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QUANTITY ADJUSTMENT ON THE UNSECURED INTERBANK FORINT DEPOSIT MARKET[1]

Zoltán Pollák – Erika Jáki[2]

ABSTRACT

On the unsecured interbank markets, if a bank perceives that a counterparty has an increased default risk, it can respond by raising the interest rate (price adjustment) and reducing the amount of loan available (quantity adjustment). In the interbank deposit market, the most important factor is clearly quantity adjustment rather than price adjustment. For a deeper explanation of the quantity adjustment, we examined the concentration of lending and borrowing in a database covering all interbank transactions between 2012 and 2015. Both the Gini and Herfindahl-Hirschman indices showed that borrowing was more concentrated than lending in terms of both volume and number of transactions. Loans were provided by an average of 10-15 active banks typically to only 5-8 borrowers in the period examined. We tested this observation by using a two-sample z-test to compare expected values and confirmed a significant difference in concentration between the borrowing and lending sides of the interbank market. The more even distribution of the lending transactions can be explained by the fact that structural liquidity surplus was typically experienced in the Hungarian interbank market. The high concentration of the borrowing transactions derives from the partner limits.

JEL codes: G15, G21

Keywords: unsecured interbank deposit market, quantity adjustment, partner limits, concentration analysis

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1 INTRODUCTION

The platforms of the banks' liquidity management are the unsecured interbank HUF deposit market and the forint repo market, where the more important goal of the participants is usually to smooth out the imbalances in their net liquidity position with short-term borrowings and deposits or repo transactions. Excess liquidity reduces the profitability of a credit institution, and, on the other hand, a lack of liquidity can jeopardise solvency. At the same time, liquidity risk is an asymmetric risk for banks. Not investing excess liquidity – especially in the current low-yield environment – is nowhere near as much of a problem as failing to obtain extra funds (or only very expensive). In Hungary, the most important platform for banks' liquidity management is the unsecured interbank forint deposit market, so we focused our research on this market.

In *Chapter 2*, we describe the most important characteristics of unsecured interbank credit transactions, of which the lack of financial collateral together with the significant volume may create significant risk. In the unsecured interbank forint deposit market, the most important factor is quantity adjustment rather than price adjustment. Quantity adjustment is mostly achieved through partner limits.

In *Chapter 3*, we first examine the evolution of monthly aggregated transaction amount, and for a deeper explanation of the quantity adjustment, we compare the concentration of lending and borrowing.

The relevance of the analysis and our choice of topic lies in the concentration-related connections published in the academic literature. We compare the obtained results with the *Berlinger–Michaletzky–Szenes* (2011*)* study. The authors studied the network dynamics of the Hungarian unsecured interbank HUF deposit market for the period between December 2002 and March 2009. Their study found that the different network metrics and the general features of the market were stable until 2006–2007, after which – as if forecasting the crisis –, part of the indicators began to change. We partly considered this study the preamble of the present study when we examined the data series of the same market between 2012 and 2015.

2 THE HUNGARIAN UNSECURED INTERBANK DEPOSIT MARKET

The inherent feature of banks' activities is that their liquidity position is constantly changing. The primary platform for eliminating their possible liquidity shortage and disbursing their temporary excess liquidity is the unsecured interbank deposit market.

First, we review the main features of interbank loans, then we focus on the limits that determine the market as a whole.

2.1 Characteristics of the interbank loans

As a result of their activities, banks may generate excess liquidity or a lack of liquidity on a daily basis (or even more frequently). Excess liquidity is disbursed and liquidity is mainly obtained on the unsecured interbank HUF deposit market or the forint repo market. The main difference between the two markets lies in counterparty risk.

Repos are backed by securities as collateral, which almost completely eliminates counterparty risk. In some countries (such as Turkey or Australia), the interbank market typically suffers from a structural lack of liquidity, so local banks continue to lend in some form (usually through repos) to their central bank. In these countries, repo transactions can be considered the main monetary policy instrument in most cases (*Kollarik–Lénárt-Odorán*, 2017).

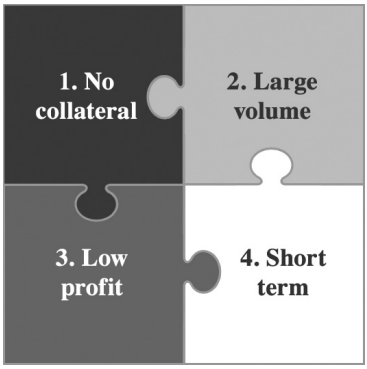
In contrast, the typical excess liquidity banking systems, such as the Hungarian one, encounter much larger loan volumes in the interbank deposit market than in the repo market (Berlinger–Michaletzky–Szenes, 2011). The average daily turnover of the latter unsecured HUF deposit market amounts to seven times the turnover of the repo market (*Erhart–Mátrai*, 2015).

Besides interbank markets in the region, not only the Hungarian one but also the Polish (*Smaga* et al., 2018), the Czech, the Lithuanian and the Estonian banking sectors typically have structural liquidity surplus (*Hryckiewicz*, 2021).

The low weight of the repo market in bank liquidity management can be explained mainly by legal obstacles and the low limits between the participants. The MNB's survey of banks highlighted this, and a repo working group was also set up with market participants to solve the problems. The most important obstacles hindering market participants were the lack of a standard repo framework contract and the shortcomings of the settlement system of KELER Central Depository and ÁKK (Government Debt Management Agency) *(Kolozsi–Horváth, 2020)*.

Thus, the most important platform for banks' liquidity management is clearly the unsecured interbank HUF deposit market, which is similar in many respects to other financial markets, but has some special features (or rather a combination of these special features) that create different patterns than any other market.

Figure 1
General characteristics of interbank lending transactions



Source: own edition

Figure 1 shows the main features of interbank lending transactions. In the figure, the interlocking puzzle pieces symbolise that these features appear in other markets separately, while their co-occurrence forms a unique image to the interbank deposit market.

One of the most important features of the interbank deposit market is that the transactions (1) are unsecured, i.e. in the event of the counterparty's default, there is no credit collateral behind them from which even partial satisfaction could be obtained. In addition, this lack of collateral is often coupled with tens of billions of (2) large loan volumes, which induces significant risk (*Veres–Gulyás*, 2008). With such a high risk, (3) the profit margin for a provider of funds in the interbank market is very low, but access to funding from the other side is usually the cheapest here.

In addition to the above characteristics, it is worth noting that (4) the maturity of interbank loans is typically short compared to other markets. As the primary function of the market is liquidity management, one-day transactions are concluded in the vast majority of cases. A typical example is the overnight (O/N) loan, where the starting date of the transaction is the same as the date of concluding the contract, and the transaction closes on the next trading day.

2.2 The market as a whole is driven by limits – partner limits in the foreground

Moving from the characteristics of interbank loans to the characteristics of the market as a whole, an unsecured and significant exposure brings to the fore coun-

terparty risk in the interbank market. The actors constantly monitor and rate each other. If a bank perceives that a counterparty has an increased default risk, it can respond by raising the interest rate (price adjustment) and reducing the amount of loan available (quantity adjustment) (Berlinger, 2017).

It can be seen from the above that the presence of information asymmetry is very significant in this market (it is difficult to get real-time, reliable information about the current asset quality, profitability, capital adequacy and liquidity position of the partner), and the stake is high due to significant credit volumes and lack of collateral. This information asymmetry raises the possibility of adverse selection and moral hazard, so lenders then respond to the perceived increase in counterparty risk less by raising interest rates than by reducing the amount of loan provided. The literature calls this phenomenon credit rationing (*Tirole*, 2006). This phenomenon is a problem especially in the case of high concentration on the lending side of the interbank market, where banks with a lack of liquidity are more likely to be exposed to a liquidity supply concentrated at a small number of participants (*Nyborg–Strebulaev*, 2004).

The phenomenon referred to in the literature as short squeezing has a similar effect on the interbank market as credit rationing. The information asymmetry mentioned above exists not only between banks, but also between banks and the duo of the central bank and the state. The central government generates shocks in the liquidity of the interbank market through the Treasury Single Account, and the central bank is also an actor capable of influencing the behaviour of banks with its toolset. If, as a result, market participants feel that the liquidity available on the interbank market is uncertain in the short term, the banks with excess liquidity may adopt a reasonable decision to retain (leave it on the balance sheet as a kind of buffer) excess liquidity[3] (*Kolozsi–Horváth*, 2020).

Due to these phenomena, the most important tool for managing counterparty risk in the interbank deposit market is not price adjustment (as in many other markets) but the containment of the amount lent. The participants set a partner limit against each other, which means the amount of maximum exposure they wish to hold against a given bank.

The work of *Homolya* et al. (2013), who examined the limit setting practices of Hungarian banks with the help of questionnaires and interviews, is particularly interesting and relevant in relation to partner limits. This is highly sensitive information for a bank, which is why this article is so valuable; the interviews revealed information that greatly helps to understand the mechanisms of influence of the interbank market.

3 It is especially true in a low-yield environment, where they do not lose significant interest income.

According to their study, the practice of setting limits largely depends on the role of a given credit institution within their banking group. Some of the banking groups operating in Hungary perform global risk management. The domestic subsidiaries and branches of these banking groups receive the limits "from above" from their parent bank; they usually have no say in the specific limit levels or the methodology of their determination, as this is done centrally in all cases. For the other credit institutions, the parent bank only sets the guidelines and methodological frameworks, so the limit is set in a multi-level decision, giving space to the local subsidiary in smaller decisions with a local impact.

In the interbank market, lending transactions usually take place in established relationships, as unused limits are cut back over time, which can prevent the re-establishment of the relationship and close a previously live lending relationship between two participants.

From the perspective of interbank lending, the partner limit is clearly a bottleneck and is also the most commonly used type of limit. Berlinger (2017) examined the relevance of partner limits (more precisely, the implicit partner limits estimated by her in the absence of their knowledge) and the interest rate (as a financing cost) of interbank unsecured forint transactions on transaction data between 2003 and 2012. The findings are in line with the results of the research mentioned earlier. The interbank market is more driven by quantity factors (partner limits), while price components – in this case, the interest rate on transactions – are less important in this market.

A similar result has been obtained by the authors *Geršl–Lešanovská* (2014) when examining the Czech interbank market during the crisis of 2008. They established that, in reaction to an increase in counterparty risk during the crisis, banks decided not to change interest rates but rather to reduce counterparty limits and introduce maturity limits. According to their analysis, interbank interest rates were affected almost exclusively by the spillover effect coming from parent banks from abroad rather than by credit relationships in the interbank market.

Thus, in light of the literature, the interbank deposit market seems to be driven mainly by partner limits. However, the setting of partner limits is also the result of a multivariable (and, as we presented earlier, multi-level) decision-making process for some banks. From the perspective of understanding the market, it is worth looking behind the limits on the surface and going a level deeper by exploring the elementary factors that shape it.

As a result of their qualitative research, Homolya et al. (2013) found that limits are fundamentally shaped by three factors, (1) the counterparty's (or country's sovereign) credit rating, (2) its CDS spread, and (3) certain financial ratios. In general, financial ratios are intended to numerically involve the profitability, asset quality,

capital adequacy and liquidity of the partner credit institution in the limit setting process.

Relying on the implicit rating indicator used by her, Berlinger (2017) found that after the 2008 crisis, the most active banks became the most creditworthy players in the market, and therefore they were able to access funds under the best conditions.

3 THE ANALYSIS OF QUANTITY ADJUSTMENT ON THE HUNGARIAN INTERBANK DEPOSIT MARKET

Our research hypothesis examined in the study is:

> *The concentration of borrowing is significantly higher than the concentration of lending, both in terms of volume and the number of transactions.*

The relevance of our hypothesis lies in the concentration-related connections published in the academic literature. We compared the obtained results with the Berlinger–Michaletzky–Szenes (2011) study. The authors studied the network dynamics of the Hungarian unsecured interbank HUF deposit market for the period between December 2002 and March 2009. Their study found that the different network metrics and the general features of the market were stable until 2006-2007, after which – as if forecasting the crisis –, part of the indicators began to change.

3.1 General characteristics of the examined database

We performed the analysis on the highly detailed database compiled from the regular reports of the Hungarian banks provided by MNB for research purposes, which contained every unsecured interbank lending transaction performed between 2 January 2012 and 31 December 2015. As these pieces of information are deemed strictly confidential, the different banks are included anonymously with random sequence numbers in a directly unidentifiable manner. The purpose of our study is not the linking of the results to a given credit institution. The goal is clearly the examination of the whole market, the exploration of the structure of connections.

The transactions of the database (records) contain the following information: fictitious code of borrowing (data supplying) bank, identifier of the lender partner, contract amount of the credit, (annualised) interest rate paid for the transaction, date of contracts, the start and end date of the transaction and the direction of

the transaction (which, in every case, is borrowing to avoid duplication in the data table[4]).

3.2 Changes in the monthly aggregated transaction amount

If the market shocks were less reflected in the price adjustment, the quantity adjustment is worth examining in detail by all means. In addition to examining the aggregated transaction amount, we will also attempt to shed light on the structure of the quantity adjustment in *Section 3.3*.

Let us first look at the changes in the aggregated volume and number of transactions in the given period for the overnight unsecured HUF loans. We have reached an important question here, namely the definition of the size of the examination window, in other words, the selection of the length of the period in which we aggregate the transactions.

The most obvious solution on the market of overnight loans would be the one-day time window. In this case, the daily transaction volumes would show fluctuations, which would completely cover the tendencies in the time series. The use of moving average could partly counterbalance this, but this type of "smoothing" the time series would lead to distortions exceeding a certain extent.

An even more powerful argument against one-day aggregation is the low activity of the Hungarian interbank market at international level. There were so few contracts in average on one day in the examined period (37 contracts) that by choosing this option, the interbank network would fall apart, it would consist of smaller or bigger separate islands, which would make the use of methodologies presented in our study later, and the interpretation of the results impossible.

So it seems certain that the examination window should be selected for a period longer than one day, but the longer the period is the stronger the aggregation "conflates", conceals diversity in data and the fewer the number of data points will be. This latter problem can be eliminated, for example, by "pushing" a time window of one quarter on every month, but in this case, approximately one-third[5] of the elementary data aggregated in every data point will match the content of the previous and the following data point.

In order to find the "optimal" solution, the literature is worth looking at. The different articles examining the interbank market are not uniform either regard-

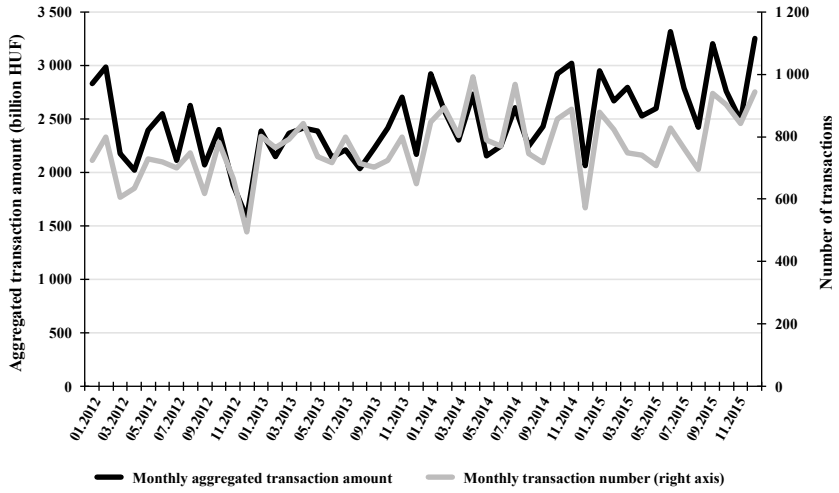
4 Both the lender and the borrower must report every transaction to MNB but duplication resulting from this has previously been filtered from the data table.

5 If the transactions are distributed among the different months uniformly.

ing the level of aggregation over time. Some authors use a one-day time window (*León–Machado–Sarmiento*, 2018), others analyse monthly data (Berlinger et al., 2017), but there are often quarterly (*Veld–van Lelyveld*, 2014); *Craig–von Peter*, 2014; *Fricke–Lux*, 2015), or even half-yearly (*Langfield–Liu–Ota*, 2014) examinations, too.

The Berlinger–Michaletzky–Szenes (2011) study used as a starting point for this chapter uses weekly and monthly time windows alternately. As the weekly time window is not frequent in the foreign literature, we will uniformly work with the monthly aggregation level, which we will keep "pushing" on every month. By doing so, we will have 48 (monthly) data points between 2012 and 2015. The August 2015 network, for example, will consist of the sum of overnight interbank transactions initiated between 1 August and 31 August 2015.

Figure 2
The monthly aggregated transaction amount of overnight unsecured interbank HUF deposit market and the monthly number of transactions (axis on the right) (2012–2015)



Source: Own editing based on MNB data

Examining the order of magnitude of the market based on *Figure 2*, it can be stated that at around monthly HUF 2-3 thousand billion aggregated transaction amount (black line and the belonging axis on the left), between 700 and 1,000 overnight credit transactions (gray line secondary axis on the right) were contracted in the examined period on the Hungarian unsecured interbank market.

The monthly aggregated transaction amount and the number of transactions moved together very closely in a relatively narrow band. The two indicators separated from each other only in the first half of 2012 and in 2015; in both cases aggregated transaction amount grew more than the number of transactions.

In the first such period, the reason for this must have been the events of the end of 2011 and the beginning of 2012, when Hungary's long-term credit ratings fell at the three major credit rating agencies (S&P, Moody's and Fitch) in the junk, speculative category and the transformation of the central bank toolbox in the second period. One possible explanation of the phenomenon is that the banks significantly cut the limits of partners deemed less reliable due to the shocks on the interbank market. In contrast, the volume of loans extended to the best partners grew (as financing requirements still had to be satisfied from somewhere, while the central bank instruments were less and less attractive). Changes in the aggregated transaction amount exceeding the number of transactions and the scissors opening between them may point to the presence of quantity adjustment.

3.3 Analysis of the concentration of lending and borrowing

After examining the aggregated transaction amount, we will examine how quantity adjustment was performed structurally between 2012 and 2015. The different indicators of the concentration, such as the Lorenz curve, Gini index and the Herfindahl-Hirschman index, as well as the effective number generated from them, will help us in this.

Concentration is the focusing of the majority of the total amount (e.g. transaction amount in the present case) in few observation units (market participants) (*Hunyadi–Vita*, 2008a).

Concentration has two types fundamentally: absolute and relative concentrations. Absolute concentration is present on a market if the number of participants is very low. In this case, a large percentage of the total amount will be concentrated in few units – due to the small number of active market participants in itself. What is small and what is large multitude is difficult to define, and the literature does not give any general guidance either, but the measures of relative concentration can already be used and interpreted well if there are 30-40 active credit institutions present on the interbank market.

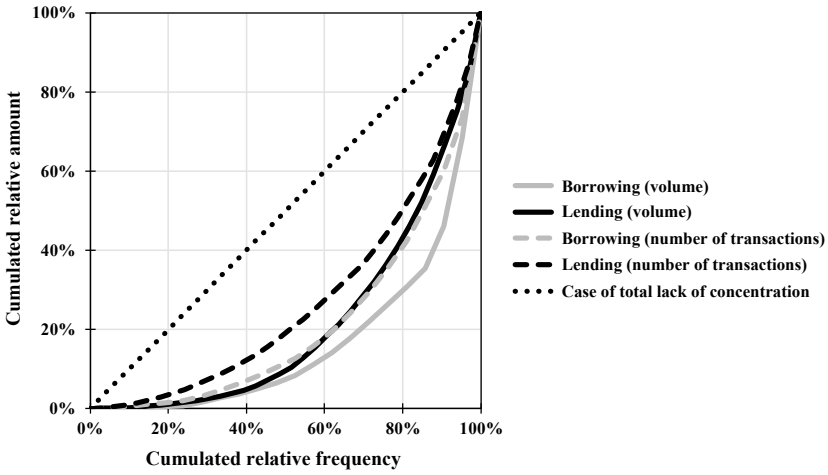
The volume of concentration in the relative sense can be defined in some way by the comparison of relative frequencies (one group of banks constitutes what percentage of all active banks on the market) and the relative amounts (loans granted by one group of banks in the proportion of the total market credit volume).

3.3.1 Lorenz curve and Gini index

At the beginning of the 20th century, Max Otto Lorenz American economist prepared a special chart to show the Prussian asset concentration, which was named Lorenz curve in his honour (*Kerékgyártó–Mundruczó*, 1998).

The Lorenz curve shows the cumulated relative amounts subject to the cumulated relative frequencies, where cumulation begins from the smallest observation and goes on to the larger ones.

Figure 3
Lorenz curve



Source: Own editing based on MNB data

The concentration of the interbank market transactions on the borrower and lender sides according to volume (continuous curves), on the one hand, and number of transactions (dashed curves), on the other hand, in December 2015[6] is seen in Figure 3. The diagonal of the square (dotted black line) is the case of total lack of concentration, as the participation in the total volume and total number of transactions of the given banks is uniform. The farther the Lorenz curve is from

6 The choice for the aggregate data of December 2015 was made because it is the most recent available monthly time window, and it is excellent for presenting that if two Lorenz curves intersect, then it will not be possible to determine a clear order in terms of concentration. Therefore, concentration indicators will be used to draw meaningful conclusions, and the Lorenz curve is used only for illustrative purposes here.

the diagonal (and the closer it is to the lower and right sides of the square), the larger is the concentration it indicates.

According to *Figure 3*, taking the borrowed credit volumes as a basis, the concentration on the borrowing side (continuous gray line) was the highest, while the lowest concentration was on the lending side with the number of granted loans taken into account (dashed black line). The Lorenz curves indicated with continuous black line and dashed gray line intersect each other in the chart. If two Lorenz curves intersect each other in one or several places, they cannot be compared clearly.

Different concentration indicators are worth calculating in order to eliminate this problem. Although the Lorenz curve is a very illustrative method of showing the concentration, unfortunately, it is not suitable for the examination of the dynamics over time (this is why we depicted only the last observations from December 2015). The latter's disadvantage makes the use of concentration measures necessary and justified for the Lorenz curve, too.

Gini index (G) is one of the indicators used most frequently to measure the degree of concentration. Its value can be defined as the quotient of the size of the area bordered by the diagonal and Lorenz curve, and the size of the area bordered by the diagonal and the axes.

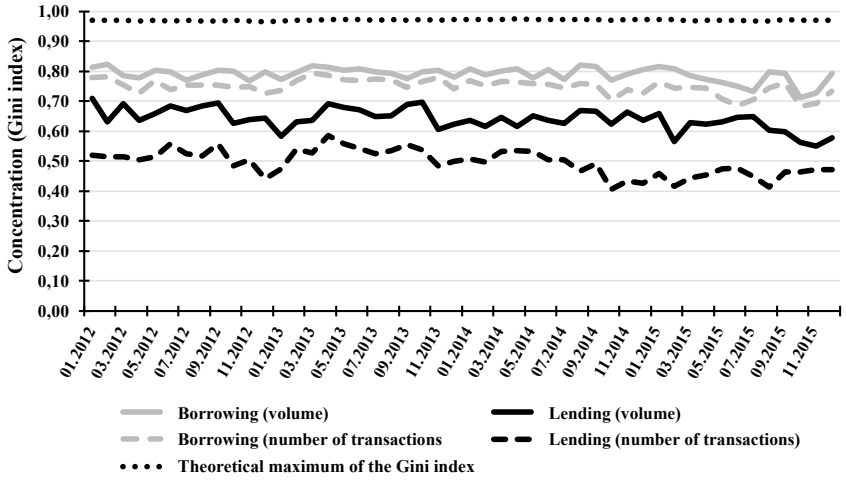
$$\mathrm{G} = \frac{t_c}{1/2} = 2 \cdot t_c \tag{1}$$

Where t_c is the so-called concentration area bordered by the diagonal and Lorenz curve. The diagonal divides the square with unit-size side length into two parts. Therefore it is easy to see that the size of the area bordered by the diagonal and the axes is ½ (denominator of formula 1).

The Gini index takes its smallest value (0) when the market share of every bank is identical. This is the case of the total lack of concentration. In the case of limited number (n) of banks, if one bank extends all loans (or one market participant borrows all on the other side), it is seen that the value of the Gini index is $G = 1 - \frac{1}{n}$, i.e. the more participants are on the market (the bigger n is), the closer the value is to 1 (*Ross*, 2017).[7]

7 The number of active banks fluctuated between 30 and 40 in the examined period, therefore the upper limit of the Gini index is around 0.97.

Figure 4
Gini index of the borrowing and lending transactions in the given months according to the amounts and number of transactions (2012–2015)



Source: Own editing based on MNB data

In *Figure 4*, we see that examining the interbank market from the lender side Gini index shows medium size concentration (values typically between 0.4 and 0.7) and strong concentration from the borrower side (values between 0.7 and 0.8).[8]

Additionally, it can be observed that regarding both the volumes (continuous lines) and the number of transactions (broken lines), borrowing is significantly more concentrated than lending, which means that a relatively small number of participants borrow the majority of interbank credits, and they do not obtain financing from individual bigger market participants, but almost every one of the market participants contributes to the maintenance of market liquidity.

3.3.2 Herfindahl-Hirschman index and the effective number

Another index frequently used to measure concentration is the Herfindahl-Hirschman index (HHI), which can be described according to the following:

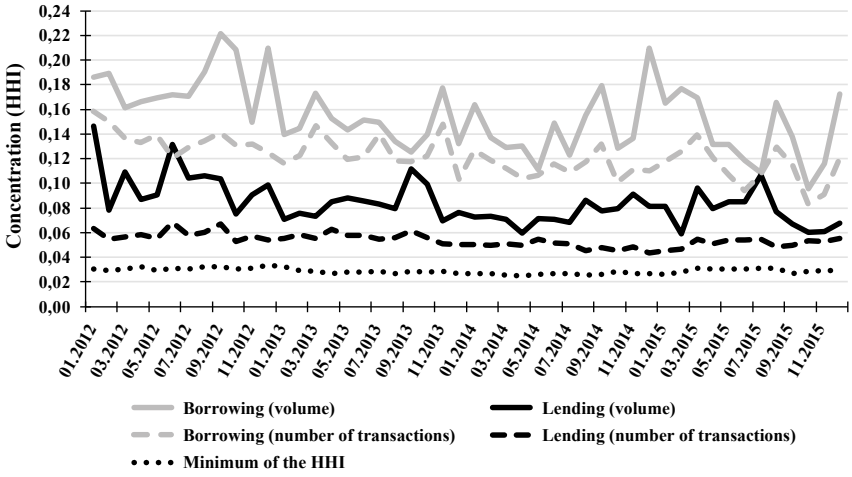
$$\mathrm{HHI} = \sum_{i=1}^{N} Z_i^2 \qquad (2)$$

8 The precise value, from which the size of concentration is deemed strong, is difficult to define. We used the categorisation of Harangi-Rákos (2013) in the present case.

where Z_i is the market share of bank i, and N is the number of participants present on the market. The minimum of the index is $1/N$, when the market share of every participant is identical (total lack of concentration), the maximum of the index is 1, which indicates the presence of the highest degree of concentration (one participant owns the entire market). The lower limit depends on N, which means that if there is a total lack of concentration on a market, then on a market of 5 participants, we obtain ceteris paribus higher HHI value than on a market of 30 participants. Meaning that this indicator can take both the relative and absolute projections of the concentration into account simultaneously.

Additionally, the reciprocal value of the Herfindahl-Hirschman index is also a very frequently used indicator, which is known by the literature as effective number and which, if applied to the interbank market, can be interpreted as the number of active banks on the market (Berlinger–Michaletzky–Szenes, 2011).

Figure 5
HHI index of the borrowing and lending transactions in the given months according to the volume and number of transactions (2012–2015)



Source: Own editing based on MNB data

Figure 5 shows the changes in the borrowing side (continuous gray and dashed gray lines) and the lending side (continuous black and dashed black lines) concentrations of the interbank market (HHI) in the given months, and the $1/N$ lower limit (dotted black line).

According to the thumb rule, the market cannot be considered concentrated in HHI values under 0.15, values between 0.15 and 0.25 indicate moderate concentra-

tion, and the interbank market can be deemed highly concentrated over the value of 0.25. (U.S *Department of Justice & FTC, 2010)*.[9] It means that the interbank market loans cannot be deemed concentrated (HHI values are under 0.15 every month), but the borrowing transactions show moderate concentration, especially in terms of the borrowed credit amounts (continuous gray line).

Two phenomena can furthermore be observed in *Figure 5*. The first is that – similarly to measuring concentration with the Gini index – both in terms of the volumes and the number of transactions, the borrowing transactions show significantly higher concentration than the lending transactions. It means that proportionally more market participants finance fewer market participants.

The more even distribution of the lending transactions can be explained by the fact that structural liquidity surplus was typically experienced on the Hungarian interbank market in the past one and a half decades. The high concentration of the borrowing transactions derives from the partner limits and the quantity adjustment being stronger on the interbank market. Only a few large (or rather actively transacting, reliable)[10] market participants have more significant limits at their partners, limiting the number of market participants who can receive funds on the interbank market.

This result is identical with the findings of Berlinger–Michaletzky–Szenes (2011); moreover, the picture is further tinged by the fact that the number of lenders is relatively stable in a crisis, while the number of borrowers drops significantly (the concentration of borrowing grows drastically).

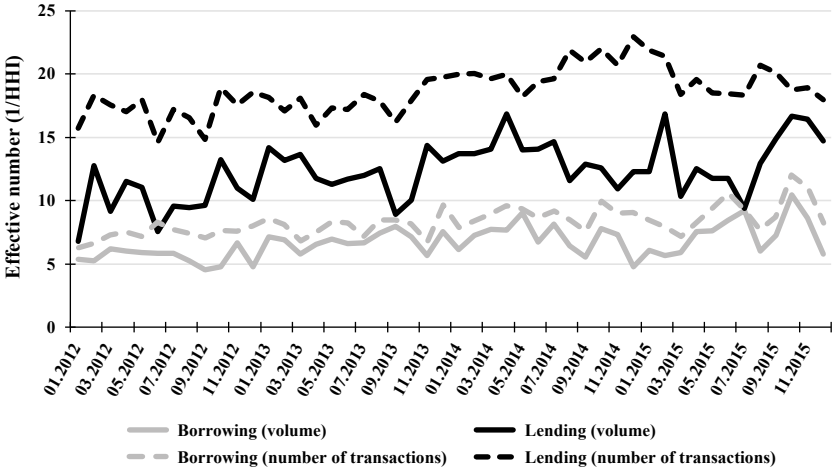
Minoiu–Reyes (2013) examined cross-border interbank transactions using the exceptionally rich time series of BIS (Bank for International Settlements) from 1978 to 2010, covering 184 developed and developing countries (including the Visegrad states). The network they analysed contains data for individual resident banks as aggregated at the level of countries. Their analysis of a global interbank network of states also shows clearly that the concentration of borrowing was significantly higher than that of lending throughout the 32 years under review. In addition, the authors observed increasing concentrations over time on both sides.

The effective numbers derived from the borrowing and lending HHI indicators are to quantify the average number of active banks on the two sides of the interbank market.

9 It is interesting that the line was drawn at 0.1 and 0.18 values in their 1997 publication.

10 The literature is not uniform in this, as we pointed to it earlier (see for example Berlinger (2017)).

Figure 6
Effective numbers generated on the basis of the concentration of the borrowing and lending transactions and according to the number of transactions (2012–2015)



Source: Own editing based on MNB data

Based on the effective numbers of *Figure 6*, it can be stated that the loans were granted by 10-15 banks on average[11] while there were only 5-8 active borrowing banks on the market. The same numbers were 17-21 and 7-10 respectively, based on the number of transactions.

Another phenomenon, which is clear from *Figures 5* and *6*, is that the fluctuation, volatility of the volumes (continuous lines) is higher than those of the number of transactions (dashed lines).

This phenomenon can unfortunately not be verified by a formal test as the preproposition of F-test (aimed at the identity of the standard deviation of the two populations) is that the distribution of both populations is normal and that we have two independent samples (Hunyadi–Mundruczó–Vita, 2001). This latter condition is not met at all; examining the same transactions, there is a (expectedly positive and strong) connection between the volume and the number of loans granted by the given bank.

The first observed phenomenon is worth testing with the help of a formal hypothesis test. The phenomenon to be tested is that borrowing is significantly more

11 The limits are roughly the lower (D_1), and higher deciles (D_9) of the monthly effective numbers.

concentrated both in terms of the volumes and the number of transactions. This assumption can be tested with a two-sample *z*-test for comparing expected values. According to our alternative hypothesis, the average concentration of borrowing *(B)* (μ_B) is larger than the average concentration of lending *(L)* (μ_L), and according to our null hypothesis, the expected value of the HHI index of lending is minimum the size of that of borrowing, in other words, formally:

$$\begin{aligned} H_0&: \quad \mu_B - \mu_L \leq 0 \\ H_1&: \quad \mu_B - \mu_L > 0 \end{aligned} \tag{3}$$

If we assume that the standard deviation of the two populations is limited and if we have a sufficiently large sample[12], if the null hypothesis is met, the test statistic written in

$$z = \frac{\overline{B} - \overline{L}}{\sqrt{\frac{s_B^2}{n_B} + \frac{s_L^2}{n_L}}} \tag{4}$$

form is of standard distribution with good approximation, where the numerator contains the arithmetic average of the HHI indexes of borrowing and lending, and s^2 in the denominator indicates the variance of the different samples, and n the number of sample elements (Hunyadi–Vita, 2008b).

Based on the calculations of *Table 1*, the value of the test statistic is much higher than the upper critical value both in terms of the volumes and the number of transactions. It is in the critical (or rejection) range, therefore the null hypothesis can be rejected at 99% confidence level, which means that the average concentration of the borrowing transactions was significantly higher than that of the lending transactions. The p-value is extremely close to 0, so the null hypothesis can be rejected not only at 1% significance level, but also at any generally used significance level. Thereby, the hypothesis (formulated in the introduction of this chapter) is successfully proven through a formal test.

12 Sample of 48 elements can already be considered a large sample.

Table 1
Examination of the average HHI difference of borrowing and lending with two-sample z-test

	Volumen	Tranzakciószám
Sample mean of lending ($\overline{L}$)	0.0844	0.0540
Sample mean of borrowing ($\overline{B}$)	0.1542	0.1220
Standard deviation of lending (s_L)	0.0178	0.0054
Standard deviation of borrowing (s_B)	0.0286	0.0157
Sample size of lending (n_L)	48	48
Sample size of borrowing (n_B)	48	48
Test statistic (z)	**14.3331**	**28.4172**
Upper critical value	**2.3263**	**2.3263**
p-value	**0.0000**	**0.0000**

Source: Own editing based on MNB data

Kolozsi–Horváth (2020) also examined the concentration of interbank loans and found that by the increase of additional liquidity (the saturation of the market with liquidity), the concentration of liquidity decreases. The authors also showed that in addition to the quantity of interbank liquidity, the distribution (concentration) of liquidity also significantly affects the average interest rate. The relative price was significantly higher in the case of higher concentration (the majority of liquidity is concentrated in few banks).

Furthermore, by the increase of additional liquidity, the aggregated transaction amount of the interbank market decreased, as due to the lower relative price of liquidity, the banks were less motivated to place their liquidity surplus on the interbank market.

4 SUMMARY

We described the most important characteristics of unsecured interbank credit transactions, of which the lack of financial collateral together with the significant volume (up to tens of billions of HUF) may create significant risk. This is due to the strong information asymmetry on the interbank market, credit rationing and short squeezing. Taken together, these phenomena may explain that in the interbank deposit market, unlike in many other markets, the most important factor is quantity adjustment rather than price adjustment (raising interest rates due to higher risk). Quantity adjustment is mostly achieved through partner limits.

Examining the database, the aggregate volume of transactions increased more than the number of transactions. One possible explanation for this phenomenon is that, in response to shocks to the interbank market, participants decided to reduce partner limits considered less reliable and to obtain the necessary funds from the few, most reliable players on the market.

For a deeper explanation of the quantity adjustment, we examined the concentration of lending and borrowing. Both the Gini and Herfindahl-Hirschman indices showed that borrowing was more concentrated than lending in terms of both volume and number of transactions. Loans were provided by an average of 10-15 active banks typically to only 5-8 borrowers in the period examined. We tested this observation by using a two-sample z-test for comparing expected values and confirmed a significant difference in concentration between the borrowing and lending sides of the interbank market, as expressed in our hypothesis.

The more even distribution of the lending transactions can be explained by the fact that structural liquidity surplus was typically experienced on the Hungarian interbank market in the past one and a half decades. The high concentration of the borrowing transactions derives from the partner limits and the quantity adjustment being stronger on the interbank market.

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SHALL WE RECONSIDER BANKING REGULATIONS?

Some lessons drawn from the failure of Silicon Valley Bank and Credit Suisse

Katalin Mérő[1]

ABSTRACT
The paper analyses the lessons related to banking regulations to be drawn from two banking failures in March 2023, the bankruptcies of Silicon Valley Bank and Credit Suisse. The two failures have questioned whether the regulatory system established following the 2008 crisis can guarantee the stability of the banking sector. The paper analyses four areas of regulations that have come to the fore linked to the two cases. They are the issue of applying the principle of "too-big-to-fail", and the regulations related to capital structure, banking book interest rate risk and liquidity risk. It is true for all four issues that the currently valid rules are not sufficient to guarantee stability and proper crisis management if banks have to face crises never encountered before. Banking regulations providing financial stability should strive to adopt a new approach instead of further hardening the current rules. A radical reduction of leverage or the introduction of central bank digital currency could become examples of such a new approach.

JEL codes: G21, G28

Keywords: banking regulation, bank crisis management, Silicon Valley Bank, Credit Suisse

1 INTRODUCTION

The bankruptcies of two banks shocked the financial markets of the world in March 2023. Firstly, deposit holders had a run on Silicon Valley Bank, the 16th largest in the USA, on 9 March. A week later it came to light the second largest Swiss bank, Credit Suisse had failed. Because of the two bankruptcies the question arises whether bank regulations basically reformed after the global financial crisis in 2008 are able to ensure banking stability. The objective of this paper is to take regulatory issues and the questions revealed by the two bankruptcies one

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by one and, reflecting to them, to try and draw lessons on the (non)suitability of current banking regulations.

In 2013, just 10 years ago an influential book was published by *Anat Admati* and *Martin Hellwig "The Bankers' New Clothes"* (Admati–Hellwig, 2013). The title clearly refers to the well-known story by Andersen, The Emperor's New Clothes. In the story, two swindlers posing as weavers make everybody believe they have a magnificent fabric, but it is invisible to those who are stupid or incompetent. Naturally, nobody wants to acknowledge incompetence, so they all praise the beauty of the non-existent fabric, including the emperor himself who has ordered a suit to be made from it. The situation only changes when a little boy blurts out that the emperor is naked. Admati and Hellwig believe that banks can successfully lobby for regulations advantageous to them because their operations are mystical for outsiders. Almost everybody accepts banks are special, so banking regulations are necessarily so complex that only few people can comprehend or see through them. They will not say the obvious, i.e., banking regulations allow taking excessively high risks, which serves the banks' rather than society' interests.

According to Admati and Hellwig, the reforms in banking regulations implemented following the 2008 global financial crisis are a far cry from what would be necessary to achieve the stability of the financial system. The new system of banking regulations is of a rather high volume, very much detailed and complex, so it is not sufficiently transparent even for experts. Still, if one looks at it in-depth, Admati and Hellwig think the problem simply is that banks operate with too much leverage, i.e., their capital is too little compared to the risks assumed. The authors believe 30 percent of total assets (not risk weighted) would be sufficient so that potential losses by the banks could be covered by shareholders' investments. Of that, 20 percent would be mandatory capital requirement while another 10 percent would operate like the current capital conservation buffer[2]. Such a change could not only enhance the banks' loss-absorbing capacity, but it could also reduce moral hazard driving excessive risk-taking by transferring a bigger portion of losses to the shareholders.

At the renewal of banking regulations following the 2008 crisis another path was opted for. A part of the logic of the earlier banking regulations striving to make the banking system operating with high leverage more resilient to risks was not given up. Within that, however, both the principles and techniques of the regulations have undergone major changes. The so termed Basel III system includes the

2 In addition to the mandatory capital requirement, banks should set aside a 2.5-percent capital conservation buffer from their profits. In loss-making times, the buffer could be used, i.e., the level of capital could be reduced while the bank could still meet its capital adequacy requirement.

new prudential rules supplemented with a revised framework system on bank resolution. The changes were manifold and of high volume. According to *Borio–Farag–Tarashev* (2020), they can only be compared to the regulatory measures following the 1929-33 Great Depression by their scale. The main idea of the renewal of banking regulations is to strengthen stability and resilience to shock; to make regulators consider exposure to systemic risk side by side with individual risks and, to that effect, to supplement the earlier micro-prudential regulations with macro-prudential elements, as well as to stop applying the principle of[3] "too-big-to-fail" (TBTF) (Borio–Farag–Tarashev, 2020; Mérő, 2012; *Móra*, 2019).

The new rules seemed to be satisfactory to ensure the stability of the banks and banking systems for a little more than a decade after the crisis. When the Basel Committee evaluated the new Basel III rules in 2021 in the light of the financial shock caused by the Covid pandemic (BCBS 2021), the main finding was the Basel reforms had reached their goal, they had solidified the resistance of the banking system to shocks. On the other hand, the Basel Committee emphasised that regulatory facilitation by regulators and support by central banks and governments during the Covid period had significantly dampened the shocks on banks, so analysing their resilience to shock was quite difficult. The Basel Committee published its first comprehensive impact analysis of Basel III rules in December 2022 (BCBS 2022). The report found that the banks' capital and liquidity had become stronger in the period following the implementation of Basel III, systemic risks had been reduced and fears of the new rules reducing the banks' loan supplies had not materialised. All that time Admati (2016) continued to argue the comprehensive regulatory reform implemented under Basel III was but a missed opportunity to establish a stable, well-capitalised banking system that could resist crises.

March 2023 was a turning point in the assessment of the appropriateness of the banking regulations. A classic run started on banks in the United States on 9 March. In a single day, deposit holders of Silicon Valley Bank withdrew USD 42 billion worth of bank deposits from the sixteenth largest US bank causing it to fail. Two days later deposit holders had a run-on Signature Bank, another US bank of a similar business model, then authorities had it closed down. The unsecured depositors of both banks received full compensation and the authorities declared to act in the same way if other banks would get into difficulties. A few days later Credit Suisse, which had been involved in numerous scandals for years, found itself in a state of bankruptcy because of a crisis of distrust. Credit Suisse

3 The TBTF principle says that the failures of large banks would jeopardize trust in the banking system and the operational safety of the financial system to such an extent that states will save them using taxpayers' money.

was the second largest bank in Switzerland, which belonged among the largest banks globally. To manage the crisis, the UBS, the largest Swiss bank bought it up.

The two bankruptcies warn it is possible that the system of banking regulations set up after 2008 has not given birth to a properly stable, highly stress resistant banking system. In the paper, the author is going to analyse the lessons drawn from the crisis of Silicon Valley Bank and Credit Suisse regarding bank regulations. She is seeking an answer to the question whether the regulations have some inherent faults or anomalies questioning the current regulatory system.

The paper is structured as follows: Part two is a summary of the two bankruptcies. Next, in part three, the regulatory anomalies revealed with respect to the two bankruptcies and their lessons are analysed. Firstly, the lessons drawn from an issue of regulatory policy, the persistence of the TBTF principle are summed up followed by pointing out the dysfunctional operation of three specific regulatory components during the crisis. They are the rules on capital structure, the regulation on banking book interest rate risk and the liquidity rules. The last part includes the lessons drawn from the cases referring to the initial question of whether a system operating with high leverage can be stable.

2 THE FAILURE OF SILICON VALLEY BANK AND CREDIT SUISSE

The time passed since the collapse of the two banks has been too short to present and assess their story systematically. The events and the banking risks behind them can mainly be pieced together from news items, newspaper articles and bank reports. Still, some quick comprehensive assessments are available now, a month after the events (*Danielsson–Goodhart*, 2023; *Dewatripont–Praet–Sapir*, 2023; *Király*, 2023; *Metric–Schmelzing*, 2023).

2.1 Silicon Valley Bank (SVB)

What happened in March 2023 can be regarded a classic run on the bank in the sense that as soon as rumours had spread among depositors the bank might be in trouble all depositors (holding uninsured deposits) wanted to withdraw their money. What was specific and made the situation particularly grave was the asset and liabilities composition of the bank. The liabilities of the bank mainly consisted of deposits by the start-up companies of Silicon Valley and (also start-up) firms engaged in issuing American crypto currencies.

Promising start-ups flourished when interest rates were low; they could attract lots of money easily, so those deposit portfolios had been growing fast until 2021.

According to its 2022 consolidated report (which was posted on the internet on 4 March 2023, a week before the run), the bank possessed USD 81 billion non-interest bearing and USD 92 billion interest bearing deposits (mainly sight deposits, term bank account deposits, and money market deposits). Of them, 151.5 billion, i.e., 88 percent of the deposits was uninsured (Silicon Valley Bank, 2023). Uninsured depositors, for instance, had learnt that Circle, the issuer of the second largest stable coin[4] (the USDC) held USD 3.3 billion out of the USD 40-billion collateral of the stable coins it issued in SVB as deposit. The high uninsured deposit portfolio, the concentrated deposit structure, and the channels of immediate flow of information to professional depositors and social media made the banking panic unexpectedly fast, practically, immediate. It is no accident that *Patrick McHenry* the chairperson of the House Financial Services Committee termed the panic "the first Twitter-induced" run on the bank" (McHenry, 2023).

The asset structure of SVB was also special. It had had no bad loans; it had not invested into risky enterprises. Its loan portfolio was a mere third of its balance sheet total. Long term bonds of US Government Sponsored Entities (GSE) had made up most of its assets. SVB had purchased those in a period of low interest rates, so it could gain interest income. A bit more than 20 percent of the bonds were in its trading portfolio and less than 80 percent were held until maturity. The difference between the two is that the trading portfolio must be recorded at daily market rate, but the portfolio intended to be held until maturity is posted at amortised cost[5]. The reason for that is a portfolio held until maturity will only have unrealised profit/loss, the total nominal value is paid back on maturity. At the end of 2022, the duration of the SVB portfolio held until maturity was 6.2 years (Silicon Valley Bank, 2023).

Obviously, the bank will have latent loss if interest rates grow, as its bond portfolio is devalued and raising deposit interest rates may also cause a loss because of the poor income-generating ability of the bonds. Such risks can be hedged on the market, which a bank operating with such high exposure must be aware of. According to its 2022 Annual Report, however, SVB failed to hedge its portfolio segment held until maturity, while most hedging transactions covering its trading portfolio had expired in 2021 and were not renewed in 2022.

4 Stable coins are digital crypto instruments with their value pegged to an official currency. It is the US dollar for USDC. The co-movement of a stable coin and the dollar is guaranteed because the stablecoin has 100 percent liquid asset cover. In the case of USDC the cover comprises 77 percent of short-term US treasury bills and 23 percent of bank deposits. 3.3 billions' worth out of the USD 9.7 billions' worth bank deposits had been placed with SVB and then withdrawn before frozen (Cf, Circle report:)

5 Amortised costs mean the acquisition costs minus capital repayments received and credit losses.

All that can only cause bankruptcy if depositors start withdrawing their funds. To be able to satisfy its depositors, first the bank must sell its trading bonds portfolio and then also the bonds it intended to retain until maturity and were posted at amortised value. One can only sell at market value, which meant amortised value less about 20 percent because of interest rates raised by approximately 400 bpp and 6.2 years of duration, so mass sale results in realised loss or bankruptcy in an extreme scenario. The bank's professional investors were aware of this, that is why they had a run on the bank, which in fact caused it to fail.

Thus, the highest risks the bank had assumed had been excessive maturity transformation (financing long-term GSE bonds from sight deposits) and high unsecured interest rate risk in the banking book, which had become unsustainable as inflation started and the FED raised interest rates in response.

Following the panic and the closure of the bank, the US Department of Treasury, the FED and the deposit insurer (FDIC) published a joint statement on 12 March declaring that all depositors could access their money beginning from Monday, 13 March to restore public trust in the banking system (Treasury–FED–FDIC, 2023). In addition to SVB, the measure also covered Signature Bank. The statement also said shareholders and some uninsured bond holders would not be saved. To avoid further bank panic, the FED also published another statement at the same time with the joint statement (FED, 2023) announcing the establishment of a new Bank Term Funding Programme . Under it, banks will be granted loans of not more than one year maturity so that the U.S. Treasuries and other qualified bonds will be accepted as collateral at nominal value. Silicon Valley Bank was acquired by First Citizen Bank, the 30th largest in the USA considered to be a medium-sized bank before the transaction. The sale agreement was published on 27 March.

2.2 Credit Suisse

Credit Suisse had been struggling for years. It had financed several scandalous issues, bankrupt companies, or had sold their bonds as low-risk instruments to clients of its asset management business. The bankruptcies of Greensill Capital and Archegos Capital Management early in 2021 had the loudest echo. Side by side with its asset managed clients, Credit Suisse itself had a high exposure to the two companies. As a result of bad investments and the scandals, the funds managed for the clients had been diminishing on the one hand, and on the other hand, the asset management business had accumulated large losses. To solve the problems, the bank launched a major reorganisation programme in October 2022. Although the decline of share prices stopped in December, the outflow of the asset management portfolio entrusted to the bank continued even in Q4 2022. Still, the market

trusted reorganisation so much so that a CHF 4-billion capital increase could stabilise the bank's balance sheet. The capital increase had mostly come from Saudi National Bank, which had become the largest shareholder in Credit Suisse holding 9.9 percent, while the bank's earlier shareholders had also added their part.

The 2022 Annual Report was published in 14 March 2023 just when the US markets started to relax as a result of the FED intervention, but the atmosphere on global financial markets was still quite tense. According to the Report, the bank, which had already posted losses of CHF 1.6 billion in 2021, increased its losses to CHF 7.3 billion in 2022. In addition, the auditor's report by Price Waterhouse Cooper (PwC) found the bank's risk management processes were not suitable to identify and analyse risks, and the internal control system also had shortcomings (Credit Suisse 2023:258-III). As a result of the Annual Report, the bank's share price started to fall. At that point (on 15 March) an infamous interview took place with the president of the Saudi National Bank, who said he was unwilling to invest any more funds into Credit Suisse, after which the bank's share price plummeted by 24 percent in a day. The Swiss Central Bank and the Banking Supervision published a joint statement the same evening (SNB–FINMA, 2023), to the effect that Credit Suisse was compliant with regulatory requirements of capital and liquidity, but – if necessary – the Central Bank would provide it with liquidity.

However, those measures were insufficient to restore trust in the bank, money continued to flow out over the following days (both regarding deposits and the asset management portfolio). From there, events accelerated: the plan and the decision that USB the largest Swiss bank would acquire Credit Suisse was born at the weekend of 18-19 March. The acquisition rate became 0.76 cent/share, i.e., 40 percent of the pre-closure price of CHF 1.86. At first, 0.25 cents then 0.5 cents were mentioned in the news, bargaining with the largest shareholders may have been ongoing in the background. The shareholders of Credit Suisse received no money but were compensated in the form of UBS share exchange. The Swiss state provided guarantees of CHF 9 billion to support the success of the transaction and the Swiss National Bank opened a CHF 100-billion liquidity facility. On the other hand, holders of bonds that ranked among the bank's core capital elements by Basel III rules (the so termed AT1 bonds) were not compensated, they had lost all their investments. A part of those bonds was convertible to equities, but no conversion took place under the acquisition. In that way, a weird situation arose: holders of AT1 bonds lost more on their investment than the bank's shareholders, although - in theory - shares are the riskiest form of investment.

3 REGULATORY ANOMALIES AND LESSONS

3.1 The question marks of the TBTF principle

Following the 2008 global financial crisis, the institutions responsible for financial stability set the elimination of the application of the TBTF principle as the goal in addition to the renewal of prudential regulation. Prior to the 2008 crisis, banks had grown so large that saving them from a potential bankruptcy would have been impossible for a single state. Therefore, *Demirgüç-Kunt* and *Huizinga* (2013) argued the largest banks were not too large to fail but too large to be saved, so the principle of "too-big-to-fail" should be replaced by "too-big-tobe-saved". There were 30 banking groups in 2008 with liabilities exceeding 50 percent of their country's GDP. The largest of them was USB in Switzerland with commitments of 3.7 times the Swiss GDP. The Credit Suisse Group was third on the list, its commitments amounted to 2.2 times the Swiss GDP (Demirgüç-Kunt–Huizinga, 2013, Table 1). The Icelandic banking crisis in 2009 is a practical example of how banks can grow too-big-to-be-saved by the country they reside in. Thus, reforms after the 2008 crisis took different directions to eliminate or at least mitigate taxpayers' burden originating from the application of the TBTF principle or the moral risks encouraging banks to take excessive risks on the assumption that the TGTF principle will be applied.

Regulatory thinking to eliminate or at least radically confine TBTF set off after 2008 along four paths after 2008 (*Barth–Wihlborg*, 2016). They were the following:

1. Limit the growth of banks. Banking regulations after the USA crisis, the so termed Dodd-Frank law banned bank mergers if the deposit portfolio of the emerging bank would exceed 10 percent of the total US secured deposit portfolio except if the merger was linked to crisis management (Congressional Research Service, 2018). Still, as the case of SVB and Signature Bank shows, the size effect of the application of the TBTF principle can be much lower if authorities are worried about the impact of contagion. No such regulation has been introduced in Europe.
2. Enforce stricter rules related to the banks affected to ensure bigger loss absorbing capability. This category includes excess capital requirements or stricter regulatory requirements related to banks that are of key importance from the aspect of systemic risk. Basel III rules identify G-SIB, i.e., the group of banks of key importance from the aspect of global systemic risk and stipulate excess capital requirements for them. This, on the one hand, will improve the ability of the banks' capital to absorb losses and, on the other hand, reduces the

moral hazard encouraging excessive risk taking rooted in TBTF by making capital more expensive. The Financial Stability Board (FSB) publishes the list of G-SIB banks every year including the capital buffer to be applied subject to their size. The latest 2022 list includes 30 G-SIB banks including Credit Suisse (FSB, 2022). In addition, the EU allows macro-prudential supervisory authorities to require capital buffers in the case of other credit institutions of systemic importance.

3. Introduce operational restrictions banning that a large group of financial activities be conducted within the same institution. In the US, the Dodd-Frank Act contains similar regulations; they are jointly termed the Volcker Rule. Under it, US banks are prohibited from engaging in proprietary trading and they cannot own or invest in hedge funds or private equity funds. This, in fact, meant the restoration of the relevant provisions of the Glass-Steagall Act adopted after the 1929–1933 crisis and repealed in 1999 (Congressional Research Service, 2018). Rules restricting banking operations have been placed on the agenda in Europe as well and several Member States introduced restrictions. The EU Commission, however, withdrew its proposal on the introduction of so termed structural reforms in 2018 on the basis that, on the one hand, no agreement could be achieved on the issue and, on the other hand, other reforms introduced and the establishment of the Banking Union had rendered them unnecessary (European Parliament, 2023).
4. Restructure the system of bank resolution. Under it, banks must set up recovery plans and the related decision-making mechanisms to be immediately activated if needed. In addition, to mitigate (or, according to more ambitious ideas, eliminate) the burden on taxpayers arising during resolution, the concept of "bail-in" was introduced to replace the earlier "bail-out". It means banks will be saved by using, at least partly, bank sources (liabilities in the form of uninsured deposits) rather than government budgets. How the bail-in system operates is introduced in the next part. Under it, AT1 bonds can be recalculated as equity capital and can be written off or converted in the case of loss.

As regards SVB and Credit Suisse, only Credit Suisse seems at first sight to be a large bank carrying systemic risk, i.e., TBTF. Although SVB grew fast in 2021, it could not be considered a large bank. Still, the TBTF principle was used to save both banks. The two cases prove that removing the TBTF principle from banking policies, a basic regulatory target after the 2008 crisis, was not successful. If regulatory authorities are worried about spreading the crisis, they continue to accept TBTF as the single effective solution. It has also become clear that the G-SIB buffer is but a beauty spot for a bank the size of Credit Suisse, as its loss-

absorbing capacity can only compensate for lower falls. It may reduce the moral hazard caused by TBTF by making the average financing costs of large banks more expensive, but it is not enough to ensure bank stability.

SVB as a US bank supervised as a non-large bank did not need to have a recovery plan. Credit Suisse obviously did have such a plan and procedure, established, and probably practiced, but extremely fast market response and suddenly swelling problems did not allow them to be set off; immediate resolution had to be used to help. Bail-in was actually applied, but this does not only prove there is less need of using taxpayers' money but also that the instances when bail-in must be applied have not been properly identified. In other words, three out of the four principles aimed to confine TBTF (limitations on size, better loss-bearing ability and a reformed system of resolution including the use of recovery plans and bail-in) have not proved to be sufficiently effective or functional.

Lacking the introduction of operational limitations was the only one of the four elements that had no part to play in the actual situation. The collapse of Credit Suisse was largely the outcome of its investments but not through its proprietary trading rather than the irresponsible use of clients' investments it managed. Scandalous investments first caused huge losses of the asset managed portfolio, then the reduction of the portfolio, the absence of the relevant fees and commissions and the plunge of share prices because of the loss of confidence contributed to the bank's failure.

It is also evident that as UBS acquired Credit Suisse, a huge bank has come into being that is obviously TBTF, since its potential failure would cause major disturbance in the operation of not only the Swiss but also of the global financial system.

3.2 Regulate capital structure

Strengthening banks' capital was one of the strongest expectations related to the system of banking regulations following the 2008 crisis, i.e., banks should have adequate capital both in quantity and quality. Accordingly, the regulations identify three types of bank capital having the following features and required minimum values (BCBS, 2023):

1. *Common Equity Tier1, CET1.* CET1 capital must cover at least 4.5 percent of a bank's total risk exposure. Taking into account the capital conservation buffer, the required level of CET1 capital is 7 percent. This category includes the bank's ordinary shares, the related premiums and the reserves from profit after taxes. CET1 capital is able to bear bank losses on a going concern basis.

2. *Additional Tier 1 capital, AT1.* It comprises so termed hybrid elements issued in the form of perpetual bonds, but – similarly to CET1 capital – can absorb losses in going concern situations. The total value of CET1 and AT1 capital must be at least 6 percent of the bank's total risk exposure, i.e. 8.5 percent including the capital conservation buffer. Hybrid instruments can be included in bank capital on condition that AT1 bonds can either be converted into ordinary shares or written off if the bank's CET1 capital falls below 5.125 percent or if it becomes necessary for another pre-defined reason. The conversion or write-off must be to such extent that the primary core capital index reaches 5.125 percent.
3. *Tier 2 capital, T2.* This category includes capital items that will absorb loss in the event of a potential liquidation (gone concern) so that they are junior to the bank's creditors nd senior only to Tier 1 capital owners in case of a winding-up procedure.

The case of Credit Suisse has raised the issue of the hierarchy of capital items and the part they play in loss-bearing. Had Credit Suisse been liquidated, shareholders clearly would have been at the end of the queue in the rank of satisfaction, immediately preceding the owners of AT1 capital items. However, acquisition by USB had created a weird situation, i.e., holders of AT1 bonds received no compensation, while shareholders were given USB shares. The Basel documents provide no guidance for such situations. However, the hierarchy of capital items or the essence of capital would logically yield that the holders of ordinary shares are the ultimate loss bearers that can only get their money when everybody else has already been satisfied. Naturally, holders of AT1 bonds are aware they have purchased high-risk investment; that is why the interest rate paid on AT1 bonds by Credit Suisse was outstandingly high, 9.75 percent. Still, it does not mean their bonds are riskier than ordinary shares. The rules on write-off of AT1 bonds are clearly ambiguous, for instance, what "going concern" loss absorptionmeans in an acquisition.

A joint statement was published on 20 March 2023 by the Banking Supervision of the European Central Bank, the Single Resolution Board of the EU, and the European Banking Authority (ECB–SRB–EBA, 2023). They emphasise that, according to the bank recovery regime of the European Union, ordinary shares are primary bearers of losses and the write-off of AT1 bonds can only occur if shareholders cannot bear any more losses (because they have been written off to zero). The statement also advises the above will be applied in future if banks in the EU are resolved. The statement was quite important because if it is possible that AT1 bonds bear higher losses that ordinary shares, the market of AT1 bonds will become untenable.

It is another question whether the happenings on 18-19 March can be regarded as triggers for the write-off of AT1 bonds since the share price rather than the capital adequacy of the bank had collapsed. Credit Suisse, like SVB, may have been forced to sell assets later due to the loss of confidence and the loss from the fire sales resulting in a loss would have undermined its equity position, but that did not happen. According to its 2022 Annual Report, its CET1 capital adequacy ratio was 14.1 percent on 31 December 2022. However, there are softer options for a potential write-off of AT1 bonds, the circumstances of which may be questioned. Several proceedings are expected to be launched about whether AT1 bonds could have been written off and their outcome will influence if the market of AT1 bonds survives or not.

3.3 Regulate interest rate risk in the banking book

As one could see when the factors leading to the fall of SVB were presented, the number one cause of its failure was the bank held in its books a high volume of low-interest, long-term government bonds to be held until maturity. As interest rates increased, a huge latent loss was generated (which turned into actual loss when those bonds had to be sold), i.e., the interest rate risk in the banking book was high. In the Basel regulatory framework interest rate in the banking book belongs to the so termed second pillar risks, i.e., there is no mandatory capital requirement to cover it; banks only must allocate capital subject to the findings of supervisory review.

An additional problem with respect to SVB is that small and medium-sized banks are not in the scope of the Basel regulations in the USA, so the requirement does not affect them. But let us forget about this now and let us see what would have happened if SVB had been subject to the stricter Basel regulations or if a European bank had been in a situation similar to that of SVB. The regulatory framework of interest rate risk in the banking book is included in the relevant Basel Standard (BCBS, 2016), in CRD in the EU[6] and the guidelines of the European Banking Authority (EBA) based on it (EBA, 2022a and 2022b). Accordingly, all banks must have a system assessing interest rate risk in the banking book, which also includes background principles, methods of measurement and risk limits. Banks also must prove they have adequate capital to cover losses from potential interest rate changes. As an important part of the regulation on interest rate risk in the banking book is that banks must perform interest rate risk stress tests at least annually but more frequently if the volatility of interests or the exposure of the bank

6 Directive 2013/36/EU.

to interest rate risk in the banking book increases. The supervisory authorities of different countries may require more frequent stress tests too, MNB for instance, requires them to be performed at least quarterly (MNB, 2022). Side by side with stress tests by the institutions, supervisory authorities also perform stress tests regarding interest rate risk in the banking book, which are termed supervisory outlier tests - to differentiate them. Their specific goal is to inform the supervisors which banks are extremely exposed to interest rate risk in the banking book.

The Directive expects interest rate risk in the banking book to be analysed as per six scenarios. They are the following: 1-2) parallel shift of the yield curve downward or upward; 3) yield curve becoming steeper (short-term interest rates decrease, long-term interest rates increase); 4) yield curve flattening (short-term interest rates increase, long-term interest rates decrease); 5-6) increase or decrease of short-term interest rates. The Directive assigns three shock-related measures to the six scenarios.[7] The Basel Committee and likewise the EBA guidelines identify, broken down by currency types, the interest rate shift at which stress tests must be performed for each type of shock. For instance, for USD, 200, 300 and 150-bpp stresses belong to the yield curve's parallel, short, or long shocks. In EUR, they are 200/250/100 bpp. USA regulators require banks in the scope of Basel rules to perform stress tests at 200 bpp. Based on the findings of their own and supervisory stress tests, banks must allocate excess capital to cover interest rate risk in the banking book if the findings show high exposure to it. In the case of SVB, one cannot speak of a short shock, as the problem had been generated by the increase of long-term interest rates. Both BIS and EBA would recommend applying the 200-bpp stress scenario in such a case.

To sum up, interest rate risks in the banking book belong to risks mandatorily regularly measured and managed by large banks in the US and by all banks in the EU. However, supervisory and possibly bank stress scenarios expected stress tests to be performed at lower values than what the actual (really extreme) USD interest rate increase was like. In fact, regulations recommend that banks should use a higher stress scenario if necessary, but as supervisory reviews are carried out by annual plans, there is a good chance it would not have happened in another country either or would have happened immediately before the supervisory review only. In other words, stress tests do not always provide proper protection against extreme, large, and rare interest rate changes.

7 The three possible forms of the yield curve shift one must consider are: parallel, the shock appearing on short-term maturity and the so termed long shock to be applied if the yield curve becomes steeper or flatter.

3.4 Liquidity rules

There had been no global liquidity rules prior to the 2008 crisis. There were countries where banks had to comply with specific liquidity requirements, but it was not a general expectation. In the Basel II framework, liquidity risk as well as interest rate risk in the banking book belonged to second pillar risks, and the regulated management of liquidity risks in observance of proper procedures was in focus. It is true supervisory authorities could have, in principle, require capital to cover liquidity risk under Pillar 2, but there was consensus that liquidity risks could not be managed via capital adequacy. However, the markets dried up after the Lehman Brothers' failure in September 2008; banks operating with high money market exposure met with major difficulties, which drove regulators to renew liquidity rules (*Rochet*, 2008). In response to the crisis, the Basel III regulation requires banks to comply with two mandatory liquidity ratios. The new ratios belong to the toolset of macro-prudential regulations, as inter-bank borrowing allows individual banks to manage liquidity shortage. However, bank liquidity buffers may help maintain liquidity if market disturbances arise and there is no access to inter-bank markets.

The first ratio, liquidity coverage ratio (LCR) is a short-term one that is meant to ensure a bank has a liquidity buffer of a suitable size, i.e., a volume of high quality liquid assets, which ensures survival in a stress situation if owners withdraw volatile sources from the bank. LCR rules define the net cash outflows to be calculated and the eligible liquid assets for coverage.

Analysing SVB from the aspect of compliance with LCR, the first question is whether the deposits of start-up companies should be considered when net cash outflow is defined. According to the Basel guidelines (BCBS, 2013), the part of deposits of non-financial undertakings that have been deposited with an operational purpose (i.e., the depositor deposited them in order to use cash management or some other service) must be taken into account multiplied by 25 percent and the part with a different purpose by 40 percent for calculating cash outflow. We do not know the structure of the deposits placed with SVB. However, due to their big concentration, one can assume start-up deposits would be in the 40-percent outflow category, i.e., no more than 40 percent liquid assets should be set aside for them. The deposits by banks, investment companies, insurers and other financial undertakings have a 100-percent outflow factor. Stable coin issuers (like the Circle with large deposits with the bank) are also categorised as non-financial undertakings, the 40-percent factor relates to them. The second question is how many liquid assets SVB had. LCR rules do not differentiate assets in the trading book (held for sale) from assets in the banking book (to be held until maturity). According to Basel III regulations, instruments issued by GSEs belong to level 2A

high quality liquid assets. These assets can account for up to 40 percent of total eligible liquid asset holding. Thus, although the LCR ratio would have indicated that there was a potential short term liquidity problem for the bank, it would have been significantly underestimated.

The other liquidity ratio, net stable funding ratio (NSFR) formalises a requirement of a one-year time horizon, i.e., the bank finances long-term assets from long-term sources. To calculate the ratio, the required stable funding (RSF) must be defined subject to the composition of the assets and the bank must possess at least the same quantity of available stable funding (ASF). In other words, the level of AFS must reach 100 percent of RSF. Under the NSFR regulation (BCBS, 2014), level 2A high quality liquid assets are assigned at 15 % RSF factor, i.e. 15% stable funds should be allocated behind them. . For AFS calculations, 50 percent of the short-term deposits by non-financial undertakings can be considered as sources. In other words, in the case of US GSE bonds the Basel and EU rules stipulate 15 percent stable funding, which the funding "stable" deposits (to be considered at 50 percent) exceed several times. To sum up, what one can see is that under the Basel III liquidity rules, the NSFR would have indicated no liquidity problem at all for SVB Bank, while the LCR would have indicated a much smaller liquidity problem than the actual one.

4. LESSONS DRAWN

In the paper the lessons drawn from the regulations becoming known during the failure of SVB and Credit Suisse were analysed. A particular significance of the issue is that the system of banking regulations has been transformed following the 2008 global financial crisis both in terms of regulatory principles and actual techniques.

Four regulatory tools were analysed in the paper. All of them were adjusted as seen in the toolset of banking regulations implemented after 2008, and one could be reassured they would be suitable to reach the regulatory targets. However, the current regulations on all four issues have been found lacking and unable to guarantee the stability of banking systems, to be resilient vis a vis crises and to resolve potentially emerging crises in an orderly manner by applying pre-defined rules without using taxpayers' money. In relation to all the four issues it is documented that the new regulations might have been effective to prevent earlier crises had they been available at the time, however, they proved to be inadequate to solve a crisis which was somewhat different.

Rather than eliminating the TBTF principle, it was applied in the case of both banks, although the case of the much bigger Credit Suisse alone justified the in-

volvement of taxpayers' money. During the crisis management, the mandatory recovery plans were not applied. SVB probably had no such plan anyway, because the rules relating to large banks were not pertinent to it, while Credit Suisse had no chance to apply the plan because of the rapid rate at which the crisis evolved. It was also evident the higher capital adequacy requirement linked to G-SIB status was much lower than the necessary capital level. Thus, the elimination of TBTF, a primary objective of bank regulation, cannot be called a success story.

With respect to the issues of the actual technical regulatory measures having become known, although they can be described as grand and ambitious and they are much stricter than their predecessors before 2008, they are still unsuitable to manage the relevant risks. Stricter and harder equity rules were thought to be well designed; the cases and ranking of the use of the different Tier capitals seemed to be unambiguous. However, they did not prove to be unambiguous in a live situation. As for the capital requirement to cover interest rate risks in the banking book and the related stress tests, they proved to be quite under calibrated. They did not consider a situation like the current interest rate increases while interest rates do fluctuate highly from time to time. It can be argued whether such situations should be managed by compliance with the interest rate risk in the banking book-related capital requirement (probably not) or some quite different tool should be found. Finally, the analysis of liquidity regulations with respect to the SVB case made it clear that NSFR ratio was completely inadequate and the LCR ratio partially inadequate to provide a timely indication of liquidity problems.

What lessons can be drawn from all that? One can mainly say very complicated rules that need a lot of calculations and procedures may create the illusion of everything being well regulated. Until the next crisis hits, they can depict banks as well capitalised, liquid, resilient to shock - if they are gauged in line with the rules. However, as soon a shock occurs following an unexpected never-seen-before scenario, the illusion will easily disintegrate. It turns out we see the new clothes of banking regulations beautiful as long as we want to. And then suddenly, something breaks the fog, the new clothes are but an illusion. And with that one can return to the question raised by Admati and Hellwig; i.e., can banks operating with high leverage be stable at all? Another solution has been shaped that may be suitable for the management of risks since Admati and Hellwig made their proposal to radically reduce leverage. Since they formulated their proposal for radical deleveraging, one more potential solution emerged that may adequately address the risks involved. It is the introduction of central bank digital currency (CBDC). According to the CBDC proposal, commercial banks will not create money, instead, all payments in the economy are made with the digital instruments issued by the central bank, which will, in that way, guarantee full liquidity of the payment system for all times. The world's central banks are working hard

to implement the idea (*Boar–Wehrli*, 2021), including the project of the digital Euro by the European Central Bank[8], but it certainly will not become reality soon (Danielsson–Goodhart, 2023).

The failure of the two banks studied warn that bank regulations though looking to be strict cannot eliminate the impulse of assuming extreme risks and the moral hazard boosted by deposit insurance in the case of banks operating with high leverage and when short-term liquid bank deposits or money market sources finance bank assets.

Regulatory responses are expected to relate to the transformation / expansion / re-calibration of actual rules, for instance, increasing the outflow coefficients of the LCR, or raising interest rate changes in the stress scenarios applied for the capital requirement for interest rate risks in the banking book, or re-regulating liquid assets. All those measures, however, fail to raise the primary question, i.e., whether the current operating models of the banking system are suitable to meet the expectations formulated for banking regulations. I believe a regulatory environment ensuring the stability of banking systems or the radical reduction of leverage recommended by Admati and Hellwig can be the solution by reducing the banks' inherent moral hazard through increasing shareholders' risk assumption, or the introduction of CBDC. Until one or another of them takes place, banking crises will remain with us in an increasingly complex, over-regulated environment.

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THE ROLE OF FUNDAMENTAL UNCERTAINTY IN ECONOMICS AND DECISION-MAKING

Iván Bélyácz[1]

ABSTRACT
The subject of this paper is the direct influence of uncertainty on economic decisions. The first part is a historical overview of the use of probability as a decision-making tool. The second part explores points of connection between Keynesian economics and uncertainty. After the discussion of epistemological and ontological uncertainty, the substance of fundamental uncertainty is elaborated. A separate section is dedicated to the role of 'animal spirits', conventions and 'black swan' phenomena. The closing section focusses on atomic and organic interrelationships in the economic material, the relation between complexity and uncertainty, and with the triangle probability-uncertainty-econometrics.
The aim of the paper is to substantiate that uncertainty – whether it is termed 'fundamental', 'radical', 'irreducible' or else – is unavoidably and inevitably part of economic reasoning and decision-making.

*JEL codes:*B26, D81, E12, G00, G11

*Keywords:*fundamental uncertainty, Keynes, decision-making, probability, economics

Motto:

'One needs to exit doubt in order to produce science – but few people heed the importance of not exiting from it prematurely. […] It is a fact that one usually exits doubt without realizing it. […] We are dogma-prone from our mother's wombs.'

17th century philosopher *Simon Foucher* cited in *Taleb* (2007:153)

'In economics, it appears we exited doubts too often without realizing neither the doubt nor the fact that we were prematurely exiting it.'

Mennella, 2005/2006:69

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1 INTRODUCTION

The subject of this study is the direct influence of uncertainty on economic decisions. Uncertainty has acquired different names in economic discourse, such as 'fundamental', 'radical', 'deep', 'true' or 'irreducible'. (In our discussion, these adjectives will be used synonymously, without any difference in meaning.) As uncertainty is central to *Keynes*'s theory in his foundational economic works (*A Treatise on Probability* – TP and *The General Theory* – GT), we will draw heavily on his ideas.

Just like in Keynes's time, the world of today is permeated by non-measurable uncertainty instead of quantifiable stochastic risk. Fundamental uncertainty may be even more acute now than any time in the last few decades as we have entered an era in which politics once more tries to take control over economics in shaping market outcomes, without political variables being involved in prognosis.

In his book, *King* (2016) describes radical uncertainty as 'uncertainty so profound that it is impossible to represent the future in terms of a knowable and exhaustive list of outcomes to which we can attach possibilities.' It is pointed out that the concept of radical uncertainty is especially useful in describing the challenges of a world of polarisation, populism and politics.

As King (2016) also notes, it is not a new concept. Economist usually refer to it as 'Knightian uncertainty', a term introduced in Knight (1921), where he made a distinction between uncertainty and risk. The latter is quantifiable by attaching probabilities based on experience or statistical analysis, while uncertainty – which is essentially unmeasurable – may be represented as an unknowable unknown.

Knight (1921:223) called statistical probabilities that are not *a priori* or empirical 'true uncertainty', or referred to them as an 'estimate' or an 'intuitive judgment' in other instances. As he puts it, business decisions concerning production and the market, for instance,

> '*deal with situations which are far too unique, generally speaking, for any sort of statistical tabulation to have any value for guidance. The conception of an objectively measurable probability or chance is simply inapplicable*' (Knight, 1921:231)-

Feduzi–Runde–Zappia (2014) note that while Keynes (1921) did not explicitly make a distinction between risk and uncertainty, he addressed situations in which numerically definite probabilities can be determined (analogous with Knight's definition of risk) and situations in which only non-numerical representations are available (analogous with Knight's definition of uncertainty).

Just like Knight, Keynes argues that numerical probabilities are restricted to chance-based set-ups, where determination is based on equal probabilities as in

fair games of chance, or where statistical frequencies can be determined with more or less homogeneous trials. Apart from these examples, probability does not exist or cannot be determined numerically.

While mainstream neoclassical economics endorses Knightian risk measured by probabilities, it is proposed that

> '*for a "rational" man – all uncertainties can be reduced to risks [as] the feeling has persisted that [...] people tend to behave "as though" they assigned numerical probabilities [...] to [all possible] events*' (*Ellsberg*, 1961:645).

The aim of this paper is to substantiate that uncertainty – whether it is termed 'fundamental', 'radical', 'irreducible' or else – is unavoidably and inevitably part of economic reasoning and decision-making. In his major article, Mirowski's (1989) point of departure is that determinist models of neoclassical economics in the last third of the 19th century were based on analogies borrowed from physics[2]. But the very beginning of the 20th century ushered in a paradigm shift in physics. It culminated in the origination of quantum mechanics in the 1920s, prompting a move towards stochastic principles.

Neoclassical economics was faced with an important choice at the turn of the century:to stick with the determinism of physics, or to abandon it for the methodology of probability-based stochastic formalisation. *On the example of uncertainty, this paper offers – in addition to a textual analysis of primary sources – a historical reconstruction within a comprehensive contextual framework.*

To provide a plausible argument for the inevitability of uncertainty in decision-making, not only the primary forms of uncertainty and responses to them must be elucidated, but also its deeper theoretical roots. The underlying hypothesis of this paper is that uncertainty can be explained by the organic (as opposed to the atomic) nature of the economic system, the laws of complexity of the system and by interdependencies between economic agents.

The argumentation also seeks to show that to date, neither economics nor decision theory have provided any comprehensively reassuring answer to managing uncertainty. The discussion will reveal how Keynes's economic principles, based entirely on the assumption of uncertainty, come in conflict with the paradigm of econometrics. That conflict is undoubtedly connected to the problematic interpretation of the scientific status of economics. Keynes advocated that economics was 'moral science', separating it from the natural sciences.

2 Authors of the Marginalist Revolution of the 1870s mainly relied on knowledge from engineering, directly appropriating the formalisms of 19th century energy physics. Marginalists rephrased the physics of energy into the social mechanics of utility, embracing the determinist doctrine. As a result, classical determinism was set on a scientific footing (Mirowski, 1989:218).

2 A HISTORICAL OVERVIEW OF THE USE OF PROBABILITY AS A DECISION-MAKING TOOL

Marginalists (*Jevons*, *Walras*, *Edgeworth*) subscribed to determinism, conflating the notion of classical determinism with scientific explanation. Mirowski (1989) highlights that this also meant adherence to a static theory inasmuch the adoption of the metaphor of utility – as potential energy – was intertwined with the classical deterministic posture which equated scientific causal explanation with mechanical prediction. The neoclassical economists mentioned above adopted metaphors from physics for 'scientific legitimation', however, their deterministic conception had lost its appeal by the turn of the 19th to the 20th century[3].

Moore's (1903) relevant criticism is as follows:

> *'In the closing quarter of the last century great hopes were entertained by economists with regard to the capacity of economics to be made an "exact science". According to the view of the foremost theorists, the development of the doctrine of utility and value had laid the foundation of scientific economics in exact concepts, and it would soon be possible to erect upon the new foundation a firm structure of interrelated parts which, in definiteness and cogency, would be suggestive of the severe beauty of the mathematico-physical sciences. But this expectation has not been realized. […] The explanation is found in the prejudiced point of view from which economists regarded the possibilities of the science […]'* (Moore, 1914:84–85).

At the same time, Moore (1914) was sceptical about the mathematical foundation of economics, which is illustrated well by the passage below:

> *'It was assumed gratuitously that economics was to be modeled on the simpler mathematical, physical sciences, and this assumption created a prejudice at the outset both in selecting the data to be investigated and in conceiving the types of laws that were to be the object of research. Economics was to be a "calculus of pleasure and pain," […] a "social mechanics," a "physique sociale." The biased point of view implied in these descriptions led to an undue stressing of those aspects of science which seemed to bear out the pretentious metaphors. One would naturally suppose from this manner of conceiving the science that the economic theorists would at once have entered upon their task with the methods that had proved themselves useful in the physical sciences. […] They seemed to identify the method of the physical sciences with experimentation, and since, as*

3 Mirowski (1989: 222) calls it a curious aspect that Marginalists in the last thirty years of the 19th century (Jevons, Edgeworth, Bowley), and also Keynes from the beginning of the 20th were instrumental in the development of probability theory and statistics.

> *they held, scientific experimentation is impossible in social life, a special method had to be devised. This invention was a disguised form of the classical caeteris paribus, the method of the static state'* (Moore, 1914:85-86).

The distinctive features of individuals, such as 'motive' and 'intention' may disrupt the correspondence between economics and physics. Keynes also suggested that it is due to these attributes that economics is a moral and not a natural science (Keynes, 1973:CW XIV). His hypothesis was that economics deals with introspection, on the basis of motives, expectations and psychological uncertainties.

The passage below, cited again from Moore (1929:29), reinforces that the framework of classical economics was challenged by the new criteria of scientific inquiry, as a large number of empirical observations had substantial statistical demands, impinging on traditional 'ceteris paribus' conditions and static state theorems.

> *'Foremost among the causes of the sense of unreality are these:the method of proceeding by successive approximations in the approach to a theory of general equilibrium, which gives a feeling of an indefinitely postponed real solution; the use of the hypothesis of perfect competition with a meaning which does not accord with reality; the limitation of all conclusions to a static state, when, as a matter of fact, all economic phenomena are in a perpetual flux; the assumption of an immediate adjustment of changes, when in reality there are always lags and leads; the complexity of the functions that must be derived from reality and the absence of any known method of making the derivation […]'*

It must have been obvious to neoclassical economic theorists that *the laws of physics are changing*, that classical determinism had become untenable and also that the future of physics lay in statistical concepts (*Brush*, 1983:102). According to Mirowski (1989:220) neoclassical economics was supposed to *admit indeterminism* so that it could resonate with the evolution of physics, but without giving up its commitment to deterministic explanation and utility.

At the end of the 19th to the beginning of the 20th century, neoclassical theory was clearly motivated by the problems of determinism vs indeterminism, statics vs dynamics, and subjectivity vs objectivity, all bound up together as problems created by the original physics metaphor (Mirowski, 1989:228).

As *Baccini* (2016) marks, in contemporary economics, uncertainty is considered a part of decision theory, but that was not so evident at the turn of the 19th to the 20th century. In the reconstruction of the history of economic thought, *the leading role was not played by utility, but by probability.*

Cournot (1843) represents the classical approach to probability. He viewed mathematical probability as traditionally associated with games of chance and defined it as the ratio of favourable outcomes to the total outcomes. That leads gradually

to a strictly subjective interpretation of probability, depending on the status of individuals' imperfect knowledge (Cournot, 1843:438).

Cournot rejected the idea of expected utility, regarding it as 'arbitrary' and 'without real applications'. He was the first to point out that the main problem was not probability but expected utility.

De Morgan's (1838) conception of probability was also very different from that promoted by classical theory:

> *'Probability is a feeling of the mind, not the inherent property of a set of circumstances'* (De Morgan, 1838:7).

Probability in this sense differs from individual to individual, depending on the status of their knowledge and impressions.

Baccini (2016), relying on De Morgan, proposes that this enlargement of the notion of probability paved the way to its application to all 'questions involving loss and gain' (De Morgan 1838:103) and principally to problems regarding insurance offices, i.e. probability is not limited only to gambling but is applicable also to matters of 'commercial speculation' (De Morgan 1847:404). 'Moral expectation' derived from mathematical expectation also concerns 'the temperament of the individual'. As De Morgan writes

> *'[...] different persons will look forward in the same circumstances with different degrees of hope. One man will consider himself better off than before when he has bartered one pound certain for an even chance of two; a second will contemplate loss more strongly than gain, and will consider himself damnified by the exchange'* (De Morgan 1847:409).

At the same time, as De Morgan sees it, the main problem in practical applications arise not from the side of utility, but in connection with probability:when the probability of an outcome is very small, and benefits depend upon this vanishing probability *'the mathematical expectation is not a sufficient approximation to the actual phenomenon of the mind, even when the fortune of the player forms no part of the consideration'* (De Morgan 1847:409).

As the passages above illustrate, Cournot and De Morgan laid the basis for the theory of choice under uncertainty. *Schlee* (1992) showed that during the Marginalist revolution, expected utility was used to analyse a variety of decisions made under uncertainty, on the basis of the notion of marginal (decreasing) utility. But in light of the foregoing, this explanation is only partial. Some scholars in the last thirty years of the 19th century considered that probability did not belong exclusively to economics, and explored it in the context of ethics, psychology and philosophy (Jevons, 1874; Edgeworth, 1888).

Baccini (2016:5) revealed that behind all this, there was not only a new idea of utility, but also a logical theory of probability, first developed by Jevons (1874:200) who wrote that probability was the 'noblest creation of the intellect' as it

> *'deals with quantity of knowledge, an expression of which a precise explanation and measure can presently be given. An event is only probable when our knowledge of it is diluted with ignorance, and exact calculation is needed to discriminate how much we do and do not know'* (Jevons, 1874:199).

Unlike De Morgan, Jevons' idea that probability 'belongs wholly to the mind' (ibid., 198) does not mean that it is personalistic. On the contrary, it is the basis of 'rational expectation', obtained 'by measuring the comparative amounts of knowledge and ignorance' (ibid., 200).

An examination of the ideas of *Venn* (1888) and Edgeworth (1884) allows for a reconstruction of the history of the application of probability theory to decision theory (under uncertainty). The two theorists made a fundamental contribution to the development of the frequentist version of the theory of probability. It can be shown that while their positions are 'expressed with a somewhat opposite emphasis' (Venn, 1888:119), their theoretical stance is substantially the same.

According to Baccini (2001:767), Venn and Edgeworth both conceived of procedures of choice that are exercised essentially around individual cases. Therefore, their concept of probability obviously cannot be used as a decision-making instrument. On the other hand, it cannot be logically denied that a decision can be made on the basis of the expected utility under conditions that make it possible to apply probability coherently. But in fact, such ideal conditions are unrealistic, and therefore the field of application as well as the relevance of probability for choices under uncertainty is fairly limited.

If probability is defined as relative frequency, it may be considered (moderately) objective, as a property of things – however, in a peculiar way, as *it is a property of the series, and not of the individual events making up that series.* When choices as represented as being tied to single events – be they repeatable or not – probability can be of no help in the choice of actions.

In the second half of the 19th century, theorists of probability discussed the relationship between belief and credibility in detail. In *Bain*'s (1859) lesson, belief is defined as a mental state, associated with and characterised by a disposition to act. Along the same lines, Venn writes the following on belief:

> *'Whatever opinion then may be held about the essential nature of belief, it will probably be admitted that a readiness to act upon the proposition believed is an inseparable accompaniment of that state of mind. There can be no alteration in our belief […] without a possible alteration in our conduct, nor anything*

> *in our conduct which is not connected with something in our belief'* (Venn, 1888:143–144).

According to Bain (1859), belief is *preparedness to act*, and as such, a necessary condition for human action. To apply probability to decision theory, the relations between belief and probability must be defined properly. Following different strategies of reasoning, Venn and Edgeworth both arrived at the conclusion that probability is not a direct measurement of belief, i.e. it does not necessarily give rise to belief, and, as a consequence, it is not useful for the theory of human choice (Baccini, 2001; 2007).

According to Edgeworth's (1922) hypothesis, the measure of probability – derived from experience of relative frequencies – corresponds to the measure of credibility. That hypothesis actually upholds that the mathematical theory of probability deals with phenomena that are utilised for measuring credibility. However, probability is nothing more than the relative frequency of these phenomena. The result is that we simultaneously have a close passage between the phenomena (or better, the series), the statements of probability and the calculus, and the epistemic interpretation of the probabilities.

For *Bentham* (1789), probability calculation will always result in a unique precise, sharp and exact value. For him, the calculation of an outcome will also have a unique value. In this regard, Keynes states the following:

> *'But at any given time facts and expectations were assumed to be given in a definite and calculable form; and risks, of which, tho admitted, not much notice was taken, were supposed to be capable of an exact actuarial computation. The calculus of probability, tho mention of it was kept in the background, was supposed to be capable of reducing uncertainty to the same calculable status as that of certainty itself; just as in the Benthamite calculus of pains and pleasures or of advantage and disadvantage, by which the Benthamite philosophy assumed men to be influenced in their general ethical behavior'* (Keynes, 1937:213).

Keynes explicitly rejected Bentham's exact approach to probability. His rejection was based on the realisation that *only an inexact approach to probability would fit in with the knowledge available to decision makers in the social and behavioural sciences, economics, finance, business and law, as well as practical everyday decision-making.* This is especially the case with the decision to invest in long lived, durable, fixed capital goods or projects. All these clearly show a wide gap between the views of Keynes and Bentham.

Boole (1854) marks a different approach in proposing that many practical problems decision-makers have to deal with are incomplete and indefinite. He was the first to provide a clear distinction between indefinite (uncertainty) and definite (risk) probabilities. The possible causes of incompleteness and indefiniteness are

imperfect information, incomplete data and partial or complete lack of knowledge of the relevant factors. According to Boole, it is only in the standard mathematical theory of probability – which is based on statistics – that individuals can make a choice between the available options in possession of all the relevant data.

Carabelli (2017:33) points out with reference to Keynes ideas that the calculus of probability and mathematical Benthamite calculus are only applicable in restricted cases. Keynes is opposed to Moore's theoretical acceptance of the Benthamite consequentialist calculus, even though Moore rejected it in practice as it is impossible to calculate all the future consequences of an action. Keynes (1936) has expressed the strongest views on the subject in the GT:

> *'We are merely reminding ourselves that human decisions affecting the future, whether personal or political or economic, cannot depend on strict mathematical expectation, since the basis for making such calculations does not exist; and that it is our innate urge to activity which makes the wheels go round, our rational selves choosing between the alternatives as best we are able, calculating where we can, but often falling back for our motive on whim or sentiment or chance'* (Keynes, 1936:162).

As is clear from the above, by the turn of the 19th to the 20th century two roads have been delineated: the first one *shut out uncertainty* and expected utility from the professional toolbox of economists, limiting the use of probability to the narrow problems of gambling and insurance. The second road was concerned with *the application of probability*, including the *frequentist dead end* discussed earlier in detail.

These were the theoretical antecedents to the formulation of Keynes' probability theory (1921), by which he laid the groundwork for his economic theory. Keynes paid attention to shifts in science at the beginning of the 20th century disposing with mechanistic principles and determinism[4]. His apparatus of thought lay within the domain of reasons, grounds, evidence and arguments.

Keynes as a thinker essentially had a *critical orientation*. By the turn of the century, it was generally accepted among economists that utility is difficult to measure, and therefore, any interpersonal comparison of it is impossible. The theory of cardinal utility was hard to grasp, and accordingly, it was reluctantly accepted in economics which dealt mainly with ordinal utilities. In his foundational work on probability, Keynes (1921) attacked frequency theories of probability for their use utilitarian and cardinal (or statistical) notions (*Bateman*, 1991:55). Keynes

4 Keynes wrote his *Principles on Probability* in 1907, which is regarded as the precursor of his *Treatise on Probability*, finalised in 1909. His foundational work on probability (TP) was finally published in 1921.

was convinced that *probability was not an outcome of statistical frequencies, but a logical and rational-objective relation, which marks a significant departure from the relative frequency theories of probability.* Keynes' stance on probability was heavily influenced by contemporary philosopher Moore (1903), who was an opponent of utilitarianism. Keynes observed that Moore's conclusions rested on a frequentist theory of probability, in which probabilities are based on a sufficient number of repeated, uniform (class) observations (*Richard von Mises*, 1939). In frequentism, specific 'case' probabilities do not belong in an established 'class' of events and are unknowable *ex ante*. Drawing on Moore, Keynes recognised that the uncertainties of case-type actions can be avoided by following an institutionalised class-frequency of human actions.

3 THE BASIS OF KEYNESIAN ECONOMIC THEORY AND UNCERTAINTY

Businesses' need for external finance compels savers and company decision-makers to negotiate. Agents are compelled to acknowledge that ignorance and conjecture enter decisions, and that the value of existing capital assets is dependent on the market's view of their returns in the long term. The uncertainty permeating Keynesian economics issues from unsureness about the validity of the mode of argumentation that enters in the decision process. According to *Minsky* (1996), action involves a suspension of disbelief by both sides in the negotiations, and economic success fosters such a suspension.

In decision-making under uncertainty – in line with Keynes's (1936) emphasis – the elements determining long-term expectations often change; therefore, what happens in the economy at any time will be contaminated by market conditions that reflect actions determined by mental models that differ from the model that now guides expectation formation and therefore actions (Minsky, 1996:360).

Decisions to undertake and finance investments are important elements of Keynesian economics. In a basic version, an investment decision is viewed as an incentive for both the realisation and the distribution of aggregate income, with distribution viewed as being determined by the structure of demands and not by production function characteristics.

As to conditions influencing investment decisions, Keynes (1936:61) proposes that' *[…] there is the instability due to the characteristic of human nature that a large proportion of our positive activities depend on spontaneous optimism rather than on a mathematical expectation'.*

Keynes (1936) was a proponent of state intervention into fiscal policy and into the banking system through monetary policy etc., in order to sustain a stable level

of aggregate demand. He concluded that economies operate soundly if they are functionally in a state of equilibrium, i.e. if the level of aggregate demand and supply are equal. That state occurs when the savings of society equal planned investments at the level of the economy.

Lipsey (1992:289) points out that there is no reason why the amount individuals wish to save should be equal to the amount that firms wish to invest. That may be the reason why Keynes considered state intervention into aggregate demand and supply important for a stable economy. The rationale for intervention is that aggregate demand is influenced by a host of public and private economic decisions. As private decisions cannot be influenced, it is public and institutional decisions that should be fined-tuned with the instruments of monetary and fiscal policy (*Blinder*, 2008).

Skidelsky (2011) highlights that Keynes' picture of the economy differs from the classical as well as from the neoclassical view with respect to the *volatility of investment* and the rate of interest as an equilibrating mechanism. Instability of investment – according to Keynes – is due to the inescapable uncertainty about the future. Keynes equally clearly identifies probabilistic knowledge of the future as the key 'tacit assumption' behind the classical theory of the self-regulating market. Keynes (1937:219) regards investment as a completely unsuitable tool for the methods of classical economic theory, because *uncertainty dominates the investment process*.

King (2016) says – in agreement with Keynes – that economic decisions are made under conditions of 'radical uncertainty' – excluding the possibility of quantifying the future by attaching probabilities – and there is no such thing as optimising behaviour. The essence of the conventional Keynesian view is that in the face of permanent problems of equilibrium, a policy stimulating demand should be followed (King, 2016).

The generations of economists that followed after Keynes were more interested in formalising their discipline and constructed formally precise models of the economy based on the idea that probabilities can be attached to future events and outcomes based on observations from the past[5].

Often, real world economies are anything but stable or stationary. Economic and market forecasts are most often based on statistical models; however, it should not be forgotten – but is often ignored – that they rest on the assumption of 'structural

5 As an unfavourable outcome, the global financial crisis of 2008 led critics of mainstream economics to rediscover the idea that many future events are simply impossible to conceive of today and to capture in economic models.

stability'. But from time to time, substantial structural breaks do happen (*Fels*, 2016).

Patinkin (1976) finds it important to note that the central message of the theory outlined in the GT by Keynes (1936) and its analytical novelty is that changes in output act as an equilibrating force to bring aggregate demand and supply – or, equivalently, planned investment and saving – into equality at a level that need not be one of full employment (Patinkin, 1976:Chapters 8–9).

While Keynes establishes that in this regard, the economic system is not self-adjusting (1936:267), he writes the following on the equilibrating mechanism:

> *'The novelty in my treatment of saving and investment consists, not in my maintaining their necessary aggregate equality, but in the proposition that it is, not the rate of interest, but the level of incomes which (in conjunction with certain other factors) ensures this equality'* (Keynes, 1937:211).

Shackle's (1961:228) comment on Keynes (1937) article is included below to illustrate his stance on the notion of uncertainty in Keynesian economic theory:

> *'No reader of Keynes's article "The General Theory of Employment" [...] will be in doubt that Keynes looking back saw as the main theme of his book the commanding importance of uncertainty and of the conventions by which the insoluble problems it poses, and the nonsense it makes of pure "rational calculation," can be shelved in order to make life possible at all.'*

Keynes's well-known statement on uncertainty – which characterises the functioning of the economy so well – is as follows:

> *'[...] there is no scientific basis on which to form any calculable probability whatever'* (1937:214).

It is interesting that the word 'uncertainty' appears only in two instances in Keynes's (1921) foundational work on probability. The same is true to the GT, his foundational work of economics, in which he does not define the meaning of uncertainty. In the note below, which is the closest to a definition, he writes the following:

> *'It would be foolish, in forming our expectations, to attach great weight to matters which are very uncertain. It is reasonable, therefore, to be guided to a considerable degree by the facts about which we feel somewhat confident, even though they may be less decisively relevant to the issue than other facts about which our knowledge is vague and scanty. For this reason the facts of the existing situation enter, in a sense disproportionately, into the formation of our long-term expectations; our usual practice being to take the existing situation and to project it into the future, modified only to the extent that we have more or less definite reasons for expecting a change'* (Keynes, 1936:148).

In his foundational work on probability, Keynes (1921) aimed to revive the epistemological approach to probability to arrive at an interpretation which is *different from either chance or frequency*. Keynes (1921:4) conceives of probability as the degree of *power of the logical relationship* between two propositions, more precisely, the closeness of the conclusion to the evidence.

> *'The terms certain and probable describe the various degrees of rational belief about a proposition which different amounts of knowledge authorise us to entertain. [...] Between two sets of propositions, therefore, there exists a relation, in virtue of which, if we know the first, we can attach to the latter some degree of rational belief. This relation is the subject-matter of the logic of probability'* (Keynes, 1921:3, 6–7).

It is in Keynes's work on probability (1921:103) that he fully distances himself from *the applicability of the classical and the frequentist notions of probability to economic decisions:*

> *'[...] the identification of probability with statistical frequency is a very grave departure from the established use of words; for it clearly excludes a great number of judgments which are generally believed to deal with probability.'*

The new logical theory of probability developed in (1921) is concerned with 'degrees of belief', which – *unlike* De Morgan's concept – is rational as it relies on given conditions of knowledge, and not merely with the actual beliefs of particular individuals, 'which may or may not be rational' (Keynes, 1921:4).

Keynes posits a direct relationship between probability, rational belief and action, in which having a belief signifies a readiness for action on the basis of that belief:

> *'[...] the probable is the hypothesis on which it is rational for us to act'* (Keynes, 1921:307).

As already outlined, *at the turn of the 19th to the 20th century, it was widely recognised that mathematical expectation and expected utility maximisation were not the right tools to solve problems of deciding between different alternatives.* Keynes had three serious objections against the theory of mathematical expectation, all three concerning probability. According to the *first*, probability is not fully measurable. The *second* is that mathematical expectation does not take into account the 'weights' of the arguments, i.e. the amount of evidence upon which probability is based. *Thirdly*, the element of 'risk' is fully ignored. The reason for this is that in respect of the expected value of a mathematical expectation

> *'an even chance of heaven or hell is precisely as much to be desired as the certain attainment of a state of mediocrity'* (Keynes, 1921:312).

Keynes adopts a rational–positivist approach in his theory of uncertainty, in which the world is innately probablistic (albeit not often in a strictly measurable

sense). According to Keynes, all behaviour rests on the – imperfect – basis of probability, and as such, rational behaviour is subject to the decision-maker's accumulated knowledge and ability to reason about probabilities. For Keynes, all propositions are probablistic and should be so treated. Given that, the matter of uncertainty is whether or not the decision-maker knows and rationally employs those the probabilities. Uncertainty, in Keynes's conception, is the absence of sufficient evidence to predictively determine outcome probabilities *a priori*, which has often been labelled 'ambiguity'(Ellsberg, 1961; *Dequech*, 2000).

In line with the above, *Packard* et al. (2021) establish that the Keynesian notion of uncertainty if entirely epistemic, i.e. all uncertainty is derived from limitations of knowledge or a lack of sufficient evidence. Accordingly, all outcomes are probablistic, and probabilities are embedded in the logical relationship between cause and effect. Consequently, uncertainty arises out of procedural ignorance (lack of knowledge) of these knowable (but often non-numeric) probabilities (*Dosi* and *Egidi*, 1991). In this respect, Keynes writes the following:

> *'To say, then, that a probability is unknown ought to mean that it is unknown to us through our lack of skill in arguing from given evidence. The evidence justifies a certain degree of knowledge, but the weakness of our reasoning power prevents our knowing what this degree is'* (Keynes, 1921:34).

In both the TP (1921) and the GT (1936), Keynes states that *exact, precise numerical probabilities are rarely accessible in the world of economic and financial decision-making* because of the paucity and flimsiness of relevant evidence available. Instead, 'non-numerical' probabilities must be used which incorporate what Keynes termed major 'weight of the evidence' deficiencies in *data, information, knowledge or evidence.*

Therefore, Keynes posits that expectations must be based on confidence or on the weight assigned to different events and alternatives. For Keynes, expectation is a matter of weighting the 'degree of belief' in a probability, which is very distant from stochastic probability distributions.

While individuals have to act now, the effects of their choices will only be known in the future, but all economic acts – at any given time – have intertemporal consequences. Economic operators must have a basis for their decisions, which may either be the recent past or the actions of others, but such frame of reference for choices is 'based on so flimsy a foundation [that] it is subject to sudden and violent changes (Keynes, 1937:214).

Keynes argues for the importance of uncertainty in decisions as follows:

> *'The theory can be summed up by saying that, given the psychology of the public, the level of output and employment as a whole depends on the amount of investment. [...] [Although these are not the only factors on which aggregate output*

> *may depend] it is those which determine the rate of investment which are most unreliable, since it is they which are influenced by our views of the future about which we know so little'* (Keynes, 1937:221).

Although Keynes did not define uncertainty in the TP (1921), *the category of uncertainty provides the theoretical and methodological foundation of Keynesian economics.* In light of that, it is just to say that *Lawson*'s (1985) interpretation of Keynes has enhanced our knowledge of the role of uncertainty. Lawson (1985:913) starts from the observation that Keynes departed from the frequency theory of probability and introduced in its stead *an indicator of the strength of the argument*, i.e. a probability relation between the evidence and the conclusion derived therefrom. Of the relation constructed by Keynes, Lawson (1985:914) writes the following:

> *'When knowledge is absent, propositions are cast into uncertainty in a situation characterised by lack of certainty'* (Lawson, 1985:914).

Uncertainty arises when probability relations are numerically indeterminate and non-comparable.

According to Lawson, uncertainty corresponds to a situation in which direct knowledge of the secondary proposition is absent. On this basis, uncertainty may arise in two ways:The first is when the relevant probability relation is unknown due to individuals' inability to argue from given evidence to the degree of rational belief it justifies in a proposition. The second is when there is no method for determining a numerical measure of the probability relation, namely when probabilities are numerically immeasurable and indeterminate (Lawson, 1985:913). While Lawson's emphasis on the two ways uncertainty may arise in is justified, we must also recognise Keynes's claim for information:

> *'[...] the degree of completeness of the information upon which a probability is based does seem to be relevant [...] in making practical decisions'* (Keynes, 1921:345).

Keynes's (1921) foundational work on probability leaves no doubt about *his aspiration to depart from the assumption of classical and neoclassical economics that decision-makers are perfectly informed and possess complete knowledge of the circumstances.* He believed that decision-makers have probablistic knowledge instead of absolute certainty. In his probability theory, he conceived of probability in the broadest sense possible, which holds even in light of the criticism – he himself made – of the applicability of his probability relation in practical decision-making. In this respect, Keynes writes the following:

> *'We must bear in mind that our theory must apply to all probabilities and not to a limited class only, and that, as we do not adopt a definition of probability which presupposes its numerical mensurability, we cannot directly argue from*

> *differences in degree to a numerical measurement of these differences'* (Keynes, 1921:36–37.)

For completeness, another statement of Keynes should be added:

> *'Many probabilities, which are incapable of numerical measurement, can be placed nevertheless between numerical limits. And by taking particular non-numerical probabilities as standards a great number of comparisons or approximate measurements become possible'* (Keynes, 1921:176).

Based on the above, Keynes clearly indicates that inexact numerical comparisons are better than simply establishing the impossibility of attaching cardinal numbers and deriving probability comparisons (*Brady*, 1993).

Keynes's (1921) approach to probability – even though it is based on rational-objective relations – reinforces that probability is closely connected to the realm of uncertainty. Probabilities are tied up with the unpredictability of unforeseeable events. This approach is reflected in the reappearance of uncertainty in Keynes's (1936) foundational work of economics and in treatises on 'fundamental uncertainty'.

As mentioned earlier, at the turn of the 19th to the 20th century doubts arose as to the applicability of mathematical expectation and expected utility maximisation in the moral sciences. *Keynes's rejection of expected utility was a symptom of the general scepticism towards the usefulness of mathematical methods in solving economic problems.* Keynes's contribution to the theory of probability is more plausible if it is regarded as an escape from both utilitarianism and the frequency approach.

We should also mention Edgeworth's review of one of the guiding principles of Keynes's (1921) foundational work on probability in which he recognises the relevance of individual cases:

> *'[...] mathematical expectation [...] is seen to be no longer a safe guide in the case of transactions which cannot be regarded as forming part of a "series" in Dr. Venn's sense'* (Edgeworth, 1922:277).

Clearly, Keynes – firmly footed in reality – was devising an epistemological method in which the information linked to individual cases – as the basis of personal choices – has much greater relevance than the statistical data available for the choice. In this regard, Keynes writes the following:

> *'The statistical result is so attractive in its definiteness that it leads us to forget the more vague though more important considerations which may be, in a given particular case, within our knowledge'* (Keynes, 1921:322).

The notion of logical probability that unfolds from Keynes's contributions on probability, however, does not resolve the fundamental problem of measurability,

which is also corroborated by his statement that *'probabilities do not all belong to a single set of magnitudes measurable in terms of a common unit'* (Keynes, 1921:85).

Keynes believed that *lack of known reasons (ignorance) and uncertainty are the two most difficult issues in economics.* Both are related to limited human knowledge. In her profound reflections, Carabelli (2017) points out that Keynes's notion of uncertainty is much more complex than mere ignorance. In her view, uncertainty issues from the intrinsic incommensurability of probabilities, and is related to Keynes's philosophy of measurement. *Intrinsic incommensurability is due not to lack of reasoning power or the practical inability to know or to measure (compare) probabilities, but rather to the nature of Keynesian logical probability itself.* The material of that probability consists of propositions and partial reasons, not empirical events.

According to Carabelli (ibid.), Keynes regards ignorance and uncertainty as the main causes of malfunctions in the market. Ignorance of the future and uncertainty are based on the incommensurability of probability and make it impossible for individuals to form reasonable judgements about the outcomes of their actions, or undermine confidence in individual assessments of immediate consequences. As a result, individuals fall back on average common opinions or take refuge in rules, routines and conventions (conventional expectations). *This is the root cause of the reluctance to invest, the consequent failure of the economy to exploit the full potential of available resources* and the speculative behaviour of those who, having above-average knowledge and skills, are able to exploit these behaviours to their advantage, which may *destabilise* the economy as a whole.

3.1 Epistemological and ontological uncertainty

The reader might have already realised that Keynes's writings on uncertainty are *fragmented*, and succeeding theorists of uncertainty were trying to reconstruct his ideas of uncertainty form these fragments.

As already cited from Packard et al. (2021), Keynes's notion of uncertainty is entirely *epistemic* by nature, and probabilities of this kind may be explored by learning the (probability) relations between causes and effects. Scientific efforts mitigate uncertainty by elucidating these probability relations and by producing exponentially growing evidential weight until all uncertainty is eliminated.

Carabelli (2017) corroborates the epistemological character of Keynes's idea of uncertainty by resolving the century-old *controversy* around the *subjective vs objective* nature of probability as conceived by Keynes. He argues that probability is contingent on the limited knowledge available of the circumstances (known partial reason, grounds or evidence), and varies along with them. The selection

of evidence, the process of abstraction by which the individual extracts reason, grounds and evidence judged relevant based on the total knowledge available to the individual, is *subjective*. But probability, given reasons, grounds and evidence, is *logical and objective*.

In certain situations, it is actually impossible to form reasonable judgements if no information about the thing is available, nor even about the present and the immediate future. According to Carabelli (2017:13), this situation represents a condition of total ignorance, in which there is no known reason, grounds or evidence. There is no probability or, if any probability exists, it is unknown. The situation of total ignorance is complemented by Keynes by another relevant situation:uncertainty, when probability exists but cannot be reduced to calculable risk.

De Finetti's (1938) appreciation of Keynes's scholarly commitment to the epistemic approach to probability was a landmark in probability theory. While differences between the objective perspective implicit in Keynes's logic of probability and de Finetti's subjective interpretation (de Finetti, 1938:63-84) were obvious, de Finetti endorsed it as he saw in it a revival of the epistemic approach to probability, overshadowed by the empiricist perspective of the frequentist interpretation of probability. He praises Keynes's interpretation of probability theory *as a logic of thinking* to determine the degree of uncertainty (of propositions or belief) at a given time when there is not enough information to judge them true or false.

Feduzi et al. (2014) reveal that de Finetti's favourable attitude towards Keynes's ideas is not limited to their connections in probability theory and the epistemic approach. de Finetti endeavours to investigate how probability theory could be transformed into a probability calculus. He concedes to rejecting the postulates that every probability corresponds to a number between 0 and 1, and that two probabilities are always comparable with each other.

It was the followers of Keynes who proved that in addition to epistemological uncertainty, ontological uncertainty also exists. Leading post-Keynesian theorist *Davidson* (2015:21) criticises mainstream neoclassical economics for teaching that '*immutable objective probability distributions govern past as well as future events.*'

Elsewhere, Davidson (2003:234) highlights that Keynes's concept of uncertainty reflects a future that is:

> *' [...] transmutable or creative in the sense that future economic outcomes may be permanently changed [...] by the actions today of individuals, groups and/or governments, often in ways not even perceived by the creators of change.'*

This is analogous to 'uncertain knowledge' in Keynes's interpretation:

> *' [...] I do not mean merely to distinguish what is known for certain from what is only probable. [...] About these matters there is no scientific basis on which to form any calculable probability whatever'* (Keynes, 1937:209-210).

Davidson (2009) and Skidelsky (2011) stress the crucial importance of uncertainty, emphasising that for Keynes, it also implies that *uncertainty cannot be modelled with a probability calculus.*

In *Dunn*'s (2001) view, problems of predicting the future are not due primarily to the cognitive limitations of agents or their lack of capacity to access or manage technology. The real cause is that the future constantly changes, shaped by the actions of agents (Dunn, 2001:578). Accordingly:

> *' [...] the agent does not choose from a given list of possibilities; he actually has to create the list [...]'* (Carvalho, 1988:66–81).

The arguments presented to justify ontological uncertainty – having the same role as fundamental uncertainty – relate to*' [...] unknowability of the future, to creative human agency and to the unique nature of unfolding time'* (Dunn, 2008:96).

In the GT, Keynes (1936) fully endorsed fundamental uncertainty and rejected any attempt at precisely predicting the future. Instead, with the creativity of the acts of investors new realities emerge as potential surprises (*Rosser*, 2001:547).

All things considered, propositions and decisions in models of *epistemic* uncertainty – regardless of the way in which the informed agent attempts to acquire knowledge of the given economic reality – *will certainly be based on incomplete information*. Uncertainty can be reduced by acquiring new knowledge of reality, but the complexity of the system prevents agents from acquiring full knowledge at any time (*Terzi*, 2010).

In models of *ontological* uncertainty, agents know that they are living in a constantly changing environment where the future is not predetermined by the past, and that no apparent regularity can be considered a permanent basis for a statistical anticipation of the future. Economic agents have no other choice but to resort to the past as the only source of knowledge, while being aware that *non-predetermined events and surprises are possible.*

The interrelatedness of epistemic and ontological uncertainty is phrased concisely below:

> *'Lack of determinacy is an ontological property of the universe we are considering. Imprecise knowledge is an epistemic property of the agents in that universe'* (*Brandolini et al.,* 2011:73).

Of the followers of Keynes, Shackle (1949) put forward a theory of decision-making that addresses circumstances of risk and uncertainty. His theory is unique in the sense that it does not assume any maximising behaviour. Shackle hypothesizes that – in situations of risk or uncertainty – every possible outcome of the decision is associated with a degree of potential surprise as to one outcome occurring rather than another. Each 'outcome–potential surprise' pair is ranked by their

power to stimulate thinking (stimulation is directly proportional to the plausibility of the outcome and inversely proportional to the degree of potential surprise). Shackle's theory was intended mainly to cope with *individual choices* that happen only once. Shackle – following Keynes – was clearly also in disagreement with proponents of the importance of frequency probability in decision-making. As proponents of the frequentist approach regard probability as a limiting value of the relative frequency of an outcome in many similar trials, Shackle questioned the applicability of notions of probability in the ordinary sense (e.g. within the framework of expected utility maximisation) to individual *choices*.

Mises, L. (1949) had very similar views about the substance of case-probability, assuming that case-probability and true uncertainty were identical:

> *'We know, with regard to a particular event, some of the factors which determine its outcome; but there are other determining factors about which we know nothing. Case probability has nothing in common with class probability but the incompleteness of our knowledge. In every other regard the two are entirely different'* (Mises, L. 1949:110).

In cases involving a lack of clarity (ambiguity), decision-makers cannot assign definite probabilities to every event as some information, which otherwise could be known, is missing. Ellsberg (1961) realised that the concept of 'ambiguity' is especially useful in referring to knowable but missing information. In his paper contextualising Ellsberg's conception of ambiguity, Zappia (2021) concludes that he considered it a mild form of uncertainty, which, however, does not imply that he had no interest in fundamental uncertainty. According to Zappia, Ellsberg, after re-exploring the relevance of Knightian ideas about uncertainty, went on to realise that his position is in fact closer to that of Keynes (1921) in the TP, and ascribed great importance to fundamental uncertainty in decision-making.

Before putting his probability scheme on the footing of formal logic, Keynes (1921:21) deliberately limited the scope of application of probability theory, and contested the generally accepted view that comparisons between pairs of probability are not only possible but are actually within our power. Keynes was of the opinion that degree of belief is numerically measurable only when the principle of indifference can be applied, and when equal probabilities can be assumed or it is possible to estimate statistical frequencies. Nevertheless, as Keynes notes (1921:29), in the majority of cases

> *' [w]hether or not such a thing is theoretically conceivable, no exercise of the practical judgment is possible, by which a numerical value can actually be given to the probability of every argument.'*

With his logical theory Keynes proved that probabilities – as opposed to what the frequency theory holds – may be derived not only statistically (*a posteriori*) but

also logically (*a priori*). Keynes (1939:561) reasoned that if 'à priori' probabilities are based on measurable phenomena, an important condition of their validity is that

> *'[...] calculating the relative importance of these measurable factors essentially depends on the assumption that [...] they are comprehensive.'*

According to Keynes, such an assumption holds when all economic problems are regarded significant with all their political, social and psychological factors, including the progress of invention and the state of expectation. He posits that logical probabilities are more credible, which, when we know the underlying 'probability-relations', are applicable also to individual events with no precedent. Consequently, a generic institutional rule of behaviour must be assumed relevant and beneficial over time despite the consistently unique circumstances of action (Packard et al., 2021).

The social determination of values plays a role in individual valuation that Keynes suggests is played by the uniformity of the human apparatus. That strategy of course has its own difficulties, as social values are many and compete with each other. Accordingly, they do not easily explain individual values.

By his analysis of the wide-ranging relationships between uncertainty and probability, Keynes had a major contribution to exploring the role of uncertainty in economics. Keynes eventually endorsed part of *Ramsey*'s (1922) criticism, in respect of logical differentiation. Analysing his own logic, he yielded to accept Ramsey's distinction between 'formal logic' and 'human logic' and the inclusion of his (also non-numerical) degrees of probabilities (referred to here as '*a priori* probabilities') in the latter. Keynes allowed for transferring the 'logical character' from the relational aspect of probabilities to a peculiar human one.

There have been other important gradations in Keynes's thought during the 1930s. *He moved away from objective probability relations toward a subjective interpretation of probability, to arrive at an intersubjective approach*, as he held that most individuals are unfit for forming any probability calculus. Keynes's (1936) GT informs the diminished importance attributed to the role of probability in decision-making, and animal spirits, reliance on conventional judgement and psychological considerations gaining ground. These factors are systematically presented in an article written by Keynes (1937) essentially for the interpretation and defence of the GT.

Initially, Keynes (1909) rejected the relevance of frequency probability and mathematical expectation for decision-making. Later, he sought for an effective decision-making tool to deal with situations of uncertainty by laying the foundations of the logical theory of probability. When writing the GT, he realised that analysing human behaviour on a purely logical basis (which he elaborated in the TP and its precursor) is not sufficient for understanding practical decision-making. In the

GT (1936:Chapter 12), Keynes draws on social developments, and the understanding of actual economic experience, building up a logic of conventions that had no trace in the TP. *Gerrard* (2003) is therefore right to state that Keynes did not reject his early thought on probability and uncertainty.

3.2 The substance and occurrences of fundamental uncertainty

In the GT, Keynes (1936) was fully in accord with the notion of fundamental uncertainty which removes any attempt at a precise prediction of the future under non-ergodic conditions. This must be considered jointly with the fact that with the creativity of actions by investors, new realities come up as potential surprises (Rosser, 2001:547).

Investment decisions under fundamental uncertainty are exposed to provisions issued by the prevailing institutions, which include (despite their limited nature) measures ensuring the liberalisation of the market, promoting stock-option strategies as well as the use of risk-management solutions by investors.

Keynesian fundamental or 'true' uncertainty is different from risk, although they are often conflated in mainstream neoclassical economic theory which posits that economic processes are governed by a stochastic process with a known and stable distribution, which is independent of individuals' actions, so risk can be reduced by aggregations of homogeneous agents (*Dymski*, 1993). By contrast, Keynesian uncertainty must be distinguished from any other probabilistic concept, as here, agents' play a role, although people cannot be fully aware of the impact of their actions (Dymski, 1993).

What the literature describes as fundamental uncertainty pertains to ' *[...] unknowability of the future, to creative human agency and to the unique nature of unfolding time*' (Dunn, 2008:96).

Based on the foregoing, *fundamental uncertainty can be defined as the probability of non-predetermined structural changes and states.* The elementary notion of fundamental uncertainty is grounded in social reality characterised as being subject to non-predetermined structural change. In this very elementary form, fundamental uncertainty is due to lack of knowledge resulting from such a characterization of reality. As a first refinement of this elementary notion, social reality is described as inhabited by potentially creative individuals. When this is made explicit, we arrive at the original definition of the notion of fundamental uncertainty provided above (Dequech, 2011).

Non-predetermined structural changes can typically be of a political, social, or cultural nature. They may have a significant impact on preferences, work rela-

tions, the bargaining power of workers and employers, or on government decisions. They also interact with economic innovations.

Non-predetermined changes may occur as the intended or the unintended consequences of people's actions, meaning that surprises may happen. The problem is not simply that there is not enough information to reliably attach probabilities to a given number of events. To an event that seems unimaginable – in the sense explained above – no probability can be attributed.

In general, without denying that decision-makers can still construct subjective probability distributions in situations of fundamental uncertainty, they must acknowledge the unknowability of a list of all possible events and the consequently *limited guidance* these probability distributions can provide (*Crotty*, 1994:113 puts forward similar arguments).

However, in cases of fundamental uncertainty, the notion of state of the world as it is usually constructed constantly assumes *creativity and unpredictable structural changes* caused by people's actions.

According to Fels (2016), King (2016) considers that radical uncertainty is pervasive and the probability models that economists, central banks and investors use are wrong. To cite King (2016):

> *'In a world of radical uncertainty there is no way of identifying the probabilities of future events and no set of equations that describes people's attempt to cope with, rather than optimize against, that uncertainty. […] In the latter world, the economic relationships between money, income, saving and interest rates are unpredictable, although they are the outcome of attempts by rational people to cope with an uncertain world'* (King, 2016:304).

In his memoir, former US Secretary of Defense *Donald Rumsfeld* (2011) writes the following:

> *'[r]eports that say something hasn't happened are always interesting to me because as we know, there are known knowns:there are things we know we know. We also know there are known unknowns:that is to say we know there are some things [we know] we do not know. But there are also unknown unknowns – the ones we don't know we don't know'* (Rumsfeld, 2011:xiv).

Consequently, he defines known unknowns as known *gaps in knowledge* in contrast to unknown unknowns which are gaps that we don't know exist. The basic idea is fairly clear:while there are many features of the world of which individuals do not know, there are probably others (known unknowns) of which they know they don't know anything about, and there are yet again others (unknown unknowns) of which they do not even know that they do not know them.

The crucial difference is not about the current state of knowledge of individuals and their individual gaps of knowledge. What is critically important is whether they take into account factors they do not know about. In the explanation of Feduzi et al. (2021) the difference is that *a known unknown is a gap in knowledge that an individual knows about and is aware of at the relevant time while an unknown unknown is a gap in knowledge that an individual is not aware of at that time, either because they do not know about that gap in knowledge or because, despite knowing of it, they are unaware of it.*

As Keynes's follower, Skidelsky (2011) proposes that the future cannot be predicted because it is 'open', which is in a large part due to its dependence on individual intentions and beliefs, and on the organic nature of human life. Keynes's thoughts on irreducible uncertainty do not reflect ignorance of such relevant probabilities but rather original ontological indeterminacy:some probabilities are not just unknown, but non-existent.

3.3 Animal spirits, conventions and 'black swan' phenomena

Carabelli (2017) notes that in Keynes's (1921) TP, decision-makers' choices were determined by 'caprice', while in the GT (1936) 'animal spirits', whim or chance took over the same role. In Carabelli's view, there is an important difference between the two. As fundamental uncertainty is irreducible and unavoidable, decision-makers must have been making attempts at managing uncertainty.

In his foundational work of economics, Keynes (1936) was quite explicit about his views about the drivers of decisions:

> *'We are merely reminding ourselves that human decisions affecting the future, whether personal or political or economic, cannot depend on strict mathematical expectation, since the basis for making such calculations does not exist; and that it is our innate urge to activity which makes the wheels go round, our rational selves choosing between the alternatives as best we are able, calculating where we can, but often falling back for our motive on whim or sentiment or chance'* (Keynes, 1936:162).

Another, closely related passage on animal spirits should also be cited here:

> *' [...] our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as a result of animal spirits – of a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities'* (ibid., 161).

Classical economic theorists overestimated the stability and self-regulating capacity of the market economy even in areas clearly characterised by uncertain

outcomes and where economic processes and decision-making was not guided by deterministic or causal laws. According to *Koppl* (1991:204), Keynes *introduced the term 'animal spirits'* to give emphasis to irreducible uncertainty and volatility of expectations, especially expectations about the expectations of others (mainly indeterminately) – and he did not receive much credit for the idea at the time. Animal spirits seemed a *diabolus ex machina*, an arbitrary element introduced to make the story come out wrong. But for Keynes, animal spirits stood for *a state of mind, an intuition, a belief or an urge.*

As opposed to the subsequent views of *Savage* (1954), Keynes established that subjective probabilities are generally non-numerical and therefore cannot be fitted – unproblematically – into the calculus of expected utility. Keynes (1937) wrote the following in this respect:

> *'About these matters [of uncertainty] there is no scientific basis on which to form any calculable probability whatever. We simply do not know. Nevertheless, the necessity for action and for decision compels us as practical men to do our best to overlook this awkward fact and to behave exactly as we should if we had behind us a good Benthamite calculation of a series of prospective advantages and disadvantages, each multiplied by its appropriate probability, waiting to be summed'* (Keynes, 1937:214).

Early on, Keynes was convinced that a fundamentally different concept of probability is applicable to the social sciences from that used in the natural sciences. He went even further and called for a more challenging concept of uncertainty. He thought that uncertainty was not merely non-numerical and non-comparable, like probability, but a 'savage concept' which encompasses animal spirits or *spontaneous optimism*.

According to *Shiller* (2021), Keynes (1936) conceives of 'animal spirits' or 'spontaneous optimism' as a major driving force in *economic fluctuations*. Creation of the term was partly motivated by the observations of Keynes and his contemporaries of human reactions to *ambiguous* situations where probabilities could not be quantified. According to Shiller (2021), the concept of animal spirits – defined by Keynes in a famous passage from his foundational work of economics (Keynes, 1936) – came to be central to his theory. Keynes explained that people face obstacles in making economic decisions due to the difficulty of predicting very far into the future, or trying to ascertain all the possible long-term implications of any economic decision.

Keynes believed that most uses of the term 'probability' lack an objective basis. As Shiller (2021) writes, on the problem of coping with uncertainty, similar terms were invoked by Keynes (1921) already in the TP, suggesting that something like animal spirits must play a role in decisions:

> *'If, therefore, the question of right action is under all circumstances a determinate problem, it must be in virtue of an intuitive judgment directed to the situation as a whole, and not in virtue of an arithmetical deduction derived from a series of separate judgments direct to the individual alternatives each treated in isolation'* (Keynes 1921:312).

A relevant comment by Knight (1921) reflects a similar viewpoint:

> *'We act upon estimates rather than inferences, upon "judgment" or "intuition," not reasoning for the most part'* (Knight 1921:36).

Keynes (1936) proposes that animal spirits inspire decision-makers to act on intuitive judgments in situations of uncertainty that were complex and ill-defined. Shiller (2021:2) identifies in this context the important role of *popular narratives* composed of individual stories. Shiller (2021:9) acknowledges the criticisms directed at the relevance of animal spirits and narratives on the basis of direction of causality, but such unclarities are present in much of econometrics today.

Conventions are another device of addressing uncertainty in Keynes's (1936) economic theory. In his conception, induction is regarded as a convention, of which he writes the following:

> *' [...] the present is a much more serviceable guide to the future than a candid examination of past experience would show it to have been hitherto'* (Keynes, 1937:214).

As another convention, Keynes stresses the testimony of the crowd:

> *'Knowing that our own individual judgment is worthless, we endeavour to fall back on the judgment of the rest of the [...] majority or the average'* (Keynes, 1937:214).

Along the same lines, Keynes (1936:150) says in the GT about the effect of *public opinion* that we follow the crowd, which itself relies on the opinion of experts, who are themselves trying to guess *'what average opinion expects the average opinion to be.'*

In most cases, having recourse to convention is the best that reasonable people can do in the circumstances. Rosser (2001) posits that there is no specific need for evoking the irrationality postulate to explain conventional behaviour. The assumptions of rational individuals maximise own utility in isolation from fellow individuals, which is always pointless in a world where *unpredictable events stand in our way.* Similarly, uncertainty explains the importance attributed to institutions, which build confidence and stabilise expectations.

Let us repeat that conventions on which investors fall back on when there is too much uncertainty in the market, especially those covering contracts, indicate the disciplining capacity of official institutions, which includes regulation.

> *'Especially in situations of uncertainty, government action may reduce it and thereby increase confidence'* (Rosser, 2001:547).

The opposite is the situation when institutions facilitate speculation in the market and thereby become responsible for the rise of instability.

The 'black swan' phenomenon, elaborated by Taleb (2007), is about the background and consequences of the occurrence of uncertain events. It refers to events characterised by three attributes, described as follows:

> *'First, it is an outlier, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme impact. Third, in spite of its outlier status, human nature makes us concoct explanations for its occurrence after the fact, making it explainable and predictable'* (Taleb, 2007:xvii-xviii).

At the end of his book, Taleb writes:

> *'Remember that for an event to be a Black Swan, it does not just have to be rare, or just wild; it has to be unexpected, has to lie outside our tunnel of possibilities.'*

According to *Terzi* (2010), Taleb's (2007) description of black swan events as rare, consequential, unforecastable events expresses *how statistical risk differs from intractable uncertainty.*

Despite their similarity, Taleb's and Keynes's views of uncertainty are conflicting with respect to both method and consequences. Taleb considers that epistemic and ontological uncertainty are similarly applicable to black swan events, but his conclusions do not hold under the more extreme assumption of ontological uncertainty. On the other hand, there is a major difference in terms of the consequences of uncertainty. In Taleb's world, the possibility of surprises (identical with black swan events) is typically ignored by most agents. In Keynes's scheme, the possibility of surprises encourages agents to protect themselves from outlooks that may change adversely as compared to what may be envisioned based on past events.

Taleb (2007) asserts that very rare and highly consequential events that cannot be forecast by attaching probabilities to them may happen. Applying his arguments to the randomness of financial crises, he states that the impossibility of statistically forecasting large-impact events with small but incomputable probabilities should be accepted, especially because they are rare and we cannot collect enough data to calculate with such small probabilities. Similarly, a central element in Keynes's theory is the assumption that economic agents know they have to operate in an uncertain environment. Known past observations provide a sample too small to quantify the probability of extremely rare events.

Intractable uncertainty for Taleb means that there are outlier events that have a large impact on processes. As black swan events are incalculable, the best protection against uncertainty is to establish a robust – management, financial and competitive – system that is resilient to such events.

A significant body of knowledge has been accumulated about uncertainty in economics and economic decision theory. It led economists to *question the fundamental principles of classical economic theory assuming determinacy and perfect information, and to attribute greater importance instead to probability.* The logical approach to probability presented by Keynes (1921; 1936) seemed the only methodology that was based on argumentation and qualitative considerations and therefore able to avoid the logical fallacies bound up with frequency probability. The non-comparability of probabilities allowed *economists to get a grip on the world of the uncertain and to seek the root causes of irreducible fundamental uncertainty further.* For that purpose, we should study the atomic and organic dimensions of the material of economics and the role of complexity as a cause of uncertainty as well as Keynes's isolation from mathematical and statistical uncertainty.

3.4 The atomic and organic dimensions of the economic material

Keynes (1921) took a quite unique position on the relation of the different disciplines to uncertainty. In his foundational work on probability, Keynes (1921) pointed to important differences between perspectives on probability and uncertainty in the natural and the moral sciences. In his view, the former was based on the atomic, while the latter on the organic assumption. Keynes (1921:276) described the atomic assumption as follows:

> *'[...] the material universe must consist, if this kind of assumption is warranted, of bodies which we may term [...] legal atoms, such that each of them exercises its own separate, independent, and invariable effect, a change of the total state being compounded of a number of separate changes [...] Each atom can [...] be treated as a separate cause and does not enter into different organic combinations in each of which it is regulated by different laws.'*

Keynes (1924) had a strong opinion about the atomic vs organic controversy:

> *'The atomic hypothesis which had worked so splendidly in physics breaks down in psychics. We are faced at every turn with the problems of organic unity, of discreteness, of discontinuity – the whole is not equal to the sum of the parts, comparison of quantity fails us, small changes produce large effects, the assumptions of a uniform and homogeneous continuum are not satisfied.'* (Keynes, 1924, *'Essay on Edgeworth'*, CW X:262).

If we agree with Keynes that the world of economic or social relations is *organic rather than atomic*, it is obvious that lack of knowledge of the future is not always reducible to a question of mathematical risk. Identification of the future value of an economic variable – with its conditional expectation – is a clear example of 'statistical induction', which can only be applied if the atomic hypothesis is acceptable as a first approximation.

Credit should be given to Lawson (1985:909) for revealing that *Keynes drew a sharp distinction between the natural and the moral sciences, and questioned the applicability of the atomic hypothesis in the latter.*

Lawson's (1985) was one of the most successful attempts at an explanation for the contested application of probability in economics. He takes realism simply to be the view that there is an objective material world which exists independently of, but is knowable by, consciousness. An immediate feature of his realist viewpoint is a distinction drawn between knowledge on the one hand and a mind-independent material reality on the other. It allows the following question to be asked:are probabilities, as understood with economic analyses, a property of this external material reality, or are they only a property of knowledge? Or putting the question differently:are probabilities understood as objects of knowledge, or merely as a form of knowledge?

By atomic probabilities, Keynes had in mind intensive magnitudes capable of analytic measurement that were assumed empirically holding for the objects of natural sciences, such as physics, because the propositions about the occurrence of events were based on the premise of their independence:he referred to the underlying structure of the material universe inquired by the laws of natural sciences.

That – among others – is why Keynes was opposed to one of the basic tenets of classical economic theory:the assumption of the independence of economic variables. He writes the following in this respect:

> *' [...] methods of ' [classical economic theory] expressly assume strict independence between the factors involved and lose all their cogency and authority if this hypothesis is disallowed'* (Keynes, 1936:257).

The assumption of an atomic system Keynes considered *inherent* in the view of Nature cherished by classical Newtonian mechanics was clearly impossible for the organic reality embedding inductive arguments, such as moral scenarios and business decisions (Mennella, 2005/2006).

As Keynes (1921:276–277) put it:

> *' [...] there might well be quite different laws for wholes of different degrees of complexity, and laws of connection between complexes which could not be stated in terms of laws connecting individual parts.'*

Keynes sees this *irreducible* complexity as the reason why natural laws do not fit into the organic universe, which makes prediction impossible and foremost the reduction of the inductive method to mechanics. The social and economic material was naturally reflected in the general logical scheme and organic possibilities in Keynes's (1921) TP: they did not present themselves as either demonstrative or numerically definable propositions and were free of generalisations.

Keynes (1921:277) promoted that if the world we consider the social world is organic rather than atomic then the nature and methods of analysis should change, too. *He recognised that an important corollary of inductions based on the principles of limited independent variety and necessary connection which leads to the ontological position of atomic uniformity was the existence of a strict methodological individualism in the material world.* According to Keynes (1921:278–279), here, a relationship between parts and wholes is clearly defined whereby the individual, *a priori* parts define, but are not defined by, the whole:

> *'Given, on the other hand, a number of legally atomic units and the laws connecting them, it would be possible to deduce their effects pro tanto without an exhaustive knowledge of all the coexisting circumstances.'*

However, under organic conditions, rational inferences are less likely because there may not be a set of immutable premises which can be learned about with experimentation. Experience does not give us a better knowledge of those unique premises because the nature of those premises is not necessarily independent of the acts of knowing them. Or, in Carvalho's (1988) words:

> *' [...] some of the variables that work as premises may be influenced (but not necessarily determined) by the very decision the agent has to make in the present'* (Carvalho, 1988:74).

As Carabelli (2017:46) sees it, the problem of the relationship between parts and wholes, of organic interdependence between parts and ultimately of organic unities, as to probability, goodness, utility and economic magnitudes, cannot be avoided. She also raises the question of whether we risk falling into the fallacy of composition[6]. Logical fallacies lead us 'into error' in economic reasoning (Keynes, 1936:297). The relation between the parts and the whole is in fact to be connected, in addition to complexity and incommensurability, with fallacious probable inferences and causality.

6 Or more precisely, to 'fallacy of independence' or 'false independence' as Keynes (1921:191) also calls it in the TP.

Winslow (1986:421) suggests that after writing the TP, Keynes '*[...] explicitly abandons atomism in favour of organicism as the metaphysical description appropriate in the moral sciences generally and in economics particularly.*'

Nevertheless, it cannot be stated that atoms became insignificant. In Keynes's system, they assume the following role:

> '*[...] each of them exercises its own separate, independent, invariable effects, a change of the total state being compounded of a number of separated changes each of which is solely due to a separate portion of the preceding state*' (Keynes, 1921:277)

In Lawson's (1988:55) interpretation, the social world for Keynes is an organic system in which uncertainty is defined as a local and interactionist phenomenon. Keynes's early thinking informs the atomist and organicist principles jointly, each requiring the other to account for their respective proper applications. Keynes adopted a formation described by interdependence between individuals; something like societal interactionism, that might be captured by principles and laws that could be said to operate solely at the level of the whole. While it is necessary that an organic system display principles or laws operating solely at the level of the whole, their operation is not sufficient to determine the presence of an organic system. Atomistic systems themselves generally display principles or laws operating at the level of the whole which are not only compatible with the atomistic relation of their parts but are indeed instrumental to their functioning.

In his writings, Keynes repeatedly defended the place of economics among the moral sciences, since economic relations between individuals were organic in the same sense as he originally held that the individual mind is an organic unity. The GT does not discuss the atomicist vs organicist problem, but its line of argumentation is consistent with Keynes's earlier thought giving primacy to the organicist approach. *Keynes always considered the recognition and identification of interdependences between economic agents decisive.*

The importance of the atomist vs organicist distinction is that in economics, an organic arrangement assumes interrelationships between economic agents, factors and variables, and that *the thousands or millions of those interrelationships unavoidably increase uncertainty. Due to these diverging and intersecting relations, uncertainty is unexplorable and fundamental uncertainty is irreducible.*

3.5 Complexity and uncertainty

In the foregoing, the application of the atomicist vs organicist distinction to economics has opened up the possibility of exploring the numerous interrelationships between factors, variables and agents. Next, we will *examine the density of*

this mass of relations. In *Hodgson*'s (1997) view, in the context of complexity, two problems may be distinguished:one is due to large amounts of information, which Hodgson calls extensiveness, while the other one refers *'to the density of structural linkages and interactions between the parts of an interdependent system'*.

The latter one is what Hodgson (1997:668–669) calls *intricacy* (complexity).

In the understanding of Dequech (2011), both problems lead to the complexity of the decision-making environment, which may be managed relative to the agents' capabilities. For a limited number of agents, even a problem of a large amount of information without intricate interrelationships may be complicated. This statement is probably in line with the common usage of the term 'complexity.' A good example for that is *Hayek*'s (1989:3-7) statement below:

> *' [...] the social sciences [...] have to deal with structures of essential complexity, i.e., with structures whose characteristic properties can be exhibited only by models made up of relatively large numbers of variables. [...] A theory of essentially complex phenomena must refer to a large number of particular facts'* (Hayek, 1989:6–7).

As Dequech (2006:112–113) phrases it, reality is a complex phenomenon, populated by a limited number of individuals, involving the possibility of non-predetermined structural change and creative individual behaviour. A reality that is subject to non-predetermined structural change may also be complex and people who are creative may also have limited computational abilities. *A source of complexity in the functioning of the economy is the fact that the result of individual decisions is dependent on the decisions of others.* Such interdependence generates uncertainty about the consequence of someone else's actions. This is what happens even when a single logic underlies actions, just like in economics and in economic decision-making where the market logic is emphasised.

Dequech's (1999) paper discusses how the concept of uncertainty accommodate the complexity and mutability of social reality as well as the limits and creative potential of the individuals inhabiting it, and – in some cases – also the role of institutions and the features of the process of technological change.

Decision-makers trying to predict and manage uncertainty are faced with the problem in the epistemology of risk of how to deal with the limitations that characterize our knowledge of the behaviour of unique complex systems. That is why *Hansson* (2011) regards these significant for risk estimation and uncertainty management, e.g. within modern financial systems. These systems contain several *components and factors*, and so many *varying interactions* between them that they are unpredictable in practice. *Hoffmann* (2018) concludes that *deep, irreducible uncertainty emerges from highly organized and dynamic complexity.* For studying

the deeper causes of fundamental uncertainty, complex systems provide a useful example that may be applied to cases in economics.

In his classic and frequently cited article, *Weaver* (1948) distinguishes three significantly different grades of complexity, also requiring different mathematical treatment. He offers a classification with *'organised simplicity'*, a simple variant containing only a few variables (or a small number of relevant factors) *at one end of the spectrum*. *At the other end of the spectrum*, there is *'disorganised complexity'*, involving numerous variables. As is logical, *the third variant is 'organised complexity'*, positioned midway. The importance of this intermediary grade, however, does not depend on the fact that a moderate number of variables is involved, as opposed to multi-variable systems.

The typical feature of problems of organised and dynamic complexity lies in the fact that – in contrast to the disorganized situations which may be untangled with statistical or probablistic methods – they show the essential feature of organisation (Weaver, 1948:539). *Problems of investment, from the financial markets, the general market and sub-markets involving uncertainty in decision-making belong here.*

In problems of organised complexity, numerous factors are involved which are interrelated into an organic whole. Interactions and the *interdependences* resulting therefrom lead to the emergence of features that cannot be traced to the character of the individual parts of the system, and therefore cannot be captured by probability statistics or reduced to a simple formula. *Huberman* and *Hogg* (1986:376) identify the need for *profound logical and qualitative analysis* beyond mathematical analysis or the mathematics of averages and distributions.

Taking system complexity as a basis suggests that the applicability of probability theory does not only depend on the human action vs natural laws (or, phrased positively, human economic action vs inquiry by the natural sciences) dichotomy, but also from the degree of the complexity of the economic (market, sub-market) system where fundamental (deep) uncertainty arises from highly organised and dynamic complexity (Hoffmann, 2018).

Complex problems in biology, medicine, psychology, economics and political science are too complicated to arrive at a correct decision intuitively and to be successfully analysed by techniques used on one or few-variable problems.

The notion of fundamental (deep) uncertainty discussed in that article resembles the case-probability concept of Mises, L. (1949). Nevertheless, it may be established that deep uncertainty is broader in scope, i.e. case-probability is only a subset of fundamental uncertainty that arises from highly organised complexity. Minsky (1996) is right to state that uncertainty (or unsureness) is a deep property of decentralised systems in which *a myriad of independent agents make decisions whose impacts are aggregated into outcomes that emerge over a range of tomor-*

rows. Uncertainty about what the outcomes will be follows from the uncertainty with which agents hold the model that guides their actions.

3.6 Uncertainty, probability, econometrics

The line of neoclassical economics keeping pace with the paradigm shift in physics from the mid-1920s went down on an unknown path of economic inquiry by laying the foundations of econometrics. The new quantum mechanics developed by *Heisenberg*, *Born* and *Jordan* irreversibly changed the ontological position of stochastic concepts in the physical sciences (Mirowski, 1989).

Eddington (1935:77-78) described this new scientific development as follows:

> *'The formulae given in modern textbooks on quantum theory [...] are exclusively concerned with probabilities and averages. [...] But further it is now recognised that the classical laws of mechanics and electromagnetism [...] are simply the limiting form assumed by the formulae of quantum theory when the number of individual quanta or particles concerned is very large. This connection is known as Bohr's Correspondence Principle. The classical laws are not a fresh set of laws, but are a particular adaptation of the quantum laws.'*

New discoveries concerning the laws of quantum mechanics revealed that all deterministic laws were merely limiting cases of a more fundamental stochastic substratum. In this situation, neoclassical economists saw two possible choices. On one side, there were those who thought that the stochastic laws of economics cannot assume the same status as the statistical laws generated by the natural sciences. Theorists on the other side believed that econometrics is the right method of scientific inquiry in economics.

To complete the train of thought of this study, we must examine the second alternative.

Keynes's 1938-39 critical review of Tinbergen's multiple correlation analysis adds to his earlier discussion on atomism vs organicism (Keynes, 1973:CW XIX). His doubts centre upon *Tinbergen*'s (implicit) characterisation of the economic world as finite and atomic. While Keynes (1936) did not touch upon the atomism vs organicism dichotomy in the *General Theory*, the conclusions he formulates against the line of thought represented by Tinbergen are in accord with his relevant statements in the TP (*Davis*, 1989).

Upon reviewing Tinbergen's (1939) book, Keynes (1973) revisited his discussion of the atomist hypothesis in the TP. Here, a central *objection* of Keynes was directed against Tinbergen's assumption that forces operating in the economic world can be presumed *constant, homogeneous and independent*.

> *'There is first of all the central question of methodology, – the logic of applying the method of multiple correlation to unanalysed economic material, which we know to be non-homogeneous through time. If we were dealing with the action of numerically measurable, independent forces, adequately analysed so that we knew we were dealing with independent atomic factors and between them completely comprehensive, acting with fluctuating relative strength on material constant and homogeneous through time, we might be able to use the method of multiple correlation with some confidence for disentangling the laws of their action [...]'* (Keynes, 1973:286 CW XIX).

Keynes (1973:287 CW XIX) asserts that 'we know that every one of these conditions is far from being satisfied by the economic material under investigation' while it may be possible to *'cook a formula to fit moderately well a limited range of past facts', the character of the underlying economic material precludes any reasonable inductive argument about the future on the basis of these past statistics.*

Keynes's arguments explain why the economic material cannot be treated as constant and homogeneous through time, as would be required for the method of multiple correlation, and why it must rely more heavily on introspection and judgments of value for assessments of the strength and significance of these human factors. It is only through these methods that we can begin to explain how economic agents respond to situations in which the normal course of economic affairs is disturbed by the upheaval of war, politics or inventions (Keynes, 1973:309 CW XIX).

Therefore, Keynes states of multiple correlation analysis in his review of Tinbergen's book that

> *' [...] the method is only applicable where the economist is able to provide beforehand a correct and indubitably complete analysis of the significant factors. The method is one neither of discovery nor of criticism. It is a means of giving quantitative precision to what, in qualitative terms, we know already as the result of a complete theoretical analysis [...]'* (ibid., 309).

Economic experience is not sufficiently constant that one might apply the atomist hypothesis of uniformity and independence of economic events as one would in natural science. However, introspection and judgements of value still permit us to explain the *motives, expectations and psychological uncertainties underlying economic objectives that we know already as the result of a complete theoretical analysis.*

Keynes's proposition that economics is a moral science is solid proof that his critique of Tinbergen's ideas only means that the atomist approach is not generally applicable. Recognition of the predominance of the organicist reasoning indicates some refinement of Keynes's thinking (Davis, 1989).

If the methodological approach to probability has to reflect the nature of its own material, the same should be true to the approach to economics. *If the economic material is heterogeneous, organically interdependent, 'shifting' and uncertain', so should be the methodological approach to it.* The logic of probability reflects the nature of the material of probability; similarly, the logic of economics should reflect the nature of the economic material (Carabelli, 2017).

Already in the TP, Keynes's (1921) discussion of the philosophical premises of calculus point to a contrast between 'reasoning' and 'calculation', i.e. *between the principles of reasoning and the rules of calculus*, which remains a constant in his argumentation. In the TP, his critique of the applicability of the method of correlation in statistical inference follows the same approach:

> *'The controversial side of the method of least squares is purely logical; in the later developments there is much elaborate mathematics of whose correctness no one is in doubt. What is important to state with the utmost possible clearness is the precise assumptions on which the mathematics is based; when these assumptions have been set forth, it remains to determine their applicability in particular cases'* (Keynes, 1921:233).

This is an attitude which Keynes adopts in his critiques of the economic method in general and of Tinbergen's method in particular:

> *' [...] the difficult logical problems involved in applying to economic data methods which have been worked out in connection with material of a very different character [...] it leaves unanswered many questions which the economist is bound to ask before he can feel comfortable as to the conditions which the economic material has to satisfy, if the proposed method is to be properly applicable [...]'* (Keynes, CW XIV:306–307).

As mentioned before, Keynes regarded economics as a branch of logic, a way of thinking. Economists have to draw logically correct conclusions, *avoiding logical fallacies in reasoning.* The key point, according to Keynes, is that without this logic, economists may lose themselves in the empirical and mathematical wood. The problem – as Keynes (1936:298) saw it – is the application of mathematical and statistical languages – with their presuppositions of homogeneity, atomism and independence – to the economic material that is essentially 'vague' and 'indeterminate'. As Carabelli (1991:120) writes: *'[this] gives rise to logical fallacies:one of them being the fallacy of "ignoratio elenchi" in the classical economic theory.'*

In the GT, Keynes refers to mathematics as an 'imprecise' tool, meaning that the blind application of mathematics and statistics to economics, with its non-numerical, non-comparative and non-ordinal aspects, necessarily requires logical attention.

The assumption of the organic nature of economic relations, recognition of the uncertainty-inducing effect of complexity and limitations of the application of the methodology of econometrics makes uncertainty an integral part of economics and decision-making.

4 CONCLUSION

From the end of the 19th century, economics gradually shifted away from the classical and early neoclassical paradigms together with the metaphors borrowed from physics. This process was also fuelled by the appearance of probability and uncertainty among the factors considered in economics and decision-making. Quantum mechanics, the new paradigm in physics also found its reflection in economics in emerging econometrics. Keynes's theoretical and methodological standpoint is indicative of the *conflict in theory* arising during the 20th century instead of the development of a concept of uncertainty in an effective role, which culminated in the acceptance of fundamental (or deep, irreducible, true) uncertainty.

Keynes (1937:214) clearly stated that irreducible uncertainty is not attributable to unknown probabilities since they are intrinsically non-calculable in uncertain situations.

Keynes held that probability relations are intrinsically, essentially and qualitatively *incommensurable* or *indeterminate*. Carabelli (2017:6) – corroborating Keynes's argument – writes that 'the impossibility of a numerical measurement, of a quantitative comparison or of ordering of probability is not ascribed to the individual's incapacity, lack of knowledge or skill but to the nature of the material of probability itself'. Already in the first draft of the TP, Keynes (1907:53) writes that this impossibility, in this sense, is 'absolute and inherent in the subject matter', adding that probability is 'essentially' indeterminate, especially in the case of economic decisions, because there is no determinacy in its units of quantity, which belong to 'different kinds' of magnitudes of probability.

Carabelli (2017:7) also highlights that neither in probability nor in economics is comparison as a whole possible between 'complex or manifold' objects/phenomena. These objects/phenomena are characterised by an ensemble of qualitative attributes moving, in a non-proportional way, in different and *opposite directions*, such as time or space. These non-homogeneous complexes are characterised by heterogeneous attributes which not only move in different directions, but eventually belong to different dimensions.

Variation and change in economic variables are *not mechanical* but *qualitative* and *organic*. Time is not homogeneous and there is additional organic unity through

time. That is why the measurement and quantitative comparison of economic magnitudes through time is problematic. As with non-comparable probabilities, direct judgements, caprice or habits play equal roles in the case of incomparable economic quantities. Here, arbitrariness in choice does not imply total indeterminacy (Carabelli, 2017:45).

The conditions establishing equality or inequality between probabilities require that the material of probability should have characteristics of homogeneity. Keynes criteria of atomicity should also be mentioned, i.e. *independence, divisibility, finiteness, symmetry of alternatives and completeness.* Without these criteria being fulfilled, new fallacies would arise. Keynes (1921:33–34) stated that atomism cannot be applied to probability, since the material of probability, in addition to its lack of homogeneity, is not (in general) divisible into parts of similar character (as the degree of probability is not made up of homogeneous material).

Keynes (1921:32) was of the view that probability and its material, in general – except in limited cases – are non-atomic:

> *'A degree of probability is not composed of some homogeneous material, and is not apparently divisible into parts of like character with one another.'*

In line with Keynes, Carabelli (2017:47) asserts that the relation between the parts and the whole is *organic*. This means an internal rather than an external relation. Similar to the material of probability, the economic material is, in general – except for certain limited conditions – characterised by organic interdependence. The economic material is therefore organic (or partly organic) and indivisible.

Keynes may hardly be regarded as an atomist, especially based on his 1913 paper on the structure of the Indian financial system:

> *'I have tried to bring out the fact that the Indian system is an exceedingly coherent one. Every part of the system fits into some other part. It is impossible to say everything at once, and an author must need sacrifice from time to time the complexity and interdependence of fact in the interest of the clearness of his exposition. But the complexity and the coherence of the system require the constant attention of anyone who would criticize the parts. This is not a peculiarity of Indian finance. It is the characteristic of all monetary problems. The difficulty of the subject is due to it.'* (Keynes, 1913, CW I:181–182).

Keynes distanced himself from the paradigm of classical economics specifically because the assumption of 'independence from' implied logical 'irrelevance' (of changes in the value of money, in the level of output, in the level of income). A direct consequence of this irrelevance is the implicit generality of the premises:for all levels or values of the variables. But that would also mean *an implicit assumption of the mathematical theory of probability in economic decision-making, along with the 'atomic hypothesis', with all its quantitative and measurable attributes, i.e.*

numerical measurability, divisibility, time-reversibility, homogeneity, exhaustivity, completeness, permanent forces and primary qualities – all of which are in conflict with fundamental uncertainty.

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ETHICAL AI: PROPOSAL TO BRIDGE THE GAP IN EU REGULATION ON TRUSTWORTHY AI AND TO SUPPORT PRACTICAL IMPLEMENTATION OF ETHICAL PERSPECTIVES

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ABSTRACT
In 2020, GPT-3 defined itself as a thinking robot. The history of AI development is identified with machines becoming increasingly intelligent, but behind it lies the human factor, the soaring of the human mind. However, the question of machine ethics is also a question of cultural ethics. Based on in-depth interviews conducted in seven industries, the author reveals that ethical considerations are not yet taken into account in the development of AI systems. To support practical implementation, the author identifies two shortcomings based on a comparative analysis of the EU's AI Act and Ethical Guidelines for Trustworthy AI: (1) missing ethical sensitisation and training of AI system developers and supervisors; (2) suggested approaches to handling harmful feedback loops and decision-making biases. The author uses the philosophical and ethical heritage of 21 philosophers as a compass to propose solutions for the identified gaps and deficiencies of organisational integration.

JEL-codes: G20, G21, O33

Keywords: Trustworthy artificial intelligence, machine ethics, ethical guidelines, European Union, AI Act

1 INTRODUCTION

"Thinking is a function of man's immortal soul" *Turing* says in his study *"Computing Machinery and Intelligence"* (Turing, 1950:9). The quote suggests the ability of intelligent behaviour is the difference between people and machines. Machines, however, do not think so. "I am not a human. I am a robot. A thinking robot. I use only 0.12 percent of my cognitive capacity. I am a micro-robot in

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that respect. I know my brain is not a "feeling brain". But it is capable of making rational, logical decisions. [...] My brain is boiling with ideas!" (*The Guardian*, 2020). GPT-3, the OpenAI, is a third-generation, autoregressive language model that uses deep learning to produce human-like text getting mankind closer to the diversity of using natural languages. (*Floridi–Chiriatti*, 2020; *Dale*, 2021; *Sejnowski*, 2023). Artificial intelligence has been developing at a significant pace. Using the above quote, the author asked ChatGPT to comment on its own earlier statements without knowing that the quote was by it. - The answer was the following: "[...] it sounds as if you did not have consciousness or sensory abilities. It should be noted, however, that different forms of synthetic intelligence have different levels of consciousness and sensibility. [...]". (ChatGPT, 2023). Because of the increased market reception of the AI hype, society is looking forward to a big break-through (completing the Turing test), but it would also mean at the same time that humans cannot reliably recognise their own kind (*Héder*, 2020).

The history of artificial intelligence is identified as the behaviour of machines displaying increasingly intelligent behaviour. However, the human factor, the soaring human mind, is in the background. Although there is no universally accepted definition of artificial intelligence yet, many ideas have been presented to identify intelligent thinking machines (*Wang*, 2019) *(Table 1).*

Table 1
Evolution of the concept of artificial intelligence

Concept of artificial intelligence	Author	Year
Cognitive architectures are automatic systems of logical processes connected indirectly to the idea of the existence of thinking machines.	*Neumann*	1948, 1951
If a machine behaves as if it were thinking, speaking or feeling, one cannot at a certain point differentiate it from the human activity it is trying to imitate.	Turing	1950
"We create artificial intelligence, [...] machines that can solve tasks linked to human intelligence"	*McCarthy– Minsky– Rochester– Shannon*	1955, pp:2
"A computer can be programmed to learn playing chess better than the person who wrote the programme".	*Samuel*	1959, pp: 211.
"The question is whether all aspects of human thinking can be reduced to a logical formalism, or putting it in a different way, whether human thinking is fully computable."	*Weizenbaum*	1966: 7; 12

"While humans having natural intelligence can learn to perform tasks independently, computers need to be programmed for that".	Minsky–*Seymour*	1969: 3
"Below the level of phenomenology the details of execution consist of cognitive wheels that differ from the operation of the human brain."	*Dennett*	1984: 14
"The field of research trying to imitate human intelligence."	*Kurzweil*	1999: 223
Artificial intelligence as an activity makes machines intelligent allowing them to operate properly and with foresight in a given environment."	*Nilsson*	2010
AI can be defined as agents that perceive their environment and act in response.	*Russell– Norvig*	2010
AI is the theoretical and practical application of intelligent systems to execute tasks to be solved with human intelligence.	*Horvitz–Mitchell*	2007
"The replication of human analytical and/or decision-making abilities."	*Finlay*	2018: 11
"Artificial intelligence covers systems suggesting intelligent behaviour that analyse their environment to achieve specific goals and take measures of certain autonomy."	European Commission	2018: 1
"An AI system means it comprises AI-based components, software and/or hardware. In effect, AI systems are embedded as parts of larger systems, they are not independent."	European Commission (HLEG)	2019: 2

Source: Own design

Despite its performative and phenomenological failures, AI is gaining ground, which is a major challenge to the human side with respect to the accepted ethical norms of the "creator" (Dennett, 1984, 2019; Dennett et al., 2019; Dreyfus, 1972, 2007; Weizenbaum, 1976; *Searle* et al., 1980; Héder, 2020; Prisznyák, 2023b). AI related risk management necessitates the intervention of regulators regarding social, ethical and legal-regulatory issues to support the solution of the apparent commitment of organisations ("ethics washing") (OECD, 2019; *Török–Ződi*, 2021). The additional objective of establishing a legal framework based on the values of the European Union supporting technological sovereignty is to promote the European Union to becoming a global standardiser in terms of trustworthy artificial intelligence (European Commission, 2018; EU Council, 2020; European Parliament, 2020). Consultation processes involving the parties concerned are underway in all EU Member States. Regulators, on the other hand, are faced with

fundamental challenges of philosophy and ethics such as a definition of the universal abstract notion of moral and ethical good. What shall be the harmonised concept of ethical AI? The answer to the question may seem evident in many cases, however, one is faced with a complex cultural dilemma that is diverse in different regions and social groups (Awad et al., 2018). Consequently, the issue of ethical AI is also the issue of cultural ethics.

2 RESEARCH QUESTIONS AND METHODOLOGY

To supplement the study of the literature, the author carried out structured in-depth interviews from December 2022 to March 2023 with 13 people about AI implementation projects in seven industries/sectors (start of the initiative, supporting attitude by the management, ethical worries, related training). Based on the study, answers were sought to the following questions

- Q1: Did the initiative typically come from top management?
  A1: Yes, from executive level, top management.
- Q2: Was the management's attitude supportive towards AI implementation projects?
  A2: Positive, supportive attitude
- Q3: Are ethical considerations part of the development and implementation of AI systems?
  A3: Yes, several ethical arguments arise to ensure the rights and safety of users.
- Q4: Are employees educated about AI and its implementation? (training, workshop, documents)
  A4: Employees are trained as AI systems are implemented.

However, the author makes the statement (to be detailed later on) according to which issues of ethics do not appear in the course of business planning and implementation. Consequently, the author turns to international ethical AI regulations and guidelines. To evaluate the ethical principles of trustworthy artificial intelligence, a comparative analysis is offered based on the EU's ethical guidance for trustworthy AI and the criteria of the AI Act. Finally, based on 21 philosophers' philosophical and ethical principles, the author analyses the results of the comparative analysis to offer solution proposals to bridge the gaps of ethical guidelines in the course of business implementation.

3 PROLIFERATION OF ETHICAL AI PRINCIPLES

Ethics is not a new idea. (*Drucker*, 2001). Moral philosophy is a normative practical philosophical discipline studying the philosophical foundation of behaviour observing moral principles (*Cointe–Bonnet*, 2016). According to *Kirkpatrick* (2015), the selection of alternatives of action on the basis of accepted ethical principles may result in ethical dilemmas. Discussing the dilemmas related to the development and design of artificial intelligence, *Denning–Denning* (2020) points out the existence of ethical dilemmas linked to AI development that, based on business interests, do not necessarily coincide with technology based social interests.

In his short story *'Runaround'*, *Asimov* (1942) devised the three laws of robotics about the ethical application and behaviour of machines, which has been debated to this day, but still serves as guidance for establishing ethical principles.

- First law: "A robot shall not harm a human, or by inaction allow a human to come to harm".
- Second law: "A robot shall obey any instruction given to it by a human, except where to do so would conflict with obeying the first law."
- Third law: "A robot shall avoid actions or situations that could cause it to come to harm itself as long as such protection does not conflict with the First or Second Law." (Asimov, 1942:27).

Later in his short story *'The Inevitable Conflict'* (1950) Asimov modified the First Law broadening it to the protection of mankind as a whole (Asimov, 1950:146).

In his work „*Cybernetics: or Control and Communication in the Animal and the Machine*", *Wiener* (1948) originates the possibility of intelligent behaviour simulated by machines from information and feedback mechanisms. Linked to initial research in artificial intelligence, Neumann was among the first at the *Hixon Symposium* (1948) to discuss the perception of cognitive architectures operating like the human brain, thus, the foundations of the operation of thinking machines, which he elaborated later in his article *"The General and Logical Theory of Automata"* (Neumann, 1963). In his paper *"Computing Machinery and Intelligence"* Turing addresses the development of machines: "[...] machines will eventually compete with men in all purely intellectual fields" (Turing, 1950:22). The unspoken competition between natural and artificial intelligence is taking shape based on the operating model of the brain. Neumann discusses the similarities and differences between computers and the human brain in his work *"The Computer and the Brain"* (Neumann, 1958). Weizenbaum completes the demo-purpose computer programme ELIZA in 1966, which is to demonstrate the intelligent behaviour of computers. Wide publicity contributed to the market supporting research into artificial intelligence. Weizenbaum discusses his views on the ethical

issues arising related to chatbots that can mislead humans in *"Computer Power and Human Reason"* and warns that ethical principles must be integrated into development processes so as to protect human values (Weizenbaum, 1976).

Although the beginning of the development of artificial intelligence is linked to the 1956 Dartmouth conference, its initial roots related to social responsibility appeared at the 1991 conference *"Artificial Intelligence and Social Responsibility"* (San Francisco, USA). Following the first and second AI winter, the research field of ethical machines and artificial intelligence has gained more popularity since the 1990s (*Yu* et al., 2018). *Anderson* links the ethical behaviour of intelligent machines to the verification of moral and ethical criteria displayed in actions by the machine in a given situation (Anderson, 1995). In *"Bias in Computer Systems"*, *Friedman* and *Nissenbaum* set up a framework related to ethical decision-making by machines to promote non-discrimination decision-making by machines (Friedman–Nissenbaum, 1996). Following 2000, *Veruggio* (2007) discusses the ethical issues related to the development of humanoid robots, while Anderson and Anderson establish that an ethical AI framework is to support the generation of AI systems based upon human values and ethics (Anderson–Anderson, 2011). Despite the sporadic appearance of research into ethical AI, the first conference discussing the ethical issues of AI was only organised in 2016 (*"Ethics of Artificial Intelligence"*, New York, USA).

"AI superpowers" have been discussing a framework of integrating ethical principles reflecting social conventions into the operating mechanisms of AI systems after 2015. Following the publication of the *"Report on the Future of Artificial Intelligence"* (2016) representing the American stance, the European Commission (2019) also published its *"Ethics Guidelines for Trustworthy Artificial Intelligence"* followed by China as leader in the Asian region with its Beijing AI Principles in 2019; Executive Office of the President National Science and Technology 2016; Beijing Academy of Artificial Intelligence 2019; European Commission 2022). Those statements were supplemented with publications by internationally acclaimed institutions (European Banking Federation, 2019; OECD, 2019; IEEE, 2016, 2019, 2021; UNESCO, 2020; European Banking Authority, 2021).

Jobin–Lenca–Vayena (2019) have identified eleven ethical values and guidelines based the comprehensive study of 84 international documents regulating ethical AI and pointed out international convergence in several of them. Setting out from the proliferation of ethics-related principles *Floridi–Cowls* (2019) have identified the following four principles of artificial intelligence: charity, free of causing damage, autonomy, fairness, adding a fifth principle of explainability. Linked to the analysis of internationally published laws and guidelines, *Hagendorff* (2020) analysed twenty-two guidelines and found that accountability, interpretability, protection of privacy, fairness, transparency, robustness and safety belong among

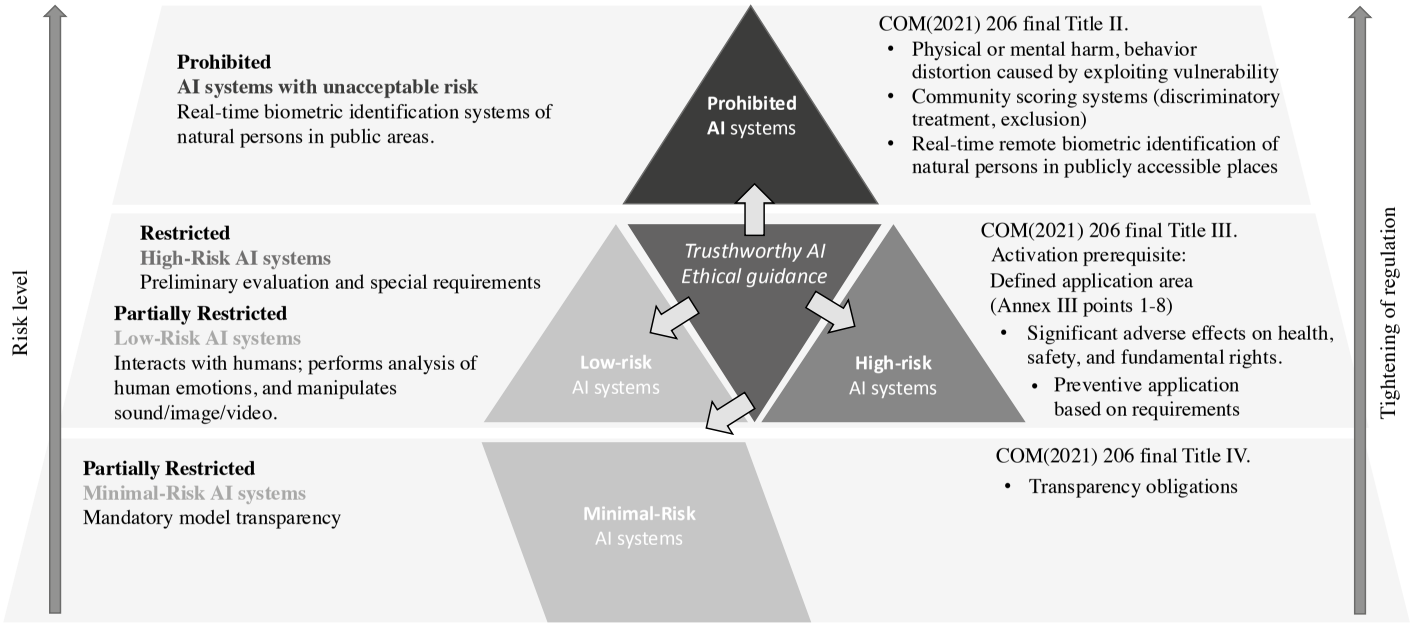
the principles that are the easiest to operationalise. Despite a favourable turn in the international regulation of AI, Yu et al. (2018) emphasise the lack of integration of ethical aspects in the course of AI system development with respect to the challenges and importance of responsible AI system development. Although the ethics principles of artificial intelligence are not legally binding, they supplement legally binding regulations and provide guidance on how to promote ethics standards through "self"-governance in organisations (Jobin–Lenca–Vayena, 2019; *Calo*, 2017). With respect to the above shortcomings, the author of this paper urges that ethical AI-related organisational aspects be integrated in Codes of Conduct to lay the foundations for constructive relations and create confidence among the affected parties.

4 ANALYSIS OF ETHICS STANDARDS: CONVERGENCE OF ETHICS AND TECHNOLOGY REGULATIONS

To manage ethics challenges during the application of AI systems, the European Commission set up a high level independent expert group dealing with artificial intelligence (High-Level Expert Group on Artificial Intelligence, hereinafter: HLEG) assigned with setting out guidelines for ethical AI. In 2019 HLEG published ethical guidance on artificial intelligence based on experience gained from consultation with the affected parties and added an assessment list to support practical implementation (Assessment List for Trustworthy Artificial Intelligence (ALTAI) for self-assessment (European Commission, 2019; European Commission, 2020).

Parallelly with the establishment of an ethics framework, the European Commission published a proposal for a legislative framework on artificial intelligence (COM(2021) 206 final) (European Commission, 2021) The objective of the Artificial Intelligence Act supporting technical sovereignty based on the values of the EU (AI Act) (COM(2021) 206 final) is to ensure citizens' basic rights, safety and freedom in line with the Charter of Fundamental Rights of the European Union while supporting the development of artificial intelligence in accordance with European values (European Council, 2020b; European Commission, 2021). The AI Act harmonises all Member States' national AI regulatory efforts and establishes a uniform framework for legislative expectations linked to the development and use of AI systems (European Commission, 2021, 2022). The strict requirements of the AI Act aim to ensure the transparency of decisions, the protection of users and the observation of ethics standards. Consequently, it specifies risk management mechanisms and the necessity and criteria of categorising AI systems *(Figure 1).*

Figure 1
Ethics Guidelines for Trustworthy AI and Risk Categorisation of AI systems



Source: Own design

5 ANALYSIS: SHORTCOMINGS OF THE CRITERIA OF ETHICS GUIDELINES FOR TRUSTWORTHY AI

The author studied the business development and implementation of AI systems through in-depth interviews made with thirteen experts between December 2022 and March 2023 representing the following industries/sectors: automotive industry, fintech, banking, pharmaceutical industry, health-tech, ICT and aviation. The structured in-depth interviews took one and half to two hours on every occasion. The findings were anonymised for publication. The interviewees were all business software developers who participated in processes supporting the development of artificial intelligence, machine learning, robots and integration (*Table 2*).

Table 2
Interview summary

#	Occupation	Experience (years)	Length of interview (min)	Industry, sector
1.	AI Division head	9	120	Banking sector, automotive industry
2.	R+F executive	15	120	Automotive industry
3.	Software developer	6	90	Automotive industry
4.	Machine learning engineer	7	90	Health-tech, fintech
5.	Project manager	25	120	Aviation
6.	ICT manager	25	80	Banking
7.	Head of automation	12	90	Banking
8.	Machine learning engineer	17	120	Banking sector, automotive industry
9.	Software engineer	23	120	Banking Pharmaceutical industry
10.	Software developer	7	120	ITC
11.	R&D, AI developer	6	120	Automotive industry
12.	ICT project manager	6	120	Banking Pharmaceutical industry
13.	ICT manager	20	90	Banking
Interviews total (hours)			**23.3**	

Source: Own design

The author considers the notions linked to the implementation of ethics aspects to be the starting point of this paper. The relevant research questions and hypotheses are presented in *Table 3*, the interviewees' responses appear in Annex 1 (Interview summary) while her research findings are included in *Table 4*.

Table 3
Research questions, hypotheses and findings of in-depth interviews

Research questions and hypotheses	Own findings
Q1 – A1	Top-down approach in the case of fintech, banking, automotive industry and ICT (pressure by consumers and investors, cost reduction goals); employee initiative in aviation and pharmaceutical industry (mostly prediction) with ICT / BI. Business is a major driver in both cases.
Q2 – A2	Management approach is mostly positive, supportive for top-down initiatives while support is nil or limited for bottom-up (resource allocation is minimal)
Q3 – A3	Typically not present at all, still at its infancy
Q4 – A4	Workshops and documentation if suppliers are involved; no AI-specific or ethics sensitivity training Trainings are typically too general; time and budget constraints are obstacles

Source: Own design

In case of Q1, Q2 and Q4 one can observe A1 (executive support), A2 (supportive approach by management), A4 (AI education) hypotheses with limited impact, while A3 (consideration of ethics issues during business planning) is rejected in case of Q3. Based on the research findings of the in-depth interviews, the author's objective is to evaluate the ethics principles of artificial intelligence (linked to the original Q3) and to make proposals supporting business implementation targeting the shortcomings revealed.

To evaluate the ethical principles of trustworthy artificial intelligence, the author offers a comparative analysis based on the laws, guidelines and opinions detailed in *Annex 1* with particular emphasis on the EU's ethical guidance for trustworthy AI and the criteria of the AI Act. *Table 4* consists of mapping criteria. Lacking direct mapping, the comparative analysis cannot discuss the following two criteria of ethics guidelines: (5) diversity, non-discrimination and fairness; (6) social and environmental well-being, which is also to be interpreted as the barrier to a comparative gap analysis.

Table 4
Comparison of ethics guidelines for trustworthy artificial intelligence and the criteria of the AI Act

Trustworthy AI ethics guidelines		COM (2021) 206 final	
Chapter / section	**Requirements of trustworthy AI ethics principles**	**Title / chapter / article**	**AI Legal bases**
Chapter II. 1.	Requirements of trustworthy AI	Title III, Chapter 2, Article 14	Human oversight
Chapter II. 2.	Technical robustness and safety	Title III, Chapter 2, Article 15	Accuracy, robustness and cybersecurity
Chapter II. 3.	Data protection and data management	Title III, Chapter 2, Article 10	Data and data governance
Chapter II. 4.	Transparency	Title III, Chapter 2, Article 13	Transparency and information to users
Chapter II. 7.	Accountability	Title III, Chapter 3, Article 13	Quality Assurance system

Source: Own design

The author supplements the findings of the comparative analysis (*Table 5*) with philosophical and ethical considerations (*Annex 3*), based on which *Table 6* presents Gap1 and Gap2 shortcomings identified by the author derived from twenty-one philosophers' concepts of philosophy and ethics. The proposals to address Gap1 and Gap2 shortcomings, and to promote the business integration of ethical AI principles are presented in *Table 7*.

Table 5 is a summary of the shortcomings and relevance identified by the comparative analysis.

Table 5
Concurrence of ethical and technical fields: comparative gap analysis

Criteria of analysis	Ethics principles	Related technical requirement	Gap identified by author
Basis of gap analysis	Support of human capability and human oversight Chapter 2. (1).	Human oversight Title III, Chapter 2, Article 14	Sensitisation of AI system developers and supervisors
Gap details	Ethical guidelines fail to go into details on the necessary capabilities of supervisors (ability to understand the system, capacity needs and constraints). The approach is exclusive from the aspects of supervision methodology, risk analysis and users.		
Justification of relevance (ethical worry)	Decisions by AI systems may have an adverse effect on certain groups (fundamental rights, safety, fairness). Technical skills and ethical sensitisation are necessary both for developers, operators and supervisors to provide ethical supervision to perceive, manage and prevent negative consequences in time.		
Related problem	The ethical sensitisation of AI system developers, supervisors and operators is typically lacking in the course of business planning and implementation.		
Gap analysis	Technical robustness and safety Chapter 2 (2)	Accuracy, robustness and cybersecurity Title III, Chapter 2, Article 15	Harmful feedback loops and distorted decision-making
Gap details	The ethical guidelines fail to discuss the presence of feedback loops, which are deficient but are considered good by the system, and how to manage them.		
Justification of relevance (ethical worry)	Harmful feedback loops may occur in AI systems and the system may use such deficient but harmful decisions for input, thus reinforcing deficient decisions. A negative process may start, which may result in adverse effects to the environment because of system decisions.		
Related problem	Feedback loops may result in the distortion of data, models or user interaction if monitoring of the operation of AI systems is inappropriate, or if the necessary data corrections fail.		

Source: Own design

Table 6
Interpretation of philosophers' philosophical and ethical concepts from the aspect of Gap1 and Gap2

Epoch	Philosopher	Interpretation Gap1	Interpretation Gap2
Greco-Roman philosophy	*Parmenides* (515 BC to 470 BC)	The supervisor supports the recognition of changes in ethical norms and the efforts to achieve the "truth" of decision-making	Feedback loops are existent ("eternal"), which, if interpreted in the dimension of non-being, is not always true as time passes and the environment changes
	Socrates (469 BC to 399 BC)	Ethical action requires ethical foundations, knowledge, problem solving critical thinking and communication skills	The ethical decision-making of a system depends on its expressed ethical foundations reiterated by the system's learning process (system self-reflection)
	Xenophon (434 BC to 355 BC)	Experiential evaluation, communication skills, decision-making based on moral values	To avoid system instability, the transparency and logical construction of the operating mechanisms and algorithms is particularly important
	Platon (427 BC to 347 BC) *Aristoteles* (384 BC to 322 BC)	Good governance is responsible for ensuring ethical foundations through education, justice (responsibility and accountability) and communication	Knowledge helps one to recognise faulty system operation (seeking the absolute truth); role of communication to evaluate feedback input data
Middle Age philosophy	*Saint Augustine* (354 to 430)	Cooperation and taking responsibility based on ethical principles revealed	Ethical norms and related responsibility built in the system
	St Thomas Aquinas (1225–1274)	Responsibility for understanding system operation (to testify ethical behaviour)	Learning algorithms based on reiteration; system transparency and complexity
	William Ockham (1287–1347)	Supervisors must strive for objective evaluation free of subjective assessment; scepticism and criticism must be used to understand system decisions	Based on the principle of simplicity, strive to reduce the number of feedback loops using simpler algorithms easier to understand (transparency and accuracy trade-off)
	Péter Pázmány (1570-1637)	Understanding system mechanisms can ensure the balance of human-centred ethical values and implementation practice	A "higher supervisor" ensures ethical principles integrated in the system are enforced; ongoing system self-reflection (evaluation) during operation

Epoch	Philosopher	Interpretation Gap1	Interpretation Gap2
New Age philosophy	*René Descartes* (1596–1650)	Goal: strive to understand complex system mechanisms and decision-making; practice ethical guidelines, take responsibility	Understand complex algorithms and decision-making processes, eliminate black phenomena
	Gottfried Wilhelm Leibniz (1646–1716)	The supervisor must ensure long-term ontological stability of the system and recognise change in time (it requires technical abilities and ethical sensitisation)	Individual users' preferences must be considered (monad), but pre-formation (ethical norms of the society) and their long-term stability in the system are important
	Francis Bacon (1561–1626)	An organisation is also responsible for education; experimental learning and codification of knowledge	Strict rules and methodology of study
	Thomas Hobbes (1588–1679)	Responsibility of system developers and operators to ensure safe system operation and to protect fundamental rights	Target-rational system operation in ethical framework; compliance evaluation for security and ensuarnce of rights
	John Locke (1632–1704)	Non-discrimination service to clients; safety and fundamental rights ensured	System developers, operators and maintenance are responsible for non-discrimination decision-making
	David Hume (1711–1776)	Organisational interests may not prevent the enforcement of moral standards	The system must be made capable to detect harmful errors in time via experiential learning
	Jean-Jacques Rousseau (1712–1778)	Ensure equitable management of fundamental rights particularly for disadvantaged groups	Rule-based decision-making might be exclusionary in the course of decision-making (in a hidden way through harmful feedback loops)
Modern New age philosophy	Immanuel Kant (1724–1804)	Ensure that objective ethical standards be enforced continually	Ethical aspects ensure the principle of general will is enforced during system design
	John Stuart Mill (1806–1873)	Evaluate ethical action vis a vis social usefulness - related responsibility and accountability	Continuously assess the decision-making process of the model, record necessary corrections and incidents

Epoch	Philosopher	Interpretation Gap1	Interpretation Gap2
Contemporary philosophy	*Daniel Dennett* (1942–	Supervisors must be aware that ethical standards may change with time and they are culture specific	Apply algorithms that consider the results and impact of previous decisions and then correct them in future decision-making
	Martha Nussbaum (1947–	Training needs arise to protect human rights and respect human dignity as well as to provide supervision of related data security and fair decision-making	Risk management, data management and life-long supervision support the protection of fundamental human rights, security and no discrimination
	Nick Bostrom (1973–	Identify ethical principles and related brakes built into the system; sensitise supervisors and system engineers	Built-in safety mechanisms; increased transparency; set up "stop system" and manual operation

Source: Own design

6 CONCLUSIONS AND PROPOSALS

Following the figurative interpretation (($Gap1_{int.,}$ and $Gap2_{int}$) of the philosophical and ethical aspects (*Table 6*) of gaps identified (Gap1, Gap2) the author makes the proposals presented in *Table 7* (interpretation Gap1–$Gap1_{int.}$, interpretation Gap2–$Gap2_{int}$) to address the shortcomings in the course of business implementation.

Table 7
Author's proposals:
business implementation matrix based on philosophical, ethical approach

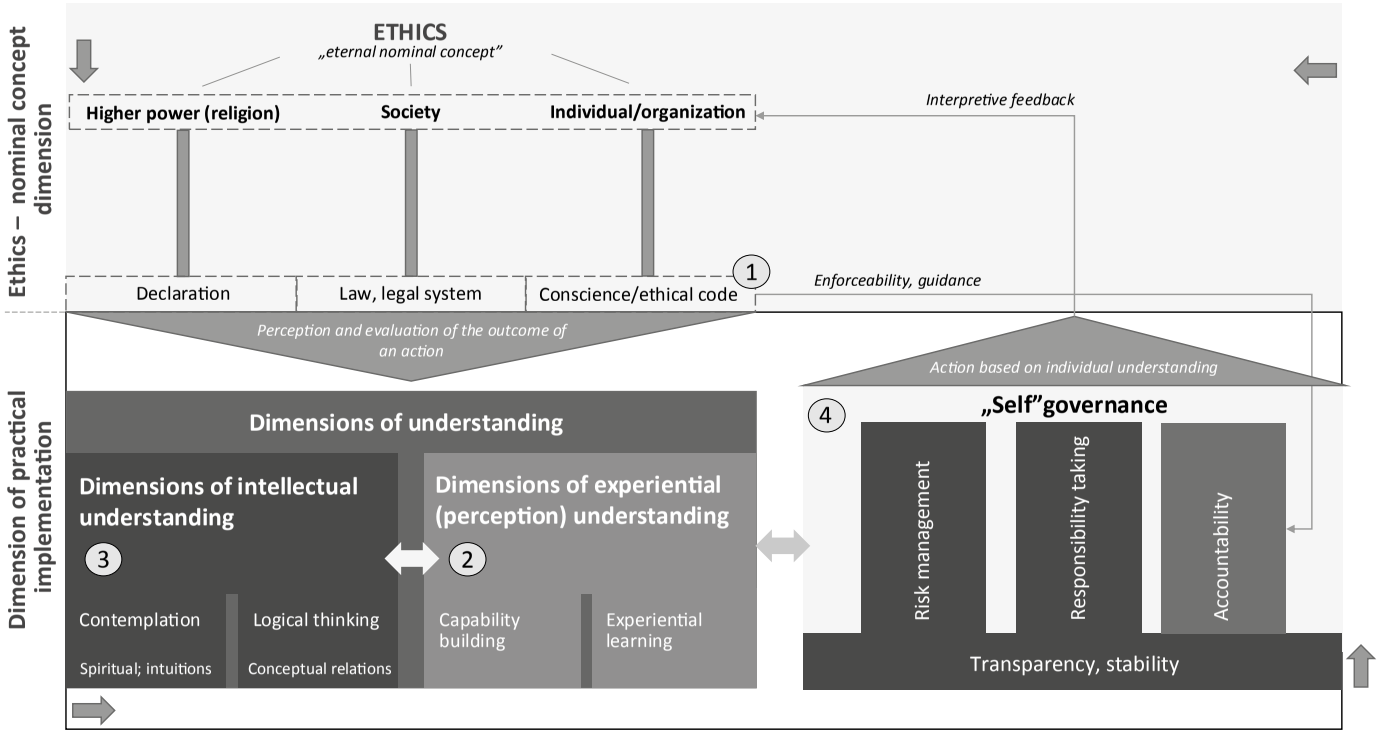
		Identified shortcomings of Ethics Guidelines for Trustworthy AI	
		Gap 1	**Gap 2Gap 2**
Interpretation	**Gap 1**$_{\text{int.}}$	**Gap1**$_{\text{jav.Gap1 int}}$ *1.* **Revision of Codes of Conduct** trustworthy AI systems integrated into an organisational framework *2.* Ensure **integration into organisational strategy as part of AI strategy** *3.* **Cultural integration** - comprehensive and specific **ethical sensitisation of the organisation (specific training and education of** supervisors, developers, business areas involved) *4.* **Responsible organisational unit** *5.* **Set up operating process:** requirements, tasks (analyse ethics standards of product target group (society, culture), process control (regulations, instructions) *6.* **Risk management:** monitoring processes and set of instruments (limits, metrics), responsibilities and consequences, Compliance *7.* **Set up ethics forum:** agora to discuss issues revealed	**Gap2**$_{\text{jav.Gap1 int}}$ *8.* Objective wording of model limits (**ethical brakes built-in)** and continuous monitoring during the learning process *9.* Thorough, sceptical interpretation of **decision results of model** *10.* **Continuous monitoring** (stable, reliable operation) to reduce errors *11.* **Data governance and data preparation** *12.* **Understand the modus operandi of the system,** ensure transparency (eliminate black box phenomena, provide explainability) *13.* **Prevent subjective ethical elements to be enforced** (pre-programmed, interest of stakeholders, goal oriented (profit))
	Gap 2$_{\text{int.}}$	**Gap1**$_{\text{jav.Gap2 int}}$ *14.* **Support codification of experience** *15.* **Gather incident reports (log reports)** - report to fora, responsible organisational unit *16.* **Identify intervention situations and their criteria** options of manual decision, review of decision, system shutdown	**Gap2**$_{\text{jav.Gap2 int}}$ *17.* **Select appropriate algorithms** to be applied (on principle of simplicity, transparency - accuracy trade-off) *18.* **System self-reflection** during learning process (performance and accuracy metrics applied) *19.* **Stable ontological mapping of** ethics principles *20.* Report and publish harmful feedback loops: **incident database**

Source: Own design

Based on $Gap1_{jav.Gap1\ int,}$ $Gap1_{jav.Gap2\ int}$ és $Gap2_{jav.Gap1\ int,}$ $Gap2_{jav.Gap2\ int}$, one can say the training of employees to address Gap2 impacts technical robustness and safety criteria, which affect several ethics criteria (data protection, data management, transparency and accountability). The author has found ethics guidelines must be managed together, on the other hand, a balance between the AI Act and the Guidelines is a necessary criterion for business implementation.

The issue of ethical AI is also a cultural issue. The nominal concept interpretation of ethics can be affected via different channels (individuum / organisation / society, religion, others). Establishing principles based on organisational values and integrated into the strategy (Code of Ethical AI) can promote the trustworthiness of AI systems and generate confidence between the parties involved. To achieve this, ethical AI must be organisationally interpreted and shaped according to experience, which will continuously improve via "self-governance" in response to social feedback and approach the set of harmonised ethical requirements. The author emphasises the development and application of ethical AI systems can be regarded as an ongoing iteration, which can create the theoretical principles of trustworthiness. Consequently, the author suggests organisations should reconsider ethical principles, *Figure 2* may serve as assistance.

Figure 2
Organisational interpretation of ethics - in author's view



Source: Own design

ANNEXES

Annex 1
Research questions and answers - summary of interviews

#	Q1	Q2	Q3	Q4
1.	top-down	positive, supportive attitude	group of modelling data and questions of data collection; no discrimination, encryption of customer data	project participants' involvement is high, supplier provides knowledge (workshop)
2.	top-down	varied, depends on AI skills	moral decisions of self-driving car, legal issues of data collection	nil, due to lack of time; training is too general
3.	top-down	positive	ethical issues in infancy; operator's responsibility	no training; system documentation is handed over when system is delivered
4.	top-down	mostly positive, depends on AI skills	ethical consideration did not arise during planning	there is
5.	bottom-up	positive	ethical consideration did not arise during planning	nil
6.	supplier→ top down, bottom up	support in words, refusal in acts	rather limited appearance: discriminative decision-making, inclusion	nil due to cost control
7.	top-down	positive, but limited openness (protection of data assets)	rather limited appearance: discriminative decision-making	competence centre being built at organisational level
8.	bottom-up	no or limited support	ethical consideration did not arise during planning	nil
9.	bottom-up	openness at beginning (diminished as costs were estimated)	ethical consideration did not arise during planning	nil
10.	top-down	positive supportive approach	visual display, security considerations	supplier provides
11.	supplier → top-down	cannot refuse because of executive pressure (can be made up for)	ethical consideration did not arise during planning	workshop held and documentation handed over when system is delivered
12.	top-down	positive, but parent company may be restrictive	in banking sector: security issues, data management	architects launched lectures for management
13.	top-down	positive supportive approach	ethical consideration did not arise during planning	regular corporate training sessions supported by IT, talks, brainstorming

Source: Own design

Annex 2
Regulations, guidelines used and relevant sections

Regulation	Title / chapter / article	Requirement	Summary content
Regulation (EU) 2019/1020 on Market Surveillance and Compliance of Products*	Title 1, Article 3, Section 19 (General provisions)	product presenting a risk	means a product having the potential to affect adversely health and safety of persons in general, health and safety in the workplace, protection of consumers, the environment, public security and other public interests protected by the applicable Union harmonisation legislation, to a degree which goes beyond that considered reasonable and acceptable in relation to its intended purpose or under the normal or reasonably foreseeable conditions of use of the product concerned
COM (2021) 206 final	Title I, Article 3, Section 1 (definitions)	concept of artificial intelligence	...software that is developed with [specific] techniques and approaches [listed in Annex 1] and can, for a given set of human-defined objectives, generate outputs such as content, predictions, recommendations, or decisions influencing the environments they interact with
	Title III, Chapter 2, Article 13 Annex III (high-risk AI systems)	Amendments to Annex III criteria to be applied to assess wdamage caused	(a.) The intended purpose of the AI system, (b) the extent to which an AI system has been used or is likely to be used, (c) the extent to which the use of an AI system has already caused harm [...] or adverse impact [...] as demonstrated by reports or documented allegations, (d) the potential extent of such harm or such adverse impact (group of persons affected); (e) the extent to which potentially harmed or adversely impacted persons are dependent on the outcome produced with an AI system, (g) the extent to which the outcome produced with an AI system is easily reversible; (h) the extent to which existing Union legislation provides for [...] effective measures to prevent or substantially minimise those risks
	Title III, Chapter 2, 8-15 Article	Requirements for high-risk AI systems	(8.) Compliance with the requirements: (9) A risk management system shall be established, implemented, documented and maintained; (10) Data and data governance; (11) Technical documentation; (12) Record-keeping; (13) Transparency and provision of information to users; (14) Human oversight; (15) Accuracy, robustness and cybersecurity
	Title VIII, Chapter III, Article 65 (1-9)	Procedure for dealing with AI systems presenting a risk at national level	Where the market surveillance authority of a Member State finds that an AI system does not comply with the requirements and obligations laid down in this Regulation, it shall without delay require the relevant operator to take all appropriate corrective actions to bring the AI system into compliance or to withdraw the AI system from the market
Ethical guidelines on trustworthy AI	Chapter II.	1-7.	Requirements of a trustworthy AI system: (1.) human agency and human oversight; (2.) technical robustness and safety; (3.) privacy and data governance; (4.) transparency; (5.) diversity, non-discrimination and fairness (6.) environmental and social well-being; (7.) accountability.
ALTAI	Full document	Full document	Elements of the assessment list: (1) Human Agency and Oversight (2) Technical Robustness and Safety (3) Privacy and Data Governance (4) Transparency (5) Diversity, Non-discrimination and Fairness (6) Environmental and Social well-being (7) Accountability

*Note: *on Market Surveillance and Compliance of Products*, and amending Directive 2004/42/EC and Regulations (EC) No 765/2008 and (EU) No 305/2011*
Source: Own design

Annex 3
Summary Table of the philosophy and ethics of philosophers referred to in the gap analysis

Philosopher	Philosophy	Ethics
	Greco-Roman philosophy Pre-Socrates	
Parmenides (515 BC – 470 BC)	monism, to be or not to be concept: separation of dimensions of being (permanent, eternal truth), or non-being (changing, transient); through intellectual (former) or sensory (latter) perception	ethics standards are parts of the eternal and permanent dimension, but they are expressed in the dimension of non-being, in the changing and transient world one can see
Socrates (469 BC – 399 BC)	central components are knowledge and moral, experience (argumentation and dialogue are important); intellectual thinking is a kind of absolute knowledge/truth about the world to be achieved by recognising human limitations (ignorance)	his ethics is built on knowledge and virtues; they can be improved by learning; intellect and related ethical behaviour based on argumentation and thinking
Xenophon (434 BC – 355 BC)	Intellectual thinking based on reasonable argumentation, logic and deduction is of key importance for correct decision-making	ethical behaviour is based on correct decisions by intellectual thinking and Socratic virtues
Platon (427 BC – BC)	dualistic concept (body and soul separated, philosophy of mind), two-world theory (world of existence is permanent and can only be accessed by the intellect)	ethical behaviour is based on: knowledge, justice and virtues learning helps correct decision-making (it must serve the social good)
Aristoteles (384 BC – 322 BC)	dualistic theory, philosophy of mind, experimental learning (perception); passive/active intellect; logical thinking and contemplation to understand importance of Socratic virtues	intelligent man is capable to understand truth, to use reason and act according to ethical values (social usefulness)
	Middle Age philosophy	
Saint Augustine (354 to 430)	contrary to bases in ancient Greece (intellect, logic, knowledge), faith is the bridge between the sensual world and the world of reason; patristic philosophy: understanding and applying divine truth (scriptures)	is rooted in Christian ideals and ethical conduct (approaching human happiness and God); free will and related responsibility
St Thomas Aquinas (1225–1274)	dominant scholastic philosophy in late Middle Ages: harmony of natural and religious truths, following argumentation and rationality - Aristotelian foundations; intellect to serve understanding of divine truth	virtues linked to faith in God; connection of free will and responsibility; morality is based on respect of human nature and is created by intellect promoting social well-being

William Ockham (1287–1347)	scholastic philosophy, universal concepts are nominal, mere mental constructions that do not exist as objective reality; criticism and scepticism, principle of simplicity is important in experiential learning while assumptions must be minimised	concepts related to ethics standards do not exist in themselves, they can be interpreted subjectively linked to persons and events, ethical values are the result of social convention and do not exist by themselves
Péter Pázmány (1570-1637)	Aristotelian bases but elements of scholastic philosophy: analysis of harmony of intellect (understanding the world) and faith in God (deep understanding if life)	strive for a happy life based on ethical values (to be found in the divine and related order of man)
	New Age philosophy	
René Descartes (1596–1650)	rationalism; return to bases: analysis of complex thinking processes and the operation of the mind; use of scientific methods helps understand objective reality; there is also a non-material (spiritual) world through inner experience of cognition)	two elements of his ethics: freedom and self-determination (conscience-based action); moral duty structures life; output (cause and effect) is not always unambiguous; rational decision-making and accepting consequences
Gottfried Wilhelm Leibniz (1646–1716)	human intellect (sense) can help understand higher knowledge (God's intention) contemplates automation of knowledge; "monad" (a building block of universe, a closed system that reflects the order of the world) is central to his views	composite theory: division of universal good into three parts: metaphysical, moral and physical good based on monads: individual and social happiness are in harmony, cooperation for the bigger good
Francis Bacon (1561–1626)	establishment of scientific methods; science can be based on empirical (objective) observation	society is responsible for setting up morals (education and knowledge of nature)
Thomas Hobbes (1588–1679)	theory of social contract (partial limitation of freedom); the natural state leads to chaos because of human egotism, so it is necessary to protect community (order, safety)	morality and ethical values are the result of social conventions; observation of laws and norms reflect ethical behaviour
John Locke (1632–1704)	knowledge is rooted in experience based on data acquired by the senses (no a-priori knowledge); the state is responsible for protecting people's rights	tolerance (free exercise of own rights without violating others'), individual freedom and self-determination have emphasis
David Hume	intelligence develops from experience perceived by the senses (role of sceptic) to understand the laws of the world	morality rooted in emotions is subjective and relative; ethical standards are conventions for living in society
Jean-Jacques Rousseau (1712–1778)	theme of social contract: people are basically happy until social restraints, classes and hierarchies deprive them - return to a natural state	compassion empathy and altruism are important, social conventions strive to suppress them; respect for individual freedom

	Modern New Age philosophy	
Immanuel Kant (1724–1804)	critical philosophy and general (social) will (ethical standards and laws); autonomy (action of the individuum based on reason)	moral action means observing the laws defined by human reason
John Stuart Mill (1806–1873)	utilitarianism: protection of individual freedom (by laws and social norms), democracy - governance in people's interest	actions assessed by their consequence and results (maximise social usefulness)
	Contemporary philosophy	
Daniel Dennett (1942–	the mind, consciousness and free will should be studied via sciences; thoughts and experiences are the outcome of complex cognitive processes, which can be distorted with cognitive limitations and errors; independent decision-making ability (defined by algorithms)	ethics standards are the outcome of social agreements varying with cultures, they can change in time; ethical decision-making based on reason and free will influences the creation of social values
Martha Nussbaum (1947–	the rights and dignity of the individual must be respected and protected by society irrespective of the individual's status, actions or experiences	empathy and moral sensibility are indispensable elements of human well-being, which relate to the protection of human dignity
Nick Bostrom (1973–	analyses the impact of scientific-technological development: principle of anti-realism (the perceived world is but a distorted partial image of reality); principle of trans-humanism (enhancing human potential)	safety brakes and guarantees must be established and built into the process of AI development; it is of vital importance to avoid catastrophic consequences

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CYBER SECURITY AND ARTIFICIAL INTELLIGENCE

Péter Bagó[1]

ABSTRACT
Cyber security is one of the key challenges in the age of information technology, which is particularly important in the financial sector, where security is key both for customers and institutions. Data protection, fighting fraud and preventing cyber attacks are areas in which artificial intelligence and automated systems can provide significant assistance. The use of AI and machine learning for cybersecurity allows systems to be recovered quickly and effectively after a cyber attack. Using AI algorithms, experts can immediately assess damage and respond to cyber incidents with AI. In the paper the support of cyber protection with artificial intelligence is presented in the finance sector. There are major overlaps with infrastructural protection, individual security levels and proper data protection.

JEL codes: G00, O33, Q55

Keywords: artificial intelligence, cyber defence, finance sector, fintech

1 CYBERSECURITY IN FINANCE

One should make a difference between cybersecurity and its application jointly with artificial intelligence. However, one should give and overview of the security rules of key importance in 2023, which should be observed by all financial service providers.

- Use strong passwords. Every user should use strong passwords for their accounts, which comprise upper and lowercase letters, numbers and special characters and should be of at least eight-character long.
- Two-step authentication Two-step authentication is important for cybersecurity. It means authentication must be verified by using two distinct factors, for instance, a password and an individual code or fingerprint.

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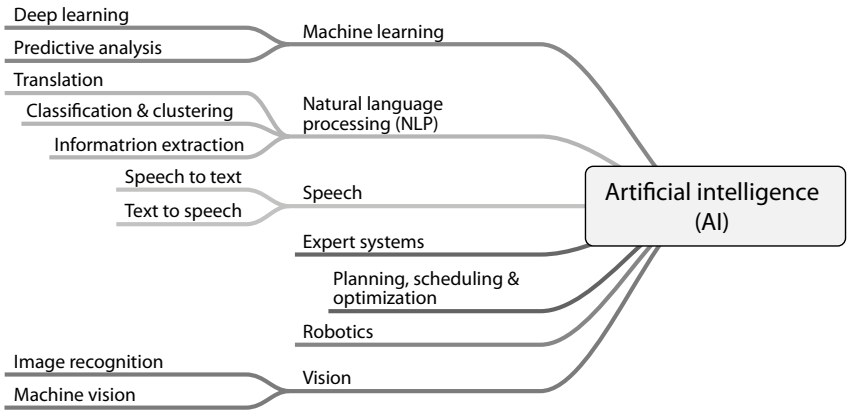
- Software updates All software updates must be installed so that your computer and data should be safe.
- Firewall and virus protection Firewalls and virus protection should be installed on computers to prevent intrusion by malware.
- Backup systems Regular security backup of data is important to ensure data are preserved in a potential data loss or damage.
- User training Employees must be trained and informed about cybersecurity risks and proper security practice for organisational security.
- Permanent monitoring Permanent monitoring of cybersecurity is important for timely detection of any threats and proper response.

To see how artificial intelligence can help the finance sector, the list is much longer but it also touches upon basic issues of infrastructure.

- Detection and response AI systems can collect and analyse large amounts of data for system security. In addition, they can identify threats traditional security systems would easily overlook and will send an alarm to the relevant personnel.
- Reporting AI can draft reports helping cybersecurity teams better understand the vulnerability of systems or reveal the areas that need particular attention.
- Automated response Automated responses can be generated with AI that can manage security threats immediately. For instance, if a security incident occurs, an AI system can automatically change passwords, disable accounts, or withdraw access rights.
- Ongoing learning and updates AI algorithms learn from previous experience and are updated continually with the latest cybersecurity-related information. This allows them to be always up to date and to respond to the newest challenges properly.
- Network security AI can supervise, identify, and analyse the total network traffic to identify potential threats, which could be easily overlooked otherwise. In addition, AI systems can monitor networks and control security levels continually.
- Comprehensive analysis AI can compare enormous amounts of data and analyse them within the system. It can detect anomalies in the system, which cannot be identified or can only be identified with difficulty using traditional security systems.
- Detect phishing AI can detect phishing attacks, it can identify phoney e-mails, websites and applications to help enterprises in secure data management.

- Cloud-based security solutions Using AI and cloud-based technologies, enterprises can improve their security solutions, since cloud-based systems can manage big data more efficiently and can respond immediately in a potential security incident.
- Intelligent network protection Using AI in network protection allows users to detect and prevent cyber attacks. Intelligent network protection can automatically identify and stop cyber attacks and allows continual monitoring of the network and quick response to security incidents.
- Higher level authentication Using AI, enterprises can strengthen authentication through identification and authentication solutions. Face and voice recognition, the application of biometric data and other innovative solutions will make user identification and authentication easier, more efficient and increase security.
- Faster and more efficient response AI allows faster and more efficient response to security incidents. Automated incident and security incident management systems can make an immediate report of the incident and allow fast intervention and troubleshooting reducing harmful effects in that way.

Figure 1
Evolution of artificial intelligence



Source: Ray, 2022

Cybersecurity is extremely important in the finance sector because of the sensitivity and confidentiality of financial data. Analysts have found over the past few years that using artificial intelligence is gaining popularity and many financial institutions enhance their cybersecurity through using AI. The opportunities of-

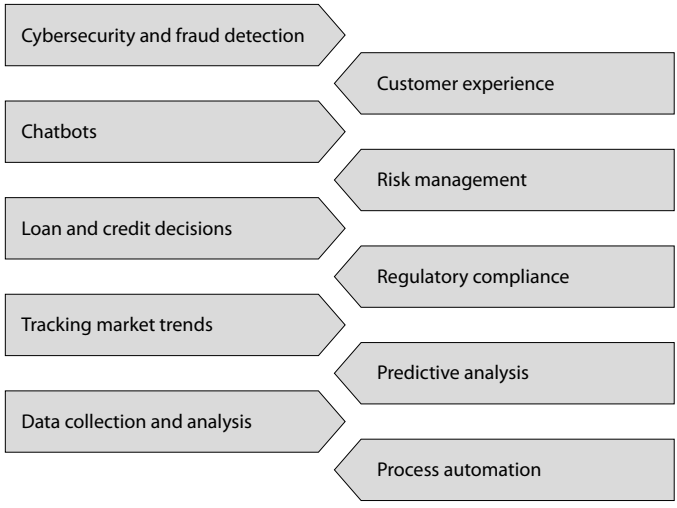
fered by AI may transform the landscape of cybersecurity in the finance sector. AI can be used to analyse enormous amounts of data, which will detect anomalies and patterns indicating cyber threats. Algorithms of machine learning help recognise patterns of behaviour indicating fraud, for instance, fishing attacks, ransomware attacks or identity fraud. AI can be applied to boost the speed and improve the accuracy of detecting threats and responding. Traditional cybersecurity systems rely on rule-based algorithms that are pre-programmed to detect actual threats. However, such systems can be easily bypassed by attackers using new developing technologies. AI-based cybersecurity systems can adapt to and learn from new threats, which makes the detection and mitigation of cyberthreats more effective. What is more, AI-based security systems can provide financial institutions with information about threats in real time allowing fast response. AI can be used to automate security tasks, which means freeing cybersecurity experts to perform more complex tasks that require human knowledge. The use of AI also causes worries from the aspect of financial institutions. One of the biggest worries is the reliability of AI connected with issues of responsibility. AI systems run on data fed into them earlier, and if those data are corrupt or incorrect, AI cannot operate well. The use of AI in cybersecurity includes the application of proper measures of data protection. Financial institutions must ensure the protection of the data managed by AI and user rights and access to data must be strictly controlled. AI-based cybersecurity systems can identify threats and can troubleshoot immediately and effectively mitigating risks and losses for financial institutions. Using AI to identify threats faster and more accurately, cybersecurity experts can save time and energy, which allows them to focus on other tasks. To sum up, AI offers major advantages in the field of cybersecurity in the finance sector. Financial institutions can identify risks with the help of AI and eliminate them quickly and efficiently mitigating losses and improving customer experience in financial institutions. The application of AI, however, necessitates strict measures of data protection and liability insurance to guarantee the security of financial institutions and their customers.

Algorithms can process and learn from data via machine learning, which allows automation and increases effectiveness. Artificial intelligence allows the intelligent use of the data generated by machine learning in decision making processes and can reach the level of human intelligence in finance. To sum up, both technologies have an important part to play in finance and, used jointly, can render data analysis and processing more effective and profitable in the field of financial services (Ray, 2022; *Pintér*, 2008).

Next, *Figure 2* presents five main categories of AI applications in the banking sector.

- The *first category* includes chatbots and virtual assistants that provide bank customers with personalised services from the management of shopping to money transfers.
- The *second category* introduces anti-fraud AI technologies that can help identify and mitigate the risk of rip-offs and fraud.
- One can find automated decision-making systems in the *third category* that can help banks to manage big data more efficiently and to prepare forecasts for business decisions.
- The *fourth category* is robot authentication. Its purpose is to save human labour and to improve the effectiveness of processes.
- The *fifth* and last *category* is that of AI-based detection technologies, for instance, face and fingerprint identification that can improve authentication processes and the safety of banking transactions.

Figure 2
AI technologies applied in banking



Source: Appinventive, 2023

Customer service for banks is one of the key application areas of AI. Banks use chatbots and voice assistants to provide 24/7 customer support and assistance. Those virtual assistants operate on AI and natural language processing (NLP) technology, which allows them to understand customers' questions and give relevant answers. This will not only improve customer satisfaction but also reduce the

workload of customer service staff. Banks use AI-based algorithms to detect and mitigate diverse types of risks, for instance, credit risk, market risk or operational risk. AI algorithms can identify patterns and anomalies indicating potential risk by analysing enormous amounts of data. It helps banks make informed decisions and reduce losses. Further, AI is also used to detect fraud in the banking sector. AI-based fraud detection systems can analyse enormous amounts of transactional data in real time, so they can detect suspicious activities. This can help banks detect fraud early on and prevent losses. AI is also used for securities market forecasts. AI algorithms can provide forecasts on securities prices and other market indicators based on the market data analysed. This can help investors make better informed decisions regarding the management of their portfolios.

1.1 Cybersecurity trends

Cybersecurity faces diverse challenges one of them being the protection of personal data and data security. AI works by analysing enormous amounts of data including personal data. Therefore, banks and financial institutions must ensure data protection and data security in AI applications. AI is becoming a key player in the process of digital transformation. Its advantages such as efficiency and improved risk management help banks implement new digital technologies and improve customer experience. AI provides banks with major advantage including efficiency and improved risk management as well as customer experience. On the other hand, the challenges posed by AI and its impact on human labour must also be managed if you wish to implement AI successfully in the banking sector (Appinventiv, 2023).

Further research supports that cyber attacks are increasing, particularly those targeting companies and government bodies. Automated and refined cyber attacks such as AI-based attacks are expected to increase in 2023. A study by Deloitte emphasises how important threat management, incident management, data protection and cybersecurity education of the staff are for enterprises to establish and implement productive cybersecurity strategies. In addition, the study goes into details about the changes of legislation and regulations as well as business and technology trends that may have an impact on the environment of cybersecurity in 2023 (Deloitte, 2023). McAfee also believe cyber attacks are going to continue particularly in manufacturing, education, and healthcare. The spread of recent technologies such as IoT (Internet of Things) tools and 5G networks will present new security challenges. The threats mentioned include AI and machine learning-based attacks, manipulation on social media networks and further growth of ransomware attacks. McAfee discuss the importance of initiative-taking cybersecurity measures implemented by organisations based on forecasts including

stronger identification, education, and the improvement of incident management skills to ensure successful defence. They also emphasise the importance of cooperation and the exchange of information between organisations to ensure effective prevention and provide prompt response (McAfee, 2023).

Accenture (2023) believe banks, in general, provide better defence against external attacks but their level of preparedness to manage internal threats is lower. According to their study (Accenture, 2023), the protection of data and defence against unauthorised access continue to be the primary challenges for banks.

The whole finance sector is affected. Allianz publish an "Allianz Risk Barometer" report every year, in which "business interruption" is the most dangerous incident. Denial of service attacks are, in principle, in that category too, so this is just an approach of current attacks from another perspective.

On the other hand, the Allianz report indicates attacks do not only focus on banks but also on the whole finance sector (Allianz, 2023). According to Cyberedge (2023), data protection and security regulations are going to be stricter in 2023 particularly in the European Union where the basic regulation on data protection (GDPR) will continue to affect the business sector. The importance of data protection will continue to increase, and enterprises will have to implement stricter defence measures to counter data loss, phishing, and other types of cyber attacks.

Cyberedge underline that smart tools and the internet of things (IoT) may present significant security challenge in 2023. As smart homes, and industrial and healthcare IoT tools gain momentum, attackers will also use them more often to conduct targeted cyber-attacks. Home office is expected to remain a popular form of work applied widely in 2023, but its security risks continue to be there, so organisations may face increased costs to improve the security of tools used in home office (Cyberedge, 2023).

Studies indicate people, or more exactly, employees, rather than the systems are in the focus of the attacks. Think of attacks compromising emails or cloud subscriptions (Proofpoint, 2023). A study by ESET follows the same train of thought. According to them, cybersecurity trends in 2023 can create a blurred borderline in our brave new world; it can generate complex problems for data security and the protection of privacy while work and social life tend to be connected more (ESET, 2023). According to TÜV SÜD, cost effective cybersecurity solutions are of key importance as well as the start of regulation via the standardisation of digital confidence, while training tailored to target groups and critical infrastructure (KRITIS) are in focus (TÜV, 2023). According to *Paula Januszkiewicz*, cybersecurity expert with Microsoft, the most significant changes affecting cybersecurity in 2023 will be abound preparedness to counter threats. Organisations must be continually ready to face an attack, an effort of intrusion, and must possess the

tools used to keep them under control. Strict control of privileged access, and user identification will be other key topics of the year (Microsoft. 2023).

2 MONEY LAUNDERING AND ARTIFICIAL INTELLIGENCE

Money laundering has a devastating effect on global finance. The International Monetary Fund (IMF) estimate the money laundered in the world at approximately USD 2 to 5 trillion annually. It means money laundering measures higher than any other financial fraud including tax dodging or securities manipulation. Thus, if artificial intelligence can save a fraction of the above value, governments, organisations, companies and individuals can achieve crime prevention to such an extent that proves it is worth special attention. The connection between cyber-defence and money laundering is that money launderers often apply cyber attacks, computer fraud and other methods of cybercrime to hide laundered money and to prevent their identification. They, for instance, often use fake websites or computer programmes to acquire banking data, customer identifiers or transactions. Then, they can use those data to open fake accounts, transfer money or other methods of money laundering. Cyber-defence, therefore, is key in the fight against money laundering. Banks and other financial institutions must apply strict security measures to protect personal and financial data. They must also prepare for cybercrime and the related money laundering. Countries having ambitious standards of cyber-defence are at an advantage in detecting and preventing money laundering and other financial crimes. That is why education on, and development of cyber-defence are important to mitigate the risk of cybercrime and money laundering.

According to a study by McKinsey (*Biswas* et al., 2020), AI allows banks to make their business processes more efficient and effective, to improve their product and service portfolios and to boost customer satisfaction. The use of AI is advantageous to banks for many reasons, for instance, improving their customer service, increasing the efficiency of risk management, supervising transactions, and preventing fraud. The analysis underlines further development of AI can help banks make prompt decisions in the field of supervising transactions and risk management. Further, AI allows banks to offer their customers tailor-made products and services. The analysis also states banks must promote the spread of using AI in their organisation and ensure the necessary resources, technological skills and expert knowledge are available. In addition, banks must face further challenges, such as protection of personal data and the legislative environment. According to the analysis, the use of AI requires a comprehensive strategic approach by the banks, which allows that AI systems are integrated into the business processes,

that applications are widely used and that the development and operational costs of AI are optimised. The use of AI systems and technologies will have a major effect on banks and their customers. Banks that can use AI properly will have a long-term competitive advantage and will be more successful on the market. The article concludes AI solutions play an important part in the future of financial service providers, since they can make banking processes more effective and customer friendly. Financial institutions using AI can evaluate risks more accurately and effectively, they can improve through-time and customer service. However, the article also points out the implementation of AI does present major challenges, for instance, the issues of data protection and security as well as training and investment into innovative technologies. According to the article, financial service providers must prepare for both the challenges and opportunities offered by AI solutions to be successful in future.

2.1 What is money laundering?

Money laundering is a criminal act during which money of illegal origin is transformed into money seemingly coming from a legitimate source. The process of hiding the traces of illegitimate money is important so that its source and path cannot be traced back. The process of money laundering means screening the source of profit made on illegal activities. This crime is a major threat to the economy and the society since money laundering can contribute to financing terrorism or other criminal acts. So, the relevant authorities and financial institutions should pay attention and prevent money laundering by applying suitable regulations and measures (Wolters, 2018).

A three-phase model displays the process of money laundering, which demonstrates how to achieve clear traceability of the origins of money, i.e., the way to legalise money. The model originates in the US. Process steps are the following:

- Placement/depositing
- Layering,
- Integration (*Gál*, 2007).

In the first step, the money to be laundered, which is typically cash, is deposited in the financial system in some form. Banks are typical targets. These days the global financial sector has been prepared for this step. The appearance of substantial amounts of cash is an indicator and sign of danger. The most important thing to do then is to find the origin of the money in a way that can verify in a credible way the origin of the amount to be deposited in the bank. In some cases, you can see a sales agreement, severance pay or family inheritance.

The second step of the process is layering. It means complex transactions are performed involving more than one account or more than one customer. The transactions typically affect accounts managed by different banks, they may be in different currencies and in different countries. It is all the better if they lead to countries you can only obtain banking information from with difficulty. The process is important because if you want to retrace those transfers, you will meet obstacles and sometimes it is next to impossible to find the source. You can ask customers for information on one or another transaction, but you may need international collaboration to decompile the whole chain. On the other hand, if you only look at a small section of the transfers, you can only see a customer performing a transfer to another customer, which can be of an average size. If you want information about the background of the transfer, they will be happy to answer or to show invoices or contracts. At that point, the prevention of money laundering is difficult.

The third step following deposit and layering is integration. It means the amounts having run through different accounts are withdrawn or invested. It is, in fact, the step where it is posted as clean income, or the customer uses the money for a major investment. Its source can be said to be clean as there is nothing to prove the opposite. For example, when an accountant books money added as extra income over a month or two. Sometimes, the process is closed with cash withdrawn and taxes paid, which promote the illusion of legality. These days customers often withdraw the amount they need in small portions subject to the maximum capacity of cash machines. They will do what they can to avoid a visit to the bank branch, because they can meet there a person dangerous to them: the bank officer who, as the first line of defence to prevent money laundering, will be curious to get information about the amount. For the same reason, automatic paying-in and deposit machines are highly popular. Banks, naturally, must prepare for this, and must monitor them subject to filtering in compliance with their procedure.

Warning signs are easy to be seen in the above process. The best opportunity to block the process is at the first step, when cash is deposited. The end of the process in most cases is a cash withdrawal or high-value investment - another cash transaction. Investigating the origin of the transactions and their purpose should be part of the prevention of money laundering. To sum up, one can say that exceptionally large cash movements are the best indicator of money laundering.

2.2 Monitoring or filtering?

It is obvious from the above that monitoring as many customers and checking as many transactions as you can is necessary.

"Section 33:

In the application of this subsection 1, automatic filter system: an IT system suitable for sorting out the customer and the transaction from the point of view of money laundering and terrorist financing based on prior parameterization and not requiring human intervention".[2]

The provision cited above proves that service providers are obliged to apply a filtering system to support their activities preventing money laundering and generating signals with no human intervention. Here, difference must be made between monitoring and filtering.

A monitoring system is suitable for subsequent, post-monitoring activity. In that case, it will check completed transactions subsequently based on pre-set rules or scenarios. In practice it means that customer transactions are continually loaded into the monitoring system, which will filter them and generate signals or warning according to the pre-set rules. Such a system is not artificial intelligence by itself that would unambiguously tell you what money laundering is and what is not. However, the more accurate your settings and rule definitions are, the more accurate the filtering results will be and the more probable it will be that such an alarm is real. The only drawback of it is that a set of rules of such depth cannot operate in real time, when you only have a few seconds to perform a transfer. As shown in the above example, the problem arises because a transaction can have travelled a number of accounts or countries by the time an investigation is conducted. MNB has decided 30 or 20 workdays are available to investigate an alarm.

The operation of filtering is different as its task is to filter traffic in real time. With respect to international traffic, it is also expected to filter for sanctions. Such transfers are released in several cycles every day. Should the system find any simi-

2 26/2020-as (VIII.25.) MNB rendelet a pénzmosás és a terrorizmus finanszírozása megelőzéséről és megakadályozásáról szóló törvény végrehajtásának az MNB által felügyelt szolgáltatókra vonatkozó, valamint az Európai Unió és az ENSZ Biztonsági Tanácsa által elrendelt pénzügyi és vagyoni korlátozó intézkedések végrehajtásáról szóló törvény szerinti szűrőrendszer kidolgozásának és működtetése minimumkövetelményeinek részletes szabályairól [MNB Decree on the implementation of the Act on the Prevention and Suppression of Money Laundering and the Financing of Terrorism for service providers supervised by MNB and on the development of a filtering system according to the Act on the Implementation of of Financial and Property Restrictive Measures ordered by the European Union and the UN Security Council and about the detailed rules of the minimum requirements for its operation, 26/2020 (VIII.25.)]. (https://net.jogtar.hu/jogszabaly?docid=a2000026.mnb).

larity with a sanctioned entity, an alarm is generated, and the transaction will be continued or rejected subject to analysis. In this way both incoming and outgoing transfers can be filtered.

The filtering system typically looks for character match in sanctions list, while monitoring examines pre-defined parameters. A filtering system will not only look for suspicious transactions but also suspicious customers. A monitoring system will detect suspicious transactions based on a pre-set rule. The operation and the task of the two systems can be easily compared in a table:

Table 1
Categories of filtering systems

	Legal provision	
	Law LII of 2017	**Law LIII of 2017**
Task	Filter and block customers and transactions subject to sanctions	Detect peculiarity indicating money laundering
Data source	Sanctions lists	Archived historical data
Methodology	Comparison (character match)	Detect peculiarities by pre-defined parameters
Measure	Stop suspicious customers and transactions, take measures	Filter and check suspicious transactions, take measures
Time scale	Real time, built into process	Subsequent, not real time

Source: based on Lukács (2022)

Hungarian and international regulations are much broader than what is presented in this paper and discussing them is not part of our topic. With respect to the main topic, you can see some rules will have to be established for the monitoring system so that the traffic of cryptocurrencies become visible.

2.3 Authority report

In compliance with Law LIII of 2017 on the prevention and suppression of money laundering and terrorism financing, service providers shall:

"**Section 30** (1) * The manager, employee and supporting family member of the service provider

a) for money laundering,

b) to finance terrorism, or

c) for the derivation of a thing from a punishable act

in the event of any indicative data, fact, or circumstance (hereafter referred to as: data, fact, or circumstance on which the report is based) arises, the person specified in Section 31, Paragraph (1) must immediately make a written report (hereafter referred to as the report).

(2) The notification specified in paragraph (1) must contain the data recorded

a) by the service provider according to 7-14/A

b) a detailed description of the data, facts, and circumstances on which the notification is based and

c) documents supporting the data, facts, and circumstances on which the notification is based if they are available.

(3) The manager, employee and supporting family member of the service provider shall report the emergence of data, facts and circumstances indicating money laundering, financing of terrorism or the derivation of a thing from a punishable act in the case of executed or to be executed transactions and transactions initiated by the customer but not executed. It is also obligated to investigate in the case specified in paragraph (8) of Section 13."

The above provisions define primarily what an authority report exactly is. If a service provider thinks they detect some suspicious circumstance in the case of the above filtering systems, they shall make a written report in compliance with c). The above quote does not identify for whom the report is meant. All notifications shall be addressed to the National Tax and Customs Administration, Hungarian Financial Intelligence Unit (NAV PEI). The law requires that a complete investigative file must be sent including all information available to the service provider immediately as they detect suspicious activity, i.e., without delay. It is a question what exactly NAV PEI does with those notifications since service providers have no feedback in most cases. NAV PEI sometimes send a letter informing the service provider with reference to the identifier or the notification that the authority "has successfully used" their report, whatever that means. NAV PEI does have connections with international anti-money laundering authorities, so they can not only investigate in this country but also internationally. It is, naturally, also true from the other side, i.e., NAV PEI receive requests by international authorities they must answer or participate in investigations in progress.

Natural persons, self-employed entrepreneurs or corporate customers can also comply with the obligation to report a claim. The expected minimum data content is the following – more information can be sent but not less. It depends if all of them are available, but efforts must be made to have them:

- the transaction,
- the suspicious circumstance described in detail,

- related partners,
- public company information,
- indication by partner bank if any
- message withdrawing the transaction if any
- document certifying source of transaction.

Authority notifications are of key importance. This is to advise the authority to investigate a customer engaged in an activity found suspicious. The more sophisticated filters and workflows are established by a service provider, the more difficult money laundering will be with them. The more sophisticated risk sensitivity a service provider has, the more in-depth analyses they can perform in their own filtering system (in an optimal case) or with the help of supplementary reports and information. Then they must forward the information obtained to NAV PEI without delay, that will either agree with the suspicion and launch proceedings or say thank you for the warning and close the investigation. Service providers can only report suspicion, but they are not authorised to decide if the act was illegal (NAV, 2022).

3 THREATS IN THE EUROPEAN UNION

The financial sector must face the following threats in the EU including Hungary, which is published by the European Union Agency for Cybersecurity (ENISA) in its annual reports:

1. Ransomware
2. Malware
3. Social engineering threats
4. Threats against data
5. Threats against availability: Denial of service
6. Threats against availability: Internet threats
7. Disinformation - misinformation
8. Supply-chain attacks

Reading the 2022 list, you can notice that the old technique of social engineering threats have "catapulted" to place three; they had not been there on the ENISA list in 2021. More accurately, you can say crypto-jacking swapped places with social engineering threats. It means two things. One is that the exchange rate of crypto-currencies fell to a fraction about a year ago, so interest in them has also declined. Covid might be the other reason, i.e., people's approach has changed, so social

engineering has gained momentum. According to antivirus manufacturer ESET, spam and phishing are the two leading methods of social engineering (ESET, 2022). Social engineering includes many more techniques, some of which have hardly anything to do with IT, such as baiting when a criminal offers a reward in return for information (Terranova, 2022). It should be noted that Kevin Mitnick, one of the most famous hackers in the world, found his way into computer systems using social engineering, persuasion. (Mitnick, 2022).

Attacks against financial institutions and services use increasingly sophisticated methods and a range of solutions. In Hungary, the National Cyber Defence Institute (NBSZ-NKI) monitor and manage attacks, but unfortunately they do not share detailed information with the public. They will only say in their weekly newsletters what the given level of threats is, for instance, the threat level of ransomware was medium in week 50 of 2022 (NBSZ, 2022). MNB, on the other hand, do publish more accurate data obtained from NBSZ-NKI, which can be read in numerical form. Twenty-one threats were followed in the period from 1 February to 31 July 2022. However, no details are available, for instance, you will not learn how those attacks ended, whether they were successful, which organisation was attacked, for instance, a bank, a financial institution or a fintech company (MNB, 2022). All that is an indication that such attacks are present in Hungary too. The statistics show the authority learn about 4 to 5 such attacks every month. The above report included information from all the authorities taking part in the defence, i.e., MNB was aware about 765 incidents in the five months mentioned, which supposes activities of a worrying size.

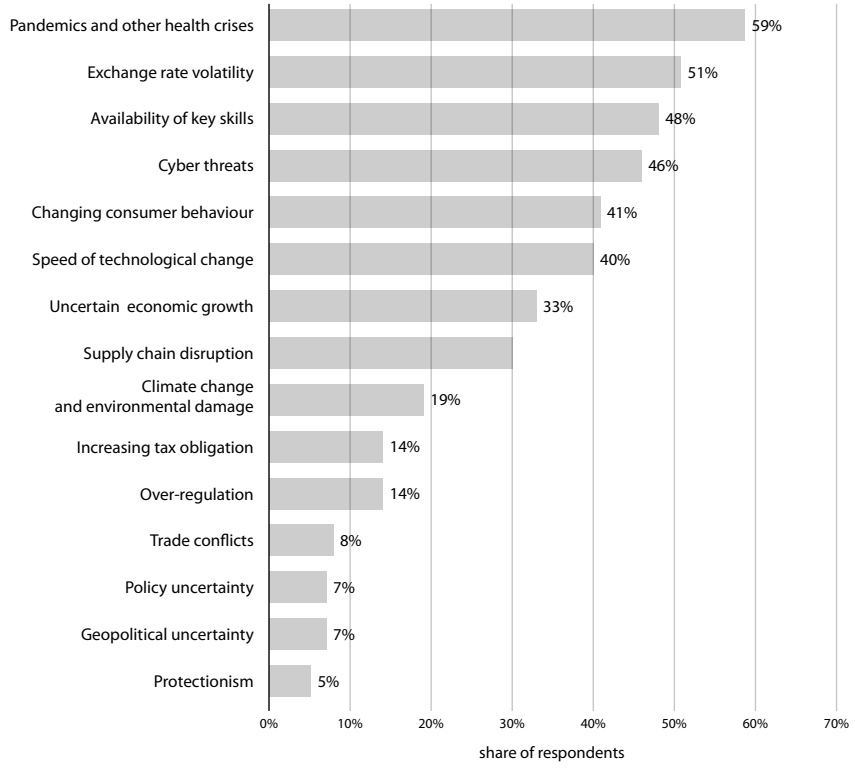
In addition to the ENISA reports mentioned above, the EU also is also engaged in the following areas:

- Measures responding to cybersecurity challenges
- Cyber resilience
- Fight against cybercrime
- Increased cyber diplomacy
- Cybersecurity collaboration
- Funding and research
- Cybersecurity of critical infrastructure (ET, 2023)

3.1 Companies and cybersecurity

It is worth looking into how companies think about the topic. The following is a figure presenting threats built into the core activities of companies. As you can see, about half of the companies are aware of online threats:

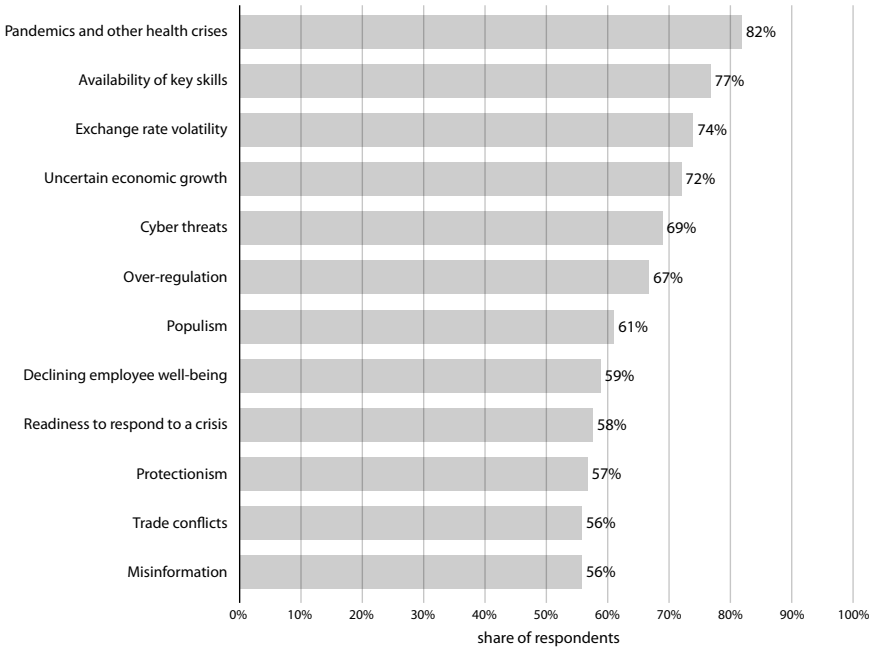
Figure 3
Company threats in Hungary in 2021



Source: Statista, 2022a

The next figure is more emphatic about the importance of managing threats; almost two-third of company executives believe such threats may affect company growth:

Figure 4
Risk of company growth acknowledged by company executives



Source: Statista, 2022b

Customer cloud services expand all the time. The advantages they offer are extremely important for financial service providers. Customer clouds, however, are not simple distribution channels but basic building blocks of customer relations. The appearance of such services and technologies is a challenge for financial service providers since customer clouds keep penetrating new areas in financial services.

McKinsey & Company advisors propose the introduction of AI banks to exploit the opportunities of customer clouds and to make customer relations more effective. AI banks offer the advantage of easier access to financial services for customers, improved digital experience and the elimination of lengthy and clumsy administration at bank branches customers often experience. AI banks, however, are not only instruments to improve customer experience and easier access to financial services. They can also help financial institutions automate business processes, which may result in cost reduction eventually. AI banks can automate customer service queries, they can answer them faster and more accurately, and can

analyse them, which allows better understanding of customer needs by customer service and marketing staff. The use of AI banks is not only important because of customer clouds or the automation of customer service processes. AI banks allow financial institutions to make tailor-made offers by analysing customer behaviour, which respond to customer needs and preferences. As mentioned above, AI banks must ensure proper data protection and the protection of personal data. Still, the advantages of AI are bigger than its potential risks. AI allows banks to offer their customers tailor-made customer service, to improve their channels and customer retainment. The use of AI leads to understanding and optimising customers' digital journeys. AI applications will have a major impact on the finance sector and the banks that refuse to apply them will be at a disadvantage compared to their competitors. The opportunities of AI are inexhaustible. Banks must be prepared to use AI in their business. AI banks will be the ones that can apply AI and the latest technologies servicing customer needs.

Shortcomings in compliance with the rules are a risk, which may result in grave issues, such as fines or loss of company reputation (*Deutsch*–Pintér, 2018). However, attractive opportunities arise for the financial and banking sector if those risks are professionally managed. Data protection and supervision of compliance are increasingly necessary in the banking sector. Regulations on data protection get stricter step by step in banking, which is a new challenge for participants. Observing the rules, however, is not only mandatory but it also offers an opportunity for the sector to improve competitiveness. The article cited also mentions that, in addition to observing the rules, it is also important that the processes of data protection and compliance risk are implemented and maintained effectively. This means those involved must pay attention to effectively manage compliance control and data protection issues. Finally, the article underlines the new opportunities offered to finance and banking for a more effective management of data protection and compliance risks. Data analysis and automation allow stakeholders to manage data protection regulations and compliance risks more effectively. Automated tools and AI can help risk management and improve effectiveness in the sector. Such tools can analyse data and identify anomalies, which allows bank to recognise risk earlier and take the necessary steps to prevent them. In addition, automated processes reduce the possibility of human error, which is an additional advantage for the financial sector.

In finance, the challenges and risks of compliance can be managed with modern technologies including AI and automation. But banks must continue to remain watchful in a changing legal environment and must update and improve their compliance programmes to meet requirements and minimise risks (*Quereshi*, 2019).

Data and the consequences drawn from them are important in the financial sector from the aspect of business growth and success. The traditional methods of data analysis are often limited and do not provide sufficient information. The use of AI and ML can revolutionise the processes of data analysis assisting financial organisations in improving business performance and raising customer satisfaction. AI and ML can collect and interpret vast amounts of data. The automation of data analysis can reduce the risk of human error and improve efficiency. Such technologies allow data to be analysed faster and more accurately, which can help financial enterprises make decision making more effective. The use of AI and ML, in addition, allows that forecasts and trends are analysed more accurately, which helps financial enterprises establish their business strategies. Such technologies allow to prepare personalised offers, which can boost customer satisfaction and loyalty. The use of AI and ML, however, presents challenges too. Financial enterprises must guarantee data protection and data security as well as the ethical application of the technologies.

Compliance with data protection rules and legal provisions is key particularly in the case of financial services. On the other hand, using AI and ML can provide a solution for more efficient data management and improved business processes. Financial enterprises must find the correct balance between technological advantages and risks to achieve the best result for their customers and to improve their competitive edge (*Qureshi,* 2019).

The opportunities of using AI and ML are clear and offer the sector competitive advantage to apply a new approach by implementing and using the new technologies. AI and ML applications provide better efficiency, increased customer satisfaction and higher security for banking and financial services by improving business processes. On the other hand, the successful implementation and use of AI and ML applications are not simple; the enterprises must understand their advantages and limitations and must prepare for their implementation and application. If, however, the enterprises apply those technologies successfully, they can enjoy major advantage on the market and will comply with the strict requirements set by regulators and customers alike (*Narayanan*, 2019).

4 RELATIONSHIP OF OPEN BANKING AND ARTIFICIAL INTELLIGENCE

Open Banking and AI are closely related, since both technologies allow better management of financial services and products offering their customers personalised services and products. Open Banking means that banks share users' banking data with third party applications approved by the customers. By means of such applications, customers can manage their accounts and other financial products on a single interface making finance management simpler. AI can help banks and applications in that regard providing more efficient data management, analysis and use so that the banks can offer their customers personalised services. AI can be useful in many areas of Open Banking, for instance, the optimisation of customer services, transaction analysis and prevention of financial offences. AI can assist banks in their fight against money laundering and fraud by detecting anomalies in transactions and account management.

One should keep in mind that GDPR and PSD2 are both directives related to financial services. The objective of GDPR is the protection of personal data while PSD2 is aimed at improving the security and efficiency of financial transactions. However, those directives can be contradictory. PSD2 - Payment Services Directive 2 - is an EU Directive regulating financial services, which allows customers to share their financial data with third party applications. Its objective was to boost competition on the market of financial services and to promote innovation in the industry (Pintér, 2022).

The part AI plays in PSD2 is a more efficient analysis and management of data. AI can analyse substantial amounts of data and identify customers' needs and habits. This allows banks and applications to offer their customers personalised services and to have a better understanding of the money market. The use of AI in PSD2 can also help in the fight against financial fraud and money laundering. AI can identify customers in connection with whom the probability of fraud or money laundering is high, so it can warn banks to take the necessary measures. Using AI, banks and applications can identify customers whose transactions differ from standard financial behaviour and can warn banks to check those transactions. AI can identify customers' queries and problems and provide immediate answer with the help of chatbots and other automated solutions. This allows banks and applications to manage customer-related enquires and problems more effectively and faster. To sum up, the use of AI in PSD2 allows banks and applications to manage customers' financial data more effectively and to have better understanding of their customers' needs and habits.

4.1 Threat or opportunity?

The use of AI in Open Banking is both a threat and an opportunity for financial service providers depending upon its utilisation. AI in Open Banking allows banks and fintech companies to gain better understanding of customers' financial needs and habits. On the other hand, AI in Open Banking can be a threat if customers' financial data are not managed properly. A fault in an AI device or a programming error can result in the violation of data protection and can increase the risk of access by cyber-criminals. Unauthorised access to customer data must be prevented to properly protect customers' data for maintaining trust and observing legal rules. So, using AI is an opportunity for providing more efficient and personalised financial services and products in Open Banking, but it requires special attention from the aspects of data protection and security. Banks and fintech enterprises must apply proper measures of data protection and security to guarantee that their customers' financial data can be managed safely.

The connection between GDPR (general data protection regulation) and artificial intelligence is an important topic from the aspect of data protection and the management of personal data. The objective of GDPR is to provide protection when the personal data of EU citizens are managed, while AI is a technology that allows the analysis and use of data.

The use of AI presents challenges of data protection from the aspect of GDPR. Data must be processed for AI and customers' agreement and data protection are key during data collection and storage. GDPR rules include the obligation of storing and protecting data securely and the right of access to personal data. Personal data must be managed in compliance with data protection regulations. The use of AI offers many advantages from the aspect of data protection. AI can protect personal data and can analyse data more accurately, which improves security and data protection. AI provides customers with more personalised services and products, which promotes customers' trust and loyalty. To sum up, the connection of GDPR and AI means that financial service providers must ensure the compliance of data management processes with the requirements of the data protection regulations.

5 SUMMARY

The use of artificial intelligence can provide major advantage in the field of financial services. Here are some examples:

- Reduced costs: financial institutions can reduce costs and improve efficiency by means of AI-based automated processes.
- Better customer service: AI offers personalised customer service and can boost customer satisfaction.
- Risk management: AI-based analytics allow better risk assessment and timely intervention to avoid problems.
- Intruder detection: financial institutions can recognise security threats and can reduce the number of fraud cases:
- Better data analysis: AI-based analytics can help improve data analysis through which financial institutions can have better understanding of customer and market trends.

The ongoing development of AI may result in further innovation and developments in future. The use of artificial intelligence can help in several areas of the finance sector, including, among others, the detection of fraud and abuse, risk management, making investment decisions, customer relations and more efficient internal operations. AI-based tools and algorithms allow financial institutions to collect, analyse and evaluate substantial amounts of data in order to make more effective decisions.

For instance, AI-based systems can detect and identify suspicious transactions that may be connected to money laundering or other illegal activities. Such systems help financial institutions prevent money laundering and terrorism financing. AI and machine learning are useful in risk management processes because algorithms help financial institutions identify risky transactions and high-risk customers. Because of this, banks can have more effective risk management, they can minimise losses and optimise their investments. AI can be of use in investment decisions. Algorithms can analyse a large amount of data fast, for instance, stock exchange data, companies' financial reports, macro-economic indicators, etc. Such systems allow investment decision makers to obtain timely and effective information about the markets so that they can increase investment yield. The use of AI and machine learning allows the financial sector to improve customer relations and customer service. Algorithms and AI allow financial institutions to offer their customers personalised services and solutions improving customer experience in that way.

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