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Review of Ph.D. Dissertation by Mgr Xiaohong Xie Entitled
**“Optimal Investment Strategies and Risk Sharing in a Hybrid
Pension Scheme”**

Scientific Supervisor:
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1 Basis for Review

This review is based on a letter from the Chairwoman of the Council for the Scientific Discipline of Economics and Finance at Nicolaus Copernicus University, Prof. dr hab. Magdalena Osińska, dated May 28, 2024. The letter contains information about my appointment as a reviewer for the above-mentioned dissertation.

2 General Evaluation of the Dissertation

The dissertation under review focuses on the development of a hybrid pension scheme for China and Poland, along with the optimization of its input parameters. The author has undertaken an ambitious task, as both countries are facing challenges related to aging populations. This demographic shift presents significant challenges for pension schemes, particularly in terms of system balance (including risk management) and intergenerational equity.

In the introduction, the author defines the primary aim of the dissertation as: “the primary aim of this dissertation is to evaluate the effectiveness of hybrid pension schemes in managing demographic risks and maintaining financial sustainability in the face of aging populations.” This primary aim is then broken down into five specific objectives:

1. “To determine the impact of birth and mortality rates on long-run consumption under the hybrid pension scheme.”
2. “To compare the efficiency of traditional DB and DC pension schemes with the hybrid pension scheme.”
3. “To compare the results obtained for China and Poland from the demographic risk perspective.”
4. “To check the results for robustness by changing the key parameters.”



5. "To provide the pension policy recommendations for China and Poland."

It is worth mentioning that these five specific objectives effectively constitute the research plan, and indeed, these detailed aims contributed to achieving the main goal of the dissertation.

Next, the author formulates three hypotheses:

H1: "There is greater stability and flexibility in hybrid pension schemes, which combine features of DB and DC plans, compared to traditional pension models when confronted with demographic shifts and economic uncertainties."

H2: "There is superior performance in terms of risk management and sustainability in hybrid pension schemes, particularly in contexts characterized by varying birth rates and aging populations, compared to standalone DB and DC schemes."

H3: "There are significant differences in the suitability of pension models across different national contexts, influenced by unique demographic structures and policy frameworks."

The first two hypotheses are well-formulated and closely align with the main aim of the dissertation. However, I have some doubts about the third hypothesis. Countries inherently differ from one another, almost by definition, and thus their economic and social systems also vary. Consequently, there is no universal socio-economic approach that applies equally well to all countries. Therefore, the implementation of pension schemes must also vary, which makes the third hypothesis somewhat trivial.

A comprehensive evaluation of the dissertation's purpose, including its breakdown into specific objectives and research hypotheses, indicates that the author has set herself an ambitious task in both theoretical and empirical spheres. Moreover, the results of this work have (or at least should have) significant implications for policymakers in China and Poland in the field of pension security. To summarize this part of the review, I conclude that both the selection of the topic and its operationalization in the form of objectives, hypotheses, and research plan should be assessed very positively.

3 Manuscript Structure

The dissertation is divided into five chapters, preceded by an *Introduction* and followed by *Conclusion*, *Policy Recommendations*, *References*, *Appendix*, *List of Figures*, *List of Tables* and *List of Appendixes*.

In Chapter 1, titled "Characteristics of Pension Schemes," the author describes two main pension schemes encountered worldwide, with an emphasis on China and Poland, specifically in terms of literature review and empirical data characteristics. My only concern is with the titles of Sections 1.5 and 1.6, labeled "Facts of China Pension Scheme" and "Facts of Poland Pension Scheme." In my opinion the contents of these sections are better described as "stylized facts."

In Chapter 2, titled "Population Dynamics," the author analyzes the demographic situation and its main features, along with their implications for pension systems. It is important to note that the analysis is not focused on delivering summary statistics of publicly available data, but rather on modeling and forecasting birth and mortality rates. However, there are some instances

of awkward wording that could be misleading. On page 38 (top half of the page), the author claims that further analysis is presented in Sections 2, 3, 4, and 5, when it should be Sections 2.2, 2.3, 2.4, and 2.5. Additionally, at the very beginning of Section 2.2.1, the word “early” is used, but it seems it should be “late.” In Section 2.3.2, the author refers to “rotation” as proposed by Li et al. (2013), but this concept is neither explained nor outlined anywhere in the manuscript. Section 2.4 presents the results of numerical analysis, but there is a lack of summary statistics. Section 2.4.4 presents the results of simulations on population structure based on different birth rates, but there is no information on how these simulations were conducted. Despite these minor issues, it should be emphasized that the overall assessment of Section 2 is highly positive.

In Chapter 3, titled “Hybrid Pension Scheme Potential for Risk Reduction,” the author introduces the concept of a hybrid pension scheme and evaluates its potential for risk reduction and enhancement of intergenerational equity. This chapter is the most important part of the dissertation, as it discusses the combination of two “classical” pension schemes, namely Defined Benefit (DB) and Defined Contribution (DC) plans. The chapter includes a comprehensive literature review, with an outline of the “Overlapping Generations” (OLG) model, which serves as a starting point for later assessing the effectiveness of the proposed hybrid pension scheme. The model proposed by the author incorporates various elements such as demography, financial market dynamics, pension plan dynamics, risk preference modeling, and welfare evaluation. This represents the most significant scientific contribution of the dissertation (though not the only one). The model is holistic, as the author integrates models and methods from different fields of economics and finance. Although the overall assessment of Chapter 3 is highly positive, I have some minor remarks. On page 62, the abbreviation *INGENUE* is used (together with reference to Aglietta et al. (2007)), but there is no explanation of what it stands for. On page 71, the author introduces a “new” equation (3.19), but this is simply a repetition of an earlier defined equation (3.1). Section 3.3.6 discusses the optimization problem of the welfare (objective) function. While there is nothing inherently wrong with this, I would like to ask what would happen if the objective function is not “very concave,” i.e., if it is close to a flat surface. Can the employed optimization procedure handle such cases?

Chapter 4, titled “Optimal Investment Strategies—China Simulation,” and Chapter 5, titled “Optimal Investment Strategies—Poland Simulation,” present the results of hybrid pension scheme simulations for China and Poland. These two chapters are empirical in nature, where the author explains all the assumptions considered during different simulation scenarios. It is important to note that both chapters compile the results presented in Chapter 2 with the methodology developed in Chapter 3. The results demonstrate that hybrid pension schemes outperform DB and DC approaches in terms of certainty equivalent consumption (CEC) for both countries, regardless of the birth rate scenario. This is a clear advantage of the hybrid approach over the non-hybrid one. Despite these convincing results, I would like to raise some remarks related to the conducted simulations. I have some concerns that, in some cases, the hybrid approach yields worse parameters than the non-hybrid ones:

1. higher contribution rate (p) compared to DC: in the low birth rate scenario for China,
2. higher allocation to risky assets (ω) compared to DB: in the moderate birth rate scenario

for Poland.

For clarity of presentation, I would like to know the *minimal* and *maximal* distances between the lines in Figures 4.1, 4.5, 4.9, 5.1, 5.5, and 5.9. For both countries, the author utilizes 5,000 Monte Carlo iterations, which seems to be a relatively low number. (More concerning is that in the robustness analysis, only 1,000 iterations were employed.) Finally, I would like to ask whether, in the case of Poland, the retirement age (R) could be set to an average between 60 and 65 (as the retirement age for women and men, respectively) instead of a fixed age of 65. To summarize, I want to emphasize again that the overall assessment of Chapters 4 and 5 is highly positive.

The list of references consists of 118 items, covering all the areas addressed in the dissertation. As a result, both the number and selection of bibliographic items should be assessed positively.

The last chapter—Appendix—contains partial Python codes used in the simulation study. The positive aspect of this element of the dissertation is that it exists. However, I have some concerns regarding its content. As mentioned earlier in this review, I don't understand why only partial codes are provided, rather than the full code. My second concern is related to the environment used: the author did not specify which Python interpreter was used, the type of machine (architecture and operating system), and—most importantly—which versions of the pandas, numpy, sklearn, pmdarima, matplotlib, scipy, and skopt modules were used. These are critical details for replicating the results, regardless of the purpose.

4 Questions and Remarks

I would like to address the three most important questions, from my point of view, related to the dissertation:

- Question 1:** What would happen if the objective function (3.1) (aka (3.19)) is not “very concave,” i.e., if it is close to a flat surface. Can the employed optimization procedure handle such cases?
- Question 2:** In some cases, the hybrid approach yields worse parameters than the non-hybrid ones. Is this a weakness of the proposed hybrid pension scheme approach, or is it simply a result of the specific dataset used?
- Question 3:** Could the retirement age (R) be set to an average between the retirement ages for women and men instead of a fixed value?

In addition, I'd like to raise the following minor questions:

- page 9: There is a mention that “Bayesian Optimization” was employed, but the text does not explain what kind of method it is.
- page 11: It is stated that the Appendices provide “partial Python” codes with the Lee-Carter model. My question is, why weren't all the codes revealed?
- page 24: When discussing the range of individual contributions, there are no units or currencies provided.

page 43: Below equation (2.3), it is written that the r_x factor is “constrained between 0 and 1 for stationarity.” That is fine, but were the time series used actually stationary?

page 48: Table 2.1 presents *RMSFE* values for China and Poland mortality rate forecasts. I have two questions related to this:

- (a) Can the Diebold-Mariano test (Diebold & Mariano, 2002) be used here?
- (b) Can mortality rate forecasts from different models be pooled in some way (e.g., averaged)?

page 52-55: There are results of simulations for different birth rate scenarios, but how were these simulations conducted?

page 62: What is the *INGENUE* model, since it’s not explained?

page 79: Are 5,000 Monte Carlo iterations sufficient here?

page 98: Are 1,000 Monte Carlo iterations sufficient here?

5 Conclusion

I conclude that the reviewed dissertation meets all the requirements of Article 187(1) of the Law of July 20, 2018, on Higher Education and Science¹ in the field of *economics and finance* to an outstanding degree. Therefore, I recommend that the dissertation be accepted, admitted for public defense, and that the doctoral process for Mgr. Xiaohong Xie be allowed to proceed.

In addition, considering the thematic scope of the dissertation, its ambitious objectives, complexity, and the quality of the research conducted, I propose that Mgr. Xiaohong Xie be awarded an honorable mention. Furthermore, given the significance of this work for pension policy—not only in China and Poland but also in all countries characterized by aging populations—I recommend that the revised manuscript, after addressing the comments, be published in the form of a monograph.

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¹In Polish: art. 187 ust. 1 Ustawy z dnia 20 lipca 2018 r. “Prawo o szkolnictwie wyższym i nauce.”

