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Unveiling financial well-being: Insights from retired people in Third Age group in Poland, Spain and Denmark

Alicja Jajko-Siwek[1]

Abstract

The study investigates the financial well-being of older people in Poland, Spain and Denmark, with a particular focus on their ability to make ends meet. Using data from the SHARE survey to analyse retired individuals aged 65 to 79 years, it aims to identify the socio-economic factors that influence financial well-being among older people in these countries. In terms of methodology, it uses Light Gradient Boosting Machine algorithm and SHAP value calculations to predict the ability to make ends meet and determine the importance of 167 various features. The study concludes that household income and financial resources are the primary determinants of older people's ability to make ends meet. The findings underscore the need for policymakers and practitioners the fields of ageing and economics to address specific challenges, such as housing costs in Denmark and food expenditure in Poland and Spain, to improve the financial well-being of older individuals.

Keywords

- financial well-being
- LightGBM
- pensioner
- silver economy
- SHAP
- SHARE
- the ability to make ends meet

JEL codes: C38, G50, H55, I31.

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Introduction

The ageing population in the European Union has seen a notable speed from 2001 to 2023, with the percentage of people aged 65 and older rising from 15.8% to 21.3% (Eurostat, 2024). This demographic shift is expected to continue, with projections indicating that by 2050 nearly 29.5% of the EU population will be 65 years or older. This trend underlines the global phenomenon of ageing populations and presents both challenges and opportunities due to the potential of the older population on both the supply and demand sides (Barković Bojanić et al., 2024). Analysing countries like Poland, Spain, and Denmark, which exhibit distinct ageing patterns and socio-economic contexts, provides valuable insights into the dynamics of financial well-being among old people (Figure 1).

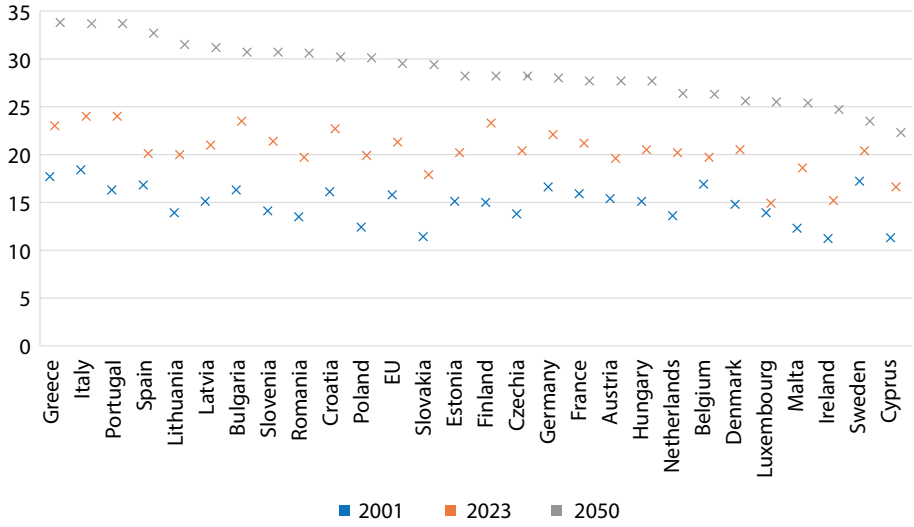

Figure 1. Population aged 65 and older (as % of the total population) in European Union countries in 2001, 2023 and 2050

Source: own calculations with data from Eurostat.

The growing proportion of older adults in the population drives the development of the silver economy, which is focused on meeting the needs of older individuals, especially retirees (Niemczyk et al., 2023). Financial well-being is a crucial aspect of this economy. The Consumer Finance Protection Bureau (CFPB), an agency of the United States government responsible for consumer protection in the financial sector, defines financial well-being as a state where individuals can meet current and ongoing financial obligations, feel secure in their financial future, and make choices that allow them to enjoy life

(CFPB, 2015, 2017). Financial well-being implies having financial security and financial freedom of choice, both in the present and in the future. Financial well-being includes four elements presented in Table 1. One of the proxies of financial well-being connected with security and the present situation is the ability to make ends meet.

Table 1. The four elements of financial well-being

	Present	**Future**
Security	Control over your day-to-day, month-to-month finances (ability to make ends meet)	Capacity to absorb a financial shock
Freedom of choice	Financial freedom to make choices to enjoy life	On track to meet your financial goals

Source: (CFPB, 2017, p. 7).

In recent statistical studies, significant variations have been observed across European countries regarding the populations' ability to make ends meet. The Eurostat Report highlighted that during the second quarter of 2022, the percentage of people who could easily make ends meet ranged widely, from as low as 3.6% in Bulgaria to 40.5% in Finland (Eurostat, 2022a). Eurostat data regarding the ability of individuals aged 65 and over to make ends meet in Spain, Poland, and Denmark indicated distinct differences across these countries. Denmark demonstrated a highly favourable scenario, with 43% of its older population finding it fairly or very easy to manage financially, reflecting a supportive environment for financial stability in old age. Conversely, in Poland, a significant portion (28.1%) faced greater difficulty in managing financially, indicating potential economic challenges for the senior population. Spain presented a more balanced situation; although a notable segment find it fairly easy, another group struggles to some extent. These findings underscore the diverse economic challenges for older individuals in different EU countries, emphasising the need for tailored financial support and policies to ensure older citizens can manage their finances adequately.

Despite extensive research on the relationship between financial well-being and various determinants, there remains a gap in understanding the comprehensive range of factors influencing retirees' ability to make ends meet. This study aims to address this gap by examining a broad spectrum of socio-economic determinants, social relations, health, household resources, and lifestyle which affect financial well-being among retirees aged 65 to 79 in Poland, Spain, and Denmark. The target group includes retirees aged 65–79 because this age range, known as the Third Age, is characterised by relatively better health, greater mobility, and social activity compared to older indivi-

duals, allowing for a more comprehensive analysis of their financial situation. Additionally, people with this market status typically have stabilised income sources from pensions, enabling a detailed examination of the determinants of their financial well-being.

By leveraging data from the SHARE (Survey of Health, Ageing and Retirement in Europe) survey and employing advanced statistical methods like Light Gradient Boosting Machine (LightGBM) and SHAP values (SHapley Additive exPlanations), this study seeks to provide a nuanced understanding of these relationships.

These insights could be valuable for policymakers, highlighting the need to consider a broad array of factors beyond the purely economic to fully understand the dynamics of making ends meet. Moreover, this study compares the financial capacity of individuals in Poland, Spain and Denmark—countries with different levels of ability to make ends meet and with varying ageing patterns. The results can contribute to a deeper understanding of the challenges faced by older individuals, which can also prove informative for entities in the silver economy.

Section 1 of this paper provides insight into ageing and retirement in Denmark, Poland, and Spain. The following part reviews the literature on financial security. Then, the paper discusses the dataset, research design, and methods. Section 4 is devoted to presenting the results. Finally, the study concludes with a critical discussion and conclusions.

1. Ageing population and retirement in Denmark, Poland, and Spain

Poland represents one of the fastest ageing populations in Europe, where the transition from a younger population to an older one is proceeding at a rapid pace. The change in the proportion of the population aged 65 and over from 12.4% in 2001 to 30.1% in 2050 gives a 17.7% change. Spain is also experiencing a significant increase in its proportion of the older population, from 16.8% in 2001 to 32.7% in 2050. In fact, this country has one of the highest projected percentages of older people by 2050. Denmark shows a moderate increase in the population aged 65 and over, from 14.8% in 2001 to 25.6% in 2050, with this 10.8 percentage point change reflecting a relatively balanced rate of population ageing. Trends in these three countries highlight the varying dynamics of population ageing across European countries, each with its own implications for silver economic planning and opportunities in the financial sphere, as well as in terms of financial well-being.

The employment rate for people aged 65 and over in Spain is currently 3.4%, in Poland 6.0%, and in Denmark 11.1% (European Commission, 2024). As a relatively small proportion of this age group remains economically active, the main source of income for people aged 65 and over in these countries is pensions. Therefore, people with this occupational status who are retired are analysed in this paper. Moreover, the pension systems in Poland, Denmark, and Spain differ significantly in their approaches and generate varying levels of pension adequacy. According to the Mercer report (Mercer, 2023), the Danish pension system, based on funded defined contribution schemes, is considered the best in the world and allows for the most adequate pensions (level A). The Polish system, based on notional defined contribution (NDC), is characterised by a low level of adequacy (C), while Spain's defined benefit system has an adequacy rated at an average level (B+). This has significant implications for the financial security of retirees in these countries.

Within the retired population aged 65 and over, it is crucial to distinguish between two subgroups: those aged 65–79, referred to as the Third Age, and those aged 80 and over, known as the "Fourth Age." This differentiation arises from significant disparities in health status, mobility, cognitive functions, and social and economic needs. Retirees aged 65–79 generally exhibit better health and greater mobility compared to those aged 80 and over, who are more likely to suffer from chronic illnesses and experience greater physical limitations (European Commission, 2024). Moreover, the social and economic aspects of life show marked differences between these groups. Retirees in the Third Age group often engage in social activities and maintain active social lives, whereas those in the Fourth Age group may face greater social isolation due to health problems and mobility restrictions. Financially, individuals in the Third Age group typically rely on pensions and savings for income, whereas those in the Fourth Age may incur higher expenses for healthcare and long-term care, impacting their financial stability (European Commission, 2024). Due to these significant differences, this article focuses on the 65–79 age group, treating it as a homogeneous cohort with similar needs.

2. Financial well-being among retired people: A literature review

The existing evidence from the international literature on financial well-being among retirees highlights the multifaceted nature of this issue, encompassing financial, health, and social dimensions. Income is a key factor in determining whether households can cover their present financial security (Badri et

al., 2022). As household income increases, the ease of covering expenses also grows (Hébert & Gyarmati, 2014). Individuals with lower incomes often find themselves more concerned with meeting their financial needs compared to those with higher incomes, both in general and in terms of personal finance (Johar et al., 2015; Kahneman & Deaton, 2010). The European Commission's report (European Commission, 2021) links the ease of meeting financial obligations to income, as well as factors like living conditions, including material deprivation, housing, living environment and access to services.

Working households, while generally having higher incomes and lower poverty levels, can still face material challenges impacting their financial stability (Danziger & Wang, 2005). The COVID-19 pandemic further strained the financial capabilities of lower-income households, making it harder for them to meet their needs (Albuquerque et al., 2022). The COVID-19 pandemic's impact on financial stability is also highlighted in surveys by Pew Research Centre (Horowitz et al., 2021; Parker et al., 2020) and reports by OECD (OECD, 2021).

Gumà-Lao (2022) and Nolen-Hoeksema et al. (2008) find a crucial link between the ability to make ends meet and the aggravation of mental health problems. Artazcoz et al. (2021) report a significant association between making ends meet and poor self-perceived health status and psychological well-being. Similarly, Marjanovic et al. (2015) and Netemeyer et al. (2018) provide evidence for the mediating role of financial capability in mental health and well-being. Social networks, as explored by Gray (2009) and Tilly (2012), are also a vital factor in the ability to make ends meet. The literature also examines variations in this ability across different household segments, with the Consumer Financial Protection Bureau (CFPB, 2020) and studies by Heflin (2016) and Tur-Sinai et al. (2022) focusing on demographic factors such as age and gender. The CFPB (2020) report highlights age as a critical factor in financial well-being. Older adults often face unique challenges, such as fixed incomes from pensions or social security, which may not keep pace with inflation or rising living costs. Additionally, unexpected health expenses can greatly affect older individuals, leading to increased financial strain. Heflin (2016) further explains that financial security can decline as people approach retirement age without sufficient savings. The gender dimension of financial well-being, as explored by Tur-Sinai et al. (2022), reveals that women often face greater financial challenges compared to men.

Silberman-Beltramella et al. (2022) look at the interplay between social relations, health, and socio-demographic factors among older people in Spain. Using data from the SHARE survey, this study emphasises the crucial role of social relations in the health and well-being of older people. It provides a comprehensive analysis of how these variables interact and impact the lives of older adults. Similarly, Serrano et al. (2014) explore demographic changes in Spain, highlighting the trend towards the ageing population. This research touches on economic aspects, living conditions, and poverty rates

among older individuals. It notes that most older adults live with others, typically a spouse or family members, although there is a growing trend of older adults, especially women, living alone. This situation presents unique challenges in terms of health, social relations, and economic well-being in Spain.

In exploring the factors affecting the ability to make ends meet in Poland, recent literature offers diverse perspectives. Dudek and Wojewódzka-Wiewiórska (2023) analyse the socioeconomic dynamics during the initial year of the COVID-19 pandemic, using data from the EU-SILC survey. Their findings indicate increased difficulty in making ends meet, results that are influenced particularly by factors such as household type, education level, urbanization, and the presence of disabled and unemployed household members. This study underlines the increased vulnerability of specific demographic groups, such as single-parent households and those with limited education or employment opportunities. The study conducted for the BIG InfoMonitor Debtors Register (BIG InfoMonitor, 2021) reveals a slight decrease in the percentage of Poles struggling to meet financial obligations in 2020 compared to 2019. However, a significant proportion of the population still expressed concerns about covering basic expenses. Complementing these insights, a report by Badowski (2022) analyses the changing consumer behaviour in Poland in response to the economic impacts of the COVID-19 pandemic and geopolitical factors like the Ukraine conflict. The report indicates a trend towards more modest lifestyles, with increased spending on necessities such as food and healthcare, and decreased expenditure on lifestyle-related categories. This shift reflects a broader trend of consumer adaptation in the face of economic uncertainties and shifting priorities. These studies highlight the importance of considering a range of factors, including demographic variables, socioeconomic status, and broader economic conditions, to understand the complexities of financial stability in Poland.

Brünner and Andersen (2018) provide valuable insights into the lives of older individuals (aged 69 to 85) in Denmark who face financial challenges, shedding light on their personal experiences, coping strategies, and the societal and historical factors that influence their current situations. They explored in particular the experiences of older people living in relative poverty and sought to understand how they manage their daily lives and financial challenges. A study by Meng et al. (2020) points out that the financial situation of older Danish people is interconnected with various factors like health, desire for leisure, and economic status. Poor health can lead to earlier retirement due to the inability to work, impacting financial stability. Similarly, a strong desire for leisure time influences the decision to retire, which can affect financial resources in later life. Economic considerations, including savings and pension plans, also play a crucial role in determining the financial well-being of retirees.

In terms of methodology, many empirical studies have investigated the determinants of the ability to make ends meet using various regression methods: logistic regression (Dudek & Wojewódzka-Wiewiórska, 2023), hierarchical multiple regression (Badri et al., 2022). Other popular methodologies include a series of fixed effects models (Wilkinson, 2016), and OECD methodology (Sconti, 2022). Some researchers also used life story interviews (Brünner & Andersen, 2018). This study employs the machine learning method Light Gradient Boosting Machine and SHAP values, which offers new possibilities in the area of statistical analysis.

Based on the literature review, this study aims to address the following research questions:

RQ1: What are the differences in the ability to make ends meet between retirees in the Third Age group in Poland, Spain, and Denmark?
RQ2: What are the main determinants of financial well-being for retirees in Poland, Spain, and Denmark?
RQ3: How do various socio-economic, health, and social network factors influence the ability to make ends meet among retirees?
RQ4: What new possibilities for statistical analysis in studies on the ability to make ends meet do machine learning methods like Light Gradient Boosting Machine and SHAP values offer?
RQ5: How can the findings of this study contribute to a better understanding of the challenges faced by older individuals, and what insights can be drawn for stakeholders in the silver economy?

These research questions guide the study's exploration of financial well-being among retirees, using advanced analytical methods to provide comprehensive insights into the factors influencing their financial stability and offer valuable recommendations for policy and practice.

3. Data and methodology

3.1. Data, variables and procedure

The data used for this study is from wave 8 of the SHARE panel survey carried out in 2019 and 2020 (Bergmann & Börsch-Supan, 2021; Börsch-Supan, 2022; SHARE ERIC, 2024) conducted in European countries by the European Research Infrastructure Consortium (ERIC) coordinated at the Munich Research Institute for the Economics of Ageing. The SHARE survey aims to understand individual health, social, economic, and family networks during the lives of

citizens aged 50 and over in Europe and beyond. In the study, retired Polish, Spanish, and Danish respondents aged 65–79 who participated in the interview were selected for the sample. These countries were selected because of their statistically different patterns of ageing and also for their financial conditions in aspects regarding the ability to make ends meet (Figure 2). Spain is just beneath the mean, suggesting that its citizens face a slightly greater difficulty in making ends meet compared to the average for EU countries. Denmark stands out with great ease in making ends meet, well above the average, whereas Poland is positioned towards the lower end, indicating that Polish pensioners find it more difficult to make ends meet compared to the majority of the countries in the chart, including Spain.

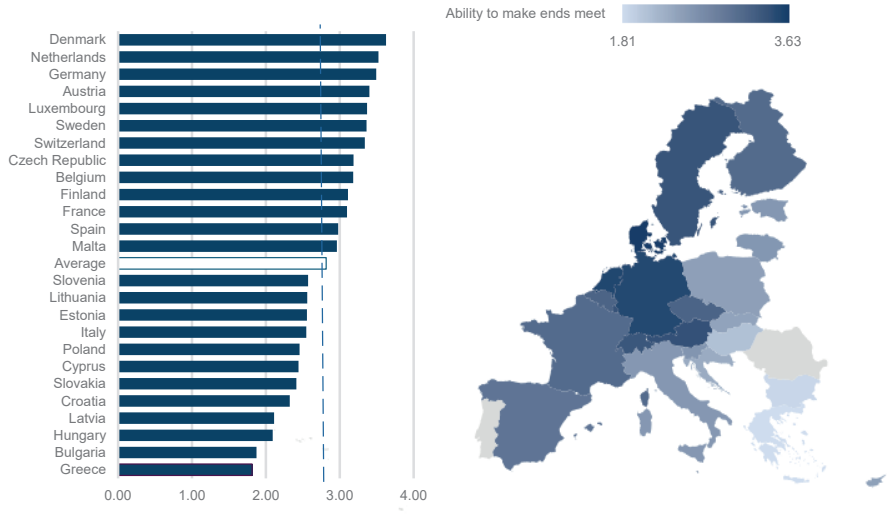

Figure 2. Ability to make ends meet of retired people in age 65–79 in European countries

Source: own calculations with data from SHARE Survey.

The total size of the sample is 2,681, with 938 pensioners from Poland, 954 from Denmark, and 789 from Spain. Approximately 55% of the sample in Poland identified as female, 42% in Spain, and 55% in Denmark (Table 2). Because, according to the *t*-test, there are no significant statistical differences in the ability to make ends meet between males and females across all three countries, the analysis is not done separately for the two sexes.

The dependent variable in the current analysis is the respondent's current ability to make ends meet, considered a subjective proxy of financial well-being. This variable is achieved as the result of the answer to the question: "Thinking of your household's total monthly income, would you say that your household is able to make ends meet with great difficulty (value 1), with

Table 2. Ability to make ends meet by gender

Country	Gender	N	M	SD
Denmark	male	432	3.63	0.633
	female	522	3.62	0.633
Poland	male	419	2.53	0.801
	female	519	2.40	0.792
Spain	male	455	2.97	0.894
	female	334	2.99	0.897

Source: own calculations with data from SHARE Survey.

some difficulty (2), fairly easily (3), with ease (4)". The study focused on the relationship with socio-demographics determinants. The explanatory variables characterised the situation of retirees in the following 19 modules: Demographics, Children, Social Networks, Social Support, Education, Physical Health, Behavioural Risks, Cognitive Function, Mental Health, Health Care, Consumption, Pensions, Housing, Household Income and Expenditure, Assets, Informal Technology, Financial Transfers, Activities, Time Expenditure. One of the explanatory variables is the CASP index (Control, Autonomy, Satisfaction, Pleasure), which holistically and integratively describes subjective and psychological well-being during early old age. This variable has been included as an explanatory factor for making ends meet because the relationship between financial security and overall well-being is complex and reciprocal. Better mental health can lead to higher levels of overall well-being, enhancing an individual's ability to work and earn money. Improved subjective well-being can also enhance the ability to cope with financial challenges. The complete list contains of 167 variables.

The first phase of this study presents descriptive statistics that analyse the ability to make ends meet in Poland, Spain and Denmark. Following this, the research details the accuracy of forecasts generated by a Light Gradient Boosting Machine model. This model uses financial capability as a dependent variable to predict overall financial well-being in each country. The final phase involves calculating SHAP values to assess the importance of various independent variables in these nations. The analysis employs statistical software packages SPSS and R throughout the study.

3.2. Method

Gradient Boosting Decision Trees (GBDT) (Friedman, 2001) have been highlighted by many researchers (Madakkatel et al., 2019; Sarker, 2021; Seto et al., 2022; Watanabe et al., 2023) as a highly effective method in various machine learning applications, particularly in scenarios involving large datasets and the need for high predictive accuracy (Olson et al., 2017). In the initial phase of the algorithm, a simple decision tree is constructed. Using information from the quality of this tree, subsequent trees are built iteratively to correct residual errors from previous models. Each new tree aims to remove the cumulative errors of its predecessors, thereby progressively improving the model. A gradient is used to systematically steer corrections in an optimal direction, increasing the efficiency of the learning process. Through this process, we ensure the development of a robust and accurate predictive model. This methodology is known as gradient boosting, in which each iteration gradually improves the accuracy of the model by focusing on correcting previous errors. The algorithm optimises the following objective function:

$$L^{(t)} = \sum_{i=1}^{n} l\left(y_i, \hat{y}_i^{(t-1)} + f_t(x_i)\right) + \Omega(f_t)$$

where l is a differentiable loss function that measures the difference between the actual and predicted values, Ω is a regularization term to avoid overfitting, y_i are the actual values, $\hat{y}_i^{(t)}$ are the predicted values, $f_t(x_i)$ represents the new function added in the t-th iteration to improve the prediction, x_i is the feature vector of the i-th observation in the training set, n is the number of observations, and t is the number of iteration (Chen & Guestrin, 2016). The first part measures the fit of the model to the training data. The second part is a regularisation term that penalises the complexity of the newly added tree.

The present study employs the Light Gradient Boosting Machine (LightGBM) algorithm (Ke et al., 2017), selected for its noted computational efficiency and accuracy preservation. This method was developed by Microsoft in 2016 as an efficient and scalable version of the Gradient Boosting algorithm (LightGBM Documentation, 2024). LightGBM grows trees leaf-wise (Best-first) rather than level-wise, leading to a more accurate model (Figure 3).

Figure 3. Decision tree learning algorithms—the tree growth process

Source: (LightGBM Documentation, 2024).

During each iteration, LightGBM minimises the following approximate objective:

$$\tilde{L}^{(t)} = \sum_{i=1}^{n} \left[g_i f_t(x_i) + \frac{1}{2} h_i f_t(x_i)^2 \right] + \Omega(f_t)$$

where g_i and h_i are the first and second order derivatives of the loss function with respect to the predictions. LightGBM enhances the efficiency of the model and reduces memory usage by incorporating two novel techniques: Gradient-based One-Side Sampling (GOSS) and Exclusive Feature Bundling (EFB), which address the limitations of the conventional GBDT techniques such as XGBoost or AdaBoost without sacrificing accuracy (Ke et al., 2017). More technical details about the GOSS and EFB techniques, which make the LightGBM the state-of-the-art for many applications, are explained by Ke et al. (2017).

Classification algorithms were used to determine the categorical dependent variable: ability to make ends meet. Model performance was quantified using the metrics of Area Under the Receiver Operating Characteristic Curve (AUC) and Accuracy. Furthermore, a 10-fold cross-validation method was implemented to establish confidence intervals for these performance indicators, thereby ensuring the robustness of the predictive model (Madakkatel et al.,

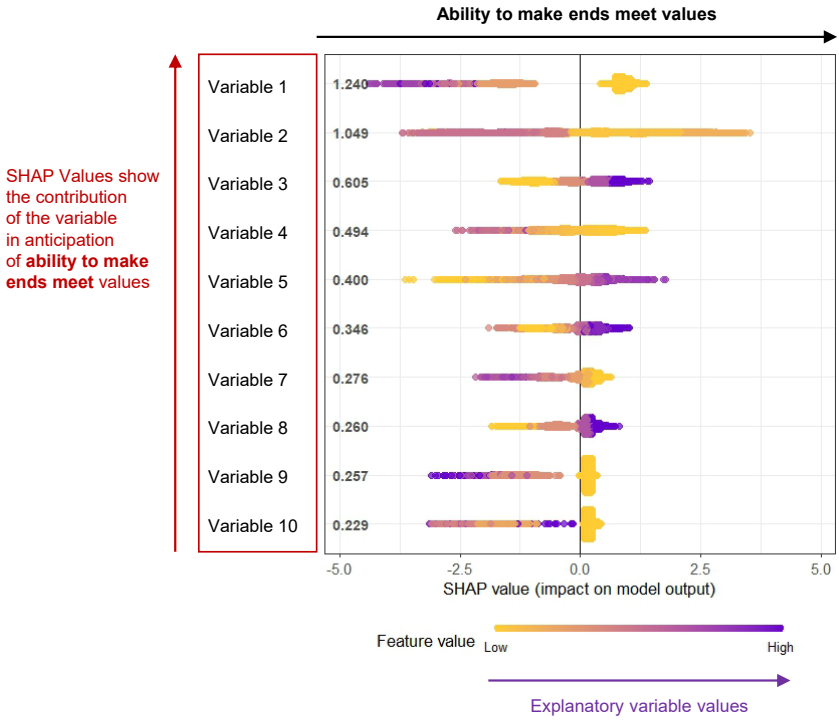

Figure 4. SHapley Additive exPlanations—sample chart

Source: own work.

2019). Important features in the LightGBM model were recognised using the SHAP values (SHapley Additive exPlanations) (Lundberg & Lee, 2017) calculated by a method derived from game theory (Figure 4).

The feature importance calculation for classification is based on how much the prediction value changes on average if the feature in question changes in its values. The bigger the changes in the prediction, the greater the feature importance. The SHAP summary plot illustrates the importance and impact of variables in the predictive model. The vertical position of a variable indicates its importance, with the most significant at the top. The horizontal spread shows the direction and extent of a variable's impact on the model's output, where rightward points suggest a positive influence on the dependent variable (the ability to make ends meet), and leftward points suggest a negative influence. The colour coding reflects the independent variable value, helping to visualise how low and high values of each variable affect the prediction.

4. Results

Figure 5 presents data highlighting disparities in financial conditions among the three countries selected. It reveals that individuals in Poland are more prone to facing difficulties in fulfilling basic financial needs, with 53% experiencing some or significant challenges in maintaining financial security. In contrast, Denmark shows the lowest percentage of individuals struggling financially: a mere 6% of the Danish population reports difficulties in meeting basic financial needs. Spain displays moderate variation, with 27% of retirees in the Third Age group encountering challenges with their current finances.

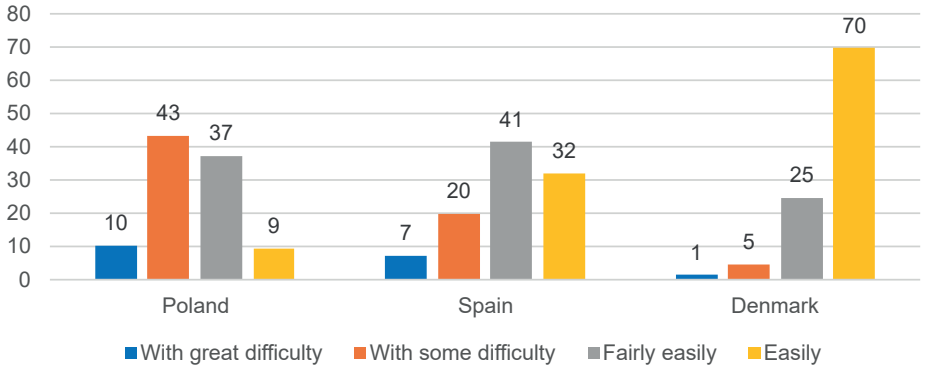

Figure 5. Ability of retired people aged 65–79 to make ends meet in Poland, Denmark, and Spain (in percentage of overall sample)

Source: own calculations with data from SHARE Survey.

Therefore, the ability to make ends meet varies markedly among pensioners in Poland, Spain, and Denmark.

Figure 6 illustrates the importance and slope of the explanatory variables for LightGBM regressors. For the features across all three countries, approximately 30 of them begin to register a zero-importance score (Tables 3–5). This indicates a threshold in feature selection where the model's performance starts to stabilise. It is instrumental in the process of selecting the most important features, helping to determine the number of features that impart significant information to the model, and identifying the juncture at which additional features cease to substantially enhance the model's performance. Additionally, it serves as a visual tool to illustrate the variations in feature importance across different countries, highlighting how the most predictive features can differ depending on the particular country being analysed.

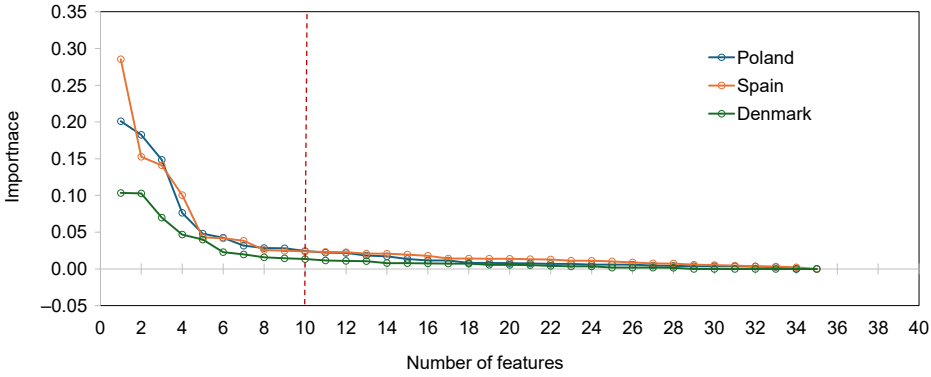

Figure 6. Importance of features affecting the ability to make ends meet

Source: own calculations with data from SHARE Survey.

As the number of features increases, the importance of the remaining features decreases. The importance scores for Poland and Spain are higher, separate from Denmark's curve at the beginning, and start to be similar as the number of features increases. Spain's importance scores decrease noticeably when the number of features increases to more than about five, indicating that the initial features are highly significant for the Spanish model. A very similar situation applies to Poland, but the first feature is less important than in the case of Spain. Denmark's curve remains relatively flat throughout the six features. The point where the shape of the curves changes direction is referred to as the 'elbow' of the plot and is identified as the point of inflection, showing that the models rely on a few features. For all the countries studied, the curves begin to plateau after the inclusion of more than 10 charac-

teristics, suggesting minimal additional importance beyond these features. Consequently, the first 10 significant features were selected for further analysis, as indicated by the vertical dashed line in the representation.

To demonstrate the precision of the learning models, Accuracy and AUC (Area Under the Curve) metrics for were calculated binary classification in the three countries. The accuracy metric for Poland reveals that the classifier accurately predicts outcomes 47.49% of the time. In Spain, the accuracy is lower at 43.98%, indicating that the model's predictions are less reliable. In contrast, Denmark shows a considerably higher accuracy rate of 62.32%, suggesting better model performance. According to the AUC (Area Under the Curve) results, the LightGBM binary classifier is most effective in Spain (0.6627). The model's performance is least effective in Poland (0.5077), while in Denmark (0.6536), it is moderate, with an AUC significantly better than Poland and closely following Spain.

4.1. Feature importance in Denmark

Table 3 shows all important variables for the ability to make ends meet in Denmark. The SHAP summary plot for Denmark (Figure 7) illustrates how different features influence the output of the LightGBM model. The most impactful features for financial present security are CASP, a measure of quality of life in older age, and household net worth, both of which positively impact the ability to make ends meet. Additionally, the third feature, total monthly household income, and the fifth feature, household size, have a positive impact. Mortgage on main residence, value of main residence, and value of old age pension have a lower impact on the model output and a negative influence on the ability to make ends meet. Among the top 10 features in the LightGBM model for Denmark, besides total household income, those related to finances include household gross financial assets, household net financial assets, and value of old age pension.

However, features such as household net worth, mortgage on main residence, value of main residence, and rent and home-related expenditures are related to the finances of the property owned. Only two features (CASP and household size) do not fall within this category. In Denmark, the most important factors for the ability of retired people to make ends meet, apart from quality of life and financial resources, are connected with housing-related financial resources.

Table 3. Performance of LightGBM binary classifiers. Variable importance in Denmark

Number	Feature	SHAP
1	CASP index for quality of life and well-being	0.1033
2	Household net worth	0.1028
3	Total household income—Version B	0.0698
4	Household gross financial assets	0.0468
5	Household size	0.0400
6	Household net financial assets	0.0229
7	Mortgage on main residence	0.0197
8	Value of main residence	0.0158
9	Rent and home-related expenditures	0.0144
10	Old age, early retirement, and survivor pensions	0.0134
11	Financial liabilities	0.0115
12	Age in 2020	0.0110
13	EURO depression scale	0.0106
14	Income from non-responding partner	0.0080
15	Children in the social network—count	0.0079
16	Total household expenditure	0.0076
17	Maximum of grip strength measures	0.0073
18	Amount spent on food at home	0.0071
19	Ever smoked daily	0.0057
20	Number of men in the social network	0.0055
21	Average contact with others in the social network	0.0052
22	Score of orientation in time test	0.0041
23	Time expenditure: paid work (mins)	0.0035
24	Health literacy: how often help needed	0.0034
25	Siblings in the social network—count	0.0018
26	The social network size in wave 8	0.0018
27	Gender	0.0018
28	Number of children	0.0016

Source: own calculations with data from SHARE Survey.

Figure 7. Importance of features influencing the ability to make ends meet in Denmark

Source: own calculations with data from SHARE Survey.

4.2. Feature importance in Poland

Table 4 presents all the important variables for ability to make ends meet in Poland. Figure 8 illustrates the direction and magnitude of the top 10 features in the classification of financial stability in Poland, as per the LightGBM model. The most influential features are the total household level of all individual income components, CASP, and total monthly household income. These three features, along with the number of financial gifts given worth 250 € or more, display a broad range of SHAP values, predominantly positive, suggesting that higher values correlate with an improved ability to make ends meet.

Notably, total household income demonstrates a significant spread in SHAP values, reflecting varied impacts based on the specific value of the feature. This spread indicates potential interactions with other features or a non-linear relationship with the dependent variable. Other features, such as the number of financial gifts given worth 250 € or more and household net financial assets, exhibit more vertical clustering around the zero line, denoting a more consistent but small impact on the LightGBM model's output.

In addition to two income-related variables, the model for Poland includes three other financial variables: number of financial gifts given worth

Table 4. Performance of LightGBM binary classifiers. Variable importance in Poland

Number	Feature	SHAP
1	Total household income—Version A*	0.2010
2	CASP index for quality of life and well-being	0.1825
3	Total household income—Version B*	0.1485
4	Number of given financial gifts 250 € or more	0.0764
5	Household net financial assets	0.0481
6	Area of building	0.0425
7	Number of children	0.0316
8	Funds in bank accounts	0.0284
9	Amount spent on food at home	0.0281
10	Frequency of dairy products consumption	0.0243
11	Social network members' year of birth—average	0.0222
12	Household gross financial assets	0.0217
13	Value of main residence	0.0182
14	Score of orientation in time test	0.0172
15	Seen/Talked to medical doctor in the last 12 months	0.0136
16	Network relationship to the closest person	0.0115
17	Weight	0.0115
18	Value of home-produced food	0.0084
19	Maximum of grip strength measures	0.0081
20	Appetite	0.0080
21	Average contact with siblings in the social network	0.0076
22	Health literacy: how often help needed	0.0069
23	Loneliness (short version of R-UCLA Loneliness Scale)	0.0069
24	Score on word list learning test—trial 2	0.0060
25	Number of the social network members with weekly contact or more frequently	0.0059
26	Activities requiring a moderate level of energy	0.0058
27	Total household expenditure	0.0047
28	Number of grandchildren	0.0042
29	Years of education	0.0037
30	Body mass index	0.0036
31	Age in 2020	0.0035
32	Age of partner in 2020	0.0033
33	Gender	0.0026

* The total household income is represented by two measures of this variable. The first measure (Total household income—Version A) is obtained by aggregating all individual income components at the household level, while the second measure (Total household income—Version B) is derived from a single question on monthly household income. There are no strong arguments for preferring one measure over the other. The availability of these two alternative measures provides complementary information on household income.

Source: own calculations with data from SHARE Survey.

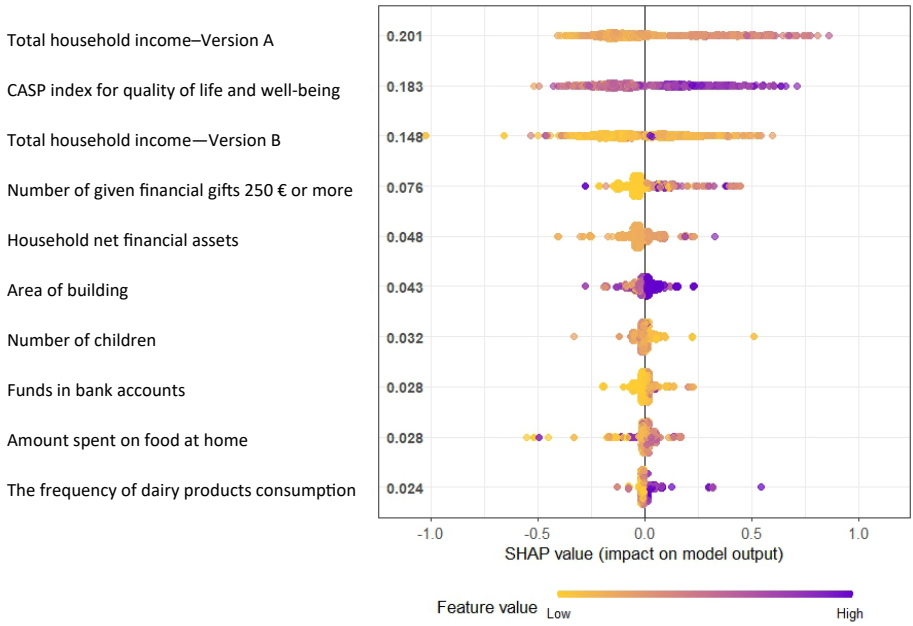

Figure 8. Importance of features influencing the ability to make ends meet in Poland

Source: own calculations with data from SHARE Survey.

250 € or more, household net financial assets, and funds in bank accounts. Non-financial variables in the model encompass CASP, area of the building, number of children, annual food at home consumption, and the frequency of dairy product consumption. The area of the building and annual food at home consumption impacts the model's predictions rather positively, whereas the number of children tends to negatively affect the model's output. In Poland, distinctive features include the number of children and home lifestyle aspects, particularly in relation to food expenditure at home.

4.3. Feature importance in Spain

Table 5 shows all important variables for ability to make ends meet in Spain. Figure 9 presents the SHAP values derived from the LightGBM model for Spain. As with the findings for Poland, the total household level of all individual income components and total monthly household income, both income-related features, emerge as the most important. The graph, marked by purple dots, indicates that higher income levels correlate with an enhanced

Table 5. Performance of LightGBM binary classifiers. Variable importance in Spain

Number	Feature	SHAP
1	Total household income—Version A	0.2854
2	Total household income—Version B	0.1526
3	Amount spent on food outside home	0.1411
4	Funds in bank accounts	0.1005
5	Household gross financial assets	0.0432
6	Number of chronic deseases	0.0416
7	Time expenditure: leisure (mins)	0.0384
8	Feels left out	0.0259
9	Interest/dividend from bank account, bond, stock and mutual funds	0.0247
10	Funds in bond, stock and mutual funds	0.0237
11	Value of main residence	0.0233
12	Percentage of house owned	0.0227
13	The frequency of legumes, beans or eggs consumption	0.0208
14	Household real assets	0.0207
15	Old age, early retirement, and survivor pensions	0.0196
16	Number of given financial gifts 250 € or more	0.0180
17	The social network members proximity—average	0.0142
18	Value of cars	0.0141
19	Height	0.0140
20	Amount spent on food at home	0.0138
21	Body mass index	0.0133
22	Maximum of grip strength measures	0.0128
23	Years of education	0.0113
24	Male or female	0.0111
25	Total household expenditure	0.0103
26	The social network members year of birth—average	0.0089
27	Network relationship to the closes person	0.0076
28	At least taking 5 different drugs a typical day	0.0074
29	Number of children	0.0057
30	Age in 2020	0.0052
31	Area of building	0.0045
32	Number of grandchildren	0.0035
33	Number of women in the social network	0.0032
34	Household size	0.0021

Source: own calculations with data from SHARE Survey.

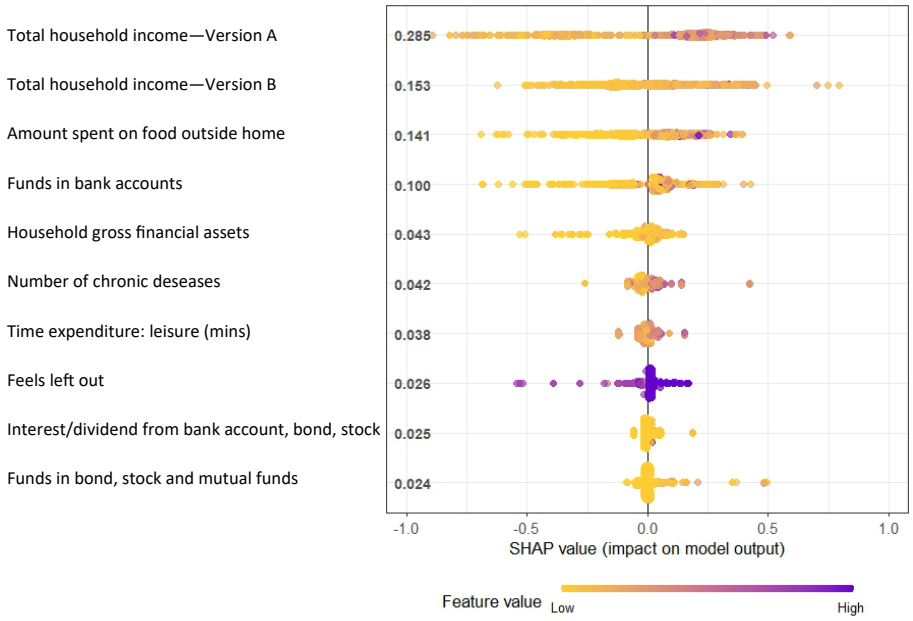

Figure 9. Importance of features influencing the ability to make ends meet in Spain

Source: own calculations with data from SHARE Survey.

capacity to make ends meet. This visualisation reveals that for most features higher values generally contribute positively to present financial security.

A notable observation is the strong positive correlation between annual food outside home consumption and the dependent variable, suggesting that increased expenditure on eating out is linked to better finance present security. Feeling left out shows a limited range of SHAP values, signifying a consistent impact on financial stability. Among the most influential variables are two related to household income and four other financial aspects: funds in bank accounts, household gross financial assets, interest from bank accounts, and government/corporate bonds. Non-financial features, apart from the amount spent on food outside home and feeling left out, include the number of chronic diseases and time spent on leisure activities, measured in minutes. The distinctive factors for Spain, as highlighted by this model, are connected to health and lifestyle aspects, particularly in relation to spending on dining out and leisure time allocation.

Conclusions

This paper provides comprehensive insights into the financial well-being of retirees aged 65–79 in Poland, Spain, and Denmark, and answers several critical research questions. In responding to the first research question regarding the differences in the ability to make ends meet among retirees in Poland, Spain, and Denmark, it is apparent that the financial well-being of retirees varies significantly between these countries, which is consistent with the Eurostat report (Eurostat, 2021). In Denmark, retirees generally find it easier to manage their finances, primarily due to higher household incomes and substantial social welfare systems. In contrast, a larger percentage of retirees in Poland face difficulties making ends meet, with financial challenges being more widespread. Spain falls between these two extremes, with moderate challenges influenced by cultural and economic factors.

With regard to the second research question, the study identifies several key determinants of financial well-being for retirees. Household income is a primary factor across all three countries. Higher incomes correlate strongly with better financial stability. Additionally, the research findings align with literature expectations, indicating that past financial resources, such as savings and household assets, are essential in determining the capacity to meet present financial security across various countries (Badri et al., 2022; Hébert & Gyarmati, 2014). In Denmark, housing costs are a major concern, with housing expenses consuming a substantial portion of retirees' budgets. According to the Eurostat data (Eurostat, 2022b), all housing expenses account for as much as 29% of retired Danes' household budgets. In Spain and Poland, food-related expenses play a more significant role. Polish retirees spend more on in-home food, while Spaniards allocate a larger share to dining out.

Taking into account the third research question, which aims to determine how various socio-economic, health and social network factors influence retirees' ability to make ends meet, the study confirms the results of other studies, namely that the critical factors influencing financial security are the mental and physical health features (Artazcoz et al., 2021; Marjanovic et al., 2015; Netemeyer et al., 2018). However, the impact of these variables varies across different countries. In Poland and Denmark, overall quality of life, encompassing both mental and physical health, is closely linked to financial security. However, in Spain, individual health aspects, such as chronic diseases, have a more pronounced impact. Social network factors, like support from family and friends, also play a critical role in financial well-being, although their influence varies across the countries.

Considering the fourth research question, which explores what new possibilities for statistical analysis in studies on the ability to make ends meet are offered by machine learning methods like Light Gradient Boosting Machine

and SHAP values, the study demonstrates that these techniques enable a more nuanced understanding of the factors influencing financial well-being. For instance, SHAP values help in identifying the most critical features and their respective impacts, offering a clearer picture of the determinants of financial security. This approach highlights the fact that while many features can influence financial well-being, only about 30 show significant importance, streamlining the focus for policymakers.

The fifth research question concerns the contributions of this analysis to understanding the challenges faced by older individuals in maintaining financial security. The study indicates that for Poland targeted policies should focus on enhancing household income and providing financial planning services to maximise returns from savings and assets. Support for households with dependents is also crucial, as the number of children negatively affects financial stability. In Spain, strategies should prioritise income enhancement and financial asset stability, with a balanced approach to spending on lifestyle and leisure activities. Financial institutions could offer tailored products for retirees to maximise returns from bank accounts and bonds. In Denmark, retirement planning and financial literacy should be emphasised, with a particular focus on managing household net worth and property-related finances. Given the high value placed on well-being, healthcare and long-term care planning are essential for addressing the needs of the ageing population.

The analysis has limitations, primarily due to the reliance on pre-crisis SHARE data. The current polycrisis, including the COVID-19 pandemic, the war in Ukraine, and the economic crisis, likely affects retirees' financial well-being. Future research should examine these impacts and explore the financial security of retirees in other European countries. Additionally, examining the specific conditions of individuals over 80 years of age, who have distinct health needs, would provide further valuable insights.

The study provides comprehensive insights into the financial well-being of retirees in Poland, Spain, and Denmark. This paper underlines the associations between financial well-being and various socio-economic variables, offering distinct recommendations for stakeholders in the silver economy. By understanding how retirees manage their resources, policymakers can better address the financial challenges faced by the ageing population. The insights gained from this research highlight the importance of comprehensive financial planning, targeted support, and balanced lifestyle considerations in enhancing the financial well-being of older individuals.

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