Stress testing pension funds—researchers present technique based on hidden Markov regime switching model

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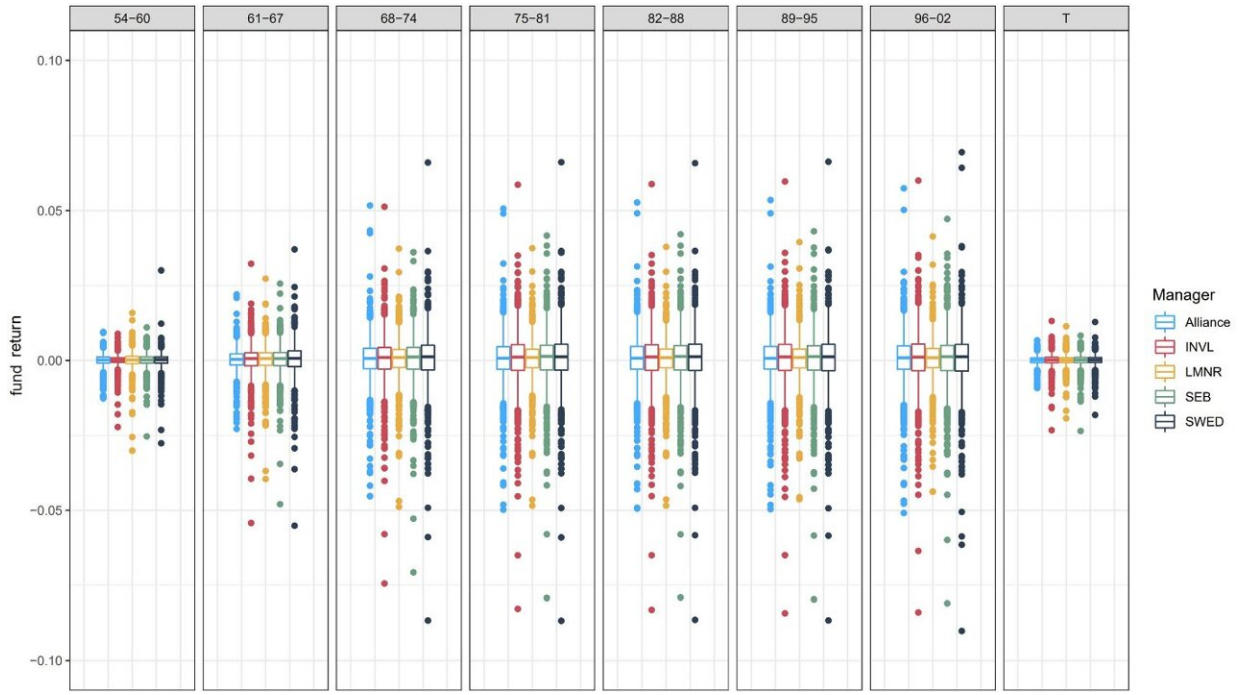

Distribution of returns of IInd pillar PFs. Manager is given in the legend, while the participant's birth-year is attributed to the title of image panel. The special case "T" stands for the asset preservation PFs. Credit: *Annals of Operations Research* (2024). DOI: 10.1007/s10479-024-06041-1

"We wanted to investigate how second pillar pension funds react to financial crises and how to protect them from the crises," says Kaunas

University of Technology (KTU) professor Dr. Audrius Kabašinskas, who, together with his team, discovered a way to achieve this goal. The discovery in question is the development of stress tests for pension funds. Lithuanian researchers were the first in the world to come up with such an adaptation of the stress tests.

Stress tests are usually carried out on banks or other financial institutions to allow market regulators to determine and assess their ability to withstand adverse economic conditions.

According to the professor at KTU Faculty of Mathematics and Natural Sciences, this innovative pension fund stress testing approach will benefit both regulators and pension fund managers.

"Making sure your pension fund is resilient to harsh financial market conditions will help you sleep better, save more, and have increased trust in your funds and the pension system itself," Kabašinskas adds.

Results based on two major crises

First, the study needed to collect data from previous periods. "Two major events that shocked the whole world—COVID-19 and the first year of Russian invasion of Ukraine—just happened to occur during the project. This allowed us to gather a lot of relevant information and data on changes in the performance of pension funds," says Kabašinskas.

The Hidden Markov Model (HMM), which, according to a professor at KTU Department of Mathematical Modelling, is quite simple in its principle of operation, helped to forecast future market conditions in this study.

The paper is published in the journal *Annals of Operations Research*.

"The observation of air temperature could be an analogy for it. All year round, without looking at the calendar, we observe the temperature outside and, based on the temperature level, we decide what time of the year it is. Of course, 15 degrees can occur in winter and sometimes it snows in May but these are random events. The state of the next day depends only on today," he explains vividly.

According to the KTU researcher, this describes the idea of the Hidden Markov Model: by observing the changes in value, one can judge the state of global markets and try to forecast the future.

"In our study, we observed two well-known investment funds from 2019 to 2022. Collected information helped us identify that global markets at any given moment are in one of four states: no shock regime, a state of shock in stock markets, a state of shock in bond markets, and a state of global financial shock—a global crisis," says Kabašinskas.

Using certain methods, the research team led by a professor Miloš Kopa representing KTU and Charles University in Prague found that these periods were aligned with the global events in question. Once the transition probabilities between the states were identified, it was possible to link the data of pension funds to these periods and simulate the future evolution of the pension funds' value.

That's where the innovation of stress testing came in. The purpose of this test is to determine whether a particular pension fund can deliver positive growth in the future when faced with a shock in the financial markets.

"In our study, we applied several scenarios, extending financial crises and modeling the evolution of fund values over the next 5 years," says a KTU researcher.

This methodology can be applied not only to pension funds but also to other investments.

Example of Lithuanian pension funds

The research and the new stress tests were carried out on Lithuanian pension funds.

Kabašinskas says that the study revealed several interesting things. Firstly, on average, Lithuanian second pillar pension funds can withstand crises that are twice as long.

"However, the results show that some Lithuanian funds struggle to cope with inflation, while others, the most conservative funds for citizens who are likely to retire within next few years or who have already retired, are very slow in recovering after negative shocks," adds the KTU expert.

This can be explained by regulatory aspects and the related investment strategy, as stock markets recover several times faster than bond markets, and the above-mentioned funds invest more than 90% in bonds and other less risky instruments.

A complementary study has also been carried out to show how pension funds should change their investment strategy to avoid the drastic negative consequences of various financial crises and shocks.

"Funds that invest heavily in stocks and other risky instruments should increase the number of risk-free instruments slightly, up to 10%, before or after the financial crisis hits. Meanwhile, funds investing mainly in bonds should increase the number of stocks in their holdings. In both cases, the end of the crisis should be followed by a slow return to the typical strategy," advises a mathematician.

Although the survey did not aim to increase people's confidence in pension funds, the results showed that Lithuania's second pillar pension funds are resilient to crisis and are worth trust. Historically they have delivered long-term growth, some have even outperformed inflation and price increases.

"Although short-term changes can be drastic, long-term growth is clearly visible," says KTU professor Dr. Kabašinskas. "Lithuania, by the way, has a better system than many European countries," he adds.

More information: Audrius Kabašinskas et al, Stress testing for IInd pillar life-cycle pension funds using hidden Markov model, *Annals of Operations Research* (2024). DOI: 10.1007/s10479-024-06041-1

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