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Research article

Impact of the COVID-19 crisis on the Portuguese banking system. Linear ordering method

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Abstract
The goal of this paper is to assess the resilience of Portuguese banks to the potential impact of the COVID-19 pandemic. For this purpose, diagnostic variables of 19 banks were selected and prioritized using linear ordering methods. This methodology allowed us to perform rankings of banks using six linear ordering methods and taking into account two weighting procedures and two variants of the diagnostic feature. The study was also supplemented by a sensitivity analysis and an optimization procedure aimed at identifying the optimal linear ordering method. The main results obtained show that the resilience of Portuguese banks is not evenly distributed among individual banks. These findings could be used by regulators to plan support measures for the most fragile banks.

Keywords: banking sector; COVID-19; pandemic crises; multidimensional comparative analysis.

Impacto de la crisis del COVID-19 en el sistema bancario portugués. Enfoque de ordenamiento lineal

Resumen
El objetivo de este trabajo es evaluar la resistencia de los bancos portugueses al impacto potencial de la pandemia por COVID-19. Para ello, se seleccionaron y priorizaron variables de diagnóstico de 19 bancos mediante métodos de ordenamiento lineal; esta metodología permitió realizar rankings de bancos utilizando seis métodos de ordenamiento lineal teniendo en cuenta dos procedimientos de ponderación y dos variantes de la característica de diagnóstico. El estudio también se complementó con un análisis de sensibilidad y un procedimiento de optimización destinado a identificar el método ideal de ordenación lineal. Los principales resultados obtenidos muestran que la resistencia de los bancos portugueses no se distribuye uniformemente entre los bancos individuales. Los reguladores podrían utilizar estos resultados para planificar medidas de apoyo a los bancos más frágiles.

Palabras clave: sector bancario; COVID-19; crisis pandémicas; análisis comparativo multidimensional.

Impacto da crise do COVID-19 no sistema bancário português. Abordagem de ordenação linear

Resumo
O objetivo deste trabalho é avaliar a resistência dos bancos portugueses ao potencial impacto da pandemia COVID-19. Para isso, variáveis de diagnóstico de 19 bancos foram selecionadas e priorizadas por meio de métodos de ordenação linear. Essa metodologia permitiu classificar os bancos usando seis métodos de ordenação linear e levando em consideração dois procedimentos de ponderação e duas variantes da característica diagnóstica. O estudo também foi complementado com uma análise de sensibilidade e um procedimento de otimização, com o objetivo de identificar o método de ordenação linear ideal. Os principais resultados obtidos mostram que a resistência dos bancos portugueses não se encontra uniformemente distribuída entre os bancos individuais. Os reguladores poderiam usar esses resultados para planear medidas de apoio aos bancos mais frágeis.

Palavras-chave: setor bancário; COVID-19; crise pandêmica; análise comparativa multidimensional.

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1. Introduction

In 2019, the Portuguese financial system comprised 152 credit institutions out of which 62 were banks. The five largest banks in Portugal account for 80-85% of the assets of the whole banking sector. Employment in credit institutions located in Portugal is over 46 000 people (Banco de Portugal, 2020). After some troubled years (2010-2017), the condition of the Portuguese banking sector has improved significantly (Association of Portuguese Banks - APB, 2019). It is evidenced, among others, by:

- Increase in Return on Equity (ROE) from (-)0.8% in December 2017 to 5.3% at the end of June 2019, compared to 6.4% for the euro area at that time,
- Decrease in Non-Performing-Loans (NPL) share in the portfolio from 17.5% in 2015 to 8.1% at the end of June 2019 (however, it is still 2.5 times the average for the euro area), and decrease in cost of credit risk in the audited period from 1.2% to 0.4%,
- Improvement in solvency (increase in Tier 1 ratio from 12.4% at the end of 2015 to 13.9% at the end of June 2019, although it is still below the euro area average),
- Improvement in liquidity (decrease in Loan-to-Deposit ratio from 96% in December 2015 to 88% in June 2019).

Meanwhile in 2020, the COVID-19 pandemic put an end to this recovery, it even reached Portugal relatively late compared to other Western European countries. In fact, pandemic-sensitive sectors such as tourism, hospitality, transportation and construction, for which a relatively early lockdown occurred, represent large shares of Portuguese banks portfolios (between 5% and 15% for the largest banks) and as a result of the COVID-19 escalation in Portugal in the second half of March 2020, some industries (bakeries, restaurants) recorded a drop in revenues over 70%, as well as traffic which decreased by 75%.

Then, as a consequence of the pandemic, the Portuguese economy has seen a sharp deterioration in macroeconomic parameters with several implications for the banking sector. Recent forecasts indicate a fall in GDP in 2020 by 3.4% (in February 2020 a rise of 1.7% was forecasted), an increase in unemployment rate up to 8.2% in 2020 (in February 2020, a 6.4% increase was indicated), a growth of the public debt-to-GDP ratio to 124.9% in 2020 (while in February 2020 it was estimated at 114.6%), and a fall in inflation rate as well as recession on the real estate market. Meanwhile, the economic support programme of the government amounts to €12.5 billion, i.e. approx. 6.2% of GDP. This scheme covers *inter alia*: investments in the national health system, subsidies for households (e.g. temporary suspension of labour contracts), measures focused on tackling the liquidity problems of companies, deferring tax payments and credit lines for companies channelled through the banking system (with lower interest rates, grace periods, and longer maturities) as well as reduction of charges on electronic payments or deferral of loan repayment schemes (Gonçalves, Belo & Pinheiro, 2020). Moreover, during this time, banks also adopted measures to support both families and companies, either on its own initiative or within government programmes. Anyway, the managers of Portuguese banks estimate that the number of increasing write-downs will mean that banks will not make profits in 2020 and 2021, and will become the most affected group of entities by the pandemic (Winterbrun, 2020).

Given these gloomy predictions for Portuguese banks, in general, it is very important to assess the implications for each of them, trying to identify the most vulnerable ones and then help them with special politics. To the authors knowledge, no study has yet been produced to analyse the impact of COVID-19 on the Portuguese banking sector and so this is the main contribution we hope to make with this research; in brief, the main purpose of this paper is to assess the Portuguese banks in terms of their resilience to the consequences of the COVID-19 pandemic, and then addressing the aforementioned research gap.

In order to do so, we employ linear ordering methods in the sequence of previous analyses, as in the case of the assessment of impact of the pandemic on the 13 largest commercial banks in Poland (Korzeb & Niedziółka, 2020). However, the aforementioned study was based on only two linear ordering methods, i.e. TOPSIS method and Hellwig's approach. Although the linear ordering methods have been used by some authors, e.g. Hellwig (1968), Hwang and Yoon (1981), Strahl (1978), Nowak (1977) or Kukuła and Luty (2015), they focused on specific individual linear ordering methods with limited procedure of double checking the results (which can be performed by the wide use of alternative approaches or by applying multi-method procedure), and those studies were not applied to the banking sector either. Meanwhile, our study is focused inter alia on the impact of the structure of bank industry portfolio on the resistance to COVID-19, since it may be decisive for NPL dynamics. In fact, Ari, Chen and Ratnovski (2020) also emphasised that the way of managing NPL portfolios seems to be crucial to the economic recovery during the COVID-19 crisis and thereafter.

The conclusions of the study presented in this article may be used in supervisory and regulatory policies and may be one of the premises that investors – who engage their funds in the purchase of bank shares – could take into account. Another contribution is related to the sensitivity of banks to the effects of the COVID-19 pandemic being important information for bank managers in the context of risk management process and in positioning banks against the peer competitors. The worked out measures may also be used in the structuring of financial stability indices or in rating methodologies.

The remainder of this article is structured as follows: section 2 reviews the most significant literature; section 3 describes the data and methodology employed in the empirical research; section 4 presents the results obtained; section 5 is dedicated to the discussion of results; whereas section 6 summarises and presents the main conclusions.

2. Literature review

After several months of the pandemic spreading and the unpredictability of its future scale, it is difficult to draw clear conclusions about the impact of COVID-19 on the economy and consumer behaviour. The sources of the present literature review were both publications relating to the impact of the COVID-19 crisis on the real economy and the banking sector. The above approach results from the assumption of strong and two-way links between the real economy and the financial system.

At the outset, it is worth noting that unlike the subprime crisis, COVID-19 found the banking sector in good condition in terms of regulatory capital and liquidity levels. Taking this into account and also the results of analysing the substance of government programmes, it can be concluded that the banking sector could be part of the system designed to absorb the effects of the pandemic crisis (Demirguc-Kunt, Pedraza & Ruiz – Ortega, 2020; Borio, 2020).

Kohlscheen, Mojon and Rees (2020) simulated the spread of the pandemic and the recession caused by it. The authors pointed out that uncoordinated confinement generate the risk of another wave of epidemics, affecting individual economies sequentially. The second challenge is to coordinate, internationally, the efforts of governments to limit the effects of the recession. The authors do not believe that an uncoordinated policy to mitigate the effects of the recession will be effective. The scale of the recession in a given economy depends not only on the fiscal and monetary policy instruments used by the government of that country, but also on the policies pursued by other governments.

As we all know, a pandemic may become a permanent state. This makes necessary to have a plan in case the economy has to be locked down so as not to do so violently and recklessly. The lockdown should be sequential and the whole process is compared to the closure of a nuclear power plant. It is also important to design economic support activities in such a way that they do not trigger moral hazard.

A separate stream of research is dedicated to the prediction of measurable effects of the crisis. Boissay and Rungcharoenkitkul (2020) estimate that the global GDP decline as a result of the COVID-19 pandemic could amount to 4-4.5% approx., with a relatively higher output reduction in the largest economies (particularly in the United States, where a reduction of up to 9% is estimated). De Santis and Van der Veken (2020) assume that financial variables allow for earlier prediction of a recession than macroeconomic variables. These authors refer to the recession in 2008 and to the COVID-19 crisis, where the same financial variables (e.g. the change in the FED reference rate, determined solely by information from the financial markets) indicated a high probability of a sharp fall in GDP and an increase in macroeconomic risk earlier than macroeconomic variables. Leiva–Leon, Perez-Quiros and Rots (2020) proposed the concept of the Global Weakness Index (GWI), which was used to assess the repercussions of the COVID-19 crisis. Based on certain soft indicators on March 2, 2020, the GWI increased significantly and was sharper than it was in the 2008 crisis.

Aldasoro, Fender, Hardy and Tarashev (2020) indicate that the COVID-19 crisis is relatively milder for well capitalised and highly profitable banks. Schmieder, Sobrun, Takáts and Lewrick (2020) remark that banks have reached the COVID-19 crisis with excess of own funds over the Pillar 1 requirement. The above mentioned authors estimate that in the negative scenario, this surplus creates space for granting new financing, crucial for the recovery process, at the level of USD 5 billion approx. Meanwhile, Borio and Restoy (2020) indicate that recommendations to banks on the use of capital and liquidity buffers should be accompanied by restrictions on the payment of dividends and bonuses and guidelines on how to rebuild those buffers. The authors also recommend that the flexibility in the rules for the classification of receivables should be accompanied by greater transparency with regard to the creditworthiness assessment criteria adopted. Referring to their findings, a hypothesis was formulated: *the level of regulatory capital is important in terms of bank resilience to pandemic crisis* (Hypothesis 1).

It is also necessary to adopt detailed guidance on the application of expected loss provisioning rules. Svoronos and Vrbaski (2020) examined the banks dividend policy during the pandemic and the extent of the restrictions that were imposed by supervisors in this respect. These authors concluded that capital conservation buffer is a necessary complement to the effective relaxation of capital requirements. At the same time, when examining different jurisdictions (including the United States, China, Japan, Russia, India, the euro area, and the United Kingdom), authors considered that COVID-19s related clear guidelines on dividends, buyback and bonuses were not implemented everywhere; moreover, no new specific guidelines have been formulated in some jurisdictions. On the other hand, the solutions used differ significantly in terms of their restrictive nature and the scope and type of solutions, so it is difficult to compare them.

Zamil (2020) recalled that supervisory authorities and the Basel Committee on Banking Supervision (BCBS) introduced a number of guidelines on how to treat different types of support schemes for borrowers, the allocation of provisions and regulatory capital. These guidelines were implemented to encourage banks to support the economy. In Zamil's view, supervisory initiatives aimed at capital relief and the flexibility of accounting standards should be accompanied by a more restrictive approach to permitted dividend payments, buybacks and bonus payments. Dooseman, Marchat and Guillard (2020) examined the impact of COVID-19 on banks reporting and pointed out the need to update the parameters determining the amount of expected loss, which affects the amount of write-offs.

As mentioned by Korzeb and Niedziółka (2020), in addition to credit risk, the most important risk factors for banks in the era of the pandemic could be relaxation of the internal control environment, cyberterrorism and liquidity risk. In April 2020, the Basel Committee on Banking Supervision published a list of guidelines for estimating expected losses and reporting changes in the economic and financial situation of bank debtors (Bank of International Settlements - BIS, 2020). In the same line, Veron (2020) states that it would not be advisable to fully liberalise the rules on risk write-downs, as well as to completely suspend supervisory activities or obligations to maintain certain quantifiable and qualitative standards.

Compared to the 2008 crisis, banks now have higher capital, the crisis did not occur during the credit boom, and forward-looking IFRS, 9 accounting standards can support NPL recognition. These factors should help address the NPL problem but, in turn, the high public debt, the low profitability of banks and the deteriorating standing of companies are factors negatively affecting the management of NPL portfolios. The aforementioned studies show that the management of the NPL portfolio after the COVID-19 crisis is likely to be different from previous banking crises.

In fact, Hardy and Takáts (2020), having examined the banking sector at the aggregate level rather than on the basis of individual bank financials, show that the issue of banking sector capitalization also proved to be decisive for the financing capacity of the real economy as the ability to expand lending is closely related to the resilience of a bank. They also noticed that the most affected banks by the crisis are focusing on restructuring their portfolios and that the existing, as well as projected consumption of capital buffers, significantly limit their ability to make new loans. *So, we assume that in case of the COVID-19 pandemic the NPL level is predominantly affected by the portfolio structure of the bank and therefore the bank sector structure is an important determinant of the resistance of banks to the crisis* (Hypothesis 2).

It may turn out that many of the debtors that will be in the NPL portfolio after COVID-19 are viable and solvent but their main problem will be liquidity. Designing effective NPL resolution policies for the post-COVID-19 NPL exposures is one of the most important financial policy issues for European banks. Ari, Chen and Ratnovski (2020) revealed factors affecting high and persistent NPL in some European countries. These authors compared NPL dynamics in Greece, Ireland, Italy, Portugal, Spain, Hungary and Slovenia with what could have been forecasted based on historical patterns.

Baudino (2020) undertook an analysis of government guarantee schemes that would increase the lending activity of banks during the pandemic, especially for small and medium-sized enterprises. The design of such programmes requires a certain balance to be struck between immediate support for businesses during a pandemic and an appropriate level of caution. The structuring elements in this case are: profile of the beneficiary, degree of coverage by the guarantees, spectrum of products covered by the guarantees, and duration of the scheme. A certain constraint on the expected effectiveness of the programme may be the complex operational procedure as well as reporting and fiscal capacity limits.

The impact of the COVID-19 crisis on the banking sector is not limited to the factor related to the industry structure of the portfolio. The macroeconomic situation of the country in which bank operations are carried out is also important. In this context, the results of the research carried out by Oravský, Tóth and Bánociová (2020), which determined the impact of the COVID-19 crisis on GDP, public debt, deficit, tax collection, interest rates, and consumer confidence index are valuable. The study covered selected European countries and the vital conclusion refers to the consumer confidence index since it fell sharply in the group of countries slightly affected by the crisis, i.e. Switzerland and Finland.

It is important to note that Banks portfolios are composed not only of credit exposures but also by financial instruments. Therefore, the volatility of security prices on the financial markets is another determinant of banks performance during the pandemic. Zhang, Hu and Ji (2020) mapped general patterns of country-specific risks and systemic risks in the global financial markets. The mentioned authors also examined the potential consequence of policy interventions like introduction of zero-percent interest rates and unlimited quantitative easing in the context of further uncertainties on global financial markets.

Donthu and Gustafsson (2020) analysed the impact of COVID-19 on 13 industries in terms of changes in consumer behaviour and businesses, ethical issues, and aspects related to employees and leadership. The research on the effects of spreading crises on the banking sector does not start with the COVID-19 pandemic. Studies of this type were carried out much

earlier, on Spanish flu of 1918, Asian flu, Hong Kong flu, SARS-CoV, A/H1N1, MERS-CoV, and Ebola. For example, Barro, Ursua and Weng (2020) used data describing 1918-1920 Great Influenza Pandemic. 100 years ago the flu resulted in mortality accounting for 2.1% of world population, implying 150 million deaths due to COVID-19 if applied to the current population. This may contribute to the reduction of GDP and consumption by 6-8%. The authors proved also statistically significant negative correlation between flu death rates and real returns on financial markets. However, it is important to note that it was not until COVID-19 that the perception of the impact of global pandemics on the functioning of modern economies and banking sectors changed. Coronavirus has radically changed the economic and social environment, the conditions of functioning of non-financial enterprises, households and financial sector institutions.

3. Methodology

The research was conducted on a sample of 19 banks operating in the Portuguese banking sector (Table 1). The survey covered all banks that published information about credit quality of exposures by industry or counterparty type (CR1-B) in their annual reports for 2019. The aggregated total assets of the banks studied represents 92.98% of the banking sector assets in Portugal as of December 12, 2019. The financial information and values of the bank ratios were obtained from the BankScope database and annual reports of the banks.

The analysis was performed by using linear ordering methods based on a synthetic variable, which are included in Multiple-Criteria Decision Making (MCDM) techniques. Two pattern methods of variable aggregation – Hellwig (1968) and TOPSIS (Hwang & Yoon, 1981) – are based on determining the distance of individual objects from a defined model object. The other four techniques (Strahl, 1978, Nowak, 1977, Kukuła & Luty, 2015) are non-pattern ones. They consist in the operation of averaging the values of normalized variables. The designs of all aforementioned methods are presented in Table 2.

The following diagnostic features were adopted for the analysis (Table 3): capital adequacy (Tier 1), liquidity (LCR), profitability (ROAE), cost to income ratio (C/I), the share of impaired exposures to date (NPL), the resilience of the credit portfolio of the bank to the risk resulting from its exposure to the most risky sectors in the context of the COVID-19 pandemic (RES), and credit rating calculated on the basis of long term credit rating held or implied by Moody's (RAT).

The choice of diagnostic features was guided by substantive analysis taking into account the importance of the indicator in assessing the resilience of Portuguese banks to the crisis situation and statistical analysis, i.e. appropriate level of volatility. Then these indicators were divided into stimulants and deterrents of the studied phenomenon. The values of numerical diagnostic characteristics are shown in Table 4.

Table 1. List of commercial banks analysed in the study

Name of the Bank (Alphabetical order)
Banco ActivoBank, S.A.
Banco Comercial Portugues, S.A.
Banco Credibom, S.A.
Banco CTT, S.A.
Banco EuroBic, S.A.
Banco Finantia, S.A.
Banco Invest, S.A.
Banco Português de Investimento (BPI), S.A.
Banco Primus, S.A.
Banco Privado ATLANTICO – Europa, S.A.
Banco Santander Consumer Portugal, S.A.
Banco Santander Totta, S.A.
BEST - Banco Electrónico de Serviço Total, S.A.
Caixa - Banco de Investimento, S.A.
Caixa Central de Crédito Agrícola Mútuo, C.R.L.
Caixa Economica Montepio Geral, Caixa Economica Bancaria, S.A.
Caixa Geral de Depósitos, S.A.
Novo Banco, S.A.
Novo Banco dos Açores, S.A.

Notes: The list is presented in alphabetical order. A different order was applied in the analysis.
Source: own elaboration.

This study classifies industries according to their vulnerability to the negative effects of the COVID-19 pandemic. The risk level of the industry is described in diagnostic feature N° 6 (RES). Based on the sector structures of the bank portfolios the level of vulnerability and sensitivity of banks to the effects of the COVID-19 crisis was determined. The sector risk was estimated with the use of 2 variants: estimating the expected decrease in sales revenue in each section for 2020 and determining the return on shares of all companies listed on the Portuguese Stock Exchange in the first quarter of 2020, and then calculating the median for each sector. The first variant (Option 1) is based on the calculation of the potential decline in sales of a given industry in 2020, which in turn is derived from the lockdown schedule and subsequent de-freezing of the economy (Table 5), as well as the assumed period of companies recovery resulting in reaching pre-pandemic levels of sales and profitability. Changes in social behaviour that result in permanent weakening or strengthening of specific industries were also considered.

Table 2. Chosen linear ordering methods

Method	Standardisation	Coordinates of the pattern	Distances of objects from the pattern	Value of the aggregate variable
Pattern methods				
Hellwig	$Z_{ij}=\frac{X_{ij}-\overline{X_j}}{S_j}$	$Z_j^+=\max_i\{z_{ij}\}$	$d_i^+=\sqrt{\sum_{j=1}^{m}(z_{ij}-z_j^+)^2}$	$q_i=1-\frac{d_i^+}{d_o}$, whereby: typically $q_i \in [0;1]$ maxi{qi} – the best object; mini{qi} – the worst object; $d_o=\overline{d_o}+2S_d$; $d_o=\frac{\sum_{i=1}^{n} d_i^+}{n}$ $S_d=\sqrt{\frac{\sum_{i=1}^{n}(d_i^+-\overline{d})^2}{n}}$
TOPSIS	$Z_{ij}=\frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^2}}$	$Z_j^+=\max_i\{Z_{ij}\}$ $Z_j^-=\max_i\{Z_{ij}\}$	$d_i^+=\sqrt{\sum_{j=1}^{m}(z_{ij}-z_j^+)^2}$ $d_i^-=\sqrt{\sum_{j=1}^{m}(z_{ij}-z_j^-)^2}$	$q_i=\frac{\overline{d_i}}{(d_i^+-d_i^-)}$, whereby: $q_i \in [0;1]$, maxi{qi} – the best object; mini{qi} – the worst object.
Non-pattern methods				
Standardization	$Z_{ij}=\frac{X_{ij}-\overline{X_j}}{S_j}$			$q_i=\frac{1}{m}\sum_{j=1}^{m} z_{ij}$
Unitarization	$Z_{ij}=\frac{X_{ij}-\min_i x_{ij}}{\max_i x_{ij}-\min_i x_{ij}}$			$q_i=\frac{1}{m}\sum_{j=1}^{m} z_{ij}$
Strahl transformation	$Z_{ij}=\frac{X_{ij}}{\max_i x_{ij}}$			$q_i=\frac{1}{m}\sum_{j=1}^{m} z_{ij}$
Nowak transformation	$Z_{ij}=\frac{X_{ij}}{\overline{X_j}}$			$q_i=\frac{1}{m}\sum_{j=1}^{m} z_{ij}$

Where: xij – observation of the j-th variable for the object i, – arithmetic mean of observations of the j-th variable, Sj – standard deviation of observations of j-th variable.
Source: own elaboration.

Table 3. Selected characteristics of adopted diagnostic variables

Symbol	Selected diagnostic variables	Description		Variable profile
Z1	Tier1	Capital adequacy	Tier 1 Capital	S
Z2	LCR	ST Liquidity	Ratio of HQLA to net outflows within 30 days under extreme conditions	S
Z3	ROAE	Profitability	Return on average equity	S
Z4	C/I	Cost management	Cost to Income Ratio	D
Z5	NPL	Credit portfolio quality	Impaired assets/Total interest bearing assets - NPL	D
Z6	RES	Resilience of credit portfolio to the COVID-19 crisis	Variable determined by banks' portfolios sector risk profile in the context of the COVID - 19 crisis according to: Option 1 – Sector's risk estimation, Option 2 - rates of return of sectors in IQ 2020 (based on quotations of shares listed on the Portuguese Stock Exchange)	Option 1 – D Option 2 - S
Z7	RAT	External rating	Calculated on the basis of the long term credit rating held or implied by Moody's. In the absence of a bank rating, a country rating was used. Individual ratings were assigned values, assuming that the lowest value (1) corresponds to Aaa, the highest one (19) is assigned to the worst rating.	D

Source: own elaboration.

Table 4. The basic characteristics of selected diagnostic variables

Specification	Z1	Z2	Z3	Z4	Z5	Z6 Option 1	Z6 Option 2	Z7
Max	78.170	606.000	20.521	113.491	14.003	10.700	0.721	14.000
Min	10.900	100.000	-35.650	32.314	0.130	7.198	0.533	5.000
Arithmetic mean	20.513	215.799	5.747	61.105	4.595	9.624	0.580	9.632
Median	15.200	166.000	8.260	59.630	3.500	9.957	0.562	10.000
Standard deviation	15.893	136.402	11.411	18.368	3.581	1.184	0.054	2.241
V(x) variability coeff.	0.775	0.632	1.986	0.301	0.779	0.123	0.093	0.233

Source: own elaboration.

Table 5. Calendar of COVID-19 in Portugal

Key dates:	Action
02.03.2020	First recorded case of COVID-19 in Portugal
18.03.2020	Declaration of a 15-day state of emergency and freezing of the economy
02.04.2020	Extension by Parliament of the state of emergency (closure of airports, restrictions on movement of the population, increased border control)
30.04.2020	Announcement of the economy's de-freeze plan
02.05.2020	Cancellation of the state of emergency
04.05.2020	Phase I of the de-freeze of the economy (opening of small shops, hairdressers, public transport)
18.05.2020	Phase II of the de-freeze of the economy (partial opening of nurseries, crèches and schools; opening of restaurants, medium-sized shops, obligation to use masks)
01.06.2020	Phase III of the de-freeze of the economy (opening of shopping malls, cinemas, theatres and hotels)

Source: own elaboration.

The assumptions adopted for the expert method described above were based on data in the form of communications from listed companies representing particular sectors, analyses of banks, rating agencies and advisory entities, positions and recommendations of the European Commission, representatives of banks, Portuguese government, chambers of commerce, as well as data on the number of vehicles registered, card transactions and data from the real estate market. The impact of changes in macroeconomic parameters and the share of export and import in sales revenues and operating costs of particular industries, respectively, were also considered (Instituto Nacional de Estatística - INE, 2019).

As in Korzeb and Niedziółka (2020), the measure of risk of a specific sector was determined as a weighted average decile of the share of export in sales, import in operating costs and the expected decrease in sales revenues in 2020. The sectors were then ranked accord-ing to their risk and assigned the following designations: low risk (1st quartile), moderate risk (median), significant risk (3rd quartile), and high risk (last quartile) (Table 6).

The risk values obtained for the sectors were then related to the bank exposure to a given industry and the structure of the credit portfolio at the end of the year. The RES variable (Option 1) is therefore a weighted average of exposures to individual sectors (weights corresponding to sector risk) divided by the total interest-bearing portfolio value (assets).

Table 6. Risk measures of individual sections of the economy in the context of COVID-19 impact

Section		Risk measure	Risk level
A	Agriculture, forestry, fishing	4.50	Moderate
B	Mining	8.10	High
C	Industrial manufacturing	5.80	Moderate
D	Electricity, gas, steam and hot water supply	1.90	Low
E	Water supply; sewerage, waste management; remediation	3.40	Low
F	Construction	4.20	Moderate
G	Trade and repair of motor vehicles	7.70	Significant
H	Transport and storage	7.60	Significant
I	Accommodation and catering	7.80	High
J	Information and communication	3.60	Low
K	Financial and insurance activities	3.80	Moderate
L	Real estate management	5.80	Moderate
M	Professional, scientific and technical activities	5.60	Moderate
N	Administration and support activities	6.50	Significant
O	Public administration and defence, obligatory social security	1.00	Low
P	Education	7.80	High
Q	Health and social care	1.50	Low
R	Culture, entertainment and recreation	7.70	Significant
S	Other service activities	9.70	High

Source: own elaboration.

In case of the second variant (Option 2) rates of return on shares of all companies listed on the Portuguese Stock Exchange in the first quarter of 2020 were determined and then medians were calculated for each sector. Due to the intention not to take into account low liquidity shares, the research did not include companies whose number of quotations in the analysed period was lower than half of all quotations. The values obtained in this way were used as indicators of potential loss resulting from the existing credit exposure of the bank, then they were multiplied by the value of on-balance sheet and off-balance sheet exposures to individual sectors in bank credit portfolios as of December 12, 2019 (or December 12, 2018 if 2019 figures were not available). The result obtained for each bank was

then applied to the balance of the credit portfolio at the end of the year, and then the potential for impairment of the portfolio in % was calculated. Linear ordering methods require definitions of quantitative weights for the attributes (Ma, Fan, & Huang, 1999; Choo & Wedley, 1985; Schoemaker & Waid, 1982). In the study, the weights were adopted on the basis of subjective methods: i) w1 system - the same weights were adopted for all variables; ii) w2 system - the weights were determined on the basis of an expert method. The highest weights were given to 3 diagnostic features: capital adequacy, liquidity, and resistance of credit portfolio (Table 7).

Table 7. Values of weighting indicators

Weights	Z1	Z2	Z3	Z4	Z5	Z6	Z7
w1	0.143	0.143	0.143	0.143	0.143	0.143	0.143
w2	0.200	0.200	0.100	0.100	0.100	0.200	0.100

Source: own elaboration.

Thus, objective methods derived from statistical procedures, such as those based on the variability or correlation of indicators, which are quite often used when defining weights in this type of research (Korzeb & Niedziółka, 2020) were abandoned. Moreover, statistical approaches pertain to information about the characteristics inherent only in the data matrix itself; additionally, in particular an analysis of the variability of characteristics and an analysis of correlation between characteristics are implemented. Its specificity is the mechanical treatment of the problem of weighing, abstracted from the actual position of a given feature determined by the factual premises.

It was then verified which of the rankings drawn up according to six different methods is the most similar to the others. To achieve the above mentioned objective the Kukuła and Luty (2015, 2018) method was used. As the result of comparisons, the measure of similarity of rankings m_{pq} will be used:

$$m_{pq} = 1 - \frac{2\sum_{i=1}^{n} | c_{ip} - c_{iQ} |}{n^2 - z}, \; p, q = 1, 2, ..., v \quad (1)$$

Where:

c_{ip} – position of the i-th object in the ranking with the number p,

c_{iq} – position of the i-th object in the ranking with the number q,

$$z = \begin{cases} 0 \text{ if } n \text{ is an even natural number,} \\ 1 \text{ if is not an even natural number.} \end{cases}$$

In order to determine the degree of similarity of the ranking obtained as a result of the application of the p-th linear ordering method to the other rankings, the sum of the elements p of row (or column) of the symmetric matrix M of dimensions (v × v) was calculated, where v is the number of rankings reduced by 1. Then the result was averaged as follows:

$$\overline{u}_p = \frac{1}{v - 1} \sum_{\substack{q=1 \\ p \neq q}}^{v} m_{pq}, \; p, q = 1, 2, ..., v \quad (2)$$

There the method for which $\overline{u}_p = \max_p \overline{u}_p$ was chosen.

Additionally, in case of TOPSIS method, the sensitivity of the model was analysed due to its limitations in terms of weighting criteria. For this purpose, the method proposed by Moghassema and Fallahpour (2011) was used, which is based on decreasing and increasing all the weights of the criteria (5%, 10%, 15%, 20%) and repeating TOPSIS approach with new values:

$$w_i^{new} = w_i \pm a w_i, \; where \; a = \{0.05, 0.1, 0.15, 0.2\} \quad (3)$$

And there Spearman's and Kendall's correlation were estimated between initial ranking and rankings newly created in this way.

4. Results

In order to assess the resilience of commercial banks operating in the Portuguese banking sector to the potential impact of the COVID-19 pandemic, the rankings of banks were determined using six linear ordering methods taking into account two weighting procedures: i) w1 - as equal weights, ii) w2 - the expert method, and two variants of the diagnostic feature Z6: version 1 with risk estimation of individual sectors of the economy, and version 2 based on the rates of return of individual sectors of the economy in IQ 2020 on the Portuguese Stock Exchange.

In this way, 24 rankings were obtained, which were used to build the final classification of banks (Table 8 and Table 9). The arithmetic mean of the grades obtained is presented in Figure 1 and Figure 2.

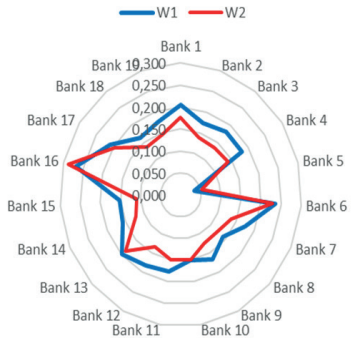

Figure 1. Final ranking as the arithmetic mean of 6 methods – version 1
Source: own elaboration.

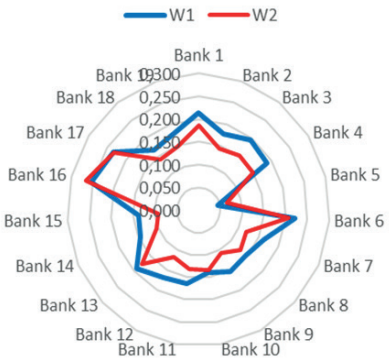

Figure 2. Final ranking as the arithmetic mean of 6 methods – version 2
Source: own elaboration.

The final ranking being the arithmetic sum of variant 1 and variant 2 is presented in Figure 3.

Although different assumptions were made for Option 1 and Option 2 for the Z6 variable, the results do not show major differences in the hierarchy of the three most resilient banks to potential COVID-19 effects and least resilient ones (Table 10 and Table 11). Banks N°5 and N°15 differ significantly from the others in their resistance level. Out of the 24 rankings performed, bank N°5 took last place 19 times, while bank N°15 was classified 7 times in the penultimate place and 4 times in the last. The situation is similar with the best banks. For example, bank N°16 was the highest ranked bank 15 times and 5 times it took second place. The results of the other 14 banks are no longer so clear since the positions occupied in the rankings are more diverse.

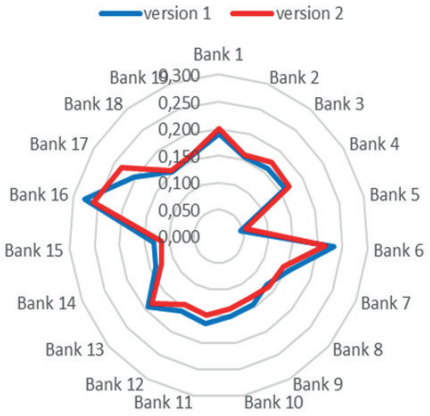

Figure 3. Final ranking – version 1 and version 2
Source: own elaboration.

Table 8. Rankings of banks obtained in the first version

Ranking	Hellwig				TOPSIS				Standardisation			
	W1		W2		W1		W2		W1		W2	
	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank
Bank 1	0.395	2	0.346	5	0.594	5	0.460	5	-0.033	14	-0.033	13
Bank 2	0.292	8	0.235	8	0.548	9	0.401	9	-0.036	15	-0.036	14
Bank 3	0.311	7	0.226	9	0.585	6	0.422	7	-0.055	18	-0.065	18
Bank 4	0.317	6	0.246	7	0.576	7	0.418	8	-0.050	16	-0.056	17
Bank 5	-0.014	19	0.112	19	0.268	19	0.214	19	-0.088	19	-0.090	19
Bank 6	0.381	3	0.340	3	0.663	2	0.574	2	0.044	3	0.089	2
Bank 7	0.191	12	0.128	13	0.542	13	0.391	13	0.019	8	0.015	5
Bank 8	0.085	18	0.146	12	0.431	18	0.320	18	0.036	5	0.004	8
Bank 9	0.186	13	0.107	15	0.545	10	0.388	15	-0.005	10	-0.007	11
Bank 10	0.116	16	0.183	10	0.488	17	0.394	12	0.044	4	0.051	3
Bank 11	0.110	17	0.115	14	0.517	16	0.397	11	0.064	2	0.049	4
Bank 12	0.197	10	0.103	16	0.602	4	0.435	6	-0.007	11	-0.010	12
Bank 13	0.343	4	0.324	4	0.611	3	0.509	3	-0.012	12	0.012	7
Bank 14	0.132	15	0.089	18	0.530	14	0.377	17	0.014	9	0.006	9
Bank 15	0.196	11	0.095	17	0.544	11	0.385	16	-0.053	17	-0.044	15
Bank 16	0.430	1	0.450	1	0.720	1	0.714	1	0.090	1	0.140	1
Bank 17	0.333	5	0.371	2	0.565	8	0.477	4	0.027	6	0.014	6
Bank 18	0.237	9	0.250	6	0.525	15	0.389	14	-0.022	13	-0.045	16
Bank 19	0.182	14	0.185	11	0.543	12	0.398	10	0.023	7	0.005	10
Ranking	Unitarisation				Strahl				Nowak			
	W1		W2		W1		W2		W1		W2	
	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank
Bank 1	0.055	13	0.053	13	0.069	9	0.071	7	0.155	8	0.156	5
Bank 2	0.051	15	0.048	15	0.061	17	0.063	14	0.124	16	0.124	17

Table 8. Rankings of banks obtained in the first version (continuation)

Bank 3	0.045	18	0.039	18	0.065	13	0.063	15	0.147	10	0.135	11
Bank 4	0.046	17	0.041	17	0.062	16	0.062	17	0.134	12	0.128	14
Bank 5	0.041	19	0.035	19	0.024	19	0.034	19	-0.018	19	0.019	19
Bank 6	0.075	3	0.084	2	0.079	4	0.088	2	0.174	4	0.195	2
Bank 7	0.067	6	0.063	5	0.075	7	0.073	5	0.161	5	0.149	8
Bank 8	0.069	5	0.058	9	0.075	6	0.071	10	0.154	9	0.141	10
Bank 9	0.061	10	0.058	10	0.068	11	0.067	13	0.140	11	0.131	12
Bank 10	0.073	4	0.072	3	0.066	12	0.071	9	0.115	18	0.130	13
Bank 11	0.078	2	0.072	4	0.088	1	0.082	3	0.205	1	0.182	4
Bank 12	0.060	11	0.057	11	0.074	8	0.071	8	0.166	6	0.148	9
Bank 13	0.057	12	0.060	7	0.063	15	0.069	11	0.133	13	0.150	6
Bank 14	0.065	9	0.061	6	0.068	10	0.067	12	0.132	14	0.125	16
Bank 15	0.049	16	0.049	14	0.058	18	0.059	18	0.116	17	0.112	18
Bank 16	0.085	1	0.094	1	0.084	2	0.095	1	0.198	2	0.231	1
Bank 17	0.065	8	0.057	12	0.081	3	0.080	4	0.185	3	0.183	3
Bank 18	0.052	14	0.042	16	0.064	14	0.062	16	0.130	15	0.127	15
Bank 19	0.066	7	0.058	8	0.076	5	0.072	6	0.161	7	0.149	7

Source: own elaboration.

Table 9. Rankings of banks obtained in the second version

Ranking	Hellwig				TOPSIS				Standardisation			
	W1		W2		W1		W2		W1		W2	
	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank
Bank 1	0.391	2	0.344	3	0.594	5	0.460	5	0.009	8	0.027	5
Bank 2	0.293	8	0.239	8	0.548	9	0.401	9	-0.019	13	-0.013	13
Bank 3	0.322	6	0.244	7	0.585	6	0.422	7	-0.010	10	-0.003	10
Bank 4	0.316	7	0.249	6	0.576	7	0.418	8	-0.016	11	-0.009	12
Bank 5	-0.005	19	0.118	14	0.268	19	0.212	19	-0.049	18	-0.035	14
Bank 6	0.359	3	0.314	4	0.664	2	0.574	2	0.006	9	0.036	4
Bank 7	0.180	13	0.119	13	0.542	13	0.392	13	-0.018	12	-0.037	15
Bank 8	0.088	18	0.148	12	0.431	18	0.320	18	0.059	2	0.037	3
Bank 9	0.176	14	0.100	16	0.546	10	0.389	14	-0.042	16	-0.058	17
Bank 10	0.111	16	0.172	11	0.488	17	0.394	12	0.011	7	0.006	8
Bank 11	0.104	17	0.107	15	0.517	16	0.398	11	0.027	5	-0.003	9
Bank 12	0.187	11	0.096	17	0.602	4	0.435	6	-0.044	17	-0.061	18
Bank 13	0.324	5	0.301	5	0.612	3	0.509	3	-0.025	15	-0.007	11
Bank 14	0.124	15	0.082	19	0.530	14	0.378	17	-0.023	14	-0.046	16
Bank 15	0.185	12	0.089	18	0.545	11	0.385	16	-0.090	19	-0.095	19
Bank 16	0.404	1	0.412	1	0.721	1	0.715	1	0.052	3	0.088	2
Bank 17	0.347	4	0.389	2	0.565	8	0.476	4	0.121	1	0.144	1
Bank 18	0.205	9	0.206	9	0.524	15	0.386	15	0.017	6	0.009	7
Bank 19	0.188	10	0.194	10	0.543	12	0.398	10	0.033	4	0.020	6
Ranking	Unitarization				Strahl				Nowak			
	W1		W2		W1		W2		W1		W2	
	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank
Bank 1	0.055	7	0.054	5	0.070	7	0.073	5	0.158	7	0.161	5
Bank 2	0.048	12	0.043	12	0.061	15	0.062	15	0.126	16	0.127	14
Bank 3	0.050	10	0.046	9	0.067	10	0.066	8	0.152	10	0.141	11
Bank 4	0.048	11	0.044	10	0.064	12	0.064	13	0.138	11	0.134	12

Table 9. Rankings of banks obtained in the second version (continuation)

Bank 5	0.044	16	0.040	14	0.026	19	0.037	19	-0.014	19	0.025	19
Bank 6	0.054	8	0.055	4	0.073	6	0.081	3	0.170	4	0.189	3
Bank 7	0.047	13	0.035	15	0.069	8	0.065	10	0.157	8	0.143	9
Bank 8	0.068	2	0.056	3	0.075	4	0.071	5	0.157	9	0.145	8
Bank 9	0.040	17	0.029	17	0.062	14	0.059	17	0.136	12	0.126	15
Bank 10	0.054	9	0.046	8	0.061	16	0.064	12	0.112	18	0.125	16
Bank 11	0.058	5	0.043	11	0.082	2	0.075	4	0.201	1	0.177	4
Bank 12	0.039	18	0.028	18	0.069	9	0.064	14	0.162	6	0.143	10
Bank 13	0.044	15	0.042	13	0.060	17	0.065	11	0.132	14	0.148	7
Bank 14	0.045	14	0.032	16	0.063	13	0.060	16	0.128	15	0.120	17
Bank 15	0.028	19	0.020	19	0.052	18	0.052	18	0.112	17	0.106	18
Bank 16	0.064	3	0.066	2	0.079	3	0.088	2	0.194	3	0.225	1
Bank 17	0.085	1	0.085	1	0.087	1	0.089	1	0.196	2	0.197	2
Bank 18	0.056	6	0.047	7	0.066	11	0.066	9	0.134	13	0.133	13
Bank 19	0.060	4	0.051	6	0.075	5	0.071	7	0.162	5	0.151	6

Source: own elaboration.

Table 10. Final ranking as the arithmetic mean of 6 methods – version 1

No.	Ranking W1				Ranking W2				Ranking Total: W1+W2			
	Arithmetic mean - scores	Rank	Arithmetic mean - places	Rank	Arithmetic mean - scores	Rank	Arithmetic mean - places	Rank	Arithmetic mean - scores	Rank	Arithmetic mean - places	Rank
Bank 1	0.206	4	8.5	6	0.176	5	8.0	6	0.191	5	8.3	7
Bank 2	0.174	12	13.3	16	0.139	10	12.8	13	0.156	11	13.1	16
Bank 3	0.183	6	12.0	14	0.137	12	13.0	14	0.160	9	12.5	14
Bank 4	0.181	8	12.3	15	0.140	9	13.3	16	0.160	7	12.8	15
Bank 5	0.036	19	19.0	19	0.054	19	19.0	19	0.045	19	19.0	19
Bank 6	0.236	2	3.2	2	0.228	2	2.2	2	0.232	2	2.7	2
Bank 7	0.176	10	8.5	6	0.137	12	8.2	7	0.156	12	8.3	6
Bank 8	0.142	18	10.2	10	0.123	16	11.2	11	0.133	17	10.7	11
Bank 9	0.166	13	10.8	11	0.124	15	12.7	12	0.145	15	11.8	12
Bank 10	0.150	17	11.8	12	0.150	6	8.3	8	0.150	14	10.1	10
Bank 11	0.177	9	6.5	4	0.150	7	6.7	5	0.163	6	6.6	5
Bank 12	0.182	7	8.3	5	0.134	14	10.3	10	0.158	10	9.3	9
Bank 13	0.199	5	9.8	9	0.187	4	6.3	4	0.193	4	8.1	4
Bank 14	0.157	15	11.8	12	0.121	17	13.0	14	0.139	16	12.4	13
Bank 15	0.152	16	15.0	18	0.109	18	16.3	18	0.130	18	15.7	18
Bank 16	0.268	1	1.3	1	0.287	1	1.0	1	0.278	1	1.2	1
Bank 17	0.209	3	5.5	3	0.197	3	5.2	3	0.203	3	5.3	3
Bank 18	0.164	14	13.3	16	0.137	11	13.8	17	0.151	13	13.6	17
Bank 19	0.175	11	8.7	8	0.145	8	8.7	9	0.160	8	8.7	8

Source: own elaboration.

Table 11. Final ranking as the arithmetic mean of 6 methods – version 2

No.	Ranking W1				Ranking W2				Ranking Total: W1+W2			
	Arithmetic mean - scores	Rank	Arithmetic mean - places	Rank	Arithmetic mean - scores	Rank	Arithmetic mean - places	Rank	Arithmetic mean - scores	Rank	Arithmetic mean - places	Rank
Bank 1	0.213	4	6.0	4	0.186	4	4.7	4	0.200	4	5.3	4
Bank 2	0.176	9	12.2	14	0.143	9	11.8	13	0.160	9	12.0	13
Bank 3	0.194	5	8.7	7	0.153	6	8.7	8	0.173	6	8.7	8

Table 11. Final ranking as the arithmetic mean of 6 methods – version 2 (continuation)

Bank 4	0.188	7	9.8	9	0.150	7	10.2	11	0.169	7	10.0	10
Bank 5	0.045	19	18.3	19	0.066	19	16.5	17	0.056	19	17.4	19
Bank 6	0.221	3	5.3	3	0.208	3	3.3	3	0.215	3	4.3	3
Bank 7	0.163	13	11.2	12	0.120	14	12.5	14	0.141	13	11.8	12
Bank 8	0.146	15	8.8	8	0.129	13	8.2	6	0.138	14	8.5	7
Bank 9	0.153	14	13.8	15	0.107	16	16.0	16	0.130	16	14.9	16
Bank 10	0.139	17	13.8	15	0.135	11	11.2	12	0.137	15	12.5	15
Bank 11	0.165	12	7.7	6	0.133	12	9.0	9	0.149	11	8.3	6
Bank 12	0.169	10	10.8	11	0.117	15	13.8	15	0.143	12	12.3	14
Bank 13	0.191	6	11.5	13	0.176	5	8.3	7	0.184	5	9.9	9
Bank 14	0.145	16	14.2	17	0.104	17	16.8	18	0.124	17	15.5	17
Bank 15	0.139	18	16.0	18	0.093	18	18.0	19	0.116	18	17.0	18
Bank 16	0.252	1	2.3	1	0.266	1	1.5	1	0.259	1	1.9	1
Bank 17	0.233	2	2.8	2	0.230	2	1.8	2	0.232	2	2.3	2
Bank 18	0.167	11	10.0	10	0.141	10	10.0	10	0.154	10	10.0	10
Bank 19	0.177	8	6.7	5	0.147	8	7.5	5	0.162	8	7.1	5

Source: own elaboration.

It seems that the authoritative results are also the data obtained by both pattern methods, i.e. Hellwig and TOPSIS, using weighting factors w2 established by the expert method, in which the diagnostic features of capital adequacy, short term liquidity and resilience of the credit portfolio play the most important role.

In case of the analysis of rankings (linear ordering methods used), the unitarization method turned out to be the most similar to the others in case of the first version for both weights 1 and 2. In the second version, also the unitarization method was the most similar to the others in case of weight 1, while for weight 2 it was the Nowak's method (Table 12). It should be noted, however, that in the case of selected linear ordering methods (as many as four are non-pattern methods) both methods determined by the Kukuła approach belong to this group.

The sensitivity analysis of the TOPSIS ranking showed no significant differences (Tables 13, 14). Both the first three positions of the banks in the ranking and above all, the last two are unchanged in all adopted weights in both versions. Although some positions within the ranking change slightly, the correlations calculated using the Spearman and Kendall methods are very high (Table 15).

Table 12. Vectors of probability's measures

Chosen linear ordering methods		1	2	3	4	5	6
version 1	Ranking w1	0.460	0.489	0.616	0.611	0.624	0.631
	Ranking w2	0.544	0.587	0.658	0.613	0.682	0.689
version 2	Ranking w1	0.469	0.533	0.611	0.611	0.647	0.631
	Ranking w2	0.619	0.679	0.734	0.728	0.732	0.692

Source: own elaboration.

Table 13. Results of the sensitivity analysis in the first version

Original ranking	Decrease in weight							
	-5%		-10%		-15%		-20%	
	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank
5	0.484	5	0.508	4	0.532	4	0.555	4
9	0.427	9	0.454	9	0.480	9	0.506	9
7	0.451	7	0.480	7	0.509	7	0.537	7
8	0.447	8	0.475	8	0.503	8	0.530	8
19	0.226	19	0.236	19	0.246	19	0.255	19
2	0.588	2	0.603	2	0.619	2	0.635	2
13	0.419	12	0.446	11	0.472	11	0.499	12
18	0.342	18	0.362	18	0.382	18	0.401	18
15	0.417	13	0.445	12	0.472	12	0.500	11
12	0.411	16	0.429	17	0.446	17	0.462	17

Table 13. Results of the sensitivity analysis in the first version (continuation)

11	0.421	11	0.443	13	0.465	14	0.485	16
6	0.465	6	0.495	6	0.524	5	0.553	5
3	0.527	3	0.545	3	0.564	3	0.582	3
17	0.405	17	0.432	16	0.459	16	0.486	15
16	0.414	15	0.442	14	0.470	13	0.498	13
1	0.715	1	0.716	1	0.717	1	0.718	1
4	0.492	4	0.507	5	0.523	6	0.539	6
14	0.414	14	0.439	15	0.463	15	0.487	14
10	0.425	10	0.451	10	0.477	10	0.502	10
Original ranking	Increase in weight							
	5%		10%		15%		20%	
	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank
5	0.437	5	0.414	5	0.392	5	0.372	5
9	0.374	10	0.347	11	0.321	11	0.295	11
7	0.393	7	0.363	7	0.333	9	0.303	9
8	0.389	8	0.361	8	0.332	8	0.304	8
19	0.202	19	0.190	19	0.177	19	0.164	19
2	0.560	2	0.548	2	0.537	2	0.527	2
13	0.364	14	0.336	14	0.308	14	0.280	14
18	0.299	18	0.277	18	0.255	18	0.234	18
15	0.360	15	0.331	15	0.303	15	0.274	15
12	0.376	9	0.359	9	0.342	7	0.326	6
11	0.373	11	0.348	10	0.323	10	0.298	10
6	0.404	6	0.373	6	0.342	6	0.311	7
3	0.490	3	0.473	3	0.457	3	0.441	3

Source: own elaboration.

Table 14. Results of the sensitivity analysis in the second version

Original ranking	Decrease in weight							
	-5%		-10%		-15%		-20%	
	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank
5	0.484	5	0.508	4	0.511	5	0.555	4
9	0.427	9	0.454	9	0.465	9	0.506	9
7	0.451	7	0.480	7	0.496	7	0.537	7
8	0.446	8	0.474	8	0.487	8	0.530	8
19	0.224	19	0.235	19	0.255	19	0.254	19
2	0.589	2	0.604	2	0.582	2	0.636	2
13	0.419	12	0.446	11	0.455	12	0.499	12
18	0.341	18	0.362	18	0.376	18	0.401	18
15	0.417	13	0.445	12	0.455	11	0.500	11
12	0.412	15	0.429	17	0.428	17	0.462	17
11	0.421	11	0.444	13	0.449	14	0.485	15
6	0.465	6	0.495	6	0.505	6	0.553	5
3	0.527	3	0.546	3	0.534	3	0.582	3
17	0.405	17	0.433	16	0.443	16	0.486	14
16	0.414	14	0.442	14	0.453	13	0.498	13
1	0.716	1	0.717	1	0.654	1	0.719	1
4	0.491	4	0.507	5	0.511	4	0.539	6
14	0.411	16	0.436	15	0.446	15	0.485	16
10	0.425	10	0.451	10	0.462	10	0.502	10

Table 14. Results of the sensitivity analysis in the second version (continuation)

Original ranking	Increase in weight							
	5%		10%		15%		20%	
	Scores	Rank	Scores	Rank	Scores	Rank	Scores	Rank
5	0.437	5	0.414	5	0.392	5	0.371	5
9	0.374	10	0.347	11	0.321	11	0.295	11
7	0.392	7	0.363	7	0.333	8	0.303	8
8	0.389	8	0.360	8	0.331	9	0.302	9
19	0.199	19	0.186	19	0.173	19	0.159	19
2	0.561	2	0.548	2	0.537	2	0.527	2
13	0.364	13	0.336	13	0.308	14	0.280	14
18	0.298	18	0.276	18	0.254	18	0.232	18
15	0.360	15	0.332	15	0.303	15	0.274	15
12	0.376	9	0.359	9	0.342	7	0.326	6
11	0.374	11	0.349	10	0.324	10	0.298	10
6	0.404	6	0.374	6	0.342	6	0.311	7
3	0.491	3	0.473	3	0.457	3	0.442	3
17	0.350	17	0.322	17	0.294	17	0.265	17
16	0.357	16	0.328	16	0.299	16	0.270	16
1	0.715	1	0.714	1	0.713	1	0.712	1
4	0.461	4	0.448	4	0.435	4	0.424	4
14	0.360	14	0.335	14	0.309	13	0.284	13
10	0.371	12	0.344	12	0.316	12	0.289	12

Source: own elaboration.

Table 15. Results of sensitivity analysis - correlations

Specification	-5%	-10%	-15%	-20%	5%	10%	15%	20%
Version 1								
Spearman's correlation	0.9807	0.9561	0.9439	0.9246	0.9860	0.9825	0.9649	0.9474
Kendall's correlations	0.9415	0.8830	0.8596	0.8246	0.9415	0.9298	0.8947	0.8713
Version 2								
Spearman's correlation	0.9807	0.9561	0.9456	0.9246	0.9877	0.9842	0.9667	0.9561
Kendall's correlations	0.9415	0.8830	0.8713	0.8246	0.9532	0.9415	0.9064	0.8947

Source: own elaboration.

5. Discussion

This study is based on selected methodologies of linear ordering methods, i. e. Hellwig (1968), TOPSIS (Hwang & Yoon, 1981), Strahl (1978), Nowak (1977), Kukuła and Luty (2015), which were adapted to the needs of quantifying the resilience of individual banks to the effects of the COVID-19 crisis, nevertheless, the proposed approach makes it possible to modify the set of variables according to the type of crisis and the nature of its impact on banks. The results obtained are consistent with those of Aldasoro et al. (2020) who indicated that the COVID-19 crisis has relatively milder impact on well capitalised and highly profitable banks. The impact of the pandemic on the condition of individual sectors of the economy and thus the quality of credit portfolios indicated in this study largely corresponds to the conclusions of the paper prepared by Donth and Gustafsson (2020) and presents solid evidences in favour of Hypothesis 1. The established ranking of banks and the possibility to determine the relative differences in the resilience of banks to the COVID-19 crisis may form the basis for an index algorithm for bank resilience to crisis on the model proposed by Leiva-Leon et al. (2020), i.e. the Global Weakness Index.

This research has many links with the study conducted by Korzeb and Niedziółka (2020), however, in this case the Portuguese banking sector was chosen for the analysis, which in many aspects is the opposite of the Polish banking sector (functioning in the euro area, a significant number of small and medium-sized banks, greater industry specialisation, smaller shareholding of the state, much larger share of COVID-19-sensitive sectors in the portfolios of large banks, greater internationalisation of the banking sector in Portugal). Asking whether in Portugal the resistance of banks to the crisis is more dependent on the structure of the portfolio than on other determinants, it was decided

to adjust the methodology to the formulated research questions, primarily by individualising the construction of a set of explanatory variables, broadening the spectrum of linear ordering methods, analysing the sensitivity of the obtained results and conducting a procedure aimed at selecting the optimal linear ordering method for the sample. The above actions are a far-reaching development of the concept described in Korzeb and Niedziółka (2020).

Thus, one of the important contributions of the study in question is the creation of an algorithm for the linear ordering of banks within a given banking sector, indicating the optimum method for that sector.

The results of the research of the Portuguese banking sector yielded different results from those of the Polish banking sector, where the largest commercial banks in terms of balance sheet total, equity and net profit generated were most resilient. The results of this study for Portugal show that the best banks in the rankings are mainly characterised by a high Tier 1 ratio, an above-average LCR level, and a relatively low C/I ratio compared to the industry. Two of them are relatively small banks. This may mean that their specialization (in this case resulting in a relatively low concentration of COVID-19-sensitive industries in their portfolios) or the specificity of their business (retail or private banking) allows them to manage their assets and liabilities in a way that ensures their stable operation in a turbulently changing business environment. It thus appears that the level of capital adequacy and liquidity are critical determinants of banks resilience to a pandemic crisis. Taking the above into account, to some extent the results of the conducted study are consistent with the conclusions formulated by Hardy and Takáts (2020). Thus, having the aforementioned conclusion on capital buffers and their relation with resistance to COVID-19 we can find strong evidences that favour Hypothesis 2.

The results obtained can also be used in supervisory policy, helping to determine the optimal relationship between permitted capital and liquidity buffers consumption and restrictions on the payment of dividends and bonuses. In this sense, the conclusions of the study complement those formulated by Borio and Restoy (2020).

6. Conclusions

Based on the previous analyses, a number of important conclusions and some contributions to subsequent studies can be highlighted and applied in the bank management and supervisory practice. The use of multidimensional statistical analysis is a useful tool for research on the impact of the crisis on the situation of banks operating in the Portuguese banking sector. The results of the research indicate that the choice of the linear ordering method did not significantly affect the identification of the most and of the least resistant banks to the effects of the pandemic. The resilience of Portuguese banks to the potential impact of the COVID-19 pandemic crisis is not evenly distributed among individual banks. Rankings of banks using six linear ordering methods, taking into account two weighting procedures and two variants of the Z6 diagnostic feature, clearly indicated the most resistant banks: bank N°16, bank N°6 and bank N°17, and also the weakest ones: bank N°5 and bank N°15. The resilience of Portuguese banks to the COVID-19 crisis varies but it should be stressed that the banking system is as strong as its weakest link of the chain. In this context it is worthy to stress that the two banks with lower resilience ability are quite different; one of them has assets 25 times larger than the other. Anyway, together they represent 14% of the whole assets in the Portuguese banking system in 2019 and the bigger one was one of the only two banks that presented losses in December 2019.

Meanwhile, Portugal's experience of rescuing banks in financial distress in previous crises clearly shows the risks stemming from the level of resources needed for this purpose. It is quite symptomatic that among the four largest Portuguese banks in terms of assets, none of them is among the most resilient to the crisis. On one hand this may indicate that these banks, by virtue of their status, are forced to finance those sectors of the economy that are more vulnerable to the effects of the crisis being at the same time the most important ones, while on the other hand, it may cause an increasing systemic risk in the event of a protracted pandemic in Portugal or in the countries where they are most involved. However, it should be noticed that the largest banks are subject to systematic stress-testing by EBA.

There are certain limitations in the approaches used in this research, which include, first of all, the relatively short period of time since the pandemic began and the final extent and economic and social consequences are still quite uncertain. This study does not take into account the extent to which credit exposures are collateralised and the amount of provisions already created. Another limitation is the high aggregated level of the sectoral analysis of the risk as within the sections the risk may be very differentiated. Credit exposure by industry was generated by use of EU CRB-D template, which does not include more precise data on sub-sectors, e.g. decomposition of manufacturing.

In addition, there are relatively few players (including banks, which make difficult an in-depth sector analysis of the portfolio) represented on the stock market in Portugal. Nevertheless, the proposed tool allows to determine the degree of vulnerability of the banks to the effects of the shock in the form of COVID-19 and other (future) shocks, which to a different extent (from very negative to extremely positive) affect individual sectors and indirectly the condition of banks.

Conflict of interest

The authors declare no conflict of interest.

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