JAQM Advisory Board

Page

JAQM

Vol. 9
No. 1
Spring
2014

III

Ion IVAN

PhD, University Professor, Department of Economic Informatics
Faculty of Cybernetics, Statistics and Economic Informatics
University of Economics, Bucharest, Romania
E-mail: ionivan@ase.ro ; **Web Page:** http://www.ionivan.ro

Claudiu HERTELIU

PhD, Associate Professor, Department of Statistics and Econometrics,
University of Economics, Bucharest, Romania

E-mail: claudiu.herteliu@gmail.com, **Web page:** http://www.hertz.ase.ro

Gheorghe NOSCA

PhD, Association for Development through Science and Education, Bucharest, Romania

E-mail: r_g-nosca@yahoo.com

We are happy to announce the winners of JAQM 2013 Awards.

After deliberations, the winners are:

1ˢᵗ Category

For his very important contribution in promoting and developing Quantitative Methods in Academia, as a recognized scholar, we grant to:

Marcel AUSLOOS
from **GRAPES, University of Liege, Belgium**

*the **2013 JAQM Medal of Honor***

2nd Category

For the most valuable, Quantitative Methods related, paper published in JAQM:
"Applying Fuzzy C-Means and Artificial Neural Networks for Analyzing the Non-Banking Financial Institutions' Sector in Romania", JAQM Fall Issue, 2013, pp. 26-32
we granted to:

Adrian COSTEA

from **Bucharest University of Economic Studies Romania**

the **2013 JAQM Best Paper Award**

3rd Category

For the most promising young researcher in Quantitative Methods area, we grant to:

Bogdan Vasile ILEANU

from **Bucharest University of Economic Studies, Romania**

*the **2013 JAQM Distinction***

HUMAN RELIABILITY MODELING

Irina-Maria DRAGAN

University of Economics, Bucharest, Romania
Department of Statistics and Econometrics

E-mail: irina.dragan@csie.ase.ro

Alexandru ISAIC-MANIU

University of Economics, Bucharest, Romania
Department of Statistics and Econometrics

E-mail: alexandru.isaic@csie.ase.ro

ABSTRACT:

As the complexity of reliability systems grew, they became increasingly dependent on the human factor. Major disasters like the one at Three Mile Island, the Challenger ship, Chernobyl, nuclear power plant accidents, aviation, industrial disasters, etc. have been attributed to the human factors. Hence the need to study the reliability of the human factor as a distinct element of the reliability of the technical and economic systems. After some conceptual clarifications, we are investigating the state of knowledge in the field of human reliability. The literature provides as usual solutions, description and calculation errors, mainly, Goel-Okumato models of class time-domain and time-domain class, where the most notorious is the model Jelinsnski-Moranda, both inspired by the reliability of the software. The study presented in this material, the suitability of a statistical model is able to capture, process, and faithfully carry out human error in "man-machine" system. The application is based on the data recorded from the testing human operators in the management of complex technical systems. Through generalization, the process can be extended to other complex systems such as "man-machine".

Key words: errors, reliability, human factor, modeling, man-machine system.

1. INTRODUCTION

It seems surprising but, as the complexity of electronic products increases, protection methods and control systems, are less prone to errors, especially human ones. Major events, some with catastrophic consequences, are becoming increasingly common. Most likely they are due to human errors.Recalling just a few (not mentioning those generated by natural disasters, or the mundane, such as car accidents): the sinking of the Titanic (14-15.04.1912) generated by a navigation error, the teaching profession with 1514 deaths; in July 1915, the SS Eastland, a cruise vessel was capsized while docked in the port of Chicago, 2,500 people were on board, and844 of them, as well as the crew, died; the power outage in the United States (9.11.1965) has affected over 30 million people (7 States) in the U.S. and parts of Southern Canada- caused by a trivial loss relay, achain connecting a wide range of national

grid power supply was wrongly operated; in Bhopal, India, on December 2nd – 3rd 1984, there was a serious industrial accident resulting in over 15,000 victims and over 500,000 people directly affected, generated by the release of over 45 tons of cyanide gas derivative in the atmosphere from a botched maneuver ; the Chernobyl nuclear accident on April 26th, 1986, was caused by poor management of a test, and , more recently, because of a human vessel negligence Costa Concordia was wrecked on the rocks (January 12, 2012); in 1987, the passenger ferry "Dona Paz" clashed with the tanker "Victor", in the Philippines, both ships sinking in an area full of sharks. Only 26 people have managed to survive. The sinking of the Haitian vessel Neptune, on February 16th, 1993 (800 dead and about 500 missing which have never been found), the ferry-boat Estonia, on September 27th, 1994 (837 dead), the ferry-boat Bukoba, on May 21st, 1996 (700 dead), the ship Le Joula, September 26th, 2002 (1.863 dead) and the ferry Al-Salam Boccaccio, on February 2nd, 2006 (1,000 dead). The plane crash on February 6th, 1958 in Munich, a disaster in which the players of the Manchester United team were involved , crashed on the runway during take-off, being almost entirely destroyed. The device tool-off in Belgrade, with 44 people on board, and had stopped at Munich to refuel. On March 27th, 1977, two Boeing 747 full of passengers collided on the runway in Tenerife, and 538 people died on the spot. In 1996 in India the largest collision in the air took place. A cargo plane from Kazakhstan collided with a Saudi Arabian passenger aircraft on top of Haryana. 349 people, from both devices, died. The accident happened due to an error of the cockpit.The latest air crash, produced in Russia (10 April 2010), decimated the political elite of Poland. In the accident which took place in strange conditions, the Polish President Lech Kaczynski, his wife and 94 other officials from the Polish political environment have lost their lives.The Tupolev-154 plane crashed into a forest near Smolensk in Western Russia, less than 19 kilometers from Katyn forest. And this at the 70th anniversary of the massacre of 22,000 Polish officers by the Russians during World War II. In Romania, the biggest naval tragedy occurred on 10 September 1989, when boat Mogosoaia sank in the vicinity of Galaţi. 215 people were killed then. The disaster at Certej (Romania) took place on Saturday, October 30th, 1971, due to the breakage of the mountain dike slipping in the tailings management facility of the Certej mine exploitation, in Hunedoara County. The dike broke over a width of 80 meters from the pond and within minutes, 300,000 cubic meters of sterile were expelled..Sterile acid waves ate in a quarter of an hour and destroyed six blocks of dwellings with 25 apartments each, a dorm with 30 rooms, numerous other dwellings. The disaster caused about 100 deaths and many were seriously wounded . In January 30th, 2000, a Lake dam near Bozânta (Romania) gave away tospillings of 100,000 cubic meters of cyanide contaminated water (approximately 100 tons of cyanide) over fields and the local river basin system. Five weeks later, another leak, this time with heavy metals, hit the region. A levee gave way in Baia Borşa (Romania) and 20,000 cubic meters of water contaminated with zinc, lead and copper have been discharged into the River Tisa, up to the Danube. An overwhelming majority of the casualties were due to human errors. A whole decade's worth of methods and design of reliability have been focused on the technical part (design, raw materials and processing). Frequent accidents and disasters are proof of this flawed approach. In dealing with reliability, the persistence of a close approach of technical elements is imposed. The reliability of modern systems of production, management, socio-economic macro-systems significantly depend on the measure of the reliability of the human factor. Usually, in the situation where reliability is inadequate technique, the human factor is considered an aggravating element of system

status and to a lesser extent improver reliability. The major goal of the reliability of the system "technical-human operator" must be to reduce errors. The human factor may be non-agent, but reliability and dependability are. "Live broadcast" of the human element of the procedures, methods and indicators used in describing the reliability of technical systems is risky and has limited values, since "human" behavior is distinct from that of technical systems.

2. HUMAN ERROR AND RELIABILITY

As a rule, when we talk about the reliability of the human factor we consider either the human as being a partner of a complex technical system, or as the human operator integrated in the socio-technical system created by himself. In this case, the human factor is often regarded as a "non-secure" element, generator of non-reliability and less like keeper (or recovery) of the reliability of the tandem "man-machine".   Human reliability is defined – according to Neboit et al. Al. (1990) as the probability that an individual, a team or an organization (human) to carry out a mission within the limits of the data, the conditions needed for a certain period of time. The main difference of this wording – from classical reliability (technical) – lies in the extension references from individual to team and defines the limits of acceptability. The latter term, however, is quite vague: it is understood that we can talk about the reliability of the human factor in a situation where "circumstances" have certain limits (noise variance) acceptable for individual, team or organization.

All Neboit et al. say, in the article cited above, is that there are two approaches concerning the reliability of the human factor, namely:

✓ The traditional version, which aims to determine the human operator error probabilities,the emphasis being placed mainly on non-performance of these operators, human factors suspected of being at the origin of faults in the system; technical system and the behavior of the human factor are considered to be very similar and this is why this approach does not take into account the management aspect, the fact that human factors can (often) prevent deflection of the functioning of the system, as well as that of correcting its own errors;

✓ The modern version, which sees man as part of the tandem, "technical system-the human factor", so as to improve the reliability of the vector system and as a non-reliable source; This approach considers that there is a clear distinction between errors of action (decision) and the cognitive in nature (stemming from shortages of knowledge). The first official European settlement in this area is from 1986 (Embrey, 1987) by the European Economic Community (EEC) adopted the following definition: "the body of knowledge relating to the analysis, prediction and reduction of human errors, centering on man's role in the design, operation, maintenance and operation of the system."Reliability approach was first in the technical field. Thus, as shown Blischke and Murthy (2000, p. 285): "Basic definitions of reliability and of most of the terms used in the analysis have appeared < acceptance of hardware >. A significant portion of these terms was transferred to study the reliability of the software, but the concepts are often interpreted differently and there is no unanimity in terms of their significance in the context of software. In reality, the opinions vary enormously – many authors consider that the definitions, concepts and models of reliability of hardware can be transposed directly (or with minor changes) in the case of software, while others considered that the idea of rate in the case of software failures does not make sense ".

Gradually, along with the evolution of computers, software reliability was established as a separate branch of the reliability in the broadest sense. Reliability software evolution continued and became a new area of study in the field of computer security (Leveson,1995).

In the development of software reliability research on evolution has been spectacular, of the most frequently cited contributions, let us mention: Nelson (1978), Govil (1984), Jelinski & Moranda(1972), Blischke & Murthy (2000). The evolution of the research to the regulations through standards like IEEE STD 730/1989: Standard for software quality assurance plans, IEEE STD 1044/1993: Standard for classification of annomalies software. IEEE STD 1059/1993: Guide for software verification and validation plans.

Gradually, researchers' attention was directed to the non-availability, source and tried to separate the approach, evaluation of reliability of technical system (car) to the human factor, is now being a new field of research – human reliability (HR). To quote and contributions from limbo, we recall the works of: Mihalache (1995), Iosif (1996), Isaic-Maniu &Voda (2002), Nitu (2009), Costea (2005).After numerous catastrophes, nuclear and aviation in particular, distinct research directions have been developed, concerning human identification, reliability modeling and preventing errors which generate such accidents (Swain & Guttman (1983), Cappelli,M., Gadomski,A., Sepielli, M.(2011), Dhillon ,B(2009). For example, the top 10 nuclear accidents indicate human factor errors as agravator element of the incidents turning disaster accidents (Idaho, SUA-1961, Jaslovske Bohunice, Slovacia-1977, Tomsk, Rusia-1993, Tokaimura, Japonia-1999, Fukushima, Japonia-2011, Chalk River, Canada-1952, Windscale Pile, Marea Britanie-1957, Three Mile Island, USA-1979, Kyshtym, Russia-1957, Cernobil, Ukrain-1986)**.

As a result, the human resources management plan were bolstered research in the field of risk evaluation and impact behaviour of human errors in managing incidents. In the 1970s, studies on the safety of the air traffic system indicated that human error had contributed to approximately 90% of incidents of air traffic management (Kinney &,1977). According to some, as the degree of automation and computerization of flights increases, the human factor becomes aggravating factor of safety compared to the less automated devices (Bowers, Deaton, Oser, Prince, Kolb, 1994; Lee, Moray -1994; Jones-1999, Senders & Moray-1991). The variability of human behavior is more than a technical system and occurs as intra-individual variability (generated by various factors such as stress, fatigue, attention, etc.) as well as intra-team variability, resulting from the combination of these individual or intra-organization variabilities. Tthe study and management of human errors (Parry1996) was thus formed, while still a branch of scientific research. When an individual or a team loses the ability to perform the functions required under specified conditions, then we are dealing with human error. A classification of the possible errors that may occur in the process of the interaction between man and a technical system errors by omission – which arise from failure to perform all phases of the tasks (missions); runtime errors - which occur through non-compliance with procedures; sequencing errors generated by breaking the order of operations;delay-induced errors of late execution of an operation. Obviously there are various specific errors, such as, programmers having syntax, semantic, logical or plain errors. It must be stressed that an error is not always synonymous with failure: a human operator can make the case for one or more errors, without it involving compulsory system loss.

An equivalent term "falling" (especially technical systems) viability theory, generated by a falling human error is the undesirable event, which can be graded according to its effects as incident, crash, and catastrophe.

Reliability analysis of socio-technical systems requires a clarification of human error sources and their limitations. Human error sources are found in the multitude of factors that determine the behavior of the people. Addressing human errors is mainly done in two directions: the psychological and management with ergonomic-applicability in the various types of technical and economic processes.

From the psychological point of view, the error can be defined as an offense or is not carried out as a function of purposeful intention. This approach is supported by the analysis of the cognitive mechanisms of generating various types of errors, internal and external conditions facilitating production errors. Among the remarkable psychological approaches to human error we can mention: Hollnagel (1998), a special type of presence, cognitive errors.

The notion of cognitive error was introduced by Tversky & Kahneman (1981) in 1972 demonstrating that in many cases the judgment and human decision deviates from the theory of "rational choice". Joseph (2010) performs a version of classification and description of cognitive errors and similarly carried out another classification criterion of human interaction after operator and technical system, Hollnagel (1998) focuses on the analysis of human error, and Wilson (1993) developed a methodology for the analysis of human error. In the area of managerial errors approach we recall the work of Mihalache (1994), a collection of essays titled "Chance to fail", which captures, in an original manner, human reliability issues, reviewing it in terms of its relationship with technology. He believes that reliability is a "Science of systems degradation laws, independent of their nature". The concept of reliability is "failure", defined by the author as the top "when at least one of the system's performance stands out of the allowable values. In the light of the definitions, the "people", as well as their relationship with the "machine" represents a failure of the source of any flexible manufacturing. Grabowski and Roberts (1996) develop human errors related to major socio-technical systems, while Reason (1990) fundamentally covers the issues of human errors, Iosif & Marhan (2005) explore human-computer interaction from the standpoint of human errors, and Wiegmann & Shappell (2003) examine the issue of human error in aviation accidents.

3. ECONOMETRIC MODELING OF HUMAN RELIABILITY (RH)

The concepts, definitions and reliability modeling appeared and developed in technical systems, or how Blischkeand & Murthy (2000) define as „the context hardware". The approach splits software reliability from human reliability. Between the two big branches of reliability (H & S) there are numerous distinctions (Table 1 presents some of them).

Major differences between the reliability of the H and S

DIFFERENCES BETWEEN RELIABILITY	
Hardware (H)	Software (S)
1. Design and production have an essential role in achieving a certain reability	1. The design almost exclusively determines reliability
2. Failure can be described and explained by causes (laws) of the physical - chemical properties	2. There are in this case such laws
3. The actual causes of failures are numerous and can be found in the project, execution mode, the maintenance activity or improper operation	3. Power failures are due almost exclusively to design deficiencies
4. Maintenance, if executed correctly, improves reliability	4. "Reprogramming" eliminates some errors, but it can be the source of new errors
5. Redundancy can increase reliability.	5. Redundancy may have a null effect
6. Currently uses standardized components	6. There are no such components
7. The interface is done with physical structures of the same type	7. The interface is conceptual only
8. Sometimes the design uses quotients of tolerance limits	8. There are no such coefficients in systems programs
9. A minor flaw may have a negligible effect on the reliability (or not affect it at all)	9. Even a "bit" can block the whole system of programs.

Practical requirements imposed, to settle, and the research literature offers today's profile on a wide range of statistical models for analysis and prediction of human reliability. To summarize, we present some of the most popular models of reliability, with mention of their essential properties.

- *Generalized exponential model*
  As it is well known, the exponential distribution is obtained from the classical relation:

$$f(x) = z(x) \cdot \exp\left\{ -\int_0^x z(u)du \right\} \qquad (1)$$

By choosing substitutes $z(x) = \theta \rangle 0$ (constant) leads us to the density:

$$X : f(x) = \theta \cdot \exp\{-\theta x\}, x \geq 0, \theta \rangle 0 \qquad (2)$$

Exponential random variable has the specific feature $CV(X) = 1$ because

$E(X) = \dfrac{1}{\theta}$ question $Var(X) = \dfrac{1}{\theta^2}$.

Distribution function is $F(x) = 1 - e^{-\theta x}$ and the reliability, $R(x) = e^{-\theta x}$.

When the order is centered $2/\theta^3$ while the order IV, $9/\theta^4$. In these situations, the coefficient of skewness is $\sqrt{\beta_1} = 2$, and the excess coefficient, $\beta_2 = 9$.

• *Goel – Okumato Model* (1979) assumes that the error can be removed even without having to remove the latent error which caused the system to malfunction.

The number of failures does not coincide with the number of errors removed. The likelihood of an error to be deleted is smaller than 1, and will be boted p. Process failures is considered separately as the elimination of errors.

If we note with $M_d(t)$ the number of failures in the range (0,t), the initial number of errors (which, in this case, is no longer equal to the number of errors removed) and the number of remaining errors no longer satisfy the relation:

$N = M_d(t) + N(t)$, but the relation:

$$N = M_c(t) + N(t) \qquad (3)$$

where: $M_c(t)$ is the number of errors removed in the range (0, t)

Either $P_r(t) = P[M_c(t) = r] \rightarrow$ distribution of the number of errors removed (0, t).Mathematically, the result is that this distribution is an exponential distribution, of the form:

$$P_r(t) = C_N^r \left(e^{-p\Phi t} \right)^{N-r} \left(1 - e^{-p\Phi t} \right)^r \qquad (4)$$

with $\quad r = 1, 2, \ldots \ldots N$

It is observed that $e^{-p\Phi t}$ is the probability that a latent error may not be corrected in (0,t), and $1 - e^{-p\Phi t}$ is the probability that a latent error to be corrected within is the probability that a latent error to be corrected within (0,t).

So the distribution parameters are: N şi $1 - e^{-p\Phi t}$. The average number of errors removed in the range (0, t) is:

$$H_c(t) = N \left(1 - e^{-p\Phi t} \right) \qquad (5)$$

In the expression of the distribution, the number of errors corrected is, easily, the distribution of the number of errors remaining:

$$Q_k(t) = P\left[N(t) = k \right] = C_N^k \left(e^{-p\Phi t} \right)^k \left(1 - e^{-p\Phi t} \right)^{N-k} \qquad (6)$$

It is observed that the number of errors remaining is distributed with a binomial parameter N and $e^{-p\Phi t}$. As a result, the average number of errors remaining in the range (0, t) is:

$$M_{N(t)} = N e^{-p\Phi t}. \qquad (7)$$

The probability at time t the number of errors remaining will be less than or equal to the default value is:

$$P\left[N\left(t\right)\le A\right]=\sum_{k=0}^{A}Q_k\left(t\right)=\sum_{k=0}^{A}C_N^k\left(e^{-p\Phi t}\right)^k\left(1-e^{-p\Phi t}\right)^{N-k} \tag{8}$$

The likelihood that all errors may be corrected (A = 0) in the range (0, t) is:

$$Q_0\left(t\right)=P\left[N\left(t\right)=0\right]=\left(1-e^{-p\Phi t}\right)^{N} \tag{9}$$

The last relationship you can calculate the required test time so that, with probability, the system does not contain any error:

$$t_{Q_0}=\frac{1}{p\Phi}\ln\frac{1}{1-Q_0^{1/N}}$$

The average time to remove all the errors:

$$D=\frac{1}{Np\Phi}+\frac{1}{\left(N-1\right)p\Phi}+\ldots\ldots+\frac{1}{p\Phi} \tag{10}$$

As I pointed out, the number of failures M_d (t) in (0,t) is equal to the number of errors in this range and is greater than the number of errors corrected $M_c(t)$ at the same time (0,t).

- *Jelinski-Moranda Model*. The assumptions of this model (Jelinski-Moranda-1972) are the following:
  - The time intervals between successive failures are treated as random variables;
  - Failures rate is proportional to the number of errors and depends on time;
    - At each fall is running a proper action of negligible duration, which removes the error generating this fall.

  In the interval between the falls i-1 and i, the number of errors is $N(t)=N-i+1$ and the density of probability range attached X_i it is – in the model J-M:

$$f_i\left(x_i|N,\theta\right)=\left(N-i+1\right)\theta^{-1}\exp\left[-\left(N-i+1\right)x_i/\theta\right] \tag{11}$$

  where : θ is the parameter function.

  There have been attempts to improve this model by introducing hypotheses on the distribution of the errors. Thus, for example, Schick and Wolverteon (1978) found a distribution of exponential type and Blischke & Murthy (2000) a Weibull-type, and Isaic-Maniu and Voda (2002), Costea (2005) they rebuilt the model for behavior after an exponential distribution errors overall. In this latter case the shape is:

$$X:f\left(x;\theta;k\right)=\frac{k}{\theta^{1/k}\Gamma\left(k\right)}\exp\left\{-x^{k/\theta}\right\},x\ge0,\theta,k\ge0 \tag{12}$$

  A form that, for k = 1 leads to a classic exponential, while for k = 2 semi-normal, so the form attached to the interval becomes:

$$f_i\left(x_i\mid N,\theta,k\right)=\frac{k\cdot\left(N-i+1\right)^{1/k}}{\theta^{1/k}\Gamma\left(1/k\right)}\cdot\exp\left\{-\left(N-i+1\right)x_i^{k}/\theta\right\} \tag{13}$$

Note that for k=1 version (13) the mdel becomes J-M, the density given in (11). In Tolle (11), $\Gamma(*)$ is Euler's Gamma function.

In version (13) of the model and the reliability of the human factor appears as a process of renewal with the failure rate descending: each failure (generated by a human error) this rate decrease, so it eliminates the sequentially one error (not repeating the same assumptions errors). Goel-Okumoto-model is in the class called "time-domain" which is based on the idea of attaching the reliability of the human factor, reliability system and differ from time-domain-class "or its main content errors. Of the same class of models are homogeneous Markov models:-heavy snowfall and describing their errors as being dependent on the "chain" of each other, Jelinski-Moranda model (1972) – which starts from the premise that errors occur randomly and that all have the same meaning and consequences on the reliability of the system, and that errors can be completely removed from the source with the Littlewood model (1996) effect - somewhat similar to Jelinski-Moranda, the difference being the manner of treating the error considered as having different importance and different system reliability track "man-machine". In short, about the characteristics of these models.

4. APPLICATION – THE ERRORS COMMITTED AT THE HELM OF AN AUTOMATED SYSTEM

Into a training center of a system of high technical complexity, the periodical training, the errors recorded by 9 employees - table 2 were presented.

The succession of major errors

Table 2

1	0	4	6	5	7	10
4	7	7	0	5	3	0
6	2	3	0	1	8	9
1	7	1	5	0	1	1
6	3	0	4	3	0	2
4	3	1	1	8	9	0
7	2	3	7	1	0	9
2	9	5	1	10	8	7
0	0	2	0	7	3	3
5	1	0	4	1	4	0
0	6	4	3	5	7	6
7	4	0	4	6	0	2
3	8	7	0	5	5	8
1	0	2	1	5	7	1
4	3	0	5	9	0	-

Processing through descriptive statistical indicators leads to the following results (table 3):

Descriptive indicators

Table 3

Statistic	Value		Percentile	Value
Sample Size	104		Min	0
Range	10		5%	0
Mean	3.625		10%	0
Variance	8.8774		25% (Q1)	1
Std. Deviation	2.9795		50% (Median)	3
Coef. of Variation	0.82193		75% (Q3)	6
Std. Error	0.29216		90%	8
Skewness	0.3657		95%	9
Excess Kurtosis	-1.0678		Max	10

Average errors committed: 3.63, with dispersion 8.9. Asymmetry and kurtosis series, as well as the significant difference between arithmetic average and median creates doubts over the possible normal distributions (Gauss) error, as it would be the first option. Any frequency distribution series of errors does not suggest a Gauss-type distribution (fig.1):

None of the classic patterns of errors (Goel-Okumoto, exponential, or Jelinski-Moranda) were confirmed through statistic testing.
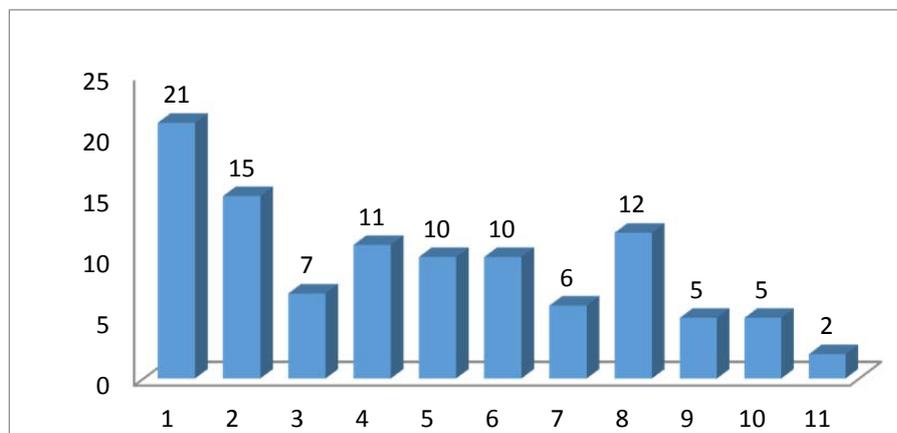
Figure 1: **Series histogram**

We use and test for confirmation χ^2. The null and the alternative hypotheses are:

- H_0: the data follow the specified distribution;
- H_1: the data do not follow the specified distribution.

The Chi-Squared test ($\chi2$) is used to determine if a sample comes from a population with a specific distribution. Although there is no optimal choice for the number of bins (k), there are several formulas which can be used to calculate this number based on the sample size (N). For example, the data can be grouped into intervals of *equal probability* or *equal width*. The first approach is generally more acceptable since it handles peaked data much better.

- The application value of the $\chi2$ test lead to computed:

$$\chi_c^{\,2} = \sum_{i=1}^{k} \frac{(n_i - np_i)^2}{np_i}$$

(12)

where: n_i represent the experimental frequencies, **n** frequency and total, p_i – theoretical probabilities.

The resulting: $\chi2_{calc.} = 19.395$, P-value $=0.0035$, and for $\alpha = 0.01$- 0.2 critical value the computed value is exceeded, so the normal distribution assumption cannot be accepted. The *official* reason why people always assume a Gaussian error distribution goes back to something called the Central Limit Theorem. The Central Limit Theorem says that whenever a measurement is subject to a very large number of very small errors, the probability distribution for the *total* error is driven toward the Gaussian distribution. This is true regardless of the form of the original probability distributions of the individual errors. A proof - and it is a pretty one - can be found in any book on the theory of statistics. The *real* reason why people always assume a Gaussian error distribution is that, having made that assumption, we can then easily derive (and have derived!) exact mathematical formulae which allow us to compute directly the "best" values for the unknown parameters. This is not necessarily possible for other probability distributions. What would happen if, for instance, the error distribution for your data were not Gaussian? The fact is, with real data you don't know what the probability distribution of the errors is, and you don't even know that it has *any* particular mathematical form that is consistent from one experiment to another. Most likely, some formula like the Lorentz function - with a well-defined core and extended wings - is a more reasonable seat-of-the-pants estimate for real error distributions than the Gaussian is, because the Gaussian's wings fall off *very* quickly. As I said, we all know that two- and three-sigma residuals are far more common in real life than the Gaussian would predict. This is because a real observation is likely to contain one or two large errors in addition to a myriad of tiny ones.

Consequently, it was switched to other distributions to statistical hypothesis testing. Through successive tests were validated as a model of a Generalized Pareto Distribution. Probability density function:

$$f(x, k, \sigma, \mu) = \begin{cases} \frac{1}{\sigma}\left(1 + k\frac{(x-\mu)}{\sigma}\right)^{-1-\frac{1}{k}} & k \neq 0 \\ \frac{1}{\sigma}exp\left(-\frac{(x-\mu)}{\sigma}\right) & k = 0 \end{cases}$$

(13)

Cumulative distribution function :

$$F(x,k,\sigma,\mu) = \begin{cases} 1 - \left(1 + k\frac{(x-\mu)}{\sigma}\right)^{-1-\frac{1}{k}} & k \neq 0 \\ 1 - exp\left(-\frac{(x-\mu)}{\sigma}\right) & k = 0 \end{cases}$$ (14)

Where:

k- shape parameter

σ- scale parameter (σ>0)

μ- location parameter

The variation of parameters:

$\mu \leq x < + \infty$ for $k \geq 0$

$\mu \leq x \leq \mu - \frac{\sigma}{k}$ for k< 0

Applied successively for validation, χ2 tests (relationship 12), Kolmogorov-Smirnov, Andersen-Darling. The tests to verify the hypothesis distribution, **Kolmogorov-Smirnov**, as follows: This test is used to decide if a sample comes from a hypothesized continuous distribution. It is based on the empirical cumulative distribution function (Fn). The empirical distribution function F_n for n observations X_i is defined as

$$F_n(x) = \frac{1}{n} \sum_{i=1}^{n} I_{X_i \leq x}$$ (15)

where $I_{X_i \leq x}$ is the indicator function, equal to 1 if $X_i \leq x$ and equal to 0 otherwise. The Kolmogorov-Smirnov statistic (D) is based on the largest vertical difference between the theoretical and the empirical cumulative distribution function:

$$D_n = \sup_x |F_n(x) - F(x)|$$ (16)

F_n(x) where sup_x is the supremum of the set of distances. In practice, the statistic requires a relatively large number of data points to properly reject the null hypothesis. The P-value, in contrast to fixed α values, is calculated based on the test statistic, and denotes the threshold value of the significance level in the sense that the null hypothesis (H_0) will be The P-value can be useful, in particular, when the null hypothesis is rejected at all predefined significance levels, and you need to know at which level it *could* be accepted. The SDK calculates the P-values based on the Kolmogorov-Smirnov test statistics (D) for each fitted distribution.To confirm the decision has been applied and the **Anderson-Darling Test**.

This test procedure is a general test to compare the fit of an observed cumulative distribution function to an expected cumulative distribution function. This test gives more weight to the tails than the Kolmogorov-Smirnov test. The Anderson–Darling test assesses whether a sample comes from a specified distribution. It makes use of the fact that, when given a hypothesized underlying distribution and assuming the data does arise from this distribution, the data can be transformed to a Uniform distribution. The transformed sample data can be then tested for uniformity with a distance test). The formula for the test statistic A to assess if data $\{Y_1 < \cdots < Y_n\}$ (note that the data must be put in order) comes from a distribution with cumulative distribution function (CDF) F is

JAQM

$$A^2 = -n - S,$$ (17)

where

$$S = \sum_{k=1}^{n} \frac{2k-1}{n} \left[\ln(F(Y_k)) + \ln\left(1 - F(Y_{n+1-k})\right)\right].$$ (18)

The test statistic can then be compared against the critical values of the theoretical distribution. Note that in this case no parameters are estimated in relation to the distribution function F.

In the synthesis of the summary results of the fitting distribution table 1 is presented as follows (table 4):

The synthesis results   **Table 4**

Statistical test	The value of the test statistic	Critical threshold value for α			P-value
		0.01	0.05	0.10	
Pearson's chi-squared test (χ2)	6.52	16.81	12.59	10.65	0.367
Kolmogorov-Sirnov	1.48	0.159	0.133	0.119	-
Anderson-Darling	0.11	3.91	2.502	1.929	0.165

Pareto distribution is known for optimum resource allocation purposes. Pareto parameter estimation problem of the distribution is treated by: Johnson & Kotz, Balakrishan (1994), Jantischi (2010), Arnold (2011), Popa (1999) and Singh & Guo (1995).

In case of application submitted, all calculations lead to only one conclusion: generalized Pareto model can be accepted.

The parameters of this model are the following:

k = - 0.5872

σ = 6.9771

μ = -0.77092

Applying the computed values of the parameters of the main function graphs are illustrated in Figure 2-5.
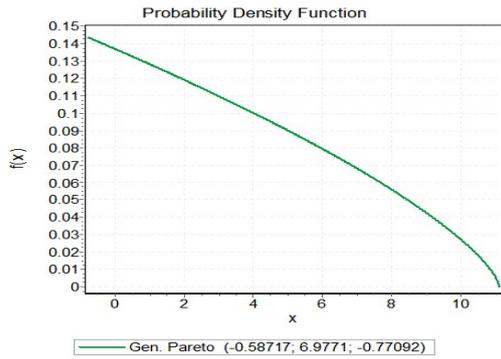
Figure 2
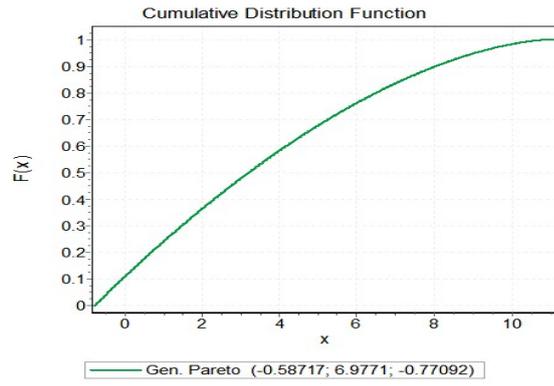
Figure 3
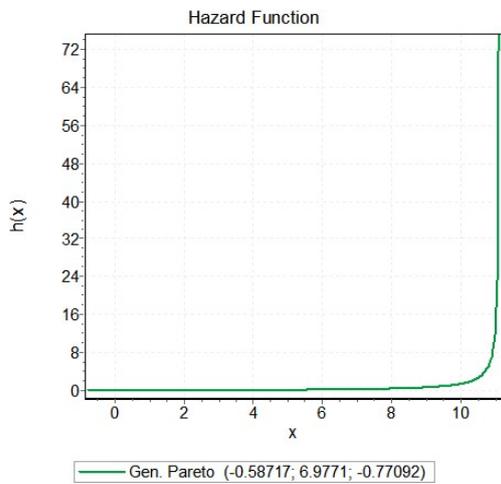
Figure 4
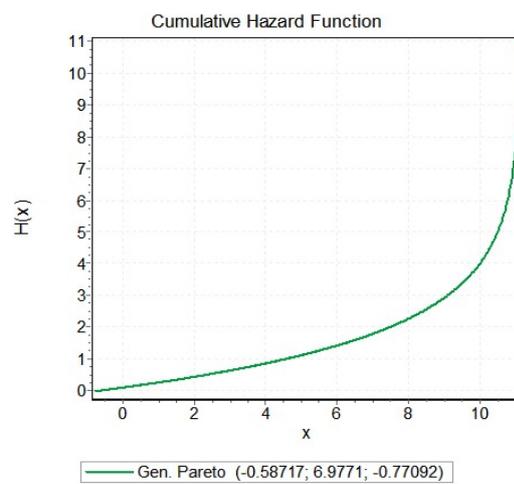
Figure 5

On the basis of indicators the estimated probabilities were determined based on a certain number of errors (table 5 include expected values of committing errors) in two assumptions (I1 and I2) determined by the values set for the x_1 and x_2 limits, these representing the number of errors that might occur.

The likelihood of errors   (%)   **Table 5**

Assumptions	Version A	VersionB	Version C	Version D
	$x_1=0$ $x_2=1$	$x_1=0$ $x_2=3$	$x_1 = 1$ $x_2= 5$	$x_1 = 0$ $x_2= 10$
P($x < x_1$)	10.79	10.79	24.03	24.03
P($x > x_1$)	89.24	89.24	75.97	75.97

P(x_1 < x < x_2)	13.24	37.01	43.74	74.20
P(x < x_2)	24.03	47.81	67.77	98.23
P(x>x_2)	75.97	52.20	32.23	1.77

Experimental data indicate that the probability to register more than one error is almost 11%, and to register more than one error, but less than three is 37%. The likelihood that more than one error occurs is about 76% more than three errors, 52%, over five of 32 percent, while more than 10, 1.8% (Figure 6 shows the survival function).
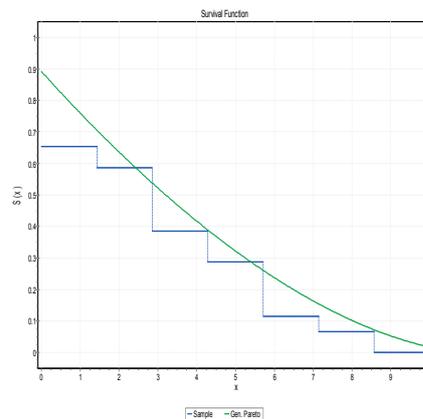
Figure 6. Survival function graph

CONCLUSIONS

The investigated literature indicates that in the recent years, of the many studies that have been carried out, some propose, on the one hand, to understand the nature of human error and the cognitive mechanisms that contribute to the production of various types of errors, and others, on the other hand, to make predictions, with probabilities as high over the chances of committing errors, and possible prevention.Moreover, resulting in the fact that the automated systems of error detection limits are important, given that, in fact, these machines cannot precisely identify the causes and motivations that guide the behavior of the operator.

The increasing interest   both scientifically and practically, for the field of management of errors generated a powerful impetus for a new attitude to human error and to the role of human operator in control systems "man-machine".

The human operator can play, in some situations, a positive role in bringing a system to normal condition and at an optimal level of safety after making an error.   All developments in the field of error management, and screening recovery methods have failed to keep up with research on the mechanisms underlying the production of human error.

A policy of "zero failure" – a major objective of safety – has been interpreted as meaning "zero error". Such an approach must factor in the fact that zero-errors is difficult to

obtain, from a practical standpoint, because it ignores the existence of a large number of variabilities of the human behavior, and some types of errors are difficult to remove.

The case study presented, operators of a system of great complexity, in a process of training and testing, illustrate the frequency of errors in handling of perpetrating the system and may pose for upper management a guide over the chances of a fair system of managers.

Evaluations are more accurate in terms of identifying the adequate distribution that describes the type of error, and stochastic calculations allow not only reflection but also behavior and prediction of committing a certain type of error to intervene in limiting the generation managerial execution, both through further technical system protections, and by improving the training and selection of staff.

BIBLIOGRAPHY

1. Abdel-Ghelly, A, Chan, P.Y,Littlewood, B. **Evaluation of Competing Software Reliability Predictions**, "IEEE Transactions on Software Engineering", vol. SE.12, N. 9. 1986

2. Arnold, B., C. **Pareto and Generalized Pareto Distributions**, Ch.7, in: Duangkamon Chotikapanich - *Modeling Distributions and Lorenz Curves*, Springer, New YorkArnold, B. C., Laguna, L (1977). *On generalized Pareto distributions with applications to income data*. Ames, Iowa: Iowa State University, Department of Economics, 2011

3. Blischke, W. R. and Murthy, D.N.P. **Reliabilitiy: Modeling, Prediction and Optimization**. Wiley Series in Probability and Statistics, New York, 2000

4. Bowers C., Deaton J., Oser R., Prince C., Kolb M. **Impact of automation on aircrew communication and decision-making performance**, International Journal Aviation Psychology, 5(2), 1994, pp.145-167.

5. Cappelli,M. ,Gadomski,A., Sepielli, M. **Human Factors in Nuclear Power Plant Safety Management: A Socio-Cognitive Modeling Approach using TOGA Meta-Theory**. Proceedings of International Congress on Advances in Nuclear Power Plants. Nice SFEN, 2011

6. Costea, A. **Computational intelligence Methods for Quantitative Data Mining**, TUCS, Åbo, Finland, 2005

7. Dhillon, B. **Human Reliability, Error, and Human Factors in Engineering Maintenance**: with Reference to Aviation and Power Generation, CRC Press, 2009

8. Embrey, D. E., Humphreys, P., Rosa, E. A., Kirwan, B. & Rea, K., SLIM-MAUD. **An Approach to Assessing Human Error Probabilities Using Structured Expert Judgment**. NUREG/CR-3518, Brookhaven National Laboratory, Upton, New York 11973, USA, 1984

9. Goel, A. and Okumoto, K. **Time-dependent error-detection rate. Model for software reliability and other performance measures**. PEEE. Presentations on Reliability, vol. 28, 1979, pp. 206-211.

10. Govil, K.K. **Philosophy of a new structure of software reliability modeling**. Microelectronics and Reliability, vol. 24, nr.3, 1984, pp. 407-409.

11. Grabowski, M. and Roberts, K. H. **Human and organizational error in large scale systems**, IEEE Transactions on Systems, Man, and Cybernetics, Volume 26, No. 1, January 1996, 1996, 2-16.

12. Hollnagel, E. **Cognitive reliability and error analysis method**.CREAM. Elsevier, 1998.

13. Ignatescu, M. **Erorile cognitive**, http://www.descopera.org/erorile-cognitive/, 2010

14. Iosif, Gh. (1996**). Fiabilitatea uman**ă **în sistemele socio-tehnice**. Editura Studenţească, Bucureşti.

15. Iosif, Gh. & Marhan, A.M. **Ergonomie cognitiv**ă **şi interacţiune om-calculator**. Editura Matrix Rom, Bucureşti, 2005

16. Isaic-Maniu, Voda,V. **Fiabilitatea factorului uman.** A VIII-a Conferinta Internationala "Calitate, Fiabilitate, Mentenabilitate - CCF'2002", Sinaia, Romania, 18-20 septembrie, 2002, www.euroqual.pub.ro/activst6.htm

17. Jantschi, L. **Algoritmi genetici si aplicatii ale acestora** ,Teza de doctorat ,Univ.de Stiinte Agricole si Medicina Veterinara ,Cluj-Napoca, 2010

18. Jelinski, Z. and Moranda, P.B. **Software reliability research**. În: „Proceedings of the Statistical Methods for the Evaluation of Computer System performance". Academic press, N. Y., 1972

19. Johnson, N. **Systems of frequency curves generated by methods of translation**. Biometrika, 36, 1949, pp.149-176.

20. Johnson, N., Kotz, S. Balakrishan, N. **Continuous Univariate distributions**, vol. 1, Wiley-Interscience Publication, 1994

21. Jones, P. M. **Human error and its amelioration**. In: Handbook of Systems Engineering and Management (A. P. Sage and W. B. Rouse, eds.), 1999, pp.687-702. Wiley.

22. Kinney, G. Spahn, J., Amato, R. **The human element in air traffic control:observations and analyses of the performance of controllers and supervisors in providing ATC separation services**. METRIEK Division of the MITRE Corporation: MTR-7655, 1977

23. Lee J., Moray N. **Trust, Selfconfidence, and operator's adaptation to automation**, International. Journal Human-Computer Studies, 40, 1994, 153-184

24. Leveson, N. **Safeware: System safety and computers**. Addison-Wesley, 1995

25. Littlewood, B. **The impact of diversity upon common mode failures**. Reliability Engineering & System Safety, 51(1), 1996, 101 - 113.

26. Meister, D. **Human reliability**, Human Factors Society Review (Muckler, F.A., Ed.), Santa Monica, 1984.

27. Mihalache, A. **Chance to Fail. Essays on the social and political impact of science and engineering**, EDP (Akademos), Bucharest, 1994

28. Mihalache, A. N. **Când calculatoarele greşesc. Fiabilitatea sistemelor de programe – software**. Editura Didactică şi Pedagogică, Bucureşti, 1995.

29. Moieni, P., Spurgin, A.J., Singh, A. **Advances in human reliability analyis methodology**, P I: Frameworks, models and data," Reliability Engineering and System Safety" 44, 1994, pp.27-55

30. Neboit, M. et al. **Fiabilite humaine: presentation du domain**. Edition OCTARES, Paris, 1990.

31. Nelson E. **Estimating software reliability from test data**. Microelectronics Reliability. Elsevier, 1978

32. Nitu ,C. **Sisteme de conducere cu calculatoare**, Ed.Matrix Rom,Bucuresti, 2009.

33. Parry, G.W. et al. **A Process for Application of ATHEANA.** A New HRAMethod, Park City, Utah, USA, 1996

34. Popa,I. **Modelarea dinamicii temporale a doboraturilor produse de vânt, prin metoda evenimentelor extreme**, "BUCOVINA FORESTIERĂ" , an VII,nr.1-2, 1999, pp.10-15

35. Reason, J. **Human error**. Cambridge University Press, 1990.

36. Singh,V.P.,Guo,H. **Parameter estimation for 3-parameter generalized pareto distribution by the principle of maximum entropy (POME)**, "Hydrological Sciences Journal", 40, 2, 1995, pp.165-182

37. Schick, J. and Wolverton,R. **An analysis of competing software reliability models**, IEEE Transactions on Software Engineering, Vol. SE-4, No. 2, 1978

38. Senders, J. and Moray, N. **Human error: Cause, prediction, and reduction**. Lawrence Erlbaum Associates, 1991.

39. Swain, A. D., & Guttman, H. E. **Handbook of human reliability analysis with emphasis on nuclear power plant applications**. NUREG/CR-1278 (Washington D.C.), 1983.

40. Tversky, A. & Kahneman, D. **The Framing of Decisions and the Psychology of Choice. Science**, Vol. 211, No. 4481, 1981, pp. 453-458

41. Wiegmann, D., A., Shappell, S. **Human Error Approach to Aviation Accident Analysis: The Human Factors Analysis and Classification System**, ASHGATE Publishing Company, 2003.

42. Wilson, J.R. **SHEAN (Simplified Human Error Analysis code) and automated THERP**. United States Department of Energy Technical Report Number WINCO--11908, 1993

43. *** IEEE STD 730/1989: **Standard for software quality assurance plans**.

44. *** IEEE STD 1044/1993: **Standard for classification of software annomalies**

45. *** IEEE STD 1059/1993: **Guide for software verification and validation plans**.

PREDICTING SHARIA STOCK PERFORMANCE IN INDONESIA STOCK MARKET USING SUPPORT VECTOR MACHINE ALGORITHM FOR IMBALANCE DATA

Retno MAHARESI[1]
Department of Information Technology, Gunadarma University, West Java, Indonesia

E-mail: rmaharesi@staff.gunadarma.ac.id

Sri HERMAWATI
Department of Management, Gunadarma University, West Java, Indonesia

E-mail: srihermawati@staff.gunadarma.ac.id

ABSTRACT:

The paper discusses the practical implementations of using the support vector machine (SVM) algorithm for imbalance data to predict the stock performances in the Indonesian stock market. SVM algorithm for imbalance data was used to model various financial ratios as independent variables to investigate indicators that significantly affect the stock's performance of large market capitalization companies which were actively traded over the last three-year periods. The model selections, namely the imbalance and the balance SVM model with dummy variables representing the appropriate weights were carried out using 10-fold cross validation methods integrated with a grid search procedure for parameter optimization. The study identified and examined six financial ratios commonly used by the stock analysts without considering macro economic variables was able to classify the performances of the companies into two categories "good" or "poor" based on the prices proportion of two consecutive periods. The result suggested that the proposed method yield competitive performance in terms of prediction accuracy level as compared with its competitors.

*   **Key words:** *Classification, financial ratios, prediction, stock's performance, support vector.*

1. INTRODUCTION

Predicting stock performance is a very difficult as well as a challenging problem. In the history of stock performance forecasting literature, no comprehensive or accurate model has been recommended to date. Hence the usage of relevant financial information to make good investment decisions in the stock market is important. Having made careful observations for the interdependence among some relevant variables such as interest rates, bond returns and volatility in affecting the probabilities of different types of stock market crashes, stock analyst should as well pay attention to emerging stock markets, since a certain local crash can be seen as a bad signal in other market places.

A stock's performance can, to some extent, be analyzed based on financial indicators presented in the company's annual report. In which, the annual report provides a vast amount of information that can be use to produce various financial ratios. Many literatures told that financial ratios can be used for assessing future stock performance namely to

project future stock price trends based on those previous values. Ratio analysis therefore becomes a key parameters used by stock analyst to determine the intrinsic value of stock shares. The study of financial ratios emerged after stock market crashes in the 1998s and 2009s in Indonesia. Today, ratios are also used in fundamental analysis to predict future company's performance. As the need in this type of analysis to grow, various new ratios, such as book value and price/cash earnings per share, have been included for share valuation. The level of importance given to these ratios differs from industry to industry and from one country to another. Thus, selecting appropriate ratios is very crucial in increasing the prediction success rate.

The objective of this paper is to analyze financial data in order to develop a simplified model for interpretation. This paper intents to build a model for classifying sharia stocks belong to *Indonesian Syariah Stock Index* (ISSI) into two categories (good or poor), based on their rate of return. Here a company's stock is classified as "good" if its share prices to be greater than of the previous period's price, provided that the price ratio of the two consecutives periods is above the predefined value, e.g., 130 % in the data sample. In this study, the SVM algorithm has been used to classify selected companies, based on their performance. The SVM algorithm is used to predict the categorical value (poor or good) of stock performances by classifying the data of feature variables. It involves optimizing the margin value to locate the hyper plane in between the two different classes of good and poor stocks. This is carried out by first transforming the feature variables using nonlinear implicit kernel mapping into a possibly higher feature dimensions to make the data to be able being delineated by the hyper plane.

Among all of the stocks listed in the Indonesia Stock Market, not all of them be grouped into sharia index. A certain stock considered to be a sharia stock after an examination and investigation processes carried out by the board of Islamic sharia commission, namely *Dewan Sharia Indonesia* (DSI). The board of commission reports the investigation results to the Government body namely Bapepam-LK. To enable helping investors for doing investment on these shares, Bapepam-LK announced a list of stocks considered to follow sharia principle called *Daftar Efek Sharia* (DES) every semester. DES contains a set of stocks in the stock market which do not violate the sharia principles. Generally the shares included in DES involve not only stock issued by public companies, but also other kinds of shares such as mutual funds, bond, obligation and some other sharia effects. The bench mark of market performance for all Indonesia sharia stocks (ISSI) is 30 most actively transacted stocks during the last year of examination process carried out by DSN, called Jakarta Islamic Index (JII). Criteria to decide whether a certain stock to be in the JII list are: The main business of share issuing company does not violating the sharia laws and already listed for more than three months (except it is included in the top 10 big market capitalization). The stocks should fulfill the following conditions: For which is based on its annual or semester financial report, it must have liability ratio upon maximal asset to be around 90%, to be considered in the 60 top stocks ranked based upon biggest market capitalization averages during the last year, be considered in the 30 stocks ranked based upon average of regular trading liquidity values during the last year.

2.   REVIEW OF LITERATURES

In the last 10 recent years, there has been a greater focus of the market because of

its rapid growth and its increasing potential for global investors to the Indonesia stock market. Emerging-market returns are usually more predictable than of the developed market returns because it is more likely to be highly influenced by local information than those of the developed markets (Harvey, 1995). Several written works examined the cross-sectional relationship between fundamental variables with indicators such as earnings yield, cash flow yield, book-to-market ratio and others to predict stock returns in the case of developed markets as well as the use of financial ratios for classifying the performance of firms (Kato et al.1996; Jung & Boyd, 1996). These indicated that a good prediction performance can be obtained based on the financial ratios data.

In light of the market's growing importance, more attention has been directed to studies concerning different classification techniques for measuring stock performance. One of the technique is Logistic regression (LR), that can be used for predicting the presence or absence of a characteristic or outcome based on values from a set of predictor variables (Lee, 2004). The model can be used for classifying firms as either defaulters or non-defaulters. The model was focused upon the ability to rank the defaulted and non-defaulted firms, based upon the failure probability to be more favorable. In order to apply logistic regression, one must consider two kinds of error rate, namely type I and type II rates in the selection of the optimal cut-off probability. Hence, there is a subjectivity of the choice of these misclassification costs in practice, which is the weakness of the LR procedure (Zavgren, 1985).

Some studies generally reported that data-mining techniques such as artificial neural networks (ANN) and support vector machine (SVM) were better suited to detect stock-price movement, in terms of classification accuracy than multivariate statistical techniques such as discriminant analysis or LR. Among them were (Cheng 1996, Van & Robert 1997, Öğüt 2009) who used data mining techniques for modeling financial time series. Min & Lee (2004) showed that SVM outperformed the ANN for predicting business failure in Korea for their comparative study. Min & Jeong (2009) compared prediction accuracy of a binary classification model with other methods such as multi-discriminant analysis, LR and ANN, who showed that their model can be a promising alternative to consider among the existing model forbankruptcy prediction. A comprehensive review of various work related to bankruptcy prediction problems carried out by Kumar & Ravi (2007) found that neural network is the most widely used technique. Mostafa (2010) showed that neuro-computational models, called quasi-Newton training algorithm is useful tools in forecasting stock exchange movements in emerging markets. The training algorithm they used produces fewer forecasting errors, compared with other training algorithms. This is because the robustness and flexibility of training algorithms serve neuro-computational models to be expected to outperform traditional time series techniques such as regression and ARIMA in forecasting price movements in stock markets.(Guresen et al. 2011) evaluated the effectiveness of neural network class models, namely multi-layer perceptron (MLP), the dynamic artificial neural network and hybrid neural networks that used generalized auto-regressive conditional heteroscedasticity (GARCH) to extract new input variables in stock market predictions. (Li et al. 2010) used a 30 times hold- out method to build a better model for predicting stock returns, along with the two commonly used methods in data mining algorithms (SVM and k Nearest Neighbor) are used. They concluded that the homogeneous multiple classifiers utilizing neural networks by majority voting perform best to predict stock returns. (Swiderski et al. 2012) demonstrated an approach for an automatic assessment of the company financial condition and developed the computerized classification system, applying a

certain representation of data and then using support vector machine (SVM) as the final binary classifier. The application of this method to the firm's financial condition assessment has shown to be superior with respect to the classical approaches.

2.1 SVM algorithm

SVM model for imbalance data is similar to SVM model of balance data, but is qualified in models where the dichotomous dependent variable shows that the number of certain outcome is very much bigger than of the other. SVM model for imbalance data can be used to predict the membership of each unit sample based on the independent variables or features values in the model. The SVM algorithm yields coefficients for each independent variable based on model selection for optimal parameter using a data sample. Support vector machine models (SVM) which contain nonlinear and noise components are widely used in practice (Hsu et al., 2013). The parameters of an SVM model are commonly estimated by learning from the data sample.

The particular advantage of SVM is that, through the application of implicit nonlinear mapping, i.e. by implementing a kernel function; for mapping the feature space of independent variables into higher dimensions. This likely to produce a new set of data sample in the higher dimensions of features space and then making possible for the usual hyper plane to delineate in between the two different groups of sample (Lee, 2004). The predictor values from the analysis (*-1* or *1* outcome) can be interpreted as a membership in the target groups (categorical dependent variables).

Existing literature indicates that SVM model for imbalance data has been rarely used to build a model for predicting out-performing sharia shares. SVM model has been used mostly for predicting financial distress and business failure. It has not been used for predicting sharia share performance in Indonesia. In terms of stock market investment destination, Indonesia is a good performing emerging market. In this context, the present study will provide useful method of stock analysis to shareholders and potential investors to help them to make good decisions regarding the investments.

3. RESEARCH OBJECTIVE AND METHODOLOGY

In this study, the relation between financial ratios and stock performance of the firms has been examined using binary Support Vector Machine algorithm for imbalance data. The earlier studies cited above have generally shown support vector machine algorithm for imbalance data, as used in the finance field can be an effective tool for decision makers. It has also been recognized fundamentally that financial ratios can noticeably enhance the forecasting model ability of stock price. The objective of this study is to build a model using financial ratios of the firms for predicting out-performing shares in Indonesia Sharia Stock Index (ISSI). The goals of this study are to answer the questions: Can the stock's prices proportion of two consecutive periods be explained by using financial ratios? (2) Can the stock's returns through the use of stock's prices proportion of two consecutive periods be analyzed using a support vector machine model for imbalance data?

3.1. Analysis of SVM model for imbalance data

The classification task in SVM model is performed by separating hyper plane for which every unit data in the sample can be assigned to one of the two different classes

containing in the data sample. The hyper plane produced by the SVM algorithm is formed such that the distance between a subset of data sample, known as vector supports should be maximal towards the hyper plane in order to have a better decision for learning process among the set of *n* data sample of *p* dimensions feature variables. The relationships between independent variables which contains several financial ratios and the dependent variables, in this case is stock categories of 'good' or 'poor' stock obtained from the learning process is then used for predictions. The outcome of SVM algorithm is a function that gives the decision of classification (good or poor) on the substitution of independent variable into the decision function Hofmann et.al (2008) obtained in the learning or training process. Hence SVM models allow one to predict a discrete outcome, such as group membership, from a set of variables that may be continuous, discrete or a mix of any of these. The relationship between the hyper plane *f(x)* and the support vectors data are described by Figure (1). Here both the vertical and horizontal axis denoted the explanatory variables x_1 and x_2.
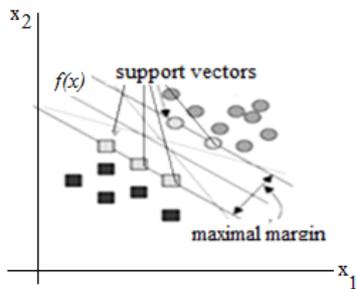

Figure 1.Hyper plane obtained by SVM algorithm in R^2 space

Real data rarely show linear separable phenomenon, hence a more suitable model to tackle for that data should accounts for non-linear as well as noise components. Based on a set of input quantities **x**$_i$, $y_i \in$ {-1, 1}; C, K(**x**$_i$, **x**$_i$) for *i, j* = 1, …,*n* where **x**$_i$ is a vector of *p* feature variables of a data sample. The assigned classification for x_i is denoted by using binary label {-1, +1}, with C is a set up parameter to represent the penalty cost of noise presence ε_i in the data. The kernel function $K(x_i, x_j)$ with parameter *γ* represents an implicit nonlinear mapping in the data feature spaces, namely $\varphi: R^p \rightarrow R^m$ where *m* ≥ *p*. The original SVM model formulation due to (Cortes & Vapnik 1995) for data sample of size *n* is

$$min \quad \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{n}\varepsilon_i \quad\quad\quad (1)$$

Subject to:

$$1 - y_i\left(\langle\varphi(x_i), \varphi(x_j)\rangle + b\right) - \varepsilon_i \le 0$$

$$\varepsilon_i \ge 0 \quad for\ i = 1, 2, …, n.$$

The solution of the SVM optimization problem obtained by first to get the solution for the dual optimization problem in terms of Lagrange multiplier α_i:

$$max \quad L(\alpha) = \sum_{i=1}^{n}\alpha_i - \frac{1}{2}\sum_{i=1}^{n}\alpha_i\alpha_j y_i y_j \sum_{j=1}^{n}K(x_i, x_j) \quad\quad\quad (2)$$

subject to: $0 \le \alpha_i \le C,\ 0 \le \beta_i \le C,\ C - \alpha_i - \beta_i = 0,\ \sum_{i=1}^{n}\alpha_i y_i = 0 \quad for \quad i = 1, …, n.$

A Quadratic Programming software (QP) may be used to get this solution. From the obtained optimal solution one arrives to the decision function after a substitution for optimal α_i into the expression of model's parameter (**w**, b). The prediction classification for the whole data is obtained based upon these parameter values. Here the optimal parameters values are obtained using grid search scheme implemented in the cross validation method based on the data training. After obtaining the optimal parameter values over the grid search areas then the prediction equation as shown in Equation (3) can be obtained.

$$y\,(\boldsymbol{x}_{test}) = sign(\textstyle\sum_{i=1}^{n} \alpha_i y_i\, K(\boldsymbol{x}_i, \boldsymbol{x}_{test}) +\; b) \tag{3}$$

The above SVM model works well on a set of balance data. However, for the case of imbalance data, where the number of 'good' and 'poor' stocks differ significantly, a more suitable model, namely SVM model for imbalance data should be used to obtain a more accurate model (Anand et al, 2010; Akbani et al, 2004; Hur and Weston, 2008). For the case of imbalance data, there are several other methods to make the imbalance data to be more balance. The most common methods applied for imbalance data include changing size of training datasets, cost-sensitive classifier (Akbani et al. 2004, Han et al. 2005, Chawla et al. 2002). Several other methods to deal with imbalance data had been as well proposed, which include modified SVMs, k nearest neighbor (kNN), neural networks, genetic programming, rough set based algorithms, probabilistic decision tree and learning methods (Ganganwar, 2012). Those methods were reported to have good classification performances on the imbalance data sets. To note for method of resizing data which include oversample the minority class or under sample the majority class can cause to non randomness of sample distribution and hence its distribution no longer approximates the target distribution. While with under sampling, this might discard instances with valuable information. For this reason, here we come out to the addition of two dummies variables in the feature variables by implementing a weighting scheme for each data sample according to the class assignment of each data sample in the training set. Having performing this stage, the usual SVM algorithm can be implemented to obtain the decision function for classification.

Formulation for C parameter for the case of imbalance data needs some modification according to the following argument: The Probability to correctly assigning a unit sample to the right class i.e., positive or negative classes can be estimated using the following conditional probability formulae: $P(True) = P(True \cap pos) + P(True \cap neg) = P(True|pos)P(pos) + P(True|neg)P(neg)$ or $w_{pos}P(True|pos) + w_{neg}P(True|neg)$.

The SVM Model in (1) used the penalty cost C equally to all data classes, which means to assign equal weight of ½ for the two different classes. As a result, the decision function tends to classify every unit sample to the majority class (Hur & Weston, 2008). To overcome this bias, the weight assignment needs to be changed proportionally according to the number of positive and negative membership. If for example the number of negative data (n^-) is much greater, then the probability of negative misclassification becomes small, therefore, the penalty cost on the negative class (C) should be a small positive number. On the contrary, if for example, the number of data to have positive sign (n^+) is very small, then the probability to occur misclassification for the positive class increases, hence the penalty cost for the positive class namely, C_+ should be a big positive number, hence equation $C_+ n_+ = C_- n_-$ is obtained or

$$C_+ = \frac{n_-}{n_+} C_- \quad \text{and} \quad C_- = 1\, C_- \;. \tag{4}$$

Applying the weight notation as before to yield: $w_{pos} = n_-/n_+$ and $w_{neg} = 1$. It is preferable to use only a penalty cost parameter C_- instead of both, this is done by substituting (5) for the total penalty cost in the second term of the objective