm occurs when the EWS predicts a value, $\hat{S}$, that exceeds the warning threshold, $c \cdot a$, while the actual value, *S*, of the intensity measure at the site turns out to be less than the value of the critical threshold, *a*. The probability of false alarm is given by:

$$P_{fa}(t) = P[S \le a | \hat{S}(t)] \quad (1)$$

Similarly the probability of missed alarm is:

$$P_{ma}(t) = P[S > a \mid \hat{S}(t)]. \tag{2}$$

TABLE 2 - CONFIGURATION OF THE DECISION MAKING PROCESS

	IF S<A WITH THE PROBABILITY *P_{FA}*	*IF S>A* WITH THE PROBABILITY *P_{MA} =1-P_{FA}*
INSTITUTE ALARM/EMIT A SIGNAL	"FALSE ALARM"(YPE II ERROR) C_{FA} IS THE COST OF THE FALSE ALARM SITUATION	"GOOD ALARM" (CORRECT PREDICTION) C_{GA} IS THE COST OF THE GOOD ALARM SITUATION
NO ALARM RAISED/NO SIGNAL IS EMITTED	"GOOD IN NOT RAISING ALARM" (CORRECT PREDICTION) C_{GMA} IS THE COST OF THE GOOD MISSED ALARM SITUATION	"MISSING ALARM" (TYPE I ERROR) C_{MA} IS THE COST OF THE "MISSED" ALARM SITUATION, EQUIVALENT TO THE COST OF THE SUFFERED LOST OR TO THE NEGATIVE CONSEQUENCE MATERIALIZED

The decision criteria for deciding between the options, emitting the signal or not, is represented by the minimum cost rule, explicitely minimizing the expected consequences (table2):

"Raise the alarm if and only if: E[cost | no-alarm]≥E[cost | alarm]"

where:

the expected cost of raising the alarm is:

$$E[\cos t \mid alarm] = C_{fa} \cdot P_{fa} + C_{ga} \cdot P_{ga} = C_{fa} \cdot P_{fa} + (C_{\exp} - C_{\mathrm{int}}) \cdot (1 - P_{fa}) \tag{3}$$

in which: C_{exp} is the expected cost of the harmful/damaging situation happened; C_{int} is the expected savings due to the foreseen intervention.

The expected cost of no raising the alarm is:

$$E[\cos t \mid no - alarm] = C_{gma} \cdot P_{gma} + C_{ma} \cdot P_{ma}. \tag{4}$$

The values of the probabilities of false and missed alarms, P_{fa} and P_{ma}, are an important tools for the decision-making process. For an improved performance of EWS, a performance-based decision making procedure needs to be based on expected consequences of taking action, in terms of *probability of false alarm (P_{fa})* and of *probability missed alarm (P_{ma})*.

5. EWS AND DECISION MAKING PROCEDURE BASED ON COST-BENEFIT ANALYSIS

An innovative approach, presented by (Grasso, 2006) sets the *threshold value* based on the acceptable probability of false (missed) alarms, from a cost-benefit analysis. In decision making strategy based on EWS on emitting the signal if a critical severity level, *a*, is exceeded, the selection between alternatives imposes the monitoring on of the predictor value as compared to a milestone value and, to acertain point, the inner subjectivity of the EWS user in terms of preference between the options. The decision of whether to *activate the alarm or not* is based on the predicted severity of the event (Figure 1). A decision model asesses continuously the uncertainty corresponding to the prediction made and to the consequences of taking action.. The EWS will provide to the user a real-time prediction of the severity of the event, $\hat{S}(t)$, and its error, $\varepsilon_{to}(t)$. A decision rule may be based on the probability of error criterion related to the analysis of the probabilities of error. The total probability of error (P_e) is defined as:

$$P_e = P_{eI} + P_{eII} \qquad (5)$$

where: P_{eI} and P_{eII} represent, respectively, the probability of a *missed* signal and of a *false* alert. During the manifestation of the hazardous event, P_{eI} and P_{eII}, representing potentialities, become probabilities of wrong decision when a decision is made. During the course of the event, the increase of data available will reduce the uncertainty and improve of the prediction accuracy. The prediction uncertainty is updated as more data are available; the actual severity of the event, S, (still unknown) may be defined by adding the prediction error ε_{to}, to the predicted value, $\hat{S}$:

$$S = \hat{S} + \varepsilon_{to} \qquad (6)$$

The total error represents the quality of the information provided by the EWS and is a basic information for consequences evaluation, representing the main source of wrong decisions. The prediction error is being modeled by Gaussian distribution, representing the most un-informative distribution possible due to lack of information. Hence, at time *t*, the actual severity of the event, S, may be modeled with a Gaussian distribution, having mean equal to the prediction $\hat{S}(t)$ and uncertainty equal to $\sigma_{to}(t)$, that is the standard deviation of the prediction error $\varepsilon_{to}(t)$.

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The estimate of the predictor and its uncertainty will be updated every instant of time. The availability of these information, $\hat{S}$ and ε_{to} enable the possibility of evaluating the consequences of taking action, representing our preference in an action or the other (alarm or doing nothing). Based on them, a real-time estimate the potential probabilities of wrong decisions will be available (Grasso, 2006)

The potential probability of false (missed) alarm is given by the probability of S being less (greater) than the critical threshold (equation 1), it becomes an actual probability of false (missed) alarm if the alarm is (not) raised. Considering that the *S* has a normal distribution with mean equal to the predicted $\hat{S}$ (if there is a known bias in the prediction it should be added to this mean) and standard deviation σ_{to} evaluated as a function of the updated uncertainties:

$$P_{fa}(t) = \int_{-\infty}^{a} \frac{1}{\sigma_{to}(t)\cdot\sqrt{2\pi}} \exp\left[\frac{-(S-\hat{S}(t))^2}{2\sigma_{to}(t)^2}\right] dS = \Phi\left(\frac{a-\hat{S}(t)}{\sigma_{to}(t)}\right) \quad \textbf{(7)}$$

The (potential) probability of missed alarm is equal to the probability of *S* being greater than the critical threshold (if the alarm is not raised is the probability of missed alarm):

$$P_{ma}(t) = \int_{a}^{\infty} \frac{1}{\sigma_{to}(t)\cdot\sqrt{2\pi}} \exp\left[\frac{-(S-\hat{S}(t))^2}{2\sigma_{to}(t)^2}\right] dS = 1-\Phi\left(\frac{a-\hat{S}(t)}{\sigma_{to}(t)}\right) \quad \textbf{(8)}$$

where: Φ represents the Gaussian cumulative distribution function.

The tolerable level at which mitigation action should be taken can be determined from a cost-benefit analysis by minimizing the cost of taking action; the probability of a false alarm is tolerable if and only if:

$$P_{fa}(t) \le \beta = \frac{C_{save}}{C_{save}+C_{fa}} \quad (9)$$

It follows that the probability of a missed alarm is tolerable if and only if:

$$P_{ma}(t) \le \alpha = \frac{C_{fa}}{C_{save}+C_{fa}} \quad (10)$$

Where:

C_{save} are the savings due to mitigation actions and C_{fa} is the cost of false alert;

the α and β being the accepted level for the involved probabilities so that $\alpha+\beta=1$.

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Note that the tolerable levels and sum up to one which directly exhibits the trade-off between the threshold probabilities that are tolerable for false and missed alarms. If the threshold β is reduced to make false alarms less likely, then the threshold α for missed alarms becomes correspondingly larger (Grasso, 2006).

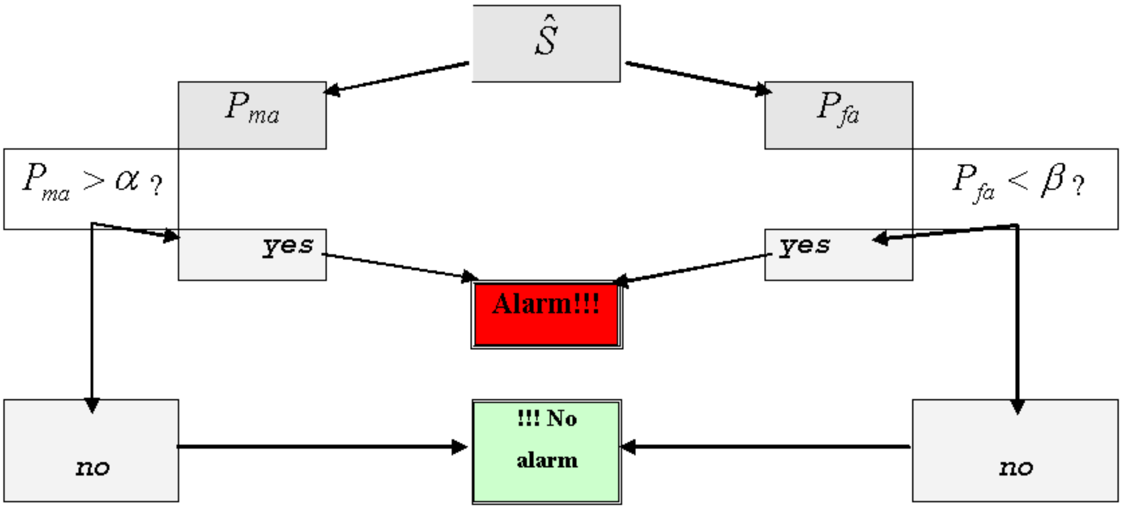

FIGURE 1 - DECISION MAKING PROCESS BASED ON PROBABILITY OF WRONG DECISIONS (GRASSO, 2006)

In the case the missed alarm is the situation of concern, in real-time the $P_{ma}(t)$ will be evaluated and compared to the tolerable level, from this condition time-varying expression for the warning threshold can be derived:

$$P_{ma}(t) = P[S > a|\hat{S}(t)] = 1 - \Phi\left(\frac{a - \hat{S}(t)}{\sigma_{to}(t)}\right) \quad (11)$$

Therefore, the setting of the alarm based on the probability of a missed alarm becoming unacceptable occurs if:

$$P_{ma}(t) > \alpha \Leftrightarrow \hat{S}(t) > a \cdot \left[1 - \frac{\sigma_{to}(t) \cdot \Phi^{-1}(1-\alpha)}{a}\right] = c_{ma}(t) \cdot a \quad (12)$$

Consequently, the level of the cost of the missed alarm is:

$$\cdot \left[1 - \frac{\sigma_{to}(t) \cdot \Phi^{-1}(1-\alpha)}{a}\right] = c_{ma}(t) \quad (13)$$

6. CONCLUSIONS

Early warning signals are used for anticipating discontinuities in market trends, for supporting decision making in developing strategies, all these for focusing attention to the fast changing business environment. A rational decision can be based on real-time monitoring of the probability of wrong decisions, choosing the situation (false alarm or missed alarm) the user is more concerned about, that will be demonstrated that is equivalent to monitoring the predicted intensity measure increase of a time variant warning threshold, *c(t)a*. The value of the probability (P_{fa} or P_{ma}) of interest, evaluated during the course of the event, is compared to the tolerable value (β or α), based on cost-benefit considerations (or provided by the user). Monitoring the value of the probability of wrong decision of interest, during the event, the signal will be raised when the value reaches the tolerable value.

The methodology offers an effective approach for decision making under uncertainty focusing on user requirements in terms of reliability and cost of action.

This paper suggests a connection among various methods possible to be used in scientific management and decision-making science. The traditional approach is mainly aimed to problem solving; for reducing the risk associated to poor forecasting and high and increasing cost of materializing decision making risks, a new concept is used to identify and assess the possible ill, unstructured, poorly – designed courses of actions. The preoccupation for studying this connection and its application for the decision making processes in management emanates from the preoccupation of the author to improve the way of thinking in problem solving methodology.

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