

The Relationship between Competitiveness, Resilience and Risk Structure*

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This study presents the relationships between enterprises' competitiveness, resilience and risk structure. The use of normal distribution and related theories is fundamental in enterprise quality management, but this is not typical in the areas of competitiveness and resilience. According to the central limit theorem, whether or not the frequencies of a company's performance characteristics follow a normal distribution depends on the risk structure. However, the normal distribution of these characteristics can be an important indicator of a company's competitiveness and resilience. The central limit theorem imposes very strict conditions on the risk structure of a company. These were modelled using dice with different numbers of sides. According to the results, well-diversified risks can form the basis for competitiveness and resilience. At the same time, the setting of business objectives and the creation of reserves remain important.

Journal of Economic Literature (JEL) codes: D81, G11, L21, P34

Keywords: competition, competitiveness, resilience, risk, risk structure, normal distribution

1. Introduction

One of the fundamental characteristics of economic competition is that competitors respond differently to the demands placed on them and thus achieve their goals with varying degrees of success. Competitors can be companies, but also industries, regions and countries. This study discusses the relationships between competition, competitiveness, resilience and risk structure at the corporate level. The significance of this micro level of analysis is that, in this case, it is the company alone that needs to survive, develop and meet the requirements of competition, while at higher, meso and macro levels, smaller or larger groups of companies must do so. In the latter case, greater compliance with competitive requirements can often

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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The first version of the Hungarian manuscript was received on 19 June 2025.

DOI: <https://doi.org/10.33893/FER.24.3.73>

be achieved if some companies are forced to retreat or even cease to exist, while others can develop, as was the case during the Covid-19 pandemic (*Canton et al. 2021*).

The concept of corporate competitiveness has been a well-researched area of economics for a relatively long time, as Megginson pointed out to US companies as early as 1963 that businesses in Western European countries, which had been devastated by the war, had not only recovered but in many respects had gained better market positions than their American competitors. “It is not the most intelligent species that survive, nor the strongest, but those that are most responsive to the changing environment in which they live” (*Megginson 1963:4*).

At the same time, the 1973 oil crisis drew attention to the fact that it is possible to manage effectively in other “peacetime” situations and in other crisis situations and their aftermath. While the oil crisis also had a strong impact on market economies, albeit to varying degrees, the development of socialist countries was clearly disrupted (*Sanchez-Sibony 2016*). The 2008–2009 financial crisis had a similarly powerful impact on economic actors, countries and regions (*Doran – Fingleton 2015*), as did the consequences of the Russian-Ukrainian war (*Kimhi et al. 2023*).

Whether in terms of competitiveness or resilience, risks are clearly unavoidable. A competitive company must be able to perceive the demands placed on it as well as changes in those demands, and must also be able to adapt to them, while consistently outperforming its competitors (*Chikán 2011*). The capabilities, characteristics and strategy of a competitive economic actor are more in line with the requirements of competition, so that overall it faces smaller and/or more manageable risks (*Rutkauskas 2008*). The ability to cope adequately in extremely unfavourable situations – i.e. resilience – also assumes that what constitutes a critical situation varies among different actors, meaning that such situations pose smaller and/or more manageable problems for resilient actors than for non-resilient actors (*van der Vegt et al. 2015*).

In biology, observations, experiments and theoretical models have also proven that from an evolutionary perspective the individual that will be more successful is the one whose numerous, relevant risks do not, on their own, have such undesirable consequences that, if realised, would decisively influence the individual’s development and survival (*Cohen 1966*). Biological relationships are often applied in economics. In general, the risk structure of economic actors is rarely extremely favourable or unfavourable; for the vast majority – those with average or near-average performance – it is relatively balanced (*Stearns 2000*). According to economic life cycle models, actors in the maturity phase have the most balanced

risk structure, while the most problematic phase – where extremely high risks must be faced – is typically the birth and growth phase (*Boussabaine – Kirkham 2004*).

This study seeks to answer the question of whether a company can be competitive and resilient without having a balanced, i.e. sufficiently diversified, risk structure. So, if one or a few of a company's risks are significantly greater than its other risks, can it achieve an adequate level of competitiveness and resilience? On the other hand, is a balanced risk structure only a necessary condition or a necessary and sufficient condition for corporate competitiveness and resilience? In general, can the competitiveness and resilience of a business be measured by its risk structure alone?

The first part of the study briefly introduces the concepts of competition, corporate competitiveness and resilience in relation to risks. Subsequently, based on the central limit theorem, the significance of the risk structure in terms of corporate competitiveness and resilience is modelled. The study ends with a set of conclusions.

2. Competition, competitiveness, resilience and risks

Defining the essence of economic competition is obviously important if we want to talk about competitiveness. Two main, essentially complementary approaches to the concept of competition have gained ground in recent decades. According to one (*Stigler 1972*), competition is the parallel, mutually influential activity of economic actors, where the strength of competition basically depends on how many are competing and the relative size of the competitors to each other and to the market. According to the other approach, competition is for certain scarce goods, such as buyers, raw materials and labour (*Huetting 1980*). Since there are many different types of competition, economic competition generally means that economic actors have a certain degree of freedom to determine their goals and the planned means of achieving them, at least in part autonomously, while also having certain obligations towards their stakeholders. In this way, through the autonomy that has been granted, economic competition is able to regulate itself to a certain extent (*Tardos 2014*). Economic actors therefore have a certain degree of freedom to set their own unique goals, as well as the freedom to decide for themselves how to achieve those goals by exploring and exploiting new opportunities. At the same time, it is not certain that economic actors will be able to use this theoretical room for manoeuvre, as their knowledge and skills, and the extent to which they have access to relevant resources may be decisive in this regard. On the other hand, it is also not certain that economic actors will want to use this room for manoeuvre, as their cultural and institutional characteristics and their expectations regarding future competitive requirements may also be decisive in this regard. The possibility

of using this room for manoeuvre is essentially a right to “decentralised initiative” (Kornai 2010:10), which is obviously accompanied by certain obligations, whether towards the government, the state, customers, suppliers or other stakeholders. However, the scope of rights and obligations only defines the framework, and the actual process of competition is then determined by a great many factors. Thus, among other things, the constantly changing requirements imposed on competing companies, the expectations placed on them (Beckert 2013) and their prior or subsequent adaptation to these expectations (Haasnoot et al. 2020) are important, as well as the influence of competitors’ simultaneous activities. In terms of how successfully competitors are able to achieve their goals in course of competition, their competitiveness is of paramount importance.

Competitiveness is an important concept in economics, which is linked to surviving in appropriate shape and the ability to hold one’s own in future competition. We can distinguish between the competitiveness of organisations, industries, regions and countries, and each level has several concepts and definitions related to competitiveness (Zuñiga-Collazos et al. 2019). This study focuses on the competitiveness of economic organisations and businesses. For the sake of comparability, it is necessary to assume that all parties involved are participating in the same competition. In other words, their goals and methods are nearly identical, and the competition imposes the same requirements on them (Porter et al. 2008). With regard to the goals and methods of achieving them, it is usually stipulated that they must be legal in the given competitive environment (Moorthy 1985). If existing legal or social and cultural institutions actually require sustainability or social responsibility, then compliance in these areas will indeed be closely linked to competitiveness (Czakó – Chikán 2007). There is no single type of competition at any given time. Even within a single country, for example within different industries, there may be several types of competition, which grant rights and impose obligations in different ways, i.e. they define the scope of action of the players in different ways. This is why it is difficult to compare competitiveness across industries and countries from different perspectives, such as social responsibility (Reisinger 2023). Even under normal, non-extreme conditions, it is not uncommon for some economic organisations to fail to survive in the face of competition (Trout – Rivkin 2008). Competitiveness is essentially about the quality of the economic actor itself in relation to the competition in each market (Chiles – Choi 2000). In general, the competitiveness of an economic actor is determined by its ability to adapt to constantly changing competitive conditions with sufficient speed and to the appropriate extent, while at the same time achieving its objectives to a sufficient degree (Megginson 1963). In terms of competitiveness – and thus the adaptation that underpins it – human resources are of decisive importance, since without sufficient innovation performance, competitiveness cannot even be discussed (Csath

2022). Adaptation reduces the risks taken, while innovations increase such risks due to their novelty.

The concept of resilience came to economics from the field of psychology. In the latter, it refers to how people are able to adapt to serious situations and risks, and to what extent they are able to preserve a good level of mental and physical health in such circumstances and maintain this in the future (*Masten et al. 2002*). Resilience is therefore a characteristic possessed by those who can continue living in a reasonably good state, despite experiencing extreme difficulties. Similarly to competitiveness, the economic concept can be interpreted at the level of economic actors, or at the industry, regional or national levels. At the level of enterprises, the concept places greater emphasis on how economic actors can minimise their losses in extremely negative circumstances, in order to continue to achieve their current goals in the future (*Hallegatte 2014*). One key difference between the biological and economic concepts of resilience is that the human body and brain are much more constrained in terms of adaptation and renewal than a business. A resilient economic actor therefore has the knowledge, skills, resources and strategies that enable it to adapt very quickly and restore the normal functioning of that which has been disrupted by an external shock or the unexpected and prolonged persistence of extreme economic conditions. Restoring the operating order often means establishing a new order or renewal, which enables the actor to once again achieve their goals sufficiently effectively (*Halmai 2021*). Resilience – much like competitiveness – is a dynamic concept that also makes predictions about the future, while both past and present facts and forecasts remain partially relevant (*Kovács 2024*). The three basic dimensions of resilience are vulnerability, shock absorption and recovery capabilities. Economic actors need resilience when a risk with serious consequences or a combination of risks with such cumulative consequences materialises. In such cases, it is advantageous for the actor to prepare contingency plans, provided that they were aware of their risk exposure in advance (*Nemeslaki 1996*). In terms of resilience, it is by no means a disadvantage for an economic actor to be part of a cooperative group (*Magas 2018*). Well-chosen insurance policies, including liability insurance, can also contribute significantly to the actor's resilience in the event of serious damage (*Markó – Pandurics 2015*).

Resilience is often measured retrospectively, based on the extent to which an economic actor has regained its economic strength and viability, and the extent to which it has managed to return to its previous growth trajectory (*Volkov et al. 2021*). At the same time, similar to competitiveness, it is useful and advisable to measure resilience before potential periods of crisis, as this provides an indication of whether the business will be sufficiently resilient in the future (*Rose – Krausmann 2013*). The main determinants and measurable factors of resilience are financial, resource and technological reserves, operational flexibility, the duration of

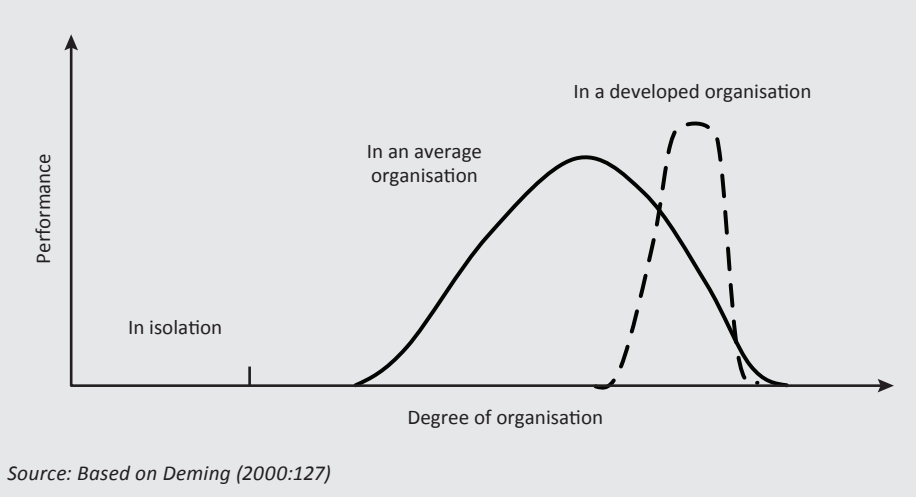
cooperation with partners and innovation activity (*Rose – Krausmann 2013*). The degree and strictness of government regulation (*Wang – Li 2022*) may be important in relation to flexibility and innovation activity, but so may the method and extent of government support (*Liang – Li 2023*). State and government regulation and involvement affect the shock-absorbing capacity and thus the resilience of all businesses via market and labour market prices and the functioning of financial markets (*Halmi 2021*). A higher level of resilience can be achieved if the enterprise develops its risk structure with great awareness, taking into account the relationship between return and risk, and making good use of the risk reduction opportunities offered by diversification (*Wang – Li 2022*). At the same time, however, stockpiling and diversification also mean foregoing some of potential economic growth, at least in the short term (*Wang – Li 2022*).

Risk is understood as the possible materialisation of some negative consequence in relation to the achievement of the actor's goals (*Aven 2016*). The success of a business in the short term may not necessarily reflect the extent of the risks taken to achieve that success. This is because risks do not necessarily have a negative impact, and thus even with high risk it is not certain that the associated undesirable negative consequences will actually materialise (*Jorion 2000*). The example of the financial company Long-Term Capital Management also shows that high risks do not necessarily materialise in the short term, thus creating the illusion of low risks, while in the longer term they inevitably have an impact (*Jorion 2000*).

The question is how the level of risk taken relates to the competitiveness of the economic actor. If we consider the product life cycle theory, there are two life cycle stages where the risk level can be favourably low (*Boussabaine – Kirkham 2004*). On the one hand, there is the growth phase, when the risks hindering growth have already been eliminated or significantly reduced, while the new risks arising from growth itself have not yet become too pronounced. On the other hand – and this is more typical – this may be the case in the maturity phase, when the associated risks have already been substantially reduced, and stable, balanced conditions have been established. From a competitiveness perspective, the maturity stage is clearly the most favourable, when product quality reaches its peak, risks are minimised and financial success is relatively strongest (*Porter 1990*). The life cycle is also applicable to companies, where the level of risk taken is also lowest in the maturity phase, while their profitability is highest (*Shahzad et al. 2019*). The level of risk taken by companies is lowest in the maturity phase because managers want to or are forced to take the least risk at this stage (*Habib – Hasan 2017*). Economic actors often compete with each other through the risks they take, which in turn can have a negative impact on their competitiveness (*Király – Nagy 2008*).

From the perspective of corporate theory, companies can remain on a growth path as long as the risks increase less than the value created (Cummins 1976). The basis of a company's existence is that it not only reduces the direct costs of production, but also transaction costs and, in connection with both, risk-related costs. In general, it can be said that companies that place greater emphasis on risk management have a higher value (Krause – Tse 2016). This is also the view of evolutionary economics, which argues that what essentially takes place in the economy is group selection. In this process, members of a community do not participate in selection primarily and decisively in isolation from others, but as part of a smaller or larger community as a selection unit. In this way, it is not individual characteristics that must meet the selection requirements, but relevant group characteristics. The group may exist because the individual derives or may derive some selection advantage from the more or less coordinated activity and “proximity” of its members: risks are reduced, chances of survival increase and survival conditions may improve (van den Bergh – Stagl 2003). Deming (2000) emphasised the importance of the group – primarily the company or organisation from an economic perspective – as a supportive environment. Some average organisations can offer little more than this to individuals, but most are able to significantly increase individual performance (Figure 1). Organisations that have been further developed through considerable effort are better able to fulfil their supportive function and ensure coordination and the conditions for continuous learning.

Figure 1
Organisations' excess performance potential



In quality management methodology – see, for example, statistical process control – normal distribution receives special attention. In well-controlled processes – where various risks have already been eliminated or minimised – the basis is that the measurement results of the various variables follow a normal distribution, and then the main goal is to further reduce the probability of extremely small and large values (Allen 2006). All of these quality efforts are made with the aim of strengthening the competitiveness of the manufactured product or service, and thus of the business. At the same time, the almost total avoidance of extreme situations also strengthens the resilience of the business (Sabatino 2016).

Risk reduction and management is one of the central categories of survival and development. Risk can be reduced with more favourable conditions, as the chances of the actor being able to control the given activity increase, thereby avoiding unfavourable outcomes. With greater knowledge, more resources and more meaningful decision-making alternatives, the actor typically faces less risk. Ultimately, culture is also a determining factor in terms of the risk taken (Vasvári 2015). With the widespread application of portfolio theory (Markowitz 1952), it is now generally accepted that diversification can significantly reduce the level of risk. McCloskey and Nash (1984) also confirmed McCloskey's earlier (1976) hypothesis that farmers in medieval England primarily established producer communities in order to stabilise the farming activities of community members by spreading potential individual losses among the members, thereby minimising potential individual losses as well as individual savings needs. The issue of portfolio diversification and reducing risk thereby often arises in conjunction with the issue of sharing risks with partners (Csóka 2003).

Traditional risk management approaches focus on identifying risks and reducing vulnerability to external disruptions. The resilience approach to extreme negative situations has a different meaning: it means that the focus of attention is on other abilities and capacities, on resources that are flexible enough, can be stored, transformed and further adapted so that systems can successfully cope with extremely negative, unexpected events and learn from them (Sutcliffe – Vogus 2003). In the case of so-called black swan events, the primary goal should not be to predict them, but rather to prepare economic actors for the possibility that their operations and activities could be seriously and extremely disrupted by something that could not have been anticipated as a real risk based on previous experience (Grandori 2020). A resilient economic actor is therefore prepared for the emergence of extremely negative situations and for coping with such situations, which presupposes that it has been able to achieve its goals successfully in near-average situations. Only economic actors which have been sufficiently successful and effective in their usual competitive environment are able to accumulate the necessary knowledge, skills and resources (van der Vegt et al. 2015).

When competition between economic actors becomes excessive in terms of risk-taking, it also has a strong impact on their resilience (*Bethlendi 2015*). At the same time, economic actors can only become and remain competitive if they are sufficiently resilient, i.e. if they are able to return to a path of growth and development after a crisis at a similar speed as their leading competitors (*Halmai 2019*).

3. Modelling the risks underlying normal distribution

Next to Lake Titicaca, Indians in the Andes traditionally grew potatoes – and often still do today – with each family cultivating an average of 17 plots measuring 225 square meters each, which are so far apart that the Indians spend three-quarters of their working day walking from one plot to another (*Diamond 2013*). This does not seem to be a very time- or cost-effective method, as, for example, by combining the plots through exchanges, each family could produce several times more than with this fragmented method. However, since this fragmented, scattered method of production is also traditional and accepted in other parts of the world, experts have examined the reasons for this. Why do these families, who live in very poor conditions, forego the possibility of much larger crop yields? The expert analysis concluded that this is essentially a very effective form of portfolio diversification, as the individual plots differ from each other in many ways, enabling them to almost completely compensate for each other's yield fluctuations, regardless of the annual weather conditions (*Diamond 2013*). Admittedly, the price of this is that even in good years, they are unable to produce exceptional yields. However, this is less important to their owners than ensuring that they have enough potatoes to meet their basic needs. If production took place on a single, consolidated plot, the Indians could harvest significantly more potatoes in an average year, but every 10 years there would be a bad year in which they would starve to death due to insufficient harvests (*Diamond 2013*).

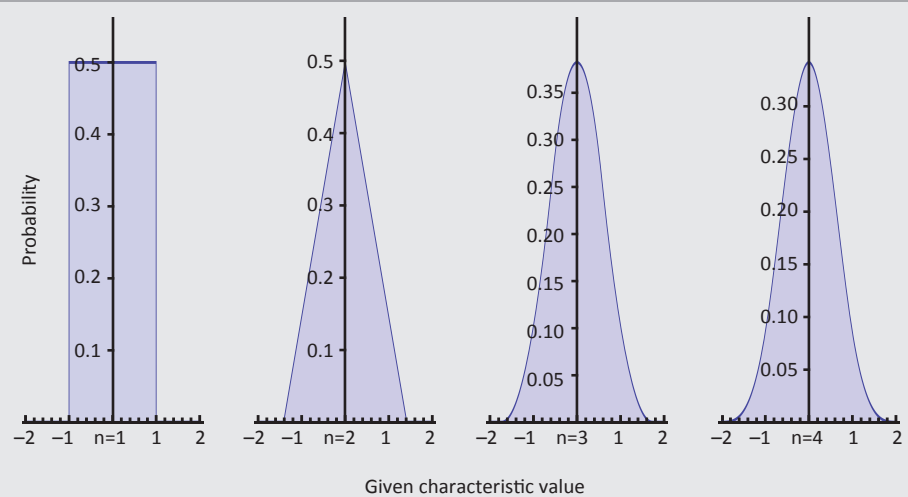
The yields of traditional Andean potato cultivation followed a normal distribution per family, where the annual harvest was almost always average or close to average, and it was very rare for them to harvest an extremely poor or good crop. This enabled the Indians to survive in the region for thousands of years. Interestingly, these Andean Indians applied the central limit theorem without being aware of it. Today, we are familiar with this theorem, but its use in everyday or strategic decisions is perhaps less widespread. What does the central limit theorem say? According to the theorem, the value of a variable will follow a normal distribution (*Dudley 2014*), which is the standardised mean of certain probability variables, provided that these probability variables:

- are independent of each other;
- are sufficiently numerous;

- have very similar ranges of influence on the sum of the probability variables; and that
- the number of measurements taking all probability variables into account at the same time is sufficiently large.

Interestingly, it does not matter whether the distribution of individual probability variables is normal or not (*Dudley 2014*). Thus, when the distribution of a variable follows for example a power law – i.e. the smaller the value that can be taken by the variable, the smaller its frequency – this does not preclude the conditions of the central limit theorem from being satisfied for all probability variables together (*Dudley 2014*). Normal distribution can therefore be achieved by ensuring that the above four conditions are met, for example by repeatedly throwing a set of six-sided dice (*Kwak – Kim 2017*). In this case, the probability variables are the dice themselves and the results of throwing them individually, die by die. The aggregate result is the one that should follow a normal distribution if we roll a sufficient number of dice and perform a sufficiently large number of rolls (*Figure 2*). The condition of independence is also fulfilled, while the possible contribution of each die (1–6) to the aggregate result is sufficiently similar, in our case identical. It is obvious that the more dice we throw, the greater the aggregate result we can expect, compared to which the contribution of each die roll becomes smaller and smaller. At the same time, it is very important to have a sufficiently high number of throws, as in the case of small series (samples), the law of large numbers cannot yet prevail, and they are more prone to producing more extreme results, i.e. non-normal distributions (*Lyon 2014*).

Figure 2
Validity of the central limit theorem according to the number of variables included



We can see that the Andean Indians correctly applied the central limit theorem in developing their production strategy, since an average of 17 plots of nearly identical size is large enough to produce a near-normal distribution of their total annual potato yield, even when considering a shorter period of time. The reason why only a near-normal distribution is achieved in this case is that the edges of the distributions are unlikely to be properly defined in such a small number of experiments. What is the reason for this? Staying with the example of throwing six-sided dice but now applying it to the Andean potato-growing Indians, the sides of the dice can represent the annual yield per plot on a scale of 1 to 6, measured in quintals (100kg). Thus, in the worst year, when each plot yields only the lowest amount of 1 quintal, the total harvest will be 17 quintals, as there are 17 plots under cultivation. Similarly, the maximum possible yield, when each plot yields 6 quintals, will be a total of 102 quintals. If the yields of the 17 different plots are determined independently of each other, then the probability of an annual yield of 17 quintals or 102 quintals will be the same, almost 0 per cent, i.e. $1:16,926,659,444,736$. The probability of any other yield between the minimum of 17 quintals and the maximum of 102 quintals is higher than that of the extremes, especially the two values close to the average of 59.5, namely 59 and 60 quintals. The probability of the latter is 5.5989 per cent, separately. If, for example, 45 quintals of potatoes is the family's annual minimum subsistence level, then the probability of a higher yield is 98.3937 per cent, which seems reassuring.

In the case of normal distribution, the probability of quantities closest to the average is so high compared to the extremes because, in the case of extremes, the conditions for production must be either the best possible (102 quintals) or the worst possible (17 quintals) for all 17 plots, which is only 1 combination (respectively), out of the possible 16.9 trillion. In the case of 59 and 60 quintals, which are closest to the average (59.5 quintals), approximately 5.6 per cent of all possible combinations are suitable (respectively) for these crop yields to be realised.

We can test the validity of the central limit theorem if we want to produce the same sum with fewer dice but with more sides. In our case, this was originally 102 for the 17 six-sided dice, and will be 100 in the other modelled cases, but the results still adequately illustrate that the originally perfectly normal distribution changes significantly with fewer dice. In the case of fewer dice, roll totals up to 16 were not taken into account, as these could not be produced with the original 17 dice. According to the results, although the average remains almost the same, the distribution becomes much flatter and its edges – or tails, to use the technical term – become much fatter. By reducing the number of dice from 17 to 5, the probability of the minimum required roll of 45 drops dramatically, by about 26 percentage points, while the fatness of the tails – still remaining below half a per cent probability – increases by about 240,000 times (*Table 1*). Thus, if the number of probability variables decreases significantly while remaining at the same risk level,

the amount of risk taken increases significantly. All of this supports *Markowitz's (1952)* portfolio theory.

| Dice | Probability of a minimum roll of 45 (1–16 not counted) | Probability of a minimum sum of 17 and a maximum sum of 25 (negative extreme) | Probability of negative extremes compared to the case of 17 six-sided dice (ratio) |
|--|--|---|--|
| 17 x 6-sided dice | 98.39 | 1:15,692,186 | 1 |
| 10 x 10-sided dice | 87.42 | 1:3,095 | 5,070 |
| 5 x 20-sided dice | 72.70 | 1:66 | 239,248 |
| 10 x 8-sided dice and 1 x 20-sided die | 84.23 | 1:57,983 | 271 |
| 8 x 10-sided dice and 1 x 20-sided die | 79.95 | 1:7,984 | 1,965 |

Source: Based on data from Georgiev, G.Z.: "Dice Probability Calculator" (<https://www.gigacalculator.com/calculators/dice-probability-calculator.php>)

If we want to examine the case where one of the probability variables has a much larger effect range than the others, i.e. they no longer influence the final result in a nearly identical manner, we find that the probability of the minimum required roll amount decreases significantly, while the fatness of the tails increases less. The larger the deviation of the selected probability variable's effect range from the others – from the base level – the greater the flattening of the normal distribution, the decrease in the frequency average and the increase in the fatness of the tails (see *Table 1*).

The independence of probability variables is also an important issue in terms of the creation and maintenance of normal distribution. In the case of dice, the effects of possible positive correlation are well illustrated by the influence on the results when the values of all other variables depend entirely on the value of one probability variable (correlation value 1). The normal distribution flattens dramatically and falls apart, while the fatness of the tails increases enormously (*Table 2*). Essentially, they can no longer be interpreted as tails at this point, as it is as if we were throwing only one six-sided die instead of 17 six-sided dice and multiplying the results by 17. Of course, such a strong correlation between probability variables is very rare, but it shows the tendency of what happens when the independence condition between probability variables is violated. In this case, the thickening of the tails is greatest. Then the negative extremes, which should occur only exceptionally rarely, become significantly more frequent.

Table 2
Effect of correlation on the probabilities of the sum of rolls in the base model

| Dice | Probability of a minimum roll of 45 (1–16 not counted) | Probability of a minimum sum of 17 and a maximum sum of 25 (negative extreme) | Probability of negative extremes compared to independent case (ratio) |
|----------------|--|---|---|
| No correlation | 98.39 | 1:15,692,186 | 1 |
| Correlation: 1 | 66.66 | 1:6 | 2,615,364 |

Source: Based on data from Georgiev, G.Z.: "Dice Probability Calculator" (<https://www.gigacalculator.com/calculators/dice-probability-calculator.php>)

Another important question – beyond the conditions of the central limit theorem – is what goals the actors set and what returns they expect and demand in connection with their activities. If they wish to achieve their goals with a high degree of certainty (i.e. with a high probability), it is reasonable to specify a value that is approximately one standard deviation below the mean of the normal distribution. Specifying higher target values initially reduces the probability of realisation and further increasing the target values drastically reduces it. In our case – see the original model – 17 six-sided dice can produce a maximum roll of 102, where the average is 59.5 (since the smallest roll is 17). Even with an expectation slightly below the average – 55 – there is a 24-per cent chance that the set goals will not be achieved. With a value slightly above the average – 65 – there is a 76-per cent probability that the goals will not be achieved. The probability of achieving a target value of 85, which is 17 per cent lower than the maximum possible value, is only 0.01 per cent (Table 3). In addition to the existence of a normal distribution, it is therefore very important to determine what target values are set in relation to the average and the standard deviation. Setting overly ambitious targets generates additional risk in itself. However, actors which are able to set their management frameworks and targets in such a way that the probability of achieving their targets is very high will be able to create and maintain a state of knowledge, skills and resources that will enable them to respond flexibly, efficiently and effectively to any usual competitive challenge. This does not mean that low goals should be set, but rather that high goals should be aligned with the normal distribution and should be below average. We have previously referred to such players as competitive.

Table 3
Probabilities of certain roll totals in the basic model

| Probability of a minimum roll of 45 | Probability of a minimum roll of 55 | Probability of a minimum roll of 65 | Probability of a minimum roll of 85 |
|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| 98.39 | 75.96 | 24.04 | 0.01 |

Source: Based on data from Georgiev, G.Z.: "Dice Probability Calculator" (<https://www.gigacalculator.com/calculators/dice-probability-calculator.php>)

It is also extremely important that if the objectives are not achieved, the economic actor must be able to cope with the consequences of strongly or extremely negative outcomes, i.e. the losses suffered in this way. Are they able to manage such losses by using the financial and non-financial reserves accumulated during their previous, more successful management in such a way that they do not exhaust their future opportunities? Sustainability is thus inevitably linked to resilience. Sustainable management is essentially resilient, but the reverse is not true, i.e. an economic actor can be resilient without managing in a completely sustainable manner (*Espinier et al. 2017*).

Competitiveness does not necessarily mean resilience. It is possible to be competitive in the short term – under normal, everyday, average and near-average conditions – but if extraordinary situations put economic actors to the test and they are found to be vulnerable, it is not possible to speak meaningfully of competitiveness in the longer term. Resilience can be maintained in the short term even without competitiveness, but in the longer term it is essential that competitive activity strengthens, develops and maintains reserves of knowledge, skills and resources, while in the absence of competitiveness, existing stocks and reserves will be depleted.

In theory, a company with a risk structure that satisfies the conditions of the central limit theorem is competitive and is not threatened by any serious negative events that could affect its resilience, as the probability of such events is negligible. In reality, however, crises and other shock events do affect even the most competitive companies, and such situations arise much more frequently than the negligible probability would suggest. This apparent contradiction may be due to the following reasons:

- Due to goals that are excessive compared to the given normal distribution and significantly exceed the average, outcomes that are not extremely disadvantageous in theory – only slightly below average – but have a significant probability are already considered relatively serious negative outcomes.
- There is no significant correlation between certain probability variables in everyday, average or near-average periods – thus, there is essentially a lack of measurement data – but under certain circumstances, the correlation becomes visible, “activated,” and this greatly increases the probability that would otherwise have been considered negligible.
- When individual risks are linked to decision-makers – such as stock exchanges – there is always a danger that, instead of diverse decisions, significant uniformity will develop, which excessively reduces probability variables and distorts the normal distribution.

Extreme values, particularly in terms of competitiveness but particularly in terms of resilience, are of great importance, especially because these values and their probabilities of occurrence are often underestimated. Extreme values and their probabilities can be estimated using a separate methodology – see extreme value theory – because it is not really possible to apply the central limit theorem, as it is often impossible to fully determine the probability variables involved, and even if it were possible, the relationships between them and dependencies between them would be underestimated (Kratz 2019).

Between 1845 and 1852, Ireland experienced the Great Famine, during which 1 million of its 8 million inhabitants starved to death due to potato blight, and another 1 million emigrated to the United States (Kinealy 1994). At that time, for many decades Ireland had been growing potatoes in huge quantities as a monoculture without crop rotation, which enabled it to meet the rapidly growing calorie needs of its population. The potato blight appeared to come out of nowhere and caused extreme damage for seven years. It has now been proven that the pathogen arrived via North America from the Andes, where it had always been present but had not been able to cause significant damage due to diversified cultivation (Saffer et al. 2024). There was never a famine in the Andes, and due to the sufficiently moderate risk structure, negative extremes only occurred once every few hundred years, in a single season. Thus, the true impact spectrum of the pathogen causing potato blight could not be known, especially in Ireland, under different production conditions. All of this demonstrates the validity of the central limit theorem, but also its limitations, as well as the applicability of extreme value theory. In certain industries, such as credit institutions, this perspective – namely, that the risk structure also indicates the quality of the actor's management – can be considered commonplace (Kovács 2015), while in other industries it is much less common or not common at all.

4. Summary and conclusions

Hope for the best, but prepare for the worst, as the English proverb says. While the concept of competitiveness focuses on the usual, average and near-average, assumed future conditions, resilience focuses on exceptional events with serious negative consequences. Here, dangers and risks obviously receive more attention, but the emphasis is on survival techniques and accumulated reserves of knowledge, skills and resources. Yet risks are one of the generally very important indicators of the state and functioning of economic actors. This study essentially sought to approach the concepts of both competitiveness and resilience from the perspective of risks. In order to make this approach more precise, the concept of normal distribution and, in connection with this, the central limit theorem were included.

According to the results, in order for an actor to be highly competitive – i.e. for there to be a small gap between the relevant competitive requirements and the actor’s capabilities related to them – its risk structure must be well moderated in accordance with the conditions of the central limit theorem. This is not simply a matter of diversification, as the participant must apply extensive risk management to create a sufficiently large number of independent risks, each with a small potential impact. This risk management includes, among other things, strategic, business model-related financial and technological decisions, efforts and developments, not just the participant’s efforts to diversify its activities or other portfolio.

The four conditions of the central limit distribution – especially the similar weight and independence of the probability variables – may seem overly sterile and “alien to life”. However, it should not be forgotten that the risk structure should satisfy this set of conditions not before risk management, but after it. In addition, in the course of risk management, priority is always given to those risk factors that have a large effect range in themselves and/or on which other risk factors are partly dependent. Within the framework of advanced quality management systems, continuous improvement will eventually result in a sufficiently moderate risk structure, which on the one hand ensures sufficient competitiveness for the future, and on the other hand creates a suitable basis for dealing with and overcoming unexpected, serious situations.

Competitiveness is fundamentally necessary in terms of resilience, but it is not a sufficient condition. Only sustained competitiveness, only consistent performance in competition during “peacetime” can create the knowledge, skills and accumulation of financial resources that enable a player to survive in appropriate shape and overcome extremely negative situations. In such cases, it is necessary to map out the risks as thoroughly as possible, as this is when the most resources, time and measurement opportunities are available. At the same time, this also requires the intention to manage potential losses appropriately, i.e. sufficient awareness, which allows for the accumulation and preparation of the appropriate knowledge, skills and resources.

Most businesses link success to the risks they take, believing that without taking a certain amount of extra risk, it is not possible to achieve sufficient success. In the case of credit institutions, for example with regard to credit risks, it is clear that a certain healthy appetite for risk is necessary in order to achieve profit targets. At the same time, in order to achieve and maintain competitiveness and resilience, it is necessary that there be no significant differences between the impact ranges of the risks taken and that there be no significant correlation between the risk factors. Credit institutions pay particular attention to this on both the deposit and credit sides, avoiding concentration risk that could be considered excessive and

balancing and proportioning the risks posed by different customers. The Coca-Cola Company, with its extremely complex, multifaceted product portfolio and its underlying procurement and manufacturing practices, is a good example of how to operate a highly competitive and resilient business with a large number of risk factors that have a similar impact spectrum and are only slightly interdependent. Due to the obvious differences in size, it seems difficult for anyone to follow the example of the Coca-Cola Company, but it was precisely the Andean potato farmers described earlier who showed how this can work on a small scale – in the given competitive environment.

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