

**UNIVERSITY OF ECONOMICS - VARNA**  
**DEPARTMENT OF FINANCE**

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**GREEN INVESTMENTS OF PRIVATE PENSION FUNDS**

**ABSTRACT**

**of a dissertation for acquiring an educational and scientific degree “Doctor”  
in a professional direction 3.8. Economics, doctoral program “Finance”**

**Varna**

**2023**

The dissertation consists of 284 pages, from which 227 pages main text and 57 pages literature sources and applications. The exposition is structured in three chapters, which contain 39 tables, 39 figures и 5 graphics. The list of references consists of 418 titles (57 in Cyrillic, 342 in Latin and 19 internet sources).

The defence of the dissertation will take place on ..... at .....in the hall ..... of the University of Economics - Varna at a meeting of the scientific jury, appointed by Order № 06-55/23.05.2023 of the Rector of the University of Economics - Varna.

The defense materials are available to the interested parties at the web page of University of Economics – Varna.

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# I. GENERAL CHARACTERISTICS OF THE DISSERTATION

## 1. Relevance of the researched topic

Global environmental problems and climate change in recent decades have brought to the fore issues related to the sustainable development of economies. It assumes that the exploitation of resources, technological development and investments are in accordance with the current needs of the population, but also with the future needs of society. Many scientists, governments and organizations are supporting a new green investment approach to pave the way for sustainable economic growth.

The transition to a low-carbon and climate resilient economy requires large-scale investment resources, which the state and local authorities do not have, therefore the attention is directed to the large institutional investors, including pension funds. The assets under management of the pension funds exceed 38 trillion. USD, which represents 40% of global GDP by the end of 2021. Part of this huge resource can be directed to eco investments that support sustainable development goals.

*Environmental, social and governance factors have increasingly tangibly supplemented traditional financial analysis* in recent years. Consideration of all risk factors in the investment process is key to achieving a stable long-term return on the portfolio, in accordance with the best interest of the beneficiaries.

Motivated by financial, environmental, reputational and regulatory reasons, pension funds are integrating climate change into their investment strategies and policies more often. However, the spread of sustainable and responsible investing among them is uneven across countries and regions. While the share of green investments in the portfolios of pension funds defined as “leaders” in the incorporation of the ecological investment approach is about 5-6% on average up to 40% for individual funds, green investments form only 1% of their assets worldwide. Pension funds have to ensure that the financial characteristics of the assets match the profile they are looking for and to be well aware of their benefits and risks in order to realize their potential in the field of green investment. Unfortunately, *there is still a lack of research* on the effect of green asset participation in broadly diversified pension fund portfolios.

## 2. Object and subject of the research

*The object* of the research is the voluntary pension funds in Bulgaria, and *the subject* - their sustainable and responsible investing.

The dissertation focuses on the investment activity of voluntary funds for several reasons. The choice of employers and employees for voluntary pension insurance is based on the perceived need for secure, stable and decent income in old age. About 1/5 of the economically active population of Bulgaria owns an individual party in a voluntary pension fund, but the amount of accumulated funds is still small. If the investment policy of the pension funds corresponds to the consumer's expectations of risk, return and investment beliefs, the potential of the market can be developed. As investments of voluntary pension funds are less regulated, they have a real opportunity to offer better product design, helping to boost confidence in the sector.

State public pension funds, due to the pay-as-you-go principle of the organization, and funds for supplementary compulsory pension insurance in Bulgaria, for which the regulatory framework provides different (stricter) investment restrictions compared to voluntary funds, remain outside the scope of the study.

### **3. Purpose and tasks**

*The aim* of the dissertation is to evaluate the opportunities for portfolio optimization of the voluntary pension funds in Bulgaria by including green assets in them. To achieve the goal, research tasks are set as following:

1. Systematization and taxonomy of the variety of definitions and financial instruments for green investing.
2. Disclosure of motivation and assessment of good practices for ecological investment of pension funds.
3. Empirical study of the effects of the inclusion of green assets in the investment portfolio of voluntary pension funds in Bulgaria.

### **4. Research thesis**

*The research thesis* of the dissertation is that the ecological dimension of the investment policies of the Voluntary pension funds in Bulgaria helps for the more comprehensive assessment of the risks and the better performance of their portfolios.

### **5. Limitations**

Defining and using the term “green investment” at the dissertation is focused on its interpretation *in the field of finance*. Other areas such as environmental and climate insurance, green lending, green foreign direct investment, international trade, emissions trading, macroeconomics and ecology that are relevant to the term remain outside the scope.

The volume of green investments of Voluntary pension funds (VPFs) in Bulgaria is calculated by the investments of *corporate securities*, which are issued by companies with main fields of activity that fall within the “green” spectrum, regardless of whether the securities are labeled/certified as “green” or not. The investments in stocks and shares under collective investment schemes (CISs), which are in accordance with Art. 8 of Regulation (EU) 2019/2088, are also marked as “green”. The segment of VPFs’ debt investments in state and municipal securities, as well as in bond securities issued by international organizations, is not included in this analysis, because of the impossibility of determining the presence or absence of “green” instruments among those reported by pension insurance companies.

The selection of green indices and funds for the portfolio optimizations is focused on the *environmental theme*. Benchmarks of assets associated with the broader principles of sustainable and environmental, social and governance (ESG) investing are not subject to analysis, as there is no way to isolate their environmental component as a factor of the financial performance of the assets.

The study is fully in line with the quantitative investment restrictions of the VPFs laid down in the Social Insurance Code (SIC). The selection of indices and funds for portfolio optimization is subject to the stipulated *regulatory requirements* for individual financial instruments (restrictions regarding issuers, investment rating, trading markets, registration, etc.).

## **6. Information sources**

The research is provided by numerous official documents published on the websites of the pension insurance companies (investment policies; rules for the organization of VPF; rules for identification, measurement and risk management; annual financial statements of the companies; ethnic codes, sustainability-related disclosure in the financial services sector, etc.). To determine the degree of “greenness” of VPF’s investment portfolios, information on the volume and structure of investments by types of assets and issuers of financial instruments, which pension insurance companies disclose, is used. Indicators of portfolio performance over a ten-year period (2012-2021) are based on the pension fund's net asset value (published by the Financial Supervisory Commission), the rate of inflation (from the National Statistical Institute) and the EONIA index (from the European Central Bank).

Green investment instruments are represented by returns on market indices and green asset funds. The diversified portfolio is supplemented by conventional asset indices, traditionally included in pension fund portfolios (sovereign and corporate bonds, corporate shares, real estate, bank deposits and cash), covering the period from 2012 to 2021. The main sources of



information are regulated securities markets (Bulgarian Stock Exchange (BSE) - Sofia, Tokyo Stock Exchange), the European Central Bank and leading providers of benchmarks, analyzes and data for investors (S&P Dow Jones, MSCI Inc., STOXX Ltd, Invesco, iShares, VanEck, First Trust, etc.).

## **7. Research approaches and methods**

Various research methods are used in the study - descriptive and comparative method, inductive and deductive method, methods of analysis and synthesis, methods for statistical data processing (descriptive and correlational analysis). The optimized solutions are implemented using the MV (mean–variance) and UPM/LPM (upper partial moment–lower partial moment) models in the MATLAB® software system. Although the application of the MV algorithm is relatively standardized, the research *achieves multiple specifications of the set of parameters*, namely: diverse investment constraints, different comparison of target risk and return, target share of green assets in investment portfolios, etc. The optimization task using the UPM/LPM model is undoubtedly more complex. Its solution is preceded by the formulation of the objective function, the input of linear and nonlinear constraints (equations and inequalities), as well as the setting of additional options (number of iterations, initial point of the optimization, etc.). The extraction of the optimized solutions through the UPM/LPM approach also goes through a *significant number of tests subject to author scripts and specific output parameters* (applied for investors classified as potential averse, neutral or seeking, as well as at different rates of target portfolio return).

## **8. Approbation**

Parts of the dissertation are published in specialized scientific journals and are presented at scientific conferences.

## **9. Opportunities for future research and application of the research**

Clean technologies and financial markets for green investments are developing very dynamically, and this implies incessant updating and adaptation of regulatory regulations and the system of definitions, standards and indicators. From this basic point, research on the usefulness of green instruments for diversified portfolios with a long-term investment horizon should be done periodically, which aims to optimize the investment process of pension funds in the best interest of the beneficiaries.

In combination with the unstable global conjuncture the above-mentioned factors inevitably affect the motivation and opportunity of private pension funds to apply environmen-

tal dimension in their investment policy. The need for some research is provoked by the *conclusions and recommendations* at this scientific study. Among them are questions about the incentives of the VPFs in Bulgaria not to take into account environmental, social and governance factors in their activity, as well as the potential effect on the capital market in Bulgaria, under conditions of increased institutional investors' demand for financial instruments with environmental or more comprehensive ESG characteristics. The results of the study of the financial culture of the economic-active population in the context of investment values, because satisfying the needs of consumers is an essential factor for the design of any product, would be interesting. In this context, future developments could explore the perspective in front of a multifund organization, incl. creating pension funds focused on environmental investing.

The results and recommendations carried out of the dissertation have their *practical application* for improving the Bulgarian VPFs' investment policy in the following directions:

- inclusion of “green” financial instruments in the investment portfolios of VPF in accordance with the specific utility function determined by the attitude to risk and potential of the fund;
- consideration of all investment portfolio's risks factors, incl. those of an environmental, social and governance nature;
- incorporating the ecological/sustainable and responsible approach into the activities of VPF, starting from the corporate culture;
- construction of an ecological investment strategy in accordance with the objectives of the European Union (EU) for the transition to a green economy and carbon neutrality;
- join into international organizations and initiatives and selection of external asset managers, applying additional environmental criteria;
- active communication with insurers and insured about the green investment trend and make an influence of investment preferences.

## **II. STRUCTURE AND CONTENT OF THE DISSERTATION**

### **LIST OF ABBREVIATIONS**

### **INTRODUCTION**

### **CHAPTER ONE. MODERN INTERPRETATION OF GREEN INVESTMENTS**

#### **1. The green genesis of investments**

##### **1.1. The irreversible evolution of sustainable and responsible investing**

1.2. The green investments' terminological puzzle

## **2. Financial instruments for green investing**

2.1. Expert analysis of investment products

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2.3. The “green label” as a driver of the bond market

## **3. The place of ESG factors in the investment process**

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3.2. Integration of ESG determinants – impetus for green investments

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# **CHAPTER TWO. THE GREEN SOLUTIONS OF PENSION FUNDS**

## **1. Motivational drivers of private pension investments**

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1.2. Normative requirements for green investments

1.3. Green investments' risk matrix

1.4. Possible optimizations in case of investment restrictions

## **2. Pension investments in the context of the green orientation**

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2.2. Pension funds' portfolio allocation in green assets

2.3. The financial consequences of the ecological investment trend

## **3. The ecological motive of pension funds in Bulgaria**

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3.3. The Bulgarian dimensions of “green” portfolios

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1.2. Inputs and limitations of MV optimization

1.3. MV approach's palette of efficient frontiers

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2.2. Research design with UPM/LPM algorithm

2.3. “Green” portfolio construction under the UPM/LPM model

2.4. UPM/LPM vs. MV in search of an optimal solution

### **3. Possibilities for more successful portfolio “ecologization”**

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# **III. BRIEF PRESENTATION OF THE DISSERTATION PAPER**

## **INTRODUCTION**

The relevance and importance of the topic is highlighted in the introduction. The object and the subject of the research are formulated. The scientific goal, the tasks and the main research thesis are determined. Used approaches and methods are indicated, as well as the limitations of the study.

## **CHAPTER ONE. Modern interpretation of green investments**

### **1. The green genesis of investments**

Two main emphases stand out at this part in the dissertation - the “evolution” of the traditional investment approach and the terminological diversity in the field of green investments. The need to collectively overcome the pressing social and environmental problems of the 21st century is outlined, which in turn raises the need to build a comprehensive system around the concept of “green investments” (definitions, taxonomies, standards, labels and technical measurement indicators).

Although the ideas of “sustainable development” and “green growth” are not new, their popularity grown significantly as businesses accept environmental, social and governance determinants as relevant to corporate performance, and meeting the needs of all stakeholders is evaluated as an integral part of economic success. In this context, the possibility of a “paradigm shift”, i.e. implementing a new investment approach that integrates sustainability factors, is commented on. The long-term effects of the manifestation of environmental risks and poor corporate governance, the low usefulness of traditional financial analysis and the radical change of the competitive environment, expose investors to

significant danger. It is considered that a longer investment horizon makes more profitable integrating “*sustainability*” (*a driver of corporate success*) to investor's investment strategy.

The development of the green investment market and the potential growth of transactions to certain extent depend on the possibility of standardizing the investment decision-making process. However, the often found problem is the different interpretation of the meaning and objectives of green investments, resulting from the extreme diversity of definitions in the field. In order to sort out the terminological “puzzle”, the relationship between climate, green and sustainable finance is discussed. Against this background, numerous definitions and taxonomies of the term “green investment” are explored, differing in approach, scope and level of detail.

“*Green investing*” is a complex and dynamic concept that is intertwined with other investment concepts – “sustainable and responsible investing”, “impact investing”, “ESG investing”. Considerable consensus is being reached around some areas, while others are open to controversy.<sup>1</sup> Green investments can generally be defined as investments, encouraging the transition to a low-emission economy and climate-sustainable growth, incl. climate change mitigation, adaptation, sustainable use of soils and water, pollution prevention and control, biodiversity protection.

Although the harmonization of definitions is not sufficient to mobilize the necessary investment resources for the global environmental goal, it would help investors, issuers and financial institutions to efficiently allocate capital and make well-informed decisions. In this chapter special attention is paid to the risks in building a comprehensive system of definitions, classifications and criteria that arise from the level of strictness and precision, the degree of environmentalism, harmonization (regional, national and international level) and the commitment to social and governance factors.

It could be recommend to create an environmental indicators and a clear methodology for their calculation, supplemented by database maintenance and benchmarking activities, which will provide an opportunity for easier comparison of investment alternatives and results, reduction of “misleading” projects and companies, as well as and easier tracking of progress towards the UN Sustainable Development Goals.

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<sup>1</sup> The sectors and technologies that are unquestionably recognized as “green” are: renewable, low-carbon energy; energy efficiency; sustainable and clean public transport; pollution prevention and control; waste management; water management; green buildings; agriculture, forestry economy and land use. On the other hand, the sectors defined as controversial are nuclear energy; “clean” coal and natural gas; biofuels, biomass and bioenergy (EC (2017). Defining “green” in the context of green finance. Final report. Available at: <https://op.europa.eu>)

## 2. Financial instruments for green investing

The study of investment products for green investing shows that the market offers a wide variety of financial instruments, distinguished by a specific “risk-return” profile, and their advantages and disadvantages depend on the investment channels through which they are realized. This section of the research paper pays special attention to *green infrastructure* as an asset for portfolio selection, and takes the consideration that a significant part of the sectors and technologies related to the environment corresponds to the construction and operation of infrastructure. The potential of green bonds to drive green investment is also highlighted, given the importance of debt securities to institutional investors' portfolios. In this context, positive aspects of the process of labeling and certification debt securities as “eco-friendly” are also considered, incl. the reduction of the risk of greenwashing. The types of green bonds, the issuer structure and the investment rating of the securities, which largely determine market demand, also are discussed.

The spectral analysis of investment instruments and outlined trends allow several conclusions to be drawn:

- the decade ago belief that Public private partnerships can play a key role in the development of green infrastructure is rejected. It turns out that this way of implementing environmental projects *is not particularly attractive* for institutional investors (and specifically for pension funds) for a number of reasons.
- interest in securitized financial instruments is indeed high, but it is mainly due to asset managers. Institutional investors - asset owners, *choose these investment products less often* (on the one hand, due to investment restrictions and their unconvincing past, on the other hand, the reduction of financial benefits for foreign (for USA) investors).
- non-listed infrastructure funds are preferred by insurance companies and defined benefit pension schemes, but *there is a lack of sufficient investment opportunities*.
- public traded shares are undoubtedly the most demanded “green” financial instrument. Green debt issuances also fall into this category, although traded volumes are significantly lower than desired. For defined contribution pension funds, especially if their assets are “marked to the market”, *highly liquid securities are among the most preferred* (including green mutual funds and exchange-traded funds).

## 3. The place of ESG factors in the investment process

The implementation of sustainable and responsible investments is usually based on one or several strategies (approaches). In this part of the thesis, their main varieties (thematic

investing, screening and engagement) are characterized in detail, the “green” application criteria, the necessary set of indicators for the company’s environmental performance and appropriate climate metrics to objectify investors’ choices, are discussed.

In fact, the nature of the investment instruments partly predetermines the possibilities of choice. The full range of strategies *can be applied to equity investments*. Investors have the opportunity to show their engagement through voting and proposals in companies to improve energy efficiency, reduce greenhouse gas emissions, reduce high-carbon capital costs, increase environmental investments, improve transparency and reporting, etc. Investment activities in debt instruments *are limited to portfolio construction* (application of screening and/or thematic approach). The thematic strategy implies focusing investments on sectors related to the environment, while screening represents the inclusion (positive screening) or exclusion (negative screening) of companies, activities or technologies according to ecological criteria.

The question of whether ESG integration should be adopted as a strategy or as an interweaving of ESG factors (with a certain materiality thresholds) into the overall investment process is discussed. The present study adopts the second perspective, which in effect puts the remaining sustainable and responsible strategies under the “hat” of ESG integration. This approach considers the inclusion of environmental, social and governance determinants as the *impetus for green investment*. Emphasis is placed on the specific stages and activities, provided by widely accepted models of scientists and investment consultants. The usual integration of environmental, social and governance factors starts at corporate culture and investment strategy, passing through portfolio construction and ending with monitoring and evaluation. In this way, episodic investments are avoided and a new perspective is created, helping to construct a portfolio of assets with sustainable returns.

The place of ESG determinants in the investment process and the development of the market for sustainable assets are interdependent. If the market is more developed, ESG factors can play a more significant role in investment selection, and conversely, increased demand for assets with sustainable characteristics stimulate their supply.

The analysis of the traded volumes of sustainable and responsible assets, used strategies and specific features of individual regions of the world during the period 2012-2020 makes it possible to outline several trends. There is a solid growth of assets invested in accordance with sustainable and responsible strategies, with volume exceeding 35 trillion USD at the end of the period. Europe and the USA have the largest share of the market - over 80%. The prevalence of ESG strategies in Europe and other regions contrasts sharply. *Negative*

*screening* emerges as the dominant strategy in Europe, corporate engagement ranks second, and ESG integration, which is leading in the other regions, occupies only the third position.

The diversity in the distribution of assets (shares, bonds, private equity and venture capital funds, real estate, etc.) inevitably has a positive impact on the development of sustainable investment strategies, thereby attracting large institutional investors with diversified portfolios.

## **CHAPTER TWO. The green solutions of pension funds**

### **1. Motivational drivers of private pension investments**

The study of incentives and challenges in the investment process is an important element of the search for suitable “green” investment solutions for private pension funds. The dissertation paper examines the entire palette of *financial and value considerations* for ecological investing, as far as distinguishing these two motivational groups has an impact on the correct design of the ESG investment framework, by choosing on different investment approaches. At the same time division of motives should be taken with some conditionality, since ESG factors for taking investment decisions often have their financial performance. Environmental risks affecting the activities of companies can be “transferred” to pension portfolios in the form of negative externalities, erosion financial risk, fat tail risk or black swan events, for example.

A thorough analysis of the motivation of pension funds for green investment makes it possible to outline the trend and assess the significance of the various motives. While contributing to sustainable development was leading a decade ago, *financial aspects, the regulatory environment and customer demand* now are of paramount importance (in Canada, Europe and the USA respectively). Environmental and social motives remain in the background.

In this section of the dissertation, special attention is paid to the *regulatory framework* for sustainable and responsible investment in individual regions and countries, due to its dual importance. Depending on the level of stringency and complexity, regulations on ESG investing can stimulate green growth or on the contrary, create obstacles to green investments of pension funds. In the context of the opinion that “global problems require global solutions”, points of contact between regulations in different jurisdictions are outlined and prerequisites for the creation of long-term state regulations and international agreements are sought. Although there is no country in which investing according to ESG factors is mandatory, pension funds from regions with progressive legislation (EU, UK and Australia) are distinguished by the highest climate ratings and overall sustainable and responsible investment policies. On the



other hand, the largest pension markets in the world – the USA and Japan, which introduce specific ESG legislative regulations from 2023, lag behind the environmental trend.

At this stage in the development of green investment markets, it would be appropriate for regulatory authorities to introduce mandatory disclosure requirements in relation to sustainability in the financial services sector, valid for all types of pension funds licensed in the relevant country. At the same time, data comparability should be boosted by clarifying the guidelines on the criteria for reporting investments as sustainable and implementing specific standardized non-financial reporting frameworks for all public companies.

Fragile regulatory frameworks and a lack of long-term political commitment indeed are perceived as significant barriers to green investing indeed. The research of the *risks and challenges* accompanying the environmental investments of the pension funds is a key prerequisite for taking a strategic approach and large-scale measures to overcome them. The paper comments multiple political and regulatory risks, the investment conditions and the investor capacity of the pension funds, which aims to direct the attention of the competent authorities to the pressing problems.

The EU undertakes a number of regulations and measures to finance sustainable development, but they can be seen as a good start against the background of the necessary reforms, in line with the ambitions of a transition to a carbon-neutral economy by 2050. Most recommendations, which aim to stimulate green investments, are addressed to policy makers, but institutional investors can also take action in this area. It is recommended that pension funds work hard to build/develop capacity and improve internal expertise, improve communication with external asset managers and implement new data processing technologies.

## **2. Pension investments in the context of the green orientation**

Although the market for green financial instruments has rapidly develop, the sustainable and responsible investment trend is relatively new. Many pension funds are still skeptical of the “risk-return” profile of green assets and are worried of the fiduciary duties (and their equivalent) interpretation to act in the best interests of beneficiaries.

Looking at pension investors in the context of green orientation, the paper aims to research the relationship between the allocation of investment portfolios and the financial consequences of ecological choice. The problem is considered on the background of imposed good practices and climate strategies of the sustainable and responsible “leaders” among

pension funds.<sup>2</sup> As long as climate change and the planned policy response carry not only risks, but also opportunities, pension funds with a working climate strategy and a sustainable and responsible investment policy, have better competitive position. Thinking like a long-term investor develops the potential of pension institutions to meet the needs of insurers and insured more fully in the future, taking into account the future performance of environmental, social and governance determinants.

In reality, the readiness of the largest institutional investors to meet climate-related risks is significantly different on a regional basis. Europe, Australia and New Zealand are leaders in integrating a sustainable and responsible investment approach, while Africa, the Middle East and the Americas are underrepresented. Europe's leadership is largely due to the Scandinavian countries, Great Britain and France.

A detailed analysis of sustainable and responsible investment reports (named also socially responsible, sustainable, green, ESG, etc.), strategic plans, investment beliefs and formal policies of environmental leaders allows several important conclusions to be drawn about the potential of green assets for the pension portfolios.

Pension funds with a high climate rating invest in green assets 6% of their investment portfolios on average compared to 1% globally. The Dutch funds ABP and PFZW are undisputed leaders in sustainable investing. Resources invested in accordance with the UN Sustainable Development Goals reached 99.3 and 50.3 billion EUR respectively at the end of 2021 and represents 18% of their investment assets. EAPF (Great Britain) with 18% and ERAPF (France) with 21.2% are also distinguished by a high relative share of sustainable and responsible investments, also at the end of 2021.<sup>3</sup>

The most important distinguishing marks of "leaders" are the *creativity of their climate strategies* and the diversity of *approaches to managing environmental risks and opportunities*. These pension funds weave ESG factors into their mission, strategy and corporate culture. They form specialized "green teams" and engage employees from all levels of the organizational structure to implement the ecological investment approach. Pension funds maintain active communication, not only with beneficiaries, but also with other interested parties (employees, labor market and industrial organizations, media, educational

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<sup>2</sup> The strategies, approaches and models applied by the pension funds defined as "leaders" according to the AODP Global Climate 500 rating for 2017 (20 in number) are considered to be leading pension practices in the sustainable and responsible sphere at the present study.

<sup>3</sup> Many pension funds seek to align their principles across all asset classes, so they do not keep statistics on their green investments by class and do not divide their investments into sustainable and non-sustainable. This is the case for the funds UNJSPF, Unilever, BT Financial Group, Ilmarien, Elo and TGAM, which are categorized as environmental leaders, as well as numerous other pension funds from the groups with a lower climate rating.

and research organizations, society, investment partners). They collaborate with various associations supporting green causes and seek to influence public policy, related to sustainability, accountability and standard setting. These pension funds pay particular attention to their rights as shareholders through voting and corporate engagement, incl. preparing proposals that aim for change towards sustainability. Some funds are even launching their own initiatives to support the transition to low carbon emissions.

The key question *if green investments pay off financially* or investors “sacrifice” the return for their value considerations is also explored at several levels - empirical results from dozens of research papers on the impact of a green investment approach on risk and return are studied; the investment performance of climate leaders among pension funds is compared to the country average value; findings on the financial performance of balanced pension schemes in Australia are analyzed, as well as the conclusions of the ABP and ERAPF pension funds, which state the link between sustainable and responsible investing and portfolio returns in their reports. In summary, the following conclusions could be drawn:

- in general, the academic results show that sustainable and responsible investments *do not harm the welfare of investors*, but can contribute to its growth in case of incorrect assessment of ESG factors by the market;
- a significant part of the environmental leaders among the pension funds report *a higher portfolio return* than the average market values;
- sustainable and responsible pension funds operating in the Australian market *outperform* conventional investment policy funds *in terms of investment returns* over all time intervals.

If the findings and conclusions stated here are viewed through the prism of risks and challenges to green investment of pension funds, some of the barriers can be defined as “*knowledge barriers*” which can be overcome by building internal expertise and capacity.

### **3. The ecological motive of pension funds in Bulgaria**

The lack of research on the spread of ecological investments approach among pension funds in Bulgaria provokes several interesting questions, namely: do our Voluntary pension funds follow the European trend of implementing ESG factors; whether the various sustainable and responsible strategies are applied when investing funds of the insured persons; what is the readiness of the portfolios to “meet” environmental risks; is there a link between the shares of green assets and the investment performance of VPFs’ portfolios. The study of

the formulated questions determines the level of environment concern of pension funds in Bulgaria and its challenges for investment portfolios.

The critical review of the VPFs' investment policy shows that the content of disclosures information is *extremely similar* and in some cases the formulation of the goals in terms of risk and return completely match. Different characteristics and a specific spirit of individual policies in general are missing. It is surprising that *only two of the funds identify* environmental, social and governance risks as potential investment risks (VPF "UBB" and "Doverie"), and it is added into investment policies relatively recently (in November 2021 and October 2022 respectively). In fact, VPF "Doverie" previously declared the implementation of a socially responsible investment policy based on its Code of Ethics.

Interestingly, the socially responsible investing of both pension funds applies to the application of *negative screening* in the investment instruments selection. And while the green criteria for the exclusion of VPF "UBB" are clear and specific, those applied by VPF "Doverie" are formulated too generally, and this makes verification for each investment difficult (even impossible). The information that both funds disclose is not detailed enough. It is recommended to mention the materiality thresholds when conducting negative screening, as well as the lists of "banned" companies and/or countries, which is practice among the environmental leaders.

In general, Pension insurance companies in Bulgaria are not members of Voluntary international cooperation initiatives regarding sustainable development and environmental protection. More surprising, however, is that VPFs belonging to international financial organizations do not implement the group's sustainability policy. In addition the country's licensed VPFs do not track how issues related to sustainability affect their outcomes, condition and development (the "outside-in perspective"), the impact of investment decisions on people and the environment (the "inside-out perspective") *is also not disclosures*. Despite the fact that Bulgaria is part of Europe and the EU, the investment policy implemented by the VPFs *places the country in the group of "laggards"* in the process of sustainable and responsible investing.

In order to get insight into the environmental investments of Voluntary funds in Bulgaria, the volume and structure of investments by types of assets and issuers of financial instruments have been carefully studied. The analysis shows that the green investments of the VPFs in Bulgaria fluctuate between 0.55% and 1.92% of the total assets of the Voluntary funds for the period 2012-2021. VPF "Doverie", "CCB – Sila" and "Saglasie" are distinguished by relative constancy in environmental investing, accounting green assets

throughout the time interval. Their share in the “Doverie” portfolio is between 1.1% and 2.4%, while for the other two funds they reach 3-4% at the end of the period. For some of the VPFs, green investments are more concentrated at the beginning of the review period, while for others they are noticeable in the second half. *Relationships between green investing and fund size are not detected*, while “small” VPFs report close values (even higher) compared to funds with a significantly higher market share.

The comparison between the available investment opportunities in green assets and the regulatory investment restrictions show that VPFs in Bulgaria are *far from utilizing the opportunities* that the capital markets of green instruments offer. Corporate shares and bonds traded on organized markets in the EU, sovereign issues and securities issued by supranational organizations, as well as green CISs, which are characterized with minimum investment restriction, have the greatest potential for deployment of the green investments of the VPFs. At this stage, green investments in “pool” instruments and real estate offer quite limited options to our voluntary funds.

Although VPFs in the country do not apply a comprehensive approach to integrating the ecological factor in their investment process, according to the realized green investments, the funds can be conditionally divided into three groups: pension funds with persistence in ecological investing, funds with fluctuating green investments and funds with episodic green investments. Through this perspective, trends of investment portfolios selection are studied and their investment performance is analyzed for the period 2012-2021. It can be concluded that VPFs do not exhibit “*herd behavior*” in the selection of investment assets, incl. and according to their “ecological” affiliation, and funds with persistence in ecological investing achieve *higher investment results* compared to the other two groups.

The picture described so far reveals a low interest of the VPFs in Bulgaria to apply environmental measurement in their investment policies. The reasons could be addressed in several directions, including:

- perception of the ecological trend as insignificant;
- lack of pressure from society, media and non-governmental organizations;
- absence of lawsuits and disputes;
- lack of mandatory prescriptions of the national legislation in the field of sustainability;
- weak competition on the Voluntary pension insurance market;
- low financial literacy of the Bulgarian society and a high degree of inertia in the capital pension insurance;

- assumption of the investment risks by the insured persons.

As the application of environmental, social and governance criteria in the investment process of institutional investors seems increasingly relevant, the focus is shifting from the question “if” to “when” the Voluntary pension funds in Bulgaria will deploy a sustainable and responsible policy.

## **CHAPTER THREE. Portfolio optimization of pension funds in Bulgaria**

### **1. MV optimized solutions for pension funds in Bulgaria**

After a thorough literature review and considering the advantages and disadvantages of a variety of optimization models, the choice of a framework for optimizing a VPF portfolio in Bulgaria by including green assets focuses on the use of “*mean – variance*” and *UPM/LPM* approaches. The application of two algorithms for portfolio optimization enables the use of various risk measures and comparative analysis of the obtained results.

Mean-variance optimizations are conducted at two levels. Due to the long-term orientation of environmental factors, first is based on data on the performance of investment assets for the period December 2011 - December 2021 (120 months). And second, based on 72 months of data, by annually rebalancing the portfolios in the 2017-2021 interval.

To generate the efficient frontiers based on the 10-year data, the following tasks are solved:

1) optimizations without investment restrictions for a different set of assets: conventional and green assets; conventional assets only; green assets only;

2) optimizations for a set of conventional and green assets under a different set of constraints:

- test 1 - basic quantitative restrictions (quantitative restrictions on investment instruments provided by SIC);
- test 2 - basic quantitative limits plus minimum liquid funds (min. 1.5% in the LEONIA+ index);
- test 3 - basic quantitative limits plus a currency limit (the share of currencies different than BGN and EUR is limited to 30%);
- test 4 - basic quantitative restrictions, minimum liquid funds and currency restriction.

3) optimizations for a set of conventional and green assets, with basic quantitative restrictions and different “shades of green” portfolios: “light green” portfolio (min. 5% in green assets), “medium green” portfolio (min. 10% in green assets) and “dark green” portfolio (min. 20% in green assets).

The solutions of the optimization tasks based on the 10-year data could be summarized as follows:

- the limited investment choice is graphically transformed into a *lower positioned frontier of the efficient portfolios* than the efficient frontier in the absence of regulatory restrictions. The difference in annualized returns for the efficient portfolios with equal risk ranges between 0.52 to 1.76%;
- green investments are represented in *all portfolios* lying on the efficient frontier and their weight ranging from 3.58% to 20.25% (subject to the basic quantity limits at SIC)
- using additional limits (minimum percent of liquid funds and currency limit) *reduce the return or increase the risk* of the efficient portfolios at the same yield. Furthermore, a decrease in the weight of green investment instruments in the optimal solutions is observed. The drop is between 0.15 and 5.55 percentage points (smaller differences are observed at the beginning of the efficient frontier);
- the investment performance of the “light green” and “medium green” portfolios is *fully competitive* with conventional portfolios and would not harm the financial interests of the beneficiaries. The “dark green” portfolio (with a minimum 20% of green assets) raises lower returns compared to the benchmark, but the divergences are minimized when the risk-return profile increases (see: table №1).

**Table № 1.**

**Return of ecological and benchmark portfolios at set values of target risk**

(annualized data, %)

portfolio	target risk							
	0.97	1.65	2.17	2.94	4.74	6.07	8.16	12.77
	portfolio return							
conventional	0.00	3.00	4.99	6.99	9.99	12.00	14.99	19.07
benchmark	0.13	3.07	5.04	7.01	10.02	12.05	15.09	19.51
"light green"	0.13	3.07	5.04	7.00	10.02	12.05	15.09	19.51
"medium green"	0.04	2.98	4.97	6.94	10.02	12.05	15.09	19.51
"dark green"	0.23*	2.46	4.62	6.77	9.96	12.03	15.09	19.50

Notes: The conventional portfolio is generated from an investment set of conventional assets only (without the participation of green instruments), and the benchmark portfolio is generated from the combined investment set (conventional and green assets). Optimizations apply the basic quantitative constraints. Risk is measured by the standard deviation of portfolio returns. \*The value is obtained at a higher standard deviation (1.3621%), as this is the lower bound for portfolio risk under the specified model constraints.

Source: Author's calculations.

The “rolling” optimization procedure makes it possible to take in consideration changing assets’ characteristics and to create a time series of portfolio allocations. By rebalancing the portfolios, more realistic allocations are provided towards the static optimization procedure, which ends up with a single efficient frontier. Optimizations with annual rebalancing generate 5 time intervals: A (2012-2017), B (2013-2018), C (2014-2019), D (2015-2020) and E (2016-2021). The following tasks are solved for each period:

- 1) optimizations with conventional and green assets under basic quantitative restrictions;
- 2) optimizations with conventional and green assets with additional restrictions (base restrictions, minimum liquid funds and currency restriction);
- 3) optimizations by adding “new” instruments (additional assets) under basic quantitative restrictions.

The first optimization procedure reveals significant changes in the composition of the efficient portfolios. The results based on time interval “A” show that *green assets take part in 9 of the 10 efficient portfolios with a weight between 6.34% and 20.14%*. It is interesting that in the optimizations for periods “B” and “C”, green instruments participate more significantly at the beginning of the efficient frontier, while in the last time intervals (D and E) - at the end, moreover, the number (variety) of selected green assets in the efficient portfolios *doubles* over time. The main reason is that the “risk-return” profile of the green CISs forming the investment pool has improved significantly in recent years of analysis.

In most cases, adding constraints contributes to a reduction in the optimal weight of green assets and provokes a lower placement of the efficient frontiers. In contrast, the “importation” of additional assets has a *markedly positive effect* on the investment performance of portfolios in the middle of the efficient frontier, while the risk and return of the “edge” efficient portfolios remain unchanged.

The decision of the pension funds towards which of the efficient portfolios to aspire is determined by the formulated objectives of risk and return in advance. To further picture analyze, the optimal investment choice is sought according to the “safety first” criterion at 5 different targets of return values (EONIA, 0%, risk-free return, inflation and VOLIDEX) based on 10 years data. In addition, the portfolios with the maximum Sharpe ratio are created, as a starting point for constructing the Capital Market Line (tangent to the efficient frontier through the point of the risk-free return with a Sharpe ratio slope). The portfolios with the maximum Sharpe ratio are characterized with returns between 5.25 and 9.81% by the “rolling” periods analyzed and 6.40% at the 10-year horizon. At the same time share of green as-



sets in these portfolios varies significantly depending on the analyzed period and with a greater extent on the change in the investment mix of assets.

Tests with the “mean-variance” model end with a comparative analysis of the actual investment performance of the “rolling” efficient portfolios on VPFs in Bulgaria for the period 2018-2021. The conduct of this experiment is provoked by the fact that the efficient frontier results could be realized in practice if the investor holds an efficient portfolio during the analyzed period. The short-term investment results would differ from the expected ones if optimizations are carried out during the “rolling” periods and the investor actually acquired a given efficient portfolio for a period of 1 year, then rebalanced the portfolio based on new market information and the optimization procedure.

## 2. Portfolio selection with UPM/LPM algorithm

The portfolio optimizations using the UPM/LPM model are carried out under the assumption that the VPF in Bulgaria are risk-averse investors. At the same time, the possibilities of different attitudes towards the potential (seeking, averse and neutral), configurable to various degrees, and a palette of target portfolio returns are considered. The solutions are derived based on 10-year data on the investment assets and basic quantity restrictions.

The derived efficient frontiers, modeled at potential seeking and target returns at the rate of inflation, allow the following conclusions to be made:

- with increasing risk aversion degree, the optimization algorithm creates portfolios with *lower risk* and at the same time *lower return*;
- the share of green assets grows when moving up and to the right along the efficient frontier and also when the degree of *risk aversion increases*. Theta  $\Theta(R)$  as a measure of risk-adjusted return shows that the *best investment choice is dominated by green assets*;<sup>4</sup>
- in the case of increasing degree of potential seeking, the optimized model is provoked to select assets with higher volatility above the target return, therefore the *risk of the portfolios also increases*. The share of investments in stocks (conventional and green)

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<sup>4</sup> The UPM/LPM algorithm take into consideration the asymmetry and kurtosis of assets return. While positively skewed return distributions are generally more desirable to investors (due to the likelihood the large gains to cover the regular small losses), negatively skewed assets are considered riskier. Thus, as the degree of risk aversion increases, the portfolio selection model chose assets with a positive and penalize assets with a negatively skewed distribution. In addition, assets with high positive kurtosis are more likely to have returns in the “tails” of the distribution, so they are considered riskier. Therefore, as the degree of risk aversion rises, assets with such characteristics become less attractive to investors.

and green CISs rise opposite to investments in bank deposits and conventional bonds in practice.

An additional set of efficient frontiers is derived when testing the effect of changing the benchmark return - a subjective choice of the investor. In the context of the utility function, the target return is interpreted as an inflection point that separates investor behavior according to attitudes toward upside potential and downside risk. Four target return levels are adopted (0%, risk-free return, inflation and the VOLIDEX index). Intuitively, a higher benchmark gives less possibility of being “beat”, therefore a higher benchmark leads to a lower investment performance ratio. Calculations confirm the stated logic. Keeping the other parameters unchanged, the highest is located at the efficient frontier with the lowest target return – 0, and vice versa, the efficient frontier at the target return on VOLIDEX value is positioned the lowest. Given that the risk-free interest rate and the rate of inflation are close to zero, the efficient frontiers of these return targets lie in the middle. Notably, as the target return increases, and moving up the efficient frontiers, *green instruments take up an ever more tangible share of the efficient portfolios*, starting from 4.58% in the lowest-risk range to 95.08% in the highest-yielding one.

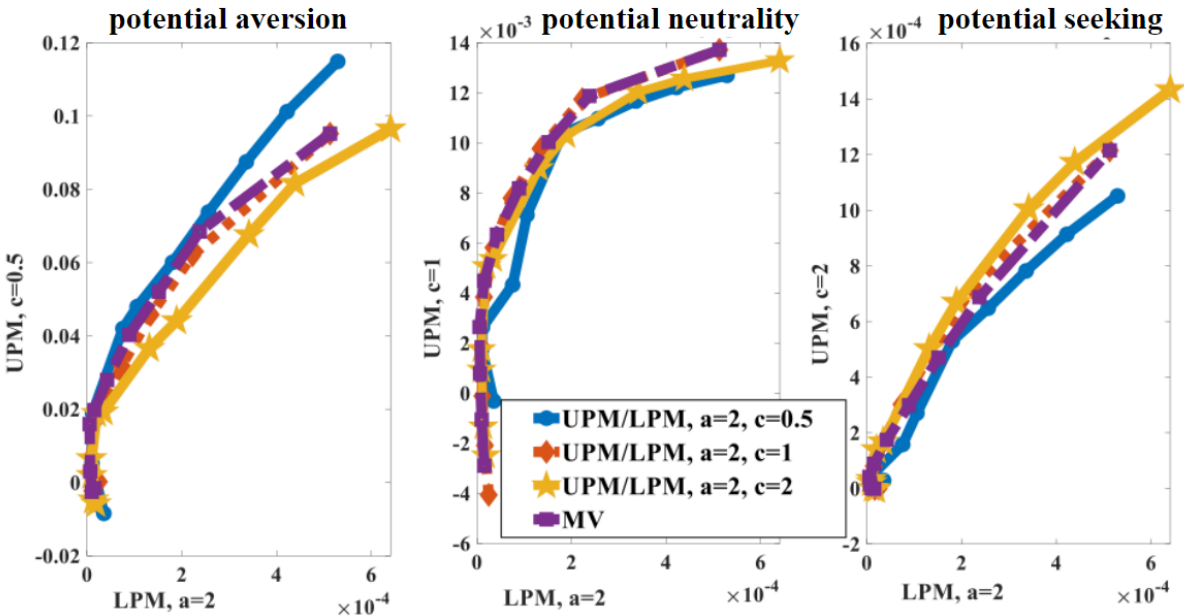
The panoramic view of the efficient portfolio structures generated by the potential-neutral and potential-seeking optimization shows that potential-neutral investors generally maintain higher weights in bank deposits and conventional bonds and lower asset weights in green investments (dominated by stocks and CISs), especially in the lower range of the efficient frontiers. At the upper end of the efficient frontier, potential-neutral investors should generate their portfolios primarily from traditional stocks compared to potential-seeking investors whose portfolios are dominated by green stocks. However, the levels of green assets would define potential neutral investors as “*medium*”, even “*dark green*”.

The considered cases when investors are simultaneously averse to both downside risk and upside potential, are emblematic of the *most conservative investment approach*. Contrary to expectations, this type of investment policy has the potential to generate quite “proper” annual returns, reaching up to 18.47% at the highest point of the efficient frontier. The change of the risk aversion degree logically leads to different portfolio structures, but it is interesting that even with the most conservative risk policy, green investments not only have a place in investment portfolios, but *should take a significant part from them or even to dominate*.

To compare the results of the two optimization models in the context of the risk-reward relationship, the efficient frontiers are generated sequentially in the MV and UPM/LPM region and different coordinate systems. It is logical to assume that optimal

solutions in a given coordinate system appear inefficient in another due to the variety of utility functions that different optimization tasks generate. If the efficient frontiers are located in a “mean – variance” frame, then MV dominates over the other frontiers. Closest is the UPM/LPM frontier ( $a=2, c=1$ )<sup>5</sup> as the objective function approaches that of the MV model. More distant is the efficient frontier for risk-averse potential-seeking investors, while the UPM/LPM frontier ( $a=2, c=0.5$ ) has areas where it is convex relative to the standard deviation.

Looking at the efficient frontiers in the UPM/LPM framework ( $a=2, c=0.5$ ) (Fig. 1), it is noticeable that they are all concave functions of the risk parameter. As expected, the efficient frontier typifying conservative investors is positioned highest, while that of aggressive investors is positioned lowest.



Source: Author's calculations.

**Fig. 1. Efficient frontiers in the UPM/LPM coordinate system for investors with different potential's attitude**

Although the UPM/LPM ( $a=2, c=1$ ) generally dominates its coordinate system, it should be noted that in some sections the UPM/LPM ( $a=2, c=2$ ) and MV frontiers duplicate its efficient frontier. Calculations show that individual portfolios (single cases) even outperform their potential neutral equivalents. The next panel of this figure again reveals four

<sup>5</sup> The “a” parameter reflects the attitude of the investor to risk and the parameter “c” to the potential. At  $a=2$ , the investor is risk averse. With  $c=0.5$  the investor is a potential averse,  $c=1$  is a symbol of a potential neutral investor,  $c=2$  – a potential seeking.

concave to LPM efficient frontiers. According to expectations in the UPM/LPM coordinate system ( $a=2$ ,  $c=2$ ) the front of the potential seeking investor is located highest and the most distant is that of the potential avoider.

Ultimately, the choice of a portfolio optimization model depends on the attitude and individual preference of the investor (the subjective perception of utility). The problem of optimal portfolio search extends beyond quantitative parameterization, as investors often complete the risk and return characteristics with their value considerations.

### **3. Possibilities for more successful portfolio “ecologization”**

The analysis of the global trend for sustainable and responsible investment among pension funds and the results of the empirical research highlight the *lack of an adequate strategy for incorporating* ESG factors into the investment process of the VPFs in Bulgaria. This can not only limit the possibilities of realizing high returns, but also generate significant risks for members and beneficiaries. Indeed, a lack of understanding of the impact of climate and ecological risks on the business environment in which institutions operate can seriously impair their ability to make informed strategic and business decisions. In such cases losses would be incurred not only by the beneficiaries, but also by other interested parties (incl. shareholders).

*A holistic approach for integrating* the sustainable dimension in the activity of Voluntary pension insurance funds *is most reasonable to be recommended*. Because any change requires time, resources and strong motivation, it is almost impossible to “switch” suddenly. Each stage of the “weaving” of the ecology/sustainable and responsible investment approach should be tied to realistic deadlines and goals. It is positive that the good practices of environmental leaders among pension funds are publicly disclosed, there are many support initiatives that Bulgarian pension funds can learn from, and VPFs belonging to large financial groups can take their ideas.

If several VPFs incorporate environmental determinants, it would be good to establish their own association. Pension funds could make efforts to build collaborative networks and provoke discussions on pressing issues by themselves, but this will lead to a greater expenditure of time, energy and resources and ultimately slow down the process. Of course, if the Bulgarian Association of Supplementary Pension Security Companies has desire, could also support the sustainability of private pension investments. Here are possible support channels:

- exerting systematic control and influence on the management of the investee companies (*corporate engagement and proxy voting*). It is necessary to develop company-

specific proposals, and on the other hand, to show sufficiently strong and constant pressure for change;

- conducting surveys regarding *customer attitudes* to sustainable and responsible investment approach, as well as forums that aim to popularize the approach among employers, employees and trade unions;
- conducting a dialogue with the Bulgarian Association of Asset Management Companies (BAAMC) and with the managers of Alternative Investment Funds (AIFs), who have the ability to develop *green investment products* suitable for pension portfolios (for example, CIS and AIF), which are currently lacking on the Bulgarian capital market;
- cooperation with the Bulgarian Association of Licensed Investment Intermediaries (BALII), which aims to identify measures to *develop the capacity of investment brokers* in the field of sustainable finance;
- deepening *cooperation with the BSE* and the non-profit organization Green Finance & Energy Center created by it;
- conducting dialogues with the Ministry of Finance and municipalities (in their capacity as issuers of state and municipal debt) regarding the desire and possibilities for issuing green bonds and/or developing standards and procedures to facilitate corporate debt issues;
- organization of trainings, round tables, seminars and conferences on the problems of sustainable investment of pension assets;
- conducting a series of events aimed at increasing the financial culture of the population.

Starting *initiatives for legislative and regulatory changes* by Voluntary pension funds, as well as their closer cooperation with the Financial Supervision Commission, could provide a strong impetus to incorporate sustainability, increase disclosure and prevent the greenwashing risk. The possibilities of changing the limit for investing in AIFs, allowing not only licensed but also registered funds, and allowing investments in growth markets (e.g. BEAM organized by the BSE) should be discussed.

The implementation and development of the sustainable and responsible investment approach by private pension funds in Bulgaria depends on many factors, which intertwine to form complex relationships. In addition to the already discussed exogenous motives and widespread risks and challenges, other determinants such as the *trust of the beneficiaries* in

the activities of the VPFs and ecological investing, the *financial culture* of the population and the *volume of investment resources* managed by the VPFs contribute to the specific “picture” in the country. The parameters of the environment can be improved if pension funds work diligently to improve their internal expertise; building a good reputation for recognizing VPF as a reliable and responsible partner in pension insurance and green capital investments; building active communication between the funds, on the one hand, and insurers and insured persons, on the other. Last but not least, pension funds should offer products that satisfy consumer needs. Pension schemes should be designed to reflect the risk tolerance, investment objectives, values and philosophies of the insured persons, especially in cases where the insured persons are not only the beneficiaries but bear overall investment risk. In this context, *the topic of a multi-pension organization is relevant again*, and VPFs can initiate new discussions and legislative changes.

Unpredictable events of recent years (pandemic and military conflicts) worry investors about the future of low-carbon sectors and the behavior of capital markets further. Although short-term measures addressed to pressing issues divert resources earmarked for environmental goals and loosen low-carbon transition benchmarks, the EU appears unwavering on its environmental future and envisages even more investments and higher targets for renewable energy and energy efficiency in the medium and long term. These actions aim using the new post-pandemic and geopolitical situation as *a lever to accelerate the development* of renewable resources in Europe and *achieve green strategic autonomy*. The future of green investment seems to be foreshadowed, so the question is what will be the role of VPFs in it.

## CONCLUSION

The results of the empirical study show that green investments *have the potential to improve the portfolio performance* of VPFs in Bulgaria and they can really take advantage of this opportunity. The optimization solutions generated by the two models (MV and UPM/LPM) outline the performance of the “light” and “medium” green portfolios as *fully competitive with the conventional portfolios*. It is noteworthy that green instruments are part of the efficient frontiers not only for potential-seeking investors, but also for neutral and potential-aversing investors.

And although VPFs’ relatively low interest in green assets can be interpreted as missing good opportunities, the more important problem is that whole categories of risks - environmental, social and governance - are almost (with few exceptions) not considered, *but are fully taken by the insured persons*.

In addition to better risk management and generating higher returns, the integration of the ecological investment approach by private pension funds in Bulgaria can also cause other positive effects, including: attracting the younger generation to Voluntary pension insurance; enhancing competition in the market; extracting competitive advantages over other financial intermediaries; increasing confidence in the system; generating a new incentive for the development of the Bulgarian capital market.

The choice of a sustainable and responsible investment policy should be accepted as a natural stage in the development of private pension investments with the aim of providing sustainable income for beneficiaries *in a world in which it is worth retiring*.

#### **IV. REFERENCE FOR CONTRIBUTIONS IN THE DISSERTATION**

1. The Bulgarian scientific literature is supplemented by the first of its kind comprehensive research on the possibilities for portfolio optimization of Voluntary pension funds in Bulgaria by inclusion of green investments.

2. An in-depth assessment of the investment policy and the importance of green assets for the portfolios of VPFs in Bulgaria are carried out. The potential for realization of ecological investments is outlined in the context of the regulatory investment restrictions and development of the capital markets.

3. The results of the empirical study are completely relevant for the portfolios of the VPFs in Bulgaria. The optimization solutions are fully subordinated to the current regulations and fit to many investor profiles, characterized by various utility functions.

4. Author scripts for formulating the objective function, incorporating restrictions and setting additional options are created in order to adapt the UMP/LPM algorithm to the specifics of the optimization procedure applicable to the portfolios of the VPFs operating in the country.

5. Based on the results of the analyzes and the conducted empirical research, a holistic approach for implementing the environmental dimension in the investment process of VPFs in Bulgaria is proposed.

#### **V. PUBLICATIONS RELATED TO THE DISSERTATION PAPER**

1. Beneva, M. (2017). The ESG determinants of private pension investments. – In: Proceedings of the Scientific Conference "Financial Science - Between Dogmas and Reality", 2017, pp. 129-145 (ISBN 978-954-21-0919-8).

2. Beneva, M. (2021). Impact of sustainable and responsible investment on the return of pension funds. – In: Proceedings of the Thirteenth Scientific Conference "Investments in the Future' 2021", 2021, pp. 187–193 (ISSN 1314-3719).

3. Beneva, M. (2022). Implementation of environmental factor in pension investments. //Dialogue, Issue 4, 2022, pp. 52-71 (ISSN 1311-9206 (online)).

4. Beneva, M. (2023). Private pension funds portfolio optimization with UPM/LPM algorithm //Economic and Social Alternatives, Volume 29, Issue 1, 2023, pp. 90-106 (ISSN (print): 1314-6556, ISSN (online): 2534-8965). Available at: DOI: <https://doi.org/10.37075/ISA.2023.1.07>

5. Beneva, M. (2023). Pension funds in the focus of green investments. - In: Proceedings of the 17<sup>th</sup> International Scientific Conference of Young Scientists "The Economy of Bulgaria and the European Union: Innovations and Transformation", 2022, pp. 307-316 (ISBN: 978-619-7622-31-7).

## **VI. DECLARATION OF ORIGINALITY**

I declare that this dissertation thesis is a completely author's product and that no external papers and publications were used in violation of their copyrights.