

Financial Risk in Investments and its Modeling

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Abstract. *The management of any economic entity constantly has a predictive character; it cannot limit itself to the solution of current problems but conducts prospections on the future, directing the organization's activity over time and ensuring its preparation for confronting future market phenomena. Achieving these goals requires, among other things, permanent and complex knowledge of the risks to which one is exposed, of the current and future level of the production cost. Risk research has led to a shift from an approach based on the negative dimension of risk to a complex one, where risk is seen as both a threat and an opportunity. Relatively recently, the approach to risk began to include the positive aspect represented by the possibility of generating opportunities through appropriate management and specific strategy. The paper presents two ways of modelling financial risk using theories from specialized literature and which are applied in an extensive manner in other works, especially in those with practical applicability. We considered two probabilistic models, namely the application of probability distributions and sensitivity analysis, which can be used for companies when it comes to risk analysis of investment projects, these being considered random variables.*

Keywords: investments, financial risk, risk monitoring, probability distributions, sensitivity analysis

JEL Classification: D81, E32, G32, G33

1. Introduction

Risk is a comprehensive concept with applicability in many fields, but in the economic field the scope is very high and helps in modelling many economic phenomena.

The current economic context, marked by rising interest rates, tensions in the energy market and generalized price increases, highlights the need for a profound analysis regarding financial risks, which may now materialize with higher probability and intensity. Starting from these considerations and taking into account the review of specialized literature, we have noticed the permanent interest, both at the microeconomic and macroeconomic level, for financial risks, for their measurement and management. Financial risks refer to a wider range of risks (e.g. currency risk, interest rate risk, price risk, etc.) and are felt both by natural people with direct or indirect exposure to financial markets, and by any legal person. Thus, financial risks are everywhere and any person is affected, even if they are not directly exposed to the financial markets, and the most common and widespread risk in Romania is the currency risk. This type of risk affects any participant in the Romanian economy considering that a number of prices in our country are expressed in euros (or another currency) or the evolution of prices is linked to the single European currency (e.g. excise duties for various energy and gas products are directly linked to the single European currency). Also, the interest rate risk is a very common one, which affects, in particular, people who have contracted loans for which the interest rate is variable.

Therefore, the importance of awareness, measurement and management of financial risks is high, and this only adds to the importance of this research.

2. Scientific literature

The specialized literature is extremely rich in terms of works that address financial risks. We have identified several definitions of risk, especially from a financial perspective. According to Gheorghită (2013) "risk can be associated with a scale that can tilt either to the side of success or to the side of failure. The notion of "break-even point", which is currently widely known in entrepreneurial activity, coincides with such an interpretation. With this combination of words is characterized in the economy the moment of transition from loss to profit and vice versa, or the moment of equal opportunities. In situations where traditional methods of securing profit are exhausted, the conscious entrepreneur takes risks." Gheorghe (2013, p. 18). Thus, this author brings into discussion the problem of risk at the level of a company, being rather or association with the risk of bankruptcy. At the same time, Gheorghită (2013) recognizes that, "from an economic point of view, risk can be defined as a state for which there is the possibility of an adverse variation in relation to one pursued by an organization." Gheorghe (2013, p. 18)

Also, Mocanu (2016) has an important contribution regarding the definition of risks, highlighting the elements that can be omitted when one sees the approach of a concrete definition of risk, regardless of the field in which it is given. He admits that there is a difference in the definition of risk, and this is given depending on of the person who is subject to this risk. Thus, there is a difference between the definition of risk that is given by an analyst and the definition of risk that is given by a person with a decision-making function in a company. Analysts view risk from an epistemic perspective, while decision makers view risk from a deontic point of view.

In the international literature I have identified an extremely useful paper. Thus, the article published by Lemos (2020) helps a lot in the effort to understand the phenomenon of risk or risk management, the work being applicable to several fields. According to it, the concept called generic risk is a more complex one, it is not just about uncertainty or volatility measurable by various statistical tools. Risk is a three-part concept: i) risk is the potential for events to have an unexpected and noteworthy impact on outcomes, i.e. a consequence of exposure while pursuing goals in an uncertain environment, ii) risk is ontological uncertainty, the unknown unknown, iii) risk is the perception of expected utility, because the way risk is perceived individually and socially amplified influences its experience and subsequent effects. So the challenge is to deal with risk by understanding the impossibility of predicting the future. We should learn from the past, but at the same time accept that not all past lessons address all the problems that come our way.

An extremely important work is the one published by Armeanu et al. (2012) or by Brăila and Mocanu (2007), through which they analysed and discussed a series of techniques regarding the identification and assessment of bankruptcy risk at the level of corporations. They tried to combine the classical methods of analysis with the newest and most complex methodologies, those based more on probabilistic models. To these works we add the research published by Grigorescu (2019) or Brîndescu-Olariu (2017), who tried to develop even more methodologies that could be the basis of the prediction, but also of the analysis of the risk of bankruptcy for different companies. Recently, works have appeared that brought the idea of bankruptcy risk research in the context of the latest crises that appeared at the level of the European economies, but also at the level of the global economy. Thus, we can talk about an analysis carried out for the case of the Republic of Moldova in the context of the Covid-19 pandemic, the one carried out by Lupaşcu and Baci (2021). On the other hand, we can talk about

works that considered various performance optimization and risk management methods, the final goal being to improve the company's performance, but in the context of a manageable and assumed risk. In this sense, we recall the work of Stanciu (2020).

Moreover, the risk was analysed from a more advanced and deeper perspective by Dincă et al. (2017). They used a model based on logit and probit regressions to make predictions regarding the insolvency risk of some Romanian companies. The models were successfully applied and gave a certain dimension to the insolvency risk that occurs at the level of companies in Romania. However, there could be some shortcomings of the study and the approach the authors took. From our point of view, the methodology used is very appropriate and has brought good results countless times in other researches, but we believe that it could have been better focused on a certain sector or several sectors of interest for our country, as Baciu, Petre and Simion (2020) did. In this way, the results could have been compared with each other for sectors of interest for our country and could have led to conclusions to be integrated at the level of a country policy regarding the support of a certain activity sector. Moreover, they could have been integrated even at the level of the strategy that a commercial bank or central bank could have applied regarding credit risk management at the level of the existing loan portfolio or regarding the future lending policy.

An analysis in the sense of the one we proposed as an improvement for the research of the authors Dincă et al. (2017) is that of Popa (2019), who focused on the sector of energy companies, within the limits of those listed on the Bucharest Stock Exchange. We believe that the research of Popa (2019) could have been improved by a comparison of the results obtained for the energy sector in Romania with other energy sectors in other countries. Thus, by comparing the results we could form a better picture in terms of performance and stability, considering the specifics of the industry. It is difficult to compare the results for companies in the energy sector in Romania with other companies in Romania in other sectors of activity, given that there is an important difference in terms of the specifics of each industry, and this can be transposed to a different level of risk assumed or performance.

A research that partially developed the work in the direction of the observation I made for Popa's article (2019) is that of the authors Bărbuță-Mișu and Madaleno (2020).

In order to capture another financial risk at the level of Romanian companies, Radoi and Olteanu (2018) conducted a study where they tried to highlight the way in which the country risk is reflected in the first CDS (credit default swap), so that this risk is finally included in the companies' cost of financing. As is known, country risk is reflected in a higher risk premium, both at the level of the cost of financing of the country and at the level of the cost of financing of the companies operating in that state. Thus, the two authors tried to analyse all these aspects.

There are also a number of other risks that later turn into a higher cost for companies. Among these, an important risk is that of legislative instability, lack of predictability, but also of deficient insolvency legislation. These issues were addressed by Gavrilă and Florin (2020), underlining the importance of insolvency legislation on the cost of financing and on how insolvency is done in Romania. At the same time, problems also arise from the legislative framework in terms of the form of financial reporting and the obligations that companies have, and this was taken into account by Ciuhureanu (2019), who highlighted the use of accounting information in the evaluations of risk of companies. Moreover, Răscolen and Rakos (2019) emphasized the manner in which the balance sheet can be used for risk analysis, this one of the accounting documents that must be submitted at least annually, depending on the important dimension being concerned.

Last but not least, I think that a series of works should be discussed and presented that addressed financial risks at the company level through the lens of new

analysis models based on artificial intelligence (machine learning) algorithms. Among these works, we mention an important article, that of the authors Vodă, Dobrotă, Țîrcă, Dumitrașcu and Dobrotă (2021). They tried to develop, based on artificial intelligence algorithms, a prediction model for insolvency risk or supply risk with machine learning algorithms, and in an economic context.

The same direction of complex prediction models based on classifiers is represented by the articles of the authors Arinichev and Bogdashev (2017) by applying these algorithms at the level of small companies. The two authors tried to identify what the risk factors would be, the factors that could amplify the risk of going bankrupt, especially for small companies, which generally have the lowest level of risk management, not having systems of complex administration developed, for various reasons, the most important one is that of limited resources. Another article that developed exactly the same type of analysis was that of Clement (2020), as it uses several methods based on machine learning algorithms to make predictions regarding the bankruptcy of some companies. This problem is one of classic classification, and machine learning algorithms are very suitable to find a solution of this kind, which is the reason why more and more research has been developed in this direction for corporate finance.

3. Financial risk in investments

Risk research has led to a shift from an approach based on the negative dimension of risk to a complex one, where risk is seen as both a threat and an opportunity. Relatively recently, the approach to risk began to include the positive aspect represented by the possibility of generating opportunities through appropriate management and specific strategy.

In business, any activity is subject to risk from the first moment an entity enters the market. That is why economic agents must know the dangers to which their business is subject. Based on a study done by the international credit agency "Dun & Bradstreet", a list of ten major threats to the survival of an entity was made, respectively: (1) the wrong location of the business - it is related to the marketing policy and involves not choosing a market favourable for sales products, an inappropriate promotion policy; (2) too high share of fixed capital, which means important immobilization of monetary funds in fixed assets and low efficiency in the use of fixed assets; (3) lack of capital, as a result of too high investments in fixed assets, hence the insufficiency of working capital for the continuity of the production process; (4) difficulties in repaying loans, because the entity does not have resources for repaying loans; (5) faulty inventory management - sales growth does not imply an increase in inventory to the same extent; (6) uncontrolled expansion of the business by launching products in a market that has not been previously tested; (7) inadequate capitalization, which makes the invested portion smaller; (8) lack of expertise and qualification of employees; (9) labour problems – when business is not going well, the staff will look for another job; (10) bureaucracy.

As long as the managers take into account the range of these threats, they can avoid certain difficulties. However, if the system of ten threats is not taken into account, the future results will be uncertain, and the transformation of risk into reality is only a matter of time.

To counter these threats, specialists analyse the factors that determine the success of an organization's activity. Here they are: *the tendency to action* - every employee is able to act without waiting for orders from anyone (successful organizational charts are those with a short and flat form); *knowing the client* in order to understand his needs; *autonomy in decision-making*; *values-based leadership*; *achievement of the proposed goal* - a new product is launched only on a known

market, and on a new market only an already known product is sold. A new product is never launched in a new market because the risk is very high; *well trained and dedicated staff; strict control of the activity*. Managers who continuously analyse the activity they are responsible for and take into account the mentioned factors can ensure the success of the business.

A business can survive in market conditions only if it is solvent, meaning that it has the ability to pay all its due obligations at a certain point in time. The assessment of the difficulties that may arise for a company is based on the following criteria:

- "insolvency, this occurs when the assets are not sufficient to pay the debts;
- over-indebtedness, in this case we are talking about a degree of indebtedness so high that it leads to compromising the company's ability to deal with debts that are due;
- decrease in profitability and volume of activity;
- difficult financial situation;
- low level of production capacity utilization." (Hada, 1999, pg. 197)

4. Financial risk modelling

In this paper we will present two ways of modelling financial risk using theories from the specialized literature that are applied in an extensive manner in other works, especially in those with practical applicability. Thus, we consider two probabilistic models that can be applied at the company level when it comes to risk analysis of investment projects, these being considered random variables. Two of the most used probabilistic models and methods that we have identified in the literature are the following:

- application of probability distributions;
- sensitivity analysis.

To prove the theory, as well as the model based on which the example is made, we used relevant works, such as the one published by Gagea (2011) or by Vişoiu and Rusu (2009), which address the issue of quantitative measurement of financial risk at the level of a company, especially when we talk about investment projects and their viability assessment in different forms. On the other hand, another interesting work that addresses an important issue is that of the authors Nichita and Vulpoi (2014), through which they correlated the risk relationship of a company with the transparency it displays in relation to the financial statements.

Table no. 1. Cash flow and probabilities of an investment project

Probability	Year 1	Year 2	Year 3
	Cash-flow net	Cash-flow net	Cash-flow net
0,10	10.000	-5.000	-10.000
0,25	15.000	0	-5.000
0,30	20.000	5.000	0
0,25	25.000	10.000	5.000
0,10	30.000	15.000	10.000
Average value	20.000	5.000	0

Source: authors' own processing

Next, we detailed and exemplified the two methods of analysis for a situation that can be a real one, applicable to any company that wants to make an investment and that is interested in evaluating its viability, in the short term, but also in the medium and long term. To present the first method, we considered an investment project involving an initial expenditure of 20,000 euros. The estimated lifetime for this project is three years, the table of net cash-flows and related probabilities being presented in table no. 1.

With the help of the average values of the net cash flow we can estimate the average value of the VNA (net present value of the project) for a benefit rate of 10%. We get:

$$M[VNA] = \frac{20.000}{1,10} + \frac{5.000}{1,10^2} + \frac{0}{1,10^3} = 2.314\text{€}.$$

We determine the standard deviation of the NPV (net present value of the project). For this we will first determine a calculation relationship for the dispersion or variance of the VNA:

$$V[VNA] = \sum_{t=0}^n \frac{V_t}{(1+k)^{2t}},$$

where $V[VNA]$ is the variance of the net present value of the project, V_t is the variance for the net cash-flow in year t , and k is the benefit rate. We note that the cash-flow variance will be the same in the three years of the project, because we consider that the probability distribution of the VNA variable has the same average value and the same dispersion (the figures for the practical example can be found in table no. 2.)

Based on table no. 2. calculations can be made for the net present value, using the net cash flow. At the same time, the deviation from the mean value, the square of the deviation and the weighted value were calculated, these being elements that are used later for the calculation of the mean squared deviation.

Given these calculations, we arrive at the following result:

$$V[VNA] = 32.500.000 \cdot \left(\frac{1}{1,10^2} + \frac{1}{1,10^4} + \frac{1}{1,10^6} \right) = 67.402.844$$

Table no. 2. The cash-flow variance of the investment project in year 1

Probability	Cash-flow net	Deviation from the mean value	The square of the deviation	The weighted value
0,10	10.000	-10.000	100.000	10.000.000
0,25	15.000	-5.000	25.000	6.250.000
0,30	20.000	0	0	0
0,25	25.000	5.000	25.000	6.250.000
0,10	30.000	10.000	100.000	10.000.000
Average value	20.000		The variation	32.500000

Source: authors' own processing

From the previous calculations, we obtained for the VNA variable parameters for the average $\mu VNA = \text{€}2,314$ and $\sigma VNA = \text{€}8,210$. Considering the normal distribution model for this random variable we will be able to make a statistical prediction regarding our capital investment project. Thus, considering 95% of the distribution values, we arrive at the following values for the interval in which two mean square deviations are

taken into account: $[-14.106;18.734]$. This tells us that, for a 95% probability, the net present value of the investment project will fall within the range shown above.

The probability that the project is considered to have a negative net present value (the marked area that is presented in figure 1) is given by:

$$\text{Prob}\{VNA < 0\} = N(0;2.314;8.210) = 0,389$$

Whereas, the probability of having a net present value higher than the considered threshold of 10,000 euros is given by:

$$\text{Prob}\{VNA > 10.000\} = 1 - N(10.000;2.314;8.210) = 0,175$$

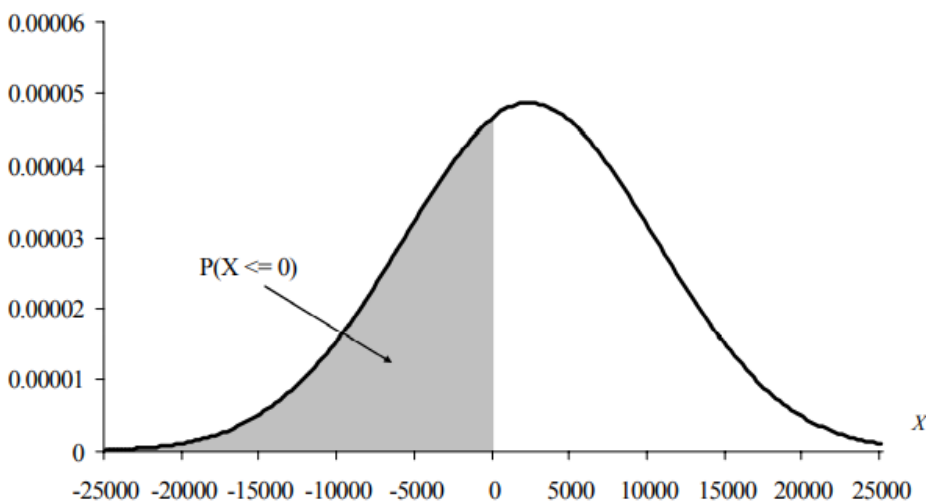


Figure 1. Probability of recording NVA less than zero

Source: authors' own processing

The second probabilistic method that can be applied to capital investment problems is the sensitivity analysis. In figure no. 2, which reproduces the sensitivity model of the VNA to the variables of the model, the variables of the model that can influence the VNA are highlighted, meaning that the sensitivity of the changes of the variables included in the composition is shown. These variables are the following, according to the theory: estimated selling price; estimated sales volume; estimated operating costs; estimated initial costs; estimated cost of capital.

Based on these variables, a sensitivity analysis can be applied that can lead to obtaining results regarding the viability of the project or how it can behave in certain situations. Therefore, we can do a **financial risk analysis** at the company level, especially in the context of evaluating the implementation of an investment project and to the extent that it can have a significant impact on the financial stability of the company. This analysis takes into account the previously mentioned variables and is schematized in figure 2.

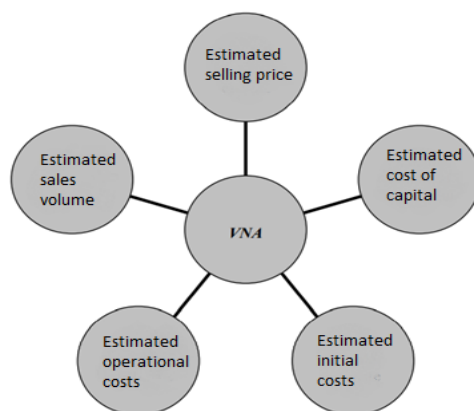


Figure 2. The VNA sensitivity model to the model variables

Source: own processing after Grigorescu and Ghic (2012)

5. Conclusions

The work highlighted the valences of the generic term risk, the ways in which it is used in different fields of activity, in order to later arrive at its applicability in the economic environment and the way in which it is used extensively in this field. We have highlighted the most important specialized works, and which are the most important results obtained by the authors, as far as we considered them relevant for the research undertaken. At the same time, we presented a series of concepts that are used at the company level to be able to measure and analyse financial risks, highlighting the fact that financial risks are also present for portfolio investments (for example: price risk, currency risk, interest rate risk etc.) in different market contexts. The approach is extremely relevant because it lays the foundations for understanding the phenomenon of financial risk.

A number of new approaches regarding financial risks were also discussed, according to the specialized literature. It is about presenting some relevant work on bankruptcy risk analysis using machine learning (artificial intelligence) algorithms, which are based on classifications and pattern recognition, and this can help in separating the results obtained in firms with a high probability of bankruptcy, but also in companies with a low probability of bankruptcy.

We have presented two ways of modelling financial risk, namely the application of probability distributions and sensitivity analysis, which can be used at the company level when it comes to risk analysis of investment projects.

References

- Arinichev, I. V., & Bogdashev, I. V. (2017). Estimation of bankruptcy risk of small business companies basing methods of machine learning, *RUDN Journal of Economics*, 25(2), 242-254.
- Armeanu, S. D., Vintilă, G., Moscalu, M., Filipescu, M. O., & Lazăr, P. (2012). Utilizarea tehnicilor de analiză cantitativă a datelor pentru estimarea riscului de faliment al corporațiilor, *Economie teoretică și aplicată*, 19(1), 566.
- Baciu, R., Brezeanu, P. & Simon, A. (2020). Insolvency Risk. Application of Altman Z-Score to the Auto Parts Sector in Romania, *International Journal of Innovation and Economic Development*, 6(1), 7-18.

- Bărbuță-Mișu, N., & Madaleno, M. (2020). Assessment of bankruptcy risk of large companies: European countries evolution analysis, *Journal of Risk and Financial Management*, 13(3), 58.
- Brăilă, A., Moraru, M. (2007). Evaluarea riscului de credit: o analiză a diverselor metode de evaluare a riscului de credit, *Studia Universitatis Moldaviae* (Seria Științe Exacte și Economice), (2), 218-221.
- Brîndescu-Olariu, D. (2017). Potențialul Indicatorilor Capacității de Plată în Anticiparea Falimentului Corporativ, *Review of Management & Economic Engineering*, 16(3).
- Ciuhureanu, A. (2019) The Use of Accounting Information for Risk Analysis-Options in Central Region Entities, ISSN 1843-682X, 25(2), 20.
- Clement, C. (2020). Machine Learning in Bankruptcy Prediction - a Review, *Journal of Public Administration, Finance and Law*, (17), 178-196.
- Dincă, M.S., Bărbuță-Mișu, N., Madaleno, M., Dincă, G., Deari, F. (2017). Integrated Analysis of EU Construction Companies' Financial Performances, *Journal of Construction Engineering and Management*, vol. 143, nr. 6, ISSN 0733-9364, DOI 10.1061/(ASCE)CO.1943-7862.0001287.
- Gagea, M. (2011). *Modele calitative/cantitative în managementul riscului financiar. Teoria riscurilor și aplicații*, Editura Universității A.I. Cuza, Iași.
- Gavrila, S. P., & Florin, T. (2020). The Impact of Legislative Policies on the Judicial Reorganization Procedure and the Risk of Illegal Financing in Romania, *Eurasian Economic Perspectives*, Springer, Cham. pp. 225-238.
- Gheorghiuță, M. (2013). Riscul-componență inevitabilă a activității de antreprenariat, *Studia Universitatis Moldaviae* (Seria Științe Exacte și Economice), 67(7), 113-116.
- Grigorescu, D. L. (2019). Model de analiză discriminantă pentru detectarea riscului de faliment, *Revista Română de Statistică-Supliment nr.*, 33.
- Lemos, F. (2020). On the definition of risk, *Journal of risk management in financial institutions*, 13(3), 266-278.
- Lupașcu, L., & Baci, P. (2021). Impactul pandemiei Covid-19 in domeniul construcțiilor Republicii Moldova comparativ cu Statele Unite ale Americii, *Technical-Scientific Conference of Undergraduate, Master and Phd Students*, Chișinău.
- Mocanu, M. (2016). Diversitatea și capcanele definirii riscului, *Revista de studii de securitate și Informații pentru Apărare*, 8(1), 62-71.
- Nichita, M., Vulpoi, M.(2016). Relationship between risk and transparency in the financial statements of professional services entities, *Revista Audit financiar*, 14(137):540. DOI: 10.20869/AUDITF/2016/137/540
- Popa, M. A. (2019). Bankruptcy Risk Assessment for the Energy Companies Listed on The Romanian Capital Market, *Annals of the University of Petroșani*, 19(1), 171-178.
- Rădoi, M. A., & Olteanu, A. (2018). The Country Risk Reflected in The CDS Quotations, *Challenges of the Knowledge Society*, 916-921.
- Răscolen, I., & Rakos, I. S. (2019). Bankruptcy Risk Analysis Based on the Patrimonial Balance Sheet, *Ovidius University Annals, Series Economic Sciences*, 19(2).
- Stanciu, M. A. (2020). Optimizarea analizei economico-financiare și a gestionării riscurilor în vederea îmbunătățirii performanței financiare, *Perspectivile și Problemele Integrării în Spațiul European al Cercetării și Educației*, Vol. 7, 202-207.
- Vișoiu, I., & Rusu, C. (2009). Managementul riscului: Exemplu de calcul utilizându-se ca metodă de analiză Matricea Probabilitate-Consecințe, *Quality-Access to Success*, 10(10).
- Vodă, A. D., Dobrotă, G., Țîrcă, D. M., Dumitrașcu, D. D., & Dobrotă, D. (2021), Corporate bankruptcy and insolvency prediction model, *Technological and Economic Development of Economy*, 27(5), 1039-1056.