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The Proposition of Enterprise Risk Management Process using Machine Learning Algorithm: Case of Mid-Size Company

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Abstract

Nowadays, companies operate in a multi-risk environment. The sustainability of SMEs depends on decision makers' awareness and capabilities to consider the systematic and unsystematic risks of their business activities. The implementation of such a standardized process concerns all the company's internal structures and sub-units intervening in the emergence of risks. The article attempts to analyze the medium-sized enterprise risk management (ERM) process using the evolution of risk factors and their impacts on business performance. The empirical study combines two scientific approaches: Artificial Neural Network (ANN) and stress testing. The results show that the labor cost and raw material variation highly impact the net profit more than any other external factors, executive officers have to monitor these factors in order to optimize the company's performance.

Disciplinary: Business Management

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1 Introduction

Companies operate in multi-risk environments. The sustainability of SMEs depends on decision makers' awareness and capabilities to consider the systematic and unsystematic risks of their business activities. The unsystematic risk can easily be managed within the scope of the risk manager. Unsystematic risks are all the factors that are specific to the business activity or sector, the scope of the consequences is limited. On the contrary, systematic risks are hard to predict and

manage. Moreover, the combination of both types of risk is a challenging fact to cope with, since it is threatening the survival of most businesses. Most of the failed companies lacked the skills and the tolls and the approach to face internal and external risks. Risk managers have to continuously and efficiently adopt sound processes. The implementation of a standardized process concerns all the company's internal structures and sub-units intervening in the emergence of risks. This article will attempt to present the theoretical framework of three paradigms that are: enterprise risk management, artificial network and stress test, and then we will discuss all the internal and external factors and their impacts on the company's performance. As well, we will focus on the empirical study with the discussion of the findings, and then a conclusion will the perspective of the study.

2 Literature Review

2.1 Enterprise Risk Management

The ERM is a new discipline that aims to strengthen the company's resilience. In fact, businesses operate in complex environments, with the presence of many risks: financial, operating, credit…etc. A company's success depends on its ability to manage all these factors. Many academic and professional bodies (such as the society of actuaries, insurance companies, Basel committee…etc), have focused on the analysis of expected and unexpected factors that may negatively impact a company's profit. Before running more insights on the theoretical framework of ERM, it is fundamental to define the concept of risk. Holton (2004) views risk as the occurrence of possible loss or gain due to present events or the future. Businesses are keen to enhance their performance, portfolio managers attempt to maximize their returns while minimizing the risk. In theory, the risk-free security presents a low return because of the related financial characteristics while risky securities offer an additional profit;

The implementation of sound ERM aims to ensure more control over the expected outcome and to monitor the risk consequences. The literature review of ERM presents a variety of definitions. COSO states that "ERM is a process, elected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risks to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives." (2004). The ERM process is based on sound management control aimed to detect the potential events. According to Anthony (1965), the management control is "the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives". Mikes and Kaplan (2014) have reviewed the ERM practices among many companies and recorded the main deficiencies, they also analyzed the evolution of such practices over many years, and presented the following definition:" Enterprise risk management consists of active and intrusive processes that (1) are capable of challenging existing assumptions about the world within and outside the organization; (2) communicate risk information with the use of distinct tools (such as risk maps, stress tests, and scenarios); (3) collectively address gaps in the control of risks that

other control functions (such as internal audit and other boundary controls) leave unaddressed; and, in doing so, (4) complement—but do not displace—existing management control practices". Mike and Kaplan reflection are more action-oriented using risk measurement tools, it also has the benefit to establish an integrated approach and ensuring the complementarities with other company's division mainly (control, audit, communication and managerial divisions) (Table 1).

Table 1: ERM process.

Step	Designation	Explanation
1	Definition of risk policy	Should be established by senior managers with collaboration with people who are directly involved with the source of risk. The policy should clearly and precisely define the goals with relation to the desired output. The inclusion of the collaborators aims to increase their awareness to the sensitivity of the issue.
2	Identification of risks	Determination of source of risks at all levels: production, administration, finance, marketing and selling, purchasing, department coordination…etc
3	Measurement of risk	*Modeling quantitative and qualitative; *Scoring every risk in order to rank risks by gravity and impact of firm output
4	Treatment actions	*Formulate adequate action to manage each type of risk individually; *Propose actions to manage all risk in more integrated perspective.
5	Monitoring	Controlling the actions proposed in precedent step and the efficiency of its implementation.
6	Reporting	*A periodical report should be established by risk manager; *Detect the deficiency of the ongoing management approach; *Propose with collaborators remedies for further enhancement

The risk policies adopted by many companies should be in cohesion with official regulations and prescriptive risk management framework (such as the risk disclosure recommendations in the UK Turnbull report, the COSO Enterprise Risk Management Framework, and the International Standards Organization's ISO 31000). This set of regulations is dynamic and evolves with any newly emerged risk factor. For instance, the subprime crisis has resulted in the issuance of new prudential regulation called the Dodd–Frank Wall Street Reform and Consumer Protection Act. The new generation of the regulatory framework determines the tools to be used (risk mapping, stress test, formulation of hypothesis…etc) which can be combined with firm performance measurement tools such as the balanced scorecard (Kaplan and Norton; 1992).

It is important to mention that there is no standardized ERM process, differences occur even within an industry (Tufano 1996; Mikes 2009; Mikes 2011). The type of ownership also impacts the implementation; whether it is a publicly or privately owned company. For certain corporations, risk management is merely about fixing limits based on risk appetite, for others it is a more integrated approach, aiming to analyze the firm uncertainties in both internal and external environment (Mikes et al., 2013; Power et al., 2013).

The implementation of ERM for Power (2004;2009) should be well mastered by regulators, senior managers and the board of directors, he also considered less viable the predetermined limits in the risk policy to the extent that they do not reflect the full reality and neglect the interconnections between risk involving factors. All the firm officers are concerned with ERM implementation, Lam (2003) mandates the company's officers to justify their decisions and make them accountable, he added that such accountability makes company officers more risk-averse.

The literature review on ERM also shows that organizations with higher financial risk are more engaged in the process implementation (Liebenberg and Hoyt, 2003; Pagach and Warr, 2011), and senior managers, and principals are aware of the consequences of higher financial leverage which is associated with the maximized return and also higher chance of failure. The context of ERM was the subject of many studies, Colquitt et al. (1999) and Beasley et al. (2005) confirmed the significance of the firm size and the nature of the activity sector on the implementation of ERM, Liebenberg and Hoyt (2003) have rejected this correlation. Other factor is the regulatory pressure, Kleffner et al. (2003) confirmed that financial as well as nonfinancial firms are subject to external obligations to adopt ERM, especially those listed in the stock exchange, Paape and Speklé (2012) announced that the market constraints are more powerful than government risk code.

Mikes (2009) proposal of a risk map is mostly used within all sectors. Each step constitutes one useful block to the whole process: risk identification, risk drivers, risk measurement, risk impact on the targeted output, risk ranking based on gravity and intensity, the establishment of a plausible scenario as a stress test, and risk mitigation.

2.2 Artificial Neural Network

It is a process initially adopted in biology, it tries to determine the reaction of cell brains under specific and more severe conditions. The purpose is to analyze the human body's reaction to the presence of stimulus or any other nondesirable events. Aftermath, with the development of daily life, and the interconnection between many social factors, the neuron network was implemented in many disciplines such as economy, industry, psychology, finance...etc. For instance, in the banking sector in order to optimize corporate governance and boost the decision-making process in an uncertain environment, a new data analysis technic has been evolved that is Artificial Neural Network (ANN).

According to DARPA Neural Network Study (1988) "A neural network is a system composed of many simple processing elements operating in parallel whose function is determined by network structure, connection strengths, and the processing performed at computing elements or nodes". Haykin (1994) added that a neural network is alike the human brain since the knowledge is acquired by the network through a learning step and that Interneuron connection is used to store the knowledge. Nigrin (1993) viewed a neural network as a system formed with an infinite number of elements called neuron that functions based on local information. Within the artificial neural network, a signal enters one neuron and passes to another one through a chemical process, the original neuron releases a transmitter substance in order to lower or increase the electrical signal within receiving neuron. Eventually, the reaction of the receiving neuron depends on its proper threshold, if the coming signal is more than the threshold, the receiving neuron will react, and vice versa.

The emergence of complicated situations and the limitation of human capability to quickly and accurately respond to unpredictable events have encouraged the adoption of a new data analysis process with duplication of the human brain function using machines and algorithms

called Artificial Neural Network (ANN). The goal was also to reduce the error of the duplication because the output layers depend on a predetermined algorithm, which in case of false interpretation of input layers, an erroneous signal will be transmitted giving undesirable decisions and results.

The ANN is composed of many single artificial neurons (Figure 1), which receive many weighted inputs and then it will transmit fires a signal based on the activation function and the threshold.

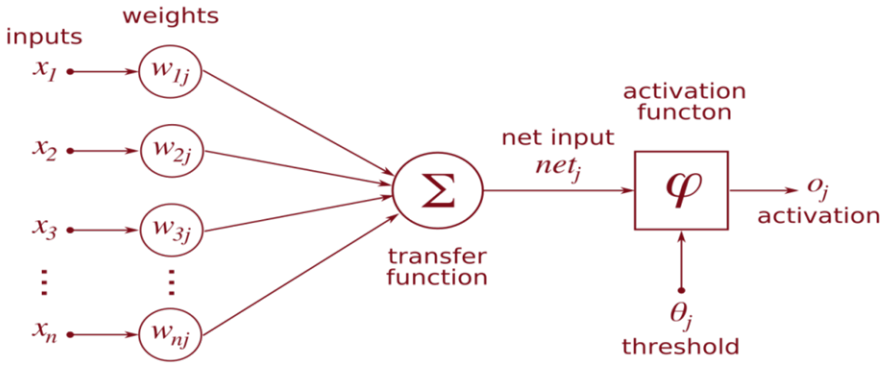

Figure 1: Artificial neural network

2.3 Stress Test

The stress test is a technique used to measure the resilience of banks under plausible scenarios such as important and unexpected withdrawals, and significant changes in the balance sheet accounts. The bank's objective is to formulate alternative actions to comply with the prudential regulation in terms of required regulatory equity.

The first stress testing was adopted by many financial institutions as part of their precautionary system in 1980 to assess the impact of interest rate volatility on bank financial statements (Houpt and Embersit; 1991). In fact, the financial situation of banks in the last century was dominated by more interest-based financial securities. The value is determined by the interest rate in the market which increases the instability of these institutions.

According to Kapinos et al. (2015), the stress test has many advantages mainly: the capture of systematic risk and provides additional information to that presented by the Basel requirement on capital adequacy, 2) it contribute to enhancing the transparency of the financial institution and thus reduce the asymmetric effect, 3) it conducts supervisors and managers to continuously examine and update the necessary actions to severe scenarios, 4) it encourages banks to enhance the quality of the collected data for more holistic management approach. The disclosure of the test results has not been adopted unanimously, based on the study of Goldstein and Leitner (2013) the disclosure of test results should only be in distressed times, the permanent publication of the result induces banks to minimize the amount of information provided to the market. Dent and Westwood (2016) have apprehended the test as an analysis of the object or system's resilience under extreme conditions. Both regulators and bank managers will be more informed and therefore

they can be more reactive to the emergence of plausible but extreme macroeconomic and microeconomic chocks.

The development of the stress testing framework generates two paradigms: direct and reverse testing (Kapinos et al., 2015) (Figure 2).

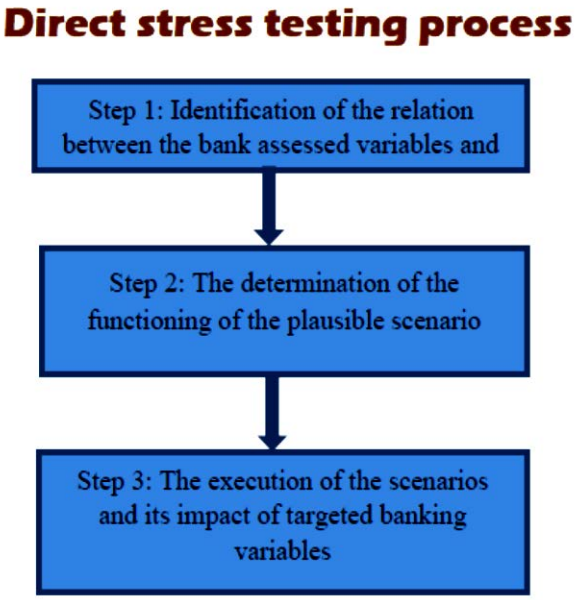

Figure 2: Direct stress testing process.

Gersl and Seidler (2011) pointed out that stress testing to generate good results have to be calibrated conservatively with the overestimations of the risks since it is hard to design severe scenario under normal time. The historical data cannot capture the intensity of unexpected events. Lian and Pazarbasioglu(2014) define the microeconomic stress test as a micro-prudential exercise with macro-prudential objectives, they inform that the transparency and the quality of the exercise are so critical, that they differentiate between crisis stress testing from supervisory stress tests undertaken in crisis time, even though both exercises have the same purpose but there are some minor differences. In fact, the first type of test may be more oriented to the microeconomic goal while the second is more macroeconomic base, the other difference according to the same source is the frequency and the transparency of the test results, in the second test, transparency and credibility are more needed to ensure systemic stability.

Under the Basel Capital Accord, amid the financial development and the complexity of banking securities, the inclusion of market and liquidity risks becomes mandatory for bank institutions. The objective is to test the financial strength of the bank mainly the reaction of tier 1 and tier 2 to any financial distress. Testing the liquidity risk is to determine the evolution of the liquidity gap under stressful conditions. The test results are analyzed for the purpose of choosing adequate plans and actions in case of occurrence of financial distress. Since 1999, the US authorities have applied the Supervisory Capital Assessment Program (SCAP), the purpose was to estimate the impact of systemic risk on regulatory capital adequacy.

The assessment of the macroeconomic risk was also subject to the Financial Sector Assessment Program (FSAP), a program monitored by the IMF, and conducted by many countries.

The implementation of the program was either by the IMF staff or with the collaboration of the country's supervisory body. Needleless to say that corporations have also implemented this tool to assess their credit and investment exposure risk (the Counterparty Risk Management Policy Group (1999)). It is clear that this technic has been helping managers and decision-makers to assess the capacity of their organization to absorb unexpected outcomes; the proliferation of this technique in the banking sector proves its efficiency and its effectiveness.

Basel (2009) has considered stress testing as a major component in bank risk management. The utility lies on its ability to alert managers to adverse unexpected outcomes that might negatively impact the financial situation of the institution.

2.4 Analysis of the SMEs' Internal and External Environments

The literature review highlights the crucial role of internal and external environments. The success of the company is fully functioning on the ability of decision-makers to include both environments in their strategic and operating planning (Indris and Primiana, 2015).

2.4.1 Internal Environment

Munizu (2010) points out internal variables as events that occur within the landscape of the company and are linked to the existing organizational structure, every department is considered from the top management to the employees operating in the ground field, and the quality of the collaboration is also crucial to the organization functioning.

Crijins and Ooghi (2000) consider that the company tries to respond to consumers' needs and desires, and the collaboration and coordination, between the company's departments mainly marketing and non-marketing activities play a major role (Ann Ledwith et.al, 2008).

2.4.2 External Environment

According to Chuck (2001), the external environment is composed of all factors outside of the companies that affect their performance. The factors are heterogeneous ranging from technological, financial, social, and political to economical ones. For instance, the globalization of the economy and the associated increase in competition, and the high development of information technology system affects a company's strategy and vision. The change in laws domestically and internationally is also affecting SMEs' performance. Indeed, the regulatory framework has been determining a firm's strategy process and objectives, and financial markets are assessing a firm's performance and its compliance with the ongoing regulatory framework. Another factor affecting SMEs is the evolution of consumers' tastes, desires and expectations. Here, firms have to be more proactive than reactive, the ability to anticipate the market trend will determine the company's performance and success. According to Munizu (2010), external factors are composed of all the macro-events that impact all the sectors such as community culture, the level and the quality of the economy, the quality of the public sector, the dynamism of NGOs and the performance of the education system.

3 Method

First of all, it is important to mention that there is no standard ERM for all companies, each one represents a specific case that needs particular attention and reflection. The ERM approach will take as input variables that represent internal and external factors (Table 2) affecting the company's performance.

Table 2: Internal and external factors.

Environment	Environment factors	Justification
Internal	Number of directors	The number of directors enhances the quality of the management
	Labor cost	Impacts net profit
	Operating costs	It drives down the net profit
	The market share	It is expressed as percentage and reflects the ability of the company to respond to clients needs.
External	Level of debt	The cost of finance is crucial component to total cost.
	Number of competitors	The competitors increase the concurrence which and impacts the profit margin.
	Cost of raw materials	Any increase of the cost of raw material
	Change in the exchange rate	It will impact export and import

In this section, we will consider the case of a medium seize company operating in the telecommunication sector. The study period is from 2001 to 2017 (Table 3), and the construction of scenarios has to deal with the interconnection between risks, the process here is complicated and needs the usage of the software that includes artificial neural network packages, such as R Studio.

Table 3: Data of the companies.

	EXTERNAL					INTERNAL			
Year	Debt Expenses	Nbr Of Competitors	Cost Of Raw Materials	Exchange Rate	Operat Costs	Nbre Of Directors	Labor Cost	Market Share	Net Profit (MMdh)
2001	159	3	2562	11,05	14700	5	1626	96%	1134
2002	104	3	2793	11,1	15200	5	1469	96%	3242
2003	53	3	2792	11,03	16100	5	1550	96%	5092
2004	71	3	2820	11,01	15600	5	1624	96%	5900
2005	28	3	3100	11,04	15800	5	2056	96%	6500
2006	70	3	3870	11,01	16700	5	2060	95%	6833
2007	75	3	4320	11,04	16500	5	2200	95%	6980
2008	80	3	4760	11,07	17400	5	2340	95%	6800
2009	124	3	4824	11,13	17320	5	2700	95%	6500
2010	238	3	4870	11,1	18500	5	2740	95%	6200
2011	260	3	4995	11,12	18458	5	2820	95%	6090
2012	352	3	5042	11,15	18881	5	2848	95%	6120
2013	341	3	4296	11,23	17580	5	2723	95%	6340
2014	323	3	4654	10,96	18878	5	2818	95%	6470
2015	439	3	6046	10,81	23795	5	3245	95%	6499
2016	322	3	6223	10,85	24785	5	3260	95%	6628
2017	491	3	5937	10,92	24653	5	3138	95%	6579

The construction of each scenario aims to assess the impact of plausible fluctuation of an individual risk factor on the company's profit, for example, the first scenario will measure the impact of an exchange rate increase by 10% on the net profit, the choice of exchange rate fluctuation because the company imports many components from abroad and this the exchange rate fluctuation will influence its net income. The fluctuation of 10% was historically the highest

one. The fluctuation of the risk factor in the other scenarios was taken from the historical data, in another way, for each risk factor; the highest fluctuation is applied to capture the consequences if such change would occur.

- Scenario 1 : Increase of exchange rate by 10%
- Scenario 2 : Increase operating costs by 20%
- Scenario 3 : Increase raw material costs by 20%.
- Scenario 4 : Increase labor cost by 20%.
- Scenario 5 : Decrease market share by 20%.

4 Result and Discussion

From the finding results (Table 2), we can conclude the following:

- According to the first scenario, an increase in exchange rate by 10% makes the net profit equal to 8518 million MAD, an increase of 39%
- According to the second scenario, an increase in operating costs by 20% has resulted in a net profit of 9356, which means an increase of 53%;
- The third scenario shows the impact of the raw material price increase; it reduced the net profit to 3598 million MAD, which is a decrease of 41%.
- The fourth scenario shows an increase to 8128 that is an increase of 33% due to an increase of labor cost by 20%
- The last scenario gives an estimated net profit of 6041 which is a drop of 1,25%.

Table 2: Results of scenarios.

	Coefficient	Value of 2017	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Constant	245907,269						
Operating cost	0,65658021	24653	24653	29583,6	24653	24653	24653
Interest expenses	12,1145266	491	491	491	491	491	491
Cost of raw materials	2,12299438	5937	5937	5937	7124,4	5937	5937
Exchange rate	2197,34436	10,92	12,012	10,92	10,92	10,92	10,92
Labor costs	3,20163758	3138	3138	3138	3138	3765,6	3138
Market share	285751,859	95%	95%	95%	95%	95%	76%
Estimated profit		6118	8518	9356	3598	8128	6041

The implementation of machine learning using multiple linear regression gives that an increase in raw material or labor is associated simultaneously with an increase in net profit, the machining process has understood that there is a linear relationship between net profit and labor cost, operating expenses, debt expenses and raw material costs. On contrary, the impact of the drop in market share will result in to drop in the net profit which is obvious even though it is not significant due to weak competition in the sector characterized by the small number of competitors (3 companies).

SME principals/directors can use these results to monitor the company's activity, they have to keep controlling the evolution of labor, and operating expenses with the evolution of the net

profit, any deviation of this later means that there is a necessity to intervene either by cutting the targeted cost or boosting sales.

In conclusion, it is relevant to say that the relationship between operating and labor cost, and operating expenses is key indicators to net profit level.

5 Conclusion

SMEs are operating in a multi-risk environment. The interaction of multiple risks undermines the management and may result in failure. The ERM is an important arsenal to monitor all these quantitative factors more appropriately. The implementation of machine learning, using an artificial neural network allows capturing the complexity of the interaction between factors both from the internal and external environment. Further research should be realized to consider qualitative factors.

6 Availability of Data and Material

Data can be made available by contacting the corresponding author.

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