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Pension Fund Investments under High Interest Rate Policies: A Panel Data Study of Capital Market Implications in the OECD Countries

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Abstract

This thesis implements panel data techniques to enlighten on the relationship between pension fund assets and market development in the OECD under demographic trends and on the asset allocation of those investors under high-interest rate policies. To investigate the relationships empirically, one-way random effects and panel vector autoregressive models (PVAR) with subsequent impulse response functions (IRFs) analysis are utilized. The findings reveal that there is a statistically significant positive relationship between assets backed for retirement and capital market growth, conditional on the level of market development. In addition, the relationship is amplified in the countries with a higher proportion of elderly population. The analysis of the dynamic relationship indicates that a shock to interest rates translates into a higher allocation of pension fund assets into fixed-income securities in a search for a higher yield, although when looking at a three-year horizon, the impact is significant with a delay. The findings of this thesis emphasize the importance of the development and regulation of pension systems for fostering financial stability and market growth, given the aging population trend in the OECD.

Key words: Pension funds; Capital market development; OECD; Panel data

Zusammenfassung

Diese Arbeit nutzt Panel-Daten-Techniken, um die Beziehung zwischen Pensionsfondsvermögen und Marktentwicklung in der OECD unter demografischen Trends sowie die Vermögensallokation dieser Investoren unter einer Hochzinspolitik zu beleuchten. Zur empirischen Untersuchung dieser Beziehungen werden Einweg-Zufallseffekte und Panel-Vektorautoregressive Modelle (PVAR) mit anschließender Impuls-Reaktions-Funktionsanalyse (IRF) verwendet. Die Ergebnisse zeigen, dass es einen statistisch signifikanten positiven Zusammenhang zwischen den für die Altersvorsorge bereitgestellten Vermögenswerten und dem Wachstum des Kapitalmarktes gibt, abhängig vom Grad der Marktentwicklung. Darüber hinaus verstärkt sich dieser Zusammenhang in Ländern mit einem höheren Anteil älterer Menschen. Die Analyse der dynamischen Beziehung zeigt, dass ein Zinsschock zu einer höheren Allokation von Pensionsfondsvermögen in festverzinsliche Wertpapiere führt, um höhere Renditen zu erzielen, wobei die Auswirkungen bei Betrachtung eines Dreijahreszeitraums mit einer Verzögerung signifikant sind. Die Ergebnisse dieser Arbeit unterstreichen die Bedeutung der Entwicklung und Regulierung von Rentensystemen für die Förderung der Finanzstabilität und des Marktwachstums angesichts der alternden Bevölkerung in den OECD-Ländern.

Schlüsselwörter: Pensionsfonds; Kapitalmarktentwicklung; OECD; Paneldaten

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1. Introduction

A pivotal institutional investor in the financial arena, with the power to influence market stability, efficiency, turnover, volatility, and development – all this describes pension funds that have collected large asset volumes in the recent years (Babalos & Stavroyiannis, 2020; OECD, 2024; Meng & Pfau, 2010; Thomas, Spataro, & Mathew, 2014). Entities managing pension funds have long established themselves in the markets, with a mean value of pension assets as a percentage of GDP across the OECD standing at 45%: from as low as 1% in Greece up to 198% in Denmark in 2023 (OECD, 2024). These assets designated for retirement are provided by public pension reserve funds (10.5% of total assets) and pension providers (89.5% of total assets) (OECD, 2024). By the end of 2023, they accumulated volumes of assets equal to USD 63.1 trillion, which is, however, still 5% below the 2021 levels due to the lasting negative repercussions of interest rate spikes (OECD, 2024).

With the growth of the pension system, its impact on economic and financial indicators has been investigated over the years in a diverse range of countries. The findings in the academic literature regarding the link between assets backed for retirement and capital market growth are twofold: from a positive effect of pension funds on market deepening (Alda, 2017; Babalos & Stavroyiannis, 2020; Bayar et al., 2022) to some analyses providing no evidence of an impact (Raddatz & Schmukler, 2008). As concluded, the results are heterogeneous due to the individual characteristics of the countries studied, such as legal origin and level of financial development, years collected, and methodological approaches (Meng & Pfau, 2010; Sun & Hu, 2014). Nevertheless, a consensus is reached among most quantitative analyses, namely that pension funds contribute to the development of capital markets through their long-term investment patterns (Alda, 2017; Babalos & Stavroyiannis, 2020; Bayar et al., 2022; Catalan, Impavido, & Musalem, 2000; Dibal et al., 2023).

Moreover, with the portfolio composition of pension investors being diverse among countries, an important behavior was discovered in the studies: considering the prolonged period of low and negative interest rates, pension fund managers tend to shift their allocation of assets to equities or other alternative investments, yielding higher performance (Boubaker et al., 2018). As outlined, a change in asset allocation can be driven by specific incentives: risk management considerations aimed at reducing risks and maintaining capital, risk shifting toward higher-yielding assets, and liability-driven strategies aimed at meeting long-term obligations of pension providers (Lucas & Zeldes, 2009; Rauh, 2009). However, the new dynamics introduced after an alteration to a tightening monetary policy, which promotes the reconsideration of asset allocation, still require a thorough investigation (Boubaker et al., 2018; OECD, 2024). A change in the portfolio strategies is believed to be prompted by a rise in rates, with fixed-income securities gaining their attractiveness back (OECD, 2024).

Concurrently, no studies focused on the period of interest rate hikes by Central Banks, unlike the long-term period of unconventional monetary policies in OECD countries, which is novel (Boubaker et al., 2018). At the same time, the pressure on the pension systems is aggravated by the continuous growth of the elderly population in OECD region (Alda, 2017; OECD, 2024). Therefore, questions of how such institutional players shape capital markets in the current environment of an aging population and how they adapt to the contractionary monetary policy arise (Alda, 2017; OECD, 2024). Addressing these gaps, the following research questions were developed:

Research Question 1*: What is the relationship between pension funds investment and capital markets development under current demographic trends in the OECD?*

Research Question 2*: How does a hike in interest rates impact the asset allocation of pension funds into fixed-income securities across OECD countries?*

To conclude, the objective of this work is to contribute to the literature by assessing the impact of pension funds under demographic trends and the asset allocation decisions of pension fund managers in an environment of elevated rates. To quantitatively analyse such questions, both static and dynamic relationship models were considered, utilizing panel data techniques for a dataset of OECD countries from the year 2001 to 2023. The model specifications and the detailed results with discussions can be found in the subsequent section of this thesis.

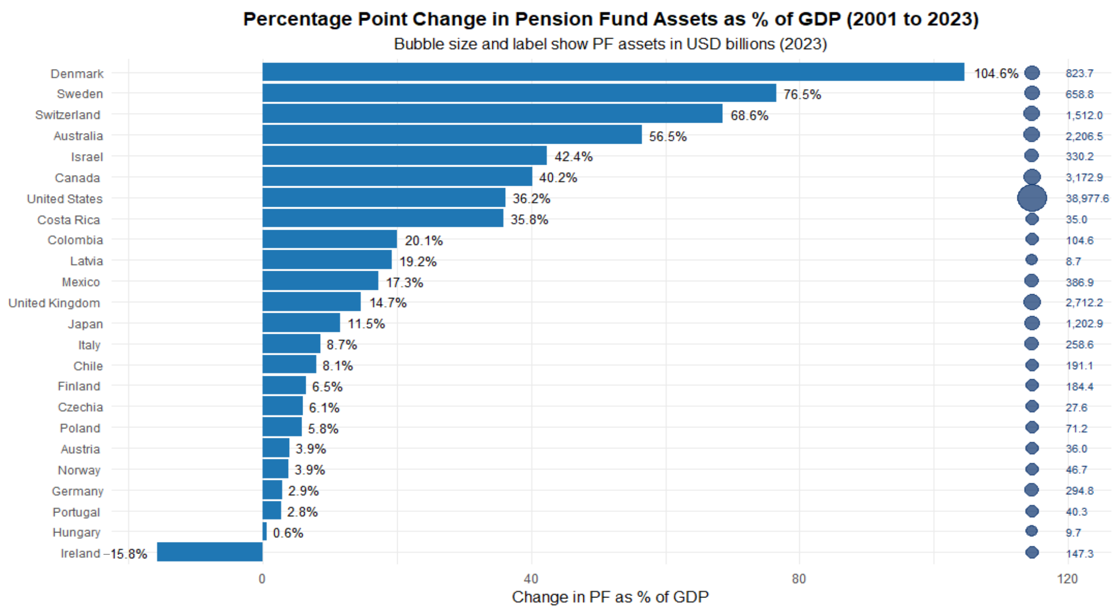
2. Pension markets in the OECD

2.1 Trends in the pension funds industry

In the past years, the pension funds industry has experienced substantial growth, with the projections of continuation of such a trend in the future (Thomas et al., 2014). The compound annual growth rate of assets from 2001 to 2023 is at the level of 6.2%, with the most significant downturns in 2008 (-5.3 trillion USD), 2022 (-9.2 trillion USD) and growth in 2019 (+6.7 trillion USD), 2020 (+6.2 trillion USD) (OECD, 2024). The sharpest increase in assets over the last 20 years was documented in countries that introduced their pension systems recently (Latvia, Estonia, Türkiye), as mature and well-established pension arrangements translate into slowed flows of new members (OECD, 2024). The growing importance of pension funds is illustrated by the increase of pension funds as a percentage of Gross Domestic Product (GDP) in OECD countries from 2001 to 2023 in Figure 1: all countries except Ireland, where GDP was growing at a more immense pace, showed a positive percentage point difference, with Denmark doubling the initial values. The largest pension funds markets are in the United States, Canada, and the United Kingdom as of 2023.

Figure 1

Development of Pension Fund Assets in the OECD



Note: Data from Statistical Annex of Pension Markets in Focus 2024 (OECD, 2024).

Countries with negative results in 2023 were the ones also experiencing the most notable reduction in 2022, such as Portugal and Luxembourg (OECD, 2024). Moreover, as the leading European markets and the United States demonstrated one of the lowest returns in 2022, the break-even of returns was more difficult (OECD, 2024). When it comes to the compound annual growth (CAGR), the largest average annual growth rates for the years 2001-2023 were observed in Latvia, Costa Rica, and Colombia (OECD, 2024). These calculations confirm that the markets that were new or underdeveloped at the beginning of this century were prone to achieve the highest acceleration compared to already well-established pension systems (OECD, 2024).

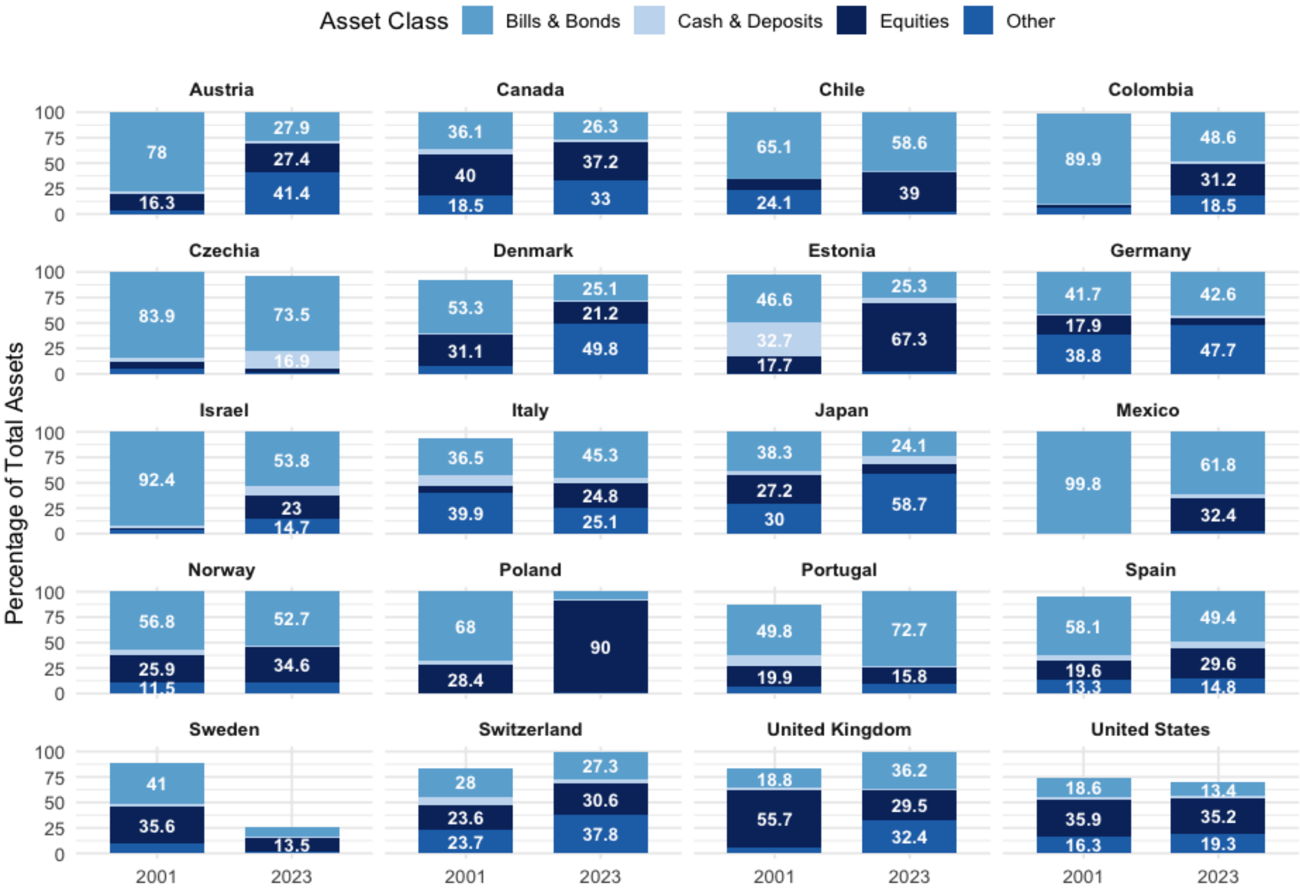
In terms of the real returns of asset-backed pension systems, on average, 4.8% returns were evidenced across the countries as the environment of either actual interest rate cuts or their expectations together with alleviated inflation pressures fostered an increase in prices in equity and bond markets in 2023 (OECD, 2024). Conversely, funds invested in real estate and unlisted equity experienced losses due to the performance of those asset categories (OECD, 2024). Hence, the composition of assets in pension fund portfolios plays a pivotal role in their performance. For instance, asset allocation with extensive overweighting of equities, which is the case of Poland, Lithuania, and Estonia, experienced one of the highest nominal returns in 2023 (OECD, 2024). In the long term, Latin American countries achieved the highest real average annual returns (OECD, 2024). In contrast, European countries and Türkiye experienced the lowest returns, mainly due to their conservative asset allocation strategies, as bond investment portfolios yielded lower returns compared to the diversified ones (OECD, 2024). In times of lower interest rates, which were persistent in the last decades, financial instruments with higher yields became more attractive, which shifted the average asset allocation of pension providers in OECD to equities, alternative investments, or foreign assets - the average share of assets invested in bills and bonds decreased from 52.4% in 2001 to 39.0% in 2023 (OECD, 2024). However, after the recent spike in interest rates, almost half of OECD pension providers increased their allocation in fixed-income securities from 2022 to 2023 (OECD, 2024). The most prominent outlier was Colombia (+12.5%), which had a focus on government bonds generating above-market returns (OECD, 2024). Figure 2 demonstrates how the asset composition of pension funds in OECD countries has changed in 22 years. Due to regulatory reasons, a steep increase in equities was evidenced in Poland (OECD, 2024). Likewise, significant growth occurred in Chile, Estonia, and Colombia. On the other hand, in the United

Kingdom, Italy, and Portugal the share of assets invested in fixed-income securities has accelerated. Therefore, OECD countries exhibit a heterogeneous asset composition of pension funds: from a focus on other securities to a substantial proportion of equities.

Moreover, the participation rates in pension plans increased throughout the decades due to automatic enrollment programs, different educational campaigns, incentives, and mandatory plans (OECD, 2024). Additionally, the growth of contributions was fostered by rising employment, inflation, and nominal wages, as well as the easing of mandatory contribution rates (OECD, 2024). Nevertheless, existing negative excess of contributions over benefits and other expenses paid might be caused by versatile reasons: early withdrawals in turbulent times, changes in the mandates on contributions, transfer of assets to pay-as-you-go (PAYG) systems. (OECD, 2024). However, such negative rates were evidenced only in the minority of OECD countries at the end of 2023 (OECD, 2024).

Figure 2

Asset Allocation of Pension Funds in the OECD: 2001 versus 2023



Note: Data from Statistical Annex of Pension Markets in Focus 2024 (OECD, 2024).

2.2 Impact of pension fund investments on capital markets

The versatile channels of the impact of pension fund investments on society have been academically studied and quantitatively proven, from the effect on saving behavior to financial stability, capital market efficiency to economic growth (Apilado, 1972). The findings that pension investments foster stock market development and financial health of the countries, reduce stock market volatility by acting as marginal investors with superior access to information, and have positive repercussions on personal and national savings are evidenced in the academic literature (Alda, 2017; Babalos & Stavroyiannis, 2020; Sun & Hu, 2014; Thomas et al., 2014; Xue, He, & Hu, 2021). The findings are present for a diverse group of countries: from regions in Europe to Asia and South America (Alda García & Marco Sanjuán, 2016; Babalos & Stavroyiannis, 2020; Hu, 2012; Meng & Pfau, 2010). The researchers working in this field have found mixed results depending on the characteristics of countries, and their legal and financial systems.

The focus of studies was diverse: OECD countries (Babalos & Stavroyiannis, 2020; Catalan et al., 2000; Hu, 2006; Meng & Pfau, 2010; Thomas et al., 2014), European countries (Alda, 2017; Alda García & Marco Sanjuán, 2016), Asia-Pacific (Hu, 2012), emerging economy countries (Bayar et al., 2022; Dibal et al., 2023; Raddatz & Schmukler, 2008). Alda (2017) elaborated on the positive effects of pension investments on stock market development in European countries, while utilizing the ratios of different age proportions as interaction terms, arguing that the rising ratio of elderly people to the working-age population can decrease these positive effects. Babalos and Stavroyiannis studied heterogeneous groups of countries separately, confirming the existence of positive effects on stock market development in Nordic, Southern European, Anglo-Saxon, and Eastern European countries, albeit Continental Europe (2020). Moreover, the distinguishment was done to isolate the effects of pension funds focusing on domestic stocks in eight European countries, with results advocating for a larger influence on short-term market characteristics, such as size, efficiency, stability, and liquidity (Alda García & Marco Sanjuán, 2016). Additionally, Hu (2012) concluded that there is a positive link between pension funds and market capitalization in the Asian-Pacific region, with a negative impact on the banking industry growth. Besides that, the researcher has classified bond markets into private and public ones, with only the first one being positively affected by pension fund assets as private bond issuance depends on the maturity of the financial market rather than the government's fiscal position and issuance decisions (Hu, 2012). Catalan et al. (2000) studied the relationship in OECD countries, concluding that the causality runs in one direction from contractual savings, which constitute assets of pension and insurance companies, to market development in Germany, Finland, Canada, Spain, Netherlands, Belgium, and the United Kingdom. Additionally, for Norway and Portugal, Granger causality runs in two directions (Catalan et al., 2000). Focusing on the emerging markets, the cointegration analysis demonstrated the existence of a positive effect of pension funds on market deepening in countries such as South Africa, Chile, Indonesia, the Korean Republic, and the Philippines in the long term (Bayar et al., 2022). The positive contribution is attributed to the nature of pension fund investments, encompassing a long-term investment horizon, reduction of asymmetric information and volatility, and stimulation of development and innovation (Bayar et al., 2022). Alternatively, a study of Chilean pension funds between 1995 and 2005 by Raddatz and Schmukler concluded that the effect of pension investments on stock market development was insignificant (2008).

The financial development of the studied countries is vital for analyzing both short-term and long-term effects on financial markets (Hu, 2012; Meng & Pfau, 2010). Emphasis was made on the heterogeneity of impact during different financial development stages: no long-term positive effect on efficiency measured by turnover ratio was evidenced in less developed economies in Asia (Hu, 2012). Hence, the development of the financial system is integral to the transmission of the impacts of assets for retirement growth on market efficiency (Alda García & Marco Sanjuán, 2016). Well-established and developed markets foster the rapid incorporation of information and provide immediate effects, hence demonstrating significant short-term evidence (Alda García & Marco Sanjuán, 2016). On the other hand, Hu (2012) claimed that liquidity and market capitalization are impacted by the pension funds' growth primarily in less developed economies. The positive impact on liquidity is attributed to the periodical rebalancing strategies of portfolios with high volumes, which results in elevated market activity (Alda García & Marco Sanjuán, 2016). In the case of less developed countries, this is attributed to the limited market depth, maturity, and inability to absorb irrational trading consequently fostering more pronounced positive effects in those markets (Hu, 2012). Conversely, according to Meng and Pfau (2010), for the OECD countries with lower levels of financial development, smaller or not statistically significant coefficients were obtained for the effects of pension funds on market size and liquidity in equity and private bond markets. On the other hand, both the long- and short-term effects of pension fund investments on capital market growth in Nigeria were evidenced using monthly time series and employing the autoregressive distributed lag (ARDL) model (Dibal et al., 2023). These recent results disproved the findings of Meng and Pfau (2010) while utilizing more recent data and focusing on Nigeria.

In addition, short-term and long-term effects were distinguished in the analysis of Alda García and Marco Sanjuán (2016). Unlike in the previous study by Hu (2012), the authors concluded that in the short-term, liquidity, turnover, and market capitalization coefficients are significant and positive for examined European countries, which might be due to the discrepancies of the markets examined in two analyses (Alda García & Marco Sanjuán, 2016). The conclusion that pension fund investments in domestic equities facilitate stability and development of the stock market to a greater extent in the short term was drawn, with a bidirectional causal relationship between pension funds and stock markets (Alda García & Marco Sanjuán, 2016).

Sun and Hu (2014) focused on the legal origin and endowment hypotheses: the researchers argued that pension funds promote innovation, which, together with an improvement of regulatory systems, can positively affect financial development. The study further elaborated that the growth in pension fund assets augments the development of capital markets to a larger extent in underdeveloped economic systems and non-common law countries (Sun & Hu, 2014). It was also evidenced that the effect of pension funds on the capital market is more pronounced and lingering than the effect of changes in GDP per capita on market development (Sun & Hu, 2014).

Moreover, the negative relationship between the share of pension funds invested in equities and market volatility for a panel of 34 OECD countries was proven, specifying also that the prudent management of pension funds and long-term mandates foster a decrease in conditional and unconditional volatility, unlike the mutual fund investments (Thomas et al., 2014; Xue et al., 2021). Focusing on global markets, Xue et al. (2021) identified that, unlike mutual funds, pension funds have a positive impact on stabilizing the country-specific market risk for both emerging and developed markets, suggesting that the continuous growth of pension assets is a vital component of a country's financial health. Diminishment of volatility is attributed to the stabilizing behavior and lower level of noise trading, with evidence from a panel of 34 OECD countries from 2000 to 2010 (Thomas et al., 2014).

To conclude, diverse studies have been conducted in the field from the last century to the current date. While utilizing different econometric methods, diverse regions, and time frames, a relationship between pension fund assets and capital market development was analyzed, with the majority concluding that pension fund assets have a positive effect, which translates into financial stability and growth. Table 1 illustrates a summary of the studies mentioned in this section, sorted by the date published, and provides details on the time frame, the region, the methodology, and the results of each of the main studies conducted so far and related to the topic of the current analysis:

Table 1

Summary of related literature (2000-2023)

Authors	Time Frame	Geographic Region	Methodology	Results
Catalan et al. (2000)	1975–1997	14 OECD and 5 developing countries	Granger causality tests	Causality runs from contractual savings to market capitalization, stronger for developing countries.
Hu (2006)	1960–2004	16 OECD and 8 emerging markets	Panel error correction model	Pension asset growth linked to stock price increases and volatility.
Raddatz and Schmukler (2008)	1996–2005	Chile	Panel data regression models	No significant evidence of pension funds contribution to market development.
Meng and Pfau (2010)	Avg. 18.5 years per country	32 developed and emerging market countries from the OECD database	Panel data regression models	Countries with high financial development have clearer benefits from the growth of pension funds on capital markets than low ones.
Hu (2012)	2001–2010	10 Asia-Pacific countries (grouped into more developed and less developed)	Panel error correction model	Strong positive link between assets of pension providers and market capitalization; different effects on turnover and market value traded.
Sun and Hu (2014)	1981–2009, 2001–2008	55 countries and regions	Cointegration test and error correction model, VAR model, panel data analysis with fixed effects model	Pension fund assets have a positive significant impact on financial development; effects larger for non-common law countries and underdeveloped financial systems.

Thomas et al. (2014)	2000–2010	34 OECD countries	Random-effects panel model and Prais–Winsten estimation	Volatility of stock prices decreases as investments of pension funds in equities rise.
Alda García and Marco Sanjuán (2016)	1995–2014	8 European countries	Granger causality test, Panel error correction model	Bidirectional relationship between share of pension funds in equities and market capitalization. Positive short-term impact on the market size, liquidity, return, growth, and activity. Long-term effect on market capitalization, return, and flows.
Alda (2017)	1999–2014	13 European countries	Panel data regression models	Positive relation between equity pension fund assets and market capitalization, supported by population size.
Babalos and Stavroyiannis (2020)	2001–2016	29 OECD countries further sub-divided in regions	Panel VAR model	Equities pension investments positively influence stock market development. Volatility is evidenced to have the largest contribution to future variations of retirement assets invested in equities.
Xue et al. (2021)	1995–2016	47 developed and emerging markets	Panel data regression models	Pension funds play a prominent role in reducing market volatility in both types of markets, whereas mutual funds have insignificant effect on emerging ones.
Bayar et al. (2022)	2004–2019	15 emerging economies, such as Brazil, Chile. China, Thailand, Turkey)	Westerlund and Edgerton bootstrap cointegration test, Augmented Mean Group (AMG) estimator, Dumitrescu and Hurlin's causality test	Causality analysis reveals significant effects of stock market development on pension funds in the short-term. Positive effect of pension funds on markets in the long-term for specific countries.
Dibal et al. (2023)	2013–2020	Nigeria	Autoregressive distributed lag (ARDL) model	Existence of long-run and short-run effects of pension investments on capital markets: negative for debt securities and positive for equities.

2.3 Asset allocation of pension funds

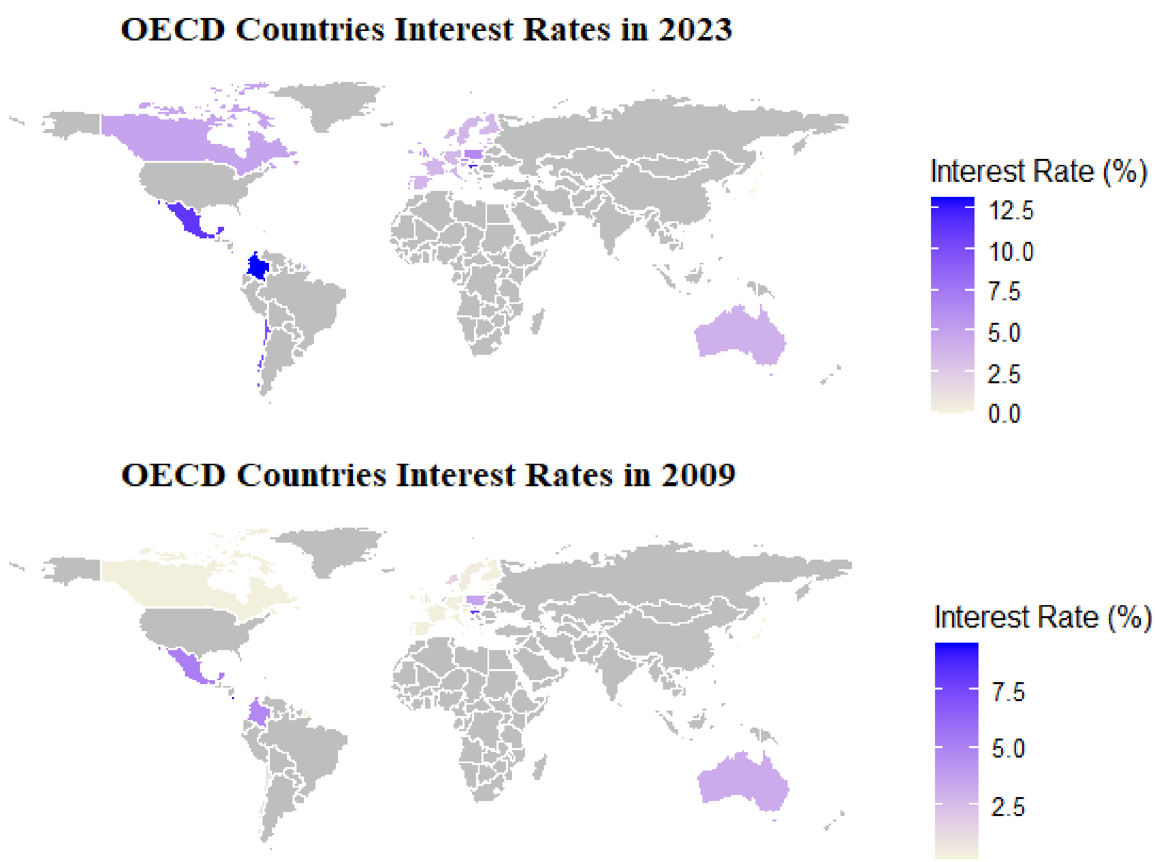
The topic of asset allocation of pension plan providers has attracted researchers hitherto (Boubaker et al., 2018, Lucas & Zeldes, 2009; Rauh, 2009). It was argued that asset allocation can be determined by the macroeconomic environment, risk management, and risk-shifting considerations (Boubaker et al., 2018; Lucas & Zeldes, 2009; Rauh, 2009). Rauh (2009) provided evidence that risk managing rather than risk-shifting is an incentive for an alteration in the asset allocation of funds designated for retirement – firms with strong credit ratings heavily allocate assets to riskier securities, whereas safer securities are selected by firms with poorly funded plans. Conversely, Lucas and Zeldes (2009) advocated that risk-shifting is the reason behind the change in asset allocation as a greater proportion of assets invested in equities, resulting in a higher return on assets, facilitates an accounting loophole for public pension plans because their liabilities are discounted based on the expectations of investment returns. The authors defined an asset allocation model for optimal investment of pension funds, where the function´s objective is to minimize the present value of distortionary taxes contingent on a funding constraint while taking into consideration the Modigliani-Miller assumption and relaxing the Ricardian equivalence (Lucas & Zeldes, 2009). The latter implies that investors can offset any allocation decision of pension providers in their individual portfolios, and the cost of distortionary taxes is incorporated (Lucas & Zeldes, 2009). Hence, the literature analysis reveals inconclusive findings regarding a definitive reason for asset allocation alteration in pension fund portfolios.

Recently, another reason for a change in asset allocation was examined, specifically, the monetary policy environment (Boubaker et al., 2018). The authors argue that persistently low interest rates, as well as unconventional monetary policies, increase equities allocation of pension funds in their search for premiums and enhance the level of risk-taking (Boubaker et al., 2018). This can be explained by the liability discount rate consideration: higher interest rates would facilitate the achievement of a substantial target return rate while lowering portfolio risk (Boubaker et al., 2018). Hence, during low interest rates and unconventional monetary policy times, reallocation to riskier higher-return asset classes would be observed (Boubaker et al., 2018). The effect of an increase in the share of equities is even more prominent during times of quantitative easing when interest rates are at zero bound level (Boubaker et al., 2018).

In the recent period, a wave of contractionary monetary policies due to the spike in inflation, triggered by the aftermath of lockdowns, asset purchase programs, and the ongoing war in Europe, has unfolded (OECD, 2024). While the general repercussions of expansionary policies on pension funds have been investigated, the effect of the current tight monetary policy is still to be examined closely. Figure 3 provides a visualization of a change in interest rates set by Central Banks in OECD countries, comparing 2009 and 2023 interest rate environments. In the year 2023, more countries have entered the darker blue zone, suggesting an increase in interest rates compared to the period of low interest rates after the financial crisis in 2008. The rates in EU countries accelerated from 0.31% in 2009 up to 3.63% in 2023. The highest rates in 2023 were observed for Columbia (13.13%), Hungary (12.44%), and Mexico (11.25%). The only country keeping negative interest rates from 2017 is Japan. Hence, such a shift in monetary policy in OECD countries fuels the research question of this thesis.

Figure 3

Change in Interest rates: 2009 vs 2023



Note: Data from World Development Indicators database (World Bank, 2025)

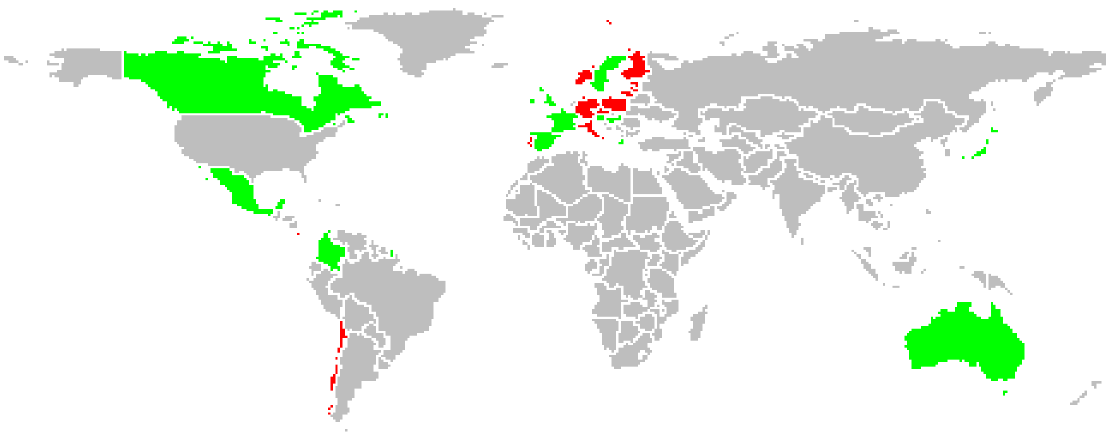
3. Dataset

3.1 Data overview

For the analysis, annual data were collected for the extensive period of 22 years, from 2001 to 2023. The data were sourced from the OECD pension statistics for pension-related variables and from the World Bank databases for demographic control variables, other macroeconomic indicators. Market performance indicators were calculated from the Morgan Stanley Capital International (MSCI) country equity index data for the net index levels. In summary, the dataset contains observations for 34 OECD countries over a period of 22 years for 18 variables. Among the explained variables are shares of pension fund assets in fixed-income securities and stock market development indicators (market capitalization (MC) to GDP). As for the explanatory variables, interest rates set by the Central Banks, GDP, Gross National Income (GNI), population ratios (over 65, between 15 and 64, age dependency ratio), stock market performance proxy (MSCI country index), total pension fund investments in USD, total pension fund investments to GDP, and public debt to GDP were collected. The OECD countries highlighted in green in Figure 4 were selected after cleaning the data of missing values for the main variables, such as public debt to GDP, to consider for the further analysis.

Figure 4

OECD members. Highlighted in green - used, red – excluded



3.2 Descriptive statistics

Table 2 provides an overview of the key macroeconomic and demographic variables for the selected OECD countries observed over a period of 22 years. The table illustrates the disparities in the weight of pension fund systems in different economies and the demographic trends. The leading country in terms of pension fund assets as a percentage of GDP over the period observed is Canada (137%), followed by the United States (127%) and Switzerland (121%). Conversely, Greece occupies the last place with only 1%, corresponding to 1 billion USD. The important variable to include in the analysis is public debt as a percentage of GDP, which indicates the level of the country´s debt sustainability and the possibility to meet financial obligations: from as low as 23% on average in Switzerland up to 167% in Japan. The most developed capital market is in Switzerland, while Hungary is lagging with 20% only, significantly below its European peer's average. Regarding demographic variables, proportions of working-age individuals (15-64) out of total population are demonstrating homogeneous results across countries, with an approximate value of 66%. On the other hand, the aging population phenomenon - measured by the proportion of people aged 65 years and above to the total population – was most evident in Japan (24%), whereas Colombia shows the lowest value (7%). In a similar way, the age dependency ratio is the highest for Japan, implying possible economic and social challenges.

Table 2

Summary of average statistics for the years 2001-2023

OECD Country	Pension Fund Assets	Pension Funds as % of GDP	GDP	Public Debt as % of GDP	Market Capitalization to GDP	MSCI Index Return	Population aged 65+	Population aged from 15 to 64	Age Dependency Ratio
Australia	1,288.9	106%	1,352.9	39%	109%	11%	14%	66%	22%
Austria	21.7	5%	438.1	82%	30%	11%	18%	67%	26%
Belgium	113.7	23%	534.3	101%	67%	7%	18%	65%	28%
Canada	2,162.8	137%	1,753.6	54%	121%	9%	15%	68%	23%
Colombia	51.0	18%	246.9	67%	43%	22%	7%	67%	10%
France	245.5	9%	2,730.5	85%	79%	6%	18%	64%	29%
Greece	1.1	1%	234.5	166%	36%	-2%	20%	65%	31%
Hungary	8.6	6%	149.7	80%	20%	12%	17%	68%	26%
Ireland	111.8	39%	320.8	66%	47%	5%	13%	67%	19%
Japan	1,394.5	28%	4,858.5	167%	89%	4%	24%	62%	40%
Korea	275.5	19%	1,506.2	40%	82%	14%	12%	72%	17%
Mexico	160.4	13%	1,201.1	44%	31%	11%	6%	64%	10%
Spain	169.4	13%	1,387.5	76%	73%	6%	18%	67%	27%
Sweden	357.3	68%	534.2	48%	84%	10%	19%	64%	29%
Switzerland	792.6	121%	697.1	23%	216%	8%	17%	67%	26%
United Kingdom	2,157.1	79%	2,861.9	131%	116%	6%	17%	65%	26%
United States	22,532.4	127%	19,808.1	85%	137%	8%	14%	67%	21%

Note: All values are averaged over the period 2001–2023. Pension Fund Assets and GDP values are shown in billions USD.

Data from Statistical Annex of Pension Markets in Focus 2024, MSCI and World Development Indicators database (MSCI, 2025; OECD, 2024; World Bank, 2025)

Table 3 illustrates additional variables and the key metrics for a group of OECD countries as of 2023. Table 3 summarizes the measures of central tendency (mean and median), dispersion (standard deviation), and position (maximum and minimum). The highest age dependency ratio in 2023 was in Japan and the lowest in Mexico, with an average for a sample of 34 countries standing at 29.8% and a standard deviation at 7.6%. A high dispersion in data is present for the ratio of pension fund assets to GDP in the OECD, as countries differ significantly in their state of economic and financial development. Mean and median values are similar for demographic variables, suggesting symmetricity of data and no significant skewness. Regarding the shares of different asset classes in the portfolio of pension fund investors, such as equities (ShareE), bonds and bills (ShareBB), cash and deposits (CD), and others (ShareO), the table provides evidence supporting the discrepancy in asset allocation among countries. The standard deviation is the highest for shares of equities and fixed-income securities. For instance, the share of assets in pension funds allocated to bonds and bills was as high as 76.9% in Costa Rica and as low as 7.1% in Poland in 2023. On the other hand, the highest share of assets allocated to equities was in Poland (90.0%) and the lowest was in Korea (0.1%). The explanation of such a difference in asset allocation lies in investment limits in regulatory frameworks and market characteristics of individual countries (OECD, 2024).

Table 3

Summary of descriptive statistics for 2023

Variable	Mean	Median	SD	Max	Min
AgeDependencyRatio	29.77%	30.6%	7.61%	50.28%	11.9%
PFUSD	1,655.1 Bn $	180.2 Bn $	6,747.8 Bn $	38,977.6 Bn $	1.5 Bn $
PFpercGDP	44.81%	19.54%	53.85%	198.09%	1.01%
Pop15to64	64.68%	64.64%	2.68%	70.69%	58.79%
Pop65plus	19.11%	20%	4.38%	29.56%	7.99%
ShareBB	39.9%	43.74%	19.55%	76.87%	7.08%
ShareCD	5.83%	3.26%	8.53%	47.64%	0.24%
ShareE	28.71%	27.44%	20.09%	90.02%	0.12%
ShareO	18.47%	14.73%	17.11%	58.75%	0.54%

Note: PFUSD = Pension Fund Assets; PFpercGDP = Pension Fund Assets as % of GDP; ShareE = Equities; ShareBB = Bills and Bonds; ShareCD = Cash and Deposits; ShareO = Other; Pop65plus = Population aged 65 and over; Pop15to64 = Population aged 15–64.

Data from Statistical Annex of Pension Markets in Focus 2024 and World Development Indicators database (OECD, 2024; World Bank, 2025)

Table 4 depicts a correlation matrix for the variables of interest, where Pearson coefficients are below the diagonal and Spearman coefficients are above. In addition, Figure 5 shows a correlation heatmap matrix to visually emphasize the sign and strength of correlation, from negative red (-1) to positive navy (+1). Firstly, an observation aligned with the literature is a positive correlation between public debt to GDP and the proportion of the population aged above 65 years (Bodnár & Nerlich, 2022). On the other hand, a strong negative correlation is observed between the same variable and the proportion of working-age population. Such a phenomenon can be explained by lower tax revenues and higher government expenditures on specific benefits for the elderly population (Bodnár & Nerlich, 2022). Moreover, the total amount of pension fund assets is positively correlated with GDP in both rank-based and linear terms. Regarding shares of different asset classes in pension funds portfolios, the correlation with interest rate is diverse: from negative for others, to no correlation for equities and positive for fixed-income securities. This simple correlation matrix gives a first perspective on the possible relationship between variables of interest, which will be studied in the next sections. The discrepancy between two types of coefficients is prominent between pension fund assets volumes and market capitalization to GDP, where Spearman coefficient (0.81) captures non-linear fit with the effects of outliers better.

Table 4

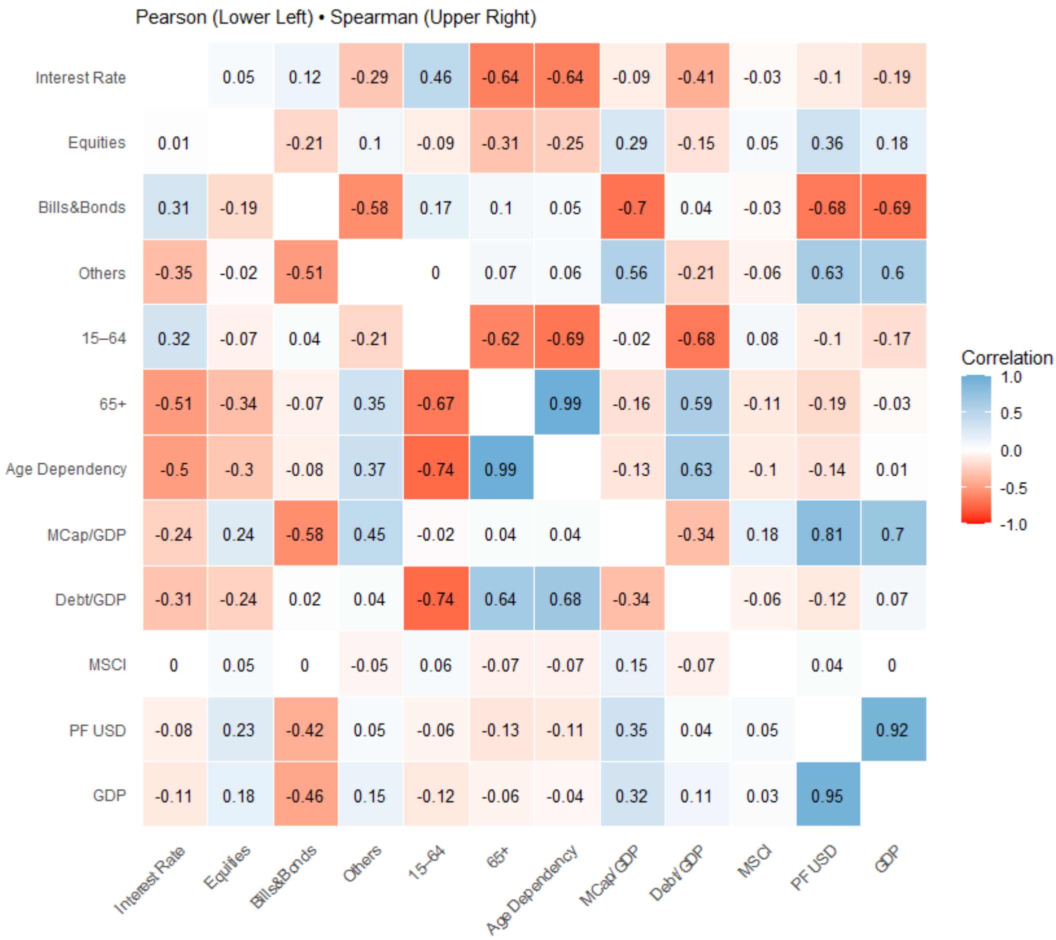
Correlation Matrix (Pearson Coefficients below the diagonal, Spearman Above)

	Interest Rate	Equities	Bills&Bonds	Others	15-64	65 +	MCap/GDP	Debt/GDP	MSCI	PF USD	GDP
Interest Rate	1.00	0.05	0.12	-0.29	0.46	-0.64	-0.09	-0.41	-0.03	-0.10	-0.19
Equities	0.01	1.00	-0.21	0.10	-0.09	-0.31	0.29	-0.15	0.05	0.36	0.18
Bills&Bonds	0.31	-0.19	1.00	-0.58	0.17	0.10	-0.70	0.04	-0.03	-0.68	-0.69
Others	-0.35	-0.02	-0.51	1.00	0.00	0.07	0.56	-0.21	-0.06	0.63	0.60
15-64	0.32	-0.07	0.04	-0.21	1.00	-0.62	-0.02	-0.68	0.08	-0.10	-0.17
65 +	-0.51	-0.34	-0.07	0.35	-0.67	1.00	-0.16	0.59	-0.11	-0.19	-0.03
MCap/GDP	-0.24	0.24	-0.58	0.45	-0.02	0.04	1.00	-0.34	0.18	0.81	0.70
Debt/GDP	-0.31	-0.24	0.02	0.04	-0.74	0.64	-0.34	1.00	-0.06	-0.12	0.07
MSCI	0.00	0.05	0.00	-0.05	0.06	-0.07	0.15	-0.07	1.00	0.04	0.00
PF USD	-0.08	0.23	-0.42	0.05	-0.06	-0.13	0.35	0.04	0.05	1.00	0.92
GDP	-0.11	0.18	-0.46	0.15	-0.12	-0.06	0.32	0.11	0.03	0.95	1.00

Note: Data from Statistical Annex of Pension Markets in Focus 2024, MSCI and World Development Indicators database (MSCI, 2025; OECD, 2024; World Bank, 2025)

Figure 5

Correlation Matrix Heatmap



Note: Data from Statistical Annex of Pension Markets in Focus 2024, MSCI and World Development Indicators database (MSCI, 2025; OECD, 2024; World Bank, 2025)

4. Panel data

4.1 Panel data characteristics

Panel data, which refers to the pool of observations on a cross-section of entities over multiple time periods, combines the properties of cross-sectional and time-series data (Baltagi, 2005). Among the well-known benefits are the ability to control for the state- and time-constant variables, more variability and more informative data, measurement of harder-to-detect effects, and complicated behavioral models (Baltagi, 2005). While panel data also has certain limitations, its advantages are facilitating the production of more reliable parameter estimates (Baltagi, 2005). A panel data regression can be written and explained in the following form according to Baltagi (2005):

$$y_{it} = \alpha + X_{it}^{'}\beta + u_{it} \quad i = 1, \ldots, N; \; t = 1, \ldots, T \qquad (1)$$

$$with\, u_{it} = \mu_i + \lambda_t + \nu_{it}$$

In the regression above, i and t stand for cross-section and time-series dimension accordingly. A scalar is denoted by α, regressors (X_{it}) are the *it*th observation on K explanatory variables with dim (c) = K. With the availability of multiple time series and *NT* data points, degrees of freedom increase unless α and β are allowed to change over time or vary across individuals (Baltagi, 2005). Hence, in order to proceed with panel data analysis, certain assumptions should be adopted, such as that the relationships are constant across the individual dimensions. For the disturbances, here a two-way error component is utilized, where μ_i stands for unobservable time-invariant individual effects, such as religion and demographics, whereas λ_t stands for unobservable time effects, such as trade policies and global economic crises, and ν_{it} captures remaining disturbance term (Baltagi, 2005).

One of the ways to estimate relationships for panel data straightforwardly would be the pooled OLS (Ordinary Least-Squares) estimator, which assumes homogeneity between individuals and ignores individual and time effects (Hsiao, 2014). However, if the assumptions of no correlation between the regressors and unobserved heterogeneity fail, the pooled OLS estimator would be biased and inconsistent (Hsiao, 2014). Should the individual-specific factors have an influence on the response variable, unobserved heterogeneity can appear, which would lead to the necessity to use random or fixed effects model accounting for it (Hsiao, 2014).

4.2 Fixed and random effects models

This section will focus on two different one-way models, accounting for individual effects. Fixed effects and random effects models are widely used in practice, where the first one assumes that parameters μ_i are fixed and the left v_{it} is stochastic disturbance - independent and identically distributed-, whereas the latter model treats μ_i as random so that both $v_{it} \sim$ IID (0, δ_{v}^2) and $\mu_i \sim$ IID (0, δ_{μ}^2) (Hsiao, 2014). For the random effects model, for all i and t, X_{it} are to be independent not only of v_{it} as in the fixed effects model, but also of μ_i (Hsiao, 2014). Hence, while the fixed effects model has limitations such as loss of degrees of freedom when including too many parameters, the random effects model characterizes individual effects as random, so that inference is made for the population based on a randomly drawn sample, which is the case for large household panels (Hsiao, 2014).

In the fixed effects model, dummy variables can be introduced to account for the two effects of omitted variables: time-invariant individual for cross-sectional units and specific to a particular time but common for all cross-section units (Hsiao, 2014). However, as N gets larger, so does the number of the individual dummies in an equation of interest, so that the estimation becomes computationally intensive (Baltagi, 2005). Hence, to circumvent this, an alternative approach of the within transformation is considered (Baltagi, 2005). An operation, where the individual effects are swept out as they are assumed to be time constant, so that deviation from individual means is zero, is implemented by multiplying the equation with a transformation matrix Q (Hsiao, 2014). While the matrix can be written as in equation 2, the transformation procedure is described as follows in equation 3:

$$Q = I_T - \frac{1}{T} e e' \qquad (2)$$

$$\begin{aligned} Q y_i &= Q e \alpha_i^* + Q X_i \beta + Q u_i \\ &= Q X_i \beta + Q u_i, \qquad i = 1, \ldots, N \end{aligned} \qquad (3)$$

Lastly, the OLS procedure can be applied, yielding the estimator of β:

$$\hat{\beta} = \left[\sum_{i=1}^{N} X_i' Q X_i\right]^{-1} \left[\sum_{i=1}^{N} X_i' Q y_i\right] \tag{4}$$

Hence, the obtained estimator is called the within-group one, as only that variation is utilized. The time-invariant individual effects will be eliminated, however, that implies that the fixed effect estimator cannot account for the effects of any constant variables, such as sex, or ethnicity (Baltagi, 2005). Moreover, an important detail is that as T → ∞, the estimator converges to its parameter value, whereas as N → ∞ with T being unchanged, the fixed effect estimators of the individual effects are not consistent as increase in the number of parameters is proportional to the increase in N - incidental parameter issue (Baltagi, 2005).

On the other hand, the random effects model assumes that factors not included in the regression but affecting the dependent variable are randomly distributed (Baltagi, 2005). The Generalized Least-Squares (GLS) estimation is applied to get efficient estimates under serial correlation so that it is a weighted average of the within – and between-group estimators, where the weight depends on the variance components of the errors (Baltagi, 2005). The transformation applied to a random effects model is: deducting a certain fraction $(1 - \psi^{1/2})$ of individual means from y_{it}, x_{it} , regressing $\left[y_{it} - (1 - \psi^{1/2})\bar{y_i}\right]$ on the second term and constant (Hsiao, 2014).

$$\psi = \frac{\sigma_u^2}{\sigma_u^2 + T\sigma_\alpha^2} \tag{5}$$

Hence, such computations allow to estimate both constant and time-variant variables since $\psi^{1/2}$ does not equal 0 (Hsiao, 2014). However, if both variance components are unknown, a feasible GLS procedure is applied where those components are estimated utilizing consistent estimators (Hsiao, 2014).

4.3 Hypothesis testing with panel data

The first question that arises when working with panel data is to pool or not to pool. To address it, two models are considered: restricted with identical parameters across entities, time, and unrestricted with different parameters (Baltagi, 2005). The presence of individual effects, time effects on top of them, or invariance of coefficients across individuals can be tested by comparing two models via Likelihood Ratio (LR) or Wald statistics (Baltagi, 2005). For example, the presence of individual effects is tested with the H_0: $\mu_i = 0, i = 1, \dots, N$, so that OLS is a null hypothesis and fixed effect is an alternative (Baltagi, 2005). Residual sums of squares are calculated for both models then to obtain an F-statistics (Baltagi, 2005). In case statistic is insignificant, individuals are assumed to be homogeneous, and the data can be pooled for the regression analysis so that no panel model is needed to be specified (Baltagi, 2005). Moreover, Baltagi (2005) specified an even more general test, with H_0: $\beta_i = \dots = \beta_N = \beta, \mu_i = \dots = \mu_N = \mu$. The rejection of the H_0 would imply either usage of some panel model or separate modeling of individuals. For testing the presence of random effects, with the help of the LR principle, the likelihood can be evaluated for the restricted OLS and unrestricted random effects-GLS (Baltagi, 2005). However, among the limitations is that an unrestricted model can require an estimation of a two-way model, which is cumbersome to obtain in practise (Baltagi, 2005). Hence, for the two-way random effects model, Breusch and Pagan suggested the usage of LM (Lagrange Multiplier) test for H_0: $\sigma_\mu^2 = \sigma_\lambda^2 = 0$, which approximates the LR test and where LM statistic is distributed as $\chi^2(2)$ (Breusch & Pagan, 1980). Nevertheless, this test also has drawbacks as it is built as a two-side test, whereas variance components are nonnegative, and is not suitable for a test of time effects in a random effects model with the presence of individual effects (Baltagi, 2005; Breusch & Pagan, 1980).

Moreover, an important test widely used in practice for model selection is the Hausman test (Hausman, 1978). Hausman´s specification test uses for its base a crucial assumption that regressors and errors terms are uncorrelated (Baltagi, 2005). In case $E\ (u_{it}|X_{it}) \neq 0$, the GLS estimator will be inconsistent and biased, whereas the within estimator eliminates individual unobserved effects and is hence unbiased and consistent (Baltagi, 2005). To exploit such facts, Hausman came up with an idea to compare two estimators, $\hat{\beta}_{GLS}\ and\ \tilde{\beta}_{Within}$, which have diverse probability limits in case H_0 is false but which are both consistent under the H_0 : $E\ (u_{it}|X_{it}) = 0$ (1978). This logic can be applied to different hypotheses testing tasks, where the specific m statistics is obtained, distributed under the H_0 as χ^2 and with the degrees of freedom equal to the dimensions of β (Baltagi, 2005).

$$m = q^{'}(varq)^{-1}q, \tag{6}$$

$$where\ \ varq = var\tilde{\beta} - var\hat{\beta}$$

Hence, in the case of interest of this thesis, the random effects GLS estimator cannot be applied in the fixed effects model, whereas the fixed effects estimator is consistent in both models (Baltagi, 2005). If the statistic is not significant, the GLS can be a preferred estimator (Baltagi, 2005).

Lastly, some other tests applied in this thesis are to be mentioned, such as tests for detecting heteroskedasticity, unit root, and cross-sectional dependence. Heteroskedasticity, which is described as a nonconstant variance across individuals and time in the regression disturbance, when neglected will result in inefficient estimates (Baltagi, 2005). Different versions of the Lagrange multiplier tests for the null hypothesis of homoskedasticity were developed for its detection (Baltagi, 2005). In case heteroskedasticity is present, the remedy is the usage of robust standard errors (Baltagi, 2005). Moreover, the presence of the unit root and cross-sectional dependence (CD), which might lead to the misleading results of the regression analysis, must be examined (Baltagi, 2005). Certain tests for unit root have as their alternative hypothesis a stationarity of each (Levin, Lin and Chu Test) or some (Im, Pesaran and Shin Test) time series and require the performance of the augmented Dickey-Fuller (ADF) regressions which account for a possible autoregressive process (Levin, Lin, & Chu, 2002; Im, Pesaran, & Shin, 2003). Additionally, in 2004, Pesaran suggested a test of CD, using an average of pairwise correlation estimates of the regression residuals, serving as proxies observable for the error terms (Pesaran, 2004). Hence, this test has at a target underlying correlation structure of errors and, unlike the standard Breusch-Pagan LM test, works well also for $N > T$ (Baltagi, 2005). In case detected, cross-sectionally augmented Dickey-Fuller (CADF) tests are implemented with a regression including a lag of the cross-sectional average and its first difference (Pesaran, 2007). Afterward, the cross-sectionally augmented Im-Pesaran-Shin statistic is calculated, averaging the $CADF_i$ to test for a presence of unit root, which is a second generation test (Baltagi, 2005; Pesaran, 2007). Hence, econometricians have a variety of tests developed so far for conducting meaningful research, however, they must be applied consciously.

4.4 Dynamic relationships in panel models

In economic research, dynamic relationships are ubiquitous, and specific models must be considered for studying their nature. In such a relationship, among the regressors are also the lagged dependent variables (Baltagi, 2005).

$$y_{it} = \delta y_{i,t-1} + X_{it}^{'}\beta + u_{it} \quad i = 1, \ldots, N; \ t = 1, \ldots, T \qquad (7)$$

When exploring the dynamic models, simple OLS regression methods are not appropriate due to the Nickell bias, as by eliminating the individual effects in a dynamic fixed effect model, new variables correlated with an error term by construction are generated: $(y_{i,t-1} - \overline{y_{\iota.-1}})$ (Nickell, 1981; Sigmund & Ferstl, 2021). As a solution, the application of a generalized method of moments (GMM) estimator was proposed in the 1990s, with two versions: first difference GMM using as instruments lags of the endogenous variables and system GMM estimator with add-on moment conditions (Sigmund & Ferstl, 2021). For a dynamic panel data analysis, a panel vector autoregressive model (PVAR) is considered, which is a combination of a vector autoregressive (VAR) one and a single equation dynamic panel model (Sigmund & Ferstl, 2021). Sigmund and Ferstl (2021) proposed a way to do a PVAR model with p lags of m endogenous variables, n strictly exogenous and k predetermined ones with a package in R. Afterward, impulse response analysis can be conducted, which deals with the response to an impulse, shock in (endogenous) variable, to some variables of interest (Sigmund & Ferstl, 2021). Impulse response functions, either orthogonal or generalized ones, can be plotted with the bootstrapped confidence intervals with the specific package in R (Sigmund & Ferstl, 2021). Unlike in the generalized impulse response analysis, in the orthogonal one the Cholesky-decomposition is applied so that an ordering of the variables is imposed and does matter for the analysis (Sigmund & Ferstl, 2021). Hence, the methods described in this section will lay a foundation for conducting an analysis for a panel of OECD countries.

5. Analysis

5.1 Capital markets development and pension funds growth

This analysis focuses on studying the relationship between capital market development and success of the pension fund systems in OECD countries. To conduct such an analysis, the following regression model is considered:

$$MarketCaptoGDP_{it} = \beta_0 + \beta_1 \, MSCI_{it} + \beta_2 \, PFUSD_{it} + \beta_3 \, GDI\_GDP_{it} + \beta_4 \, DebttoGDP_{it} + u_{it}, \tag{8}$$

$$\text{where } u_{it} = \mu_i + \lambda_t + \nu_{it}$$

Firstly, the dependent variable (*MarketCaptoGDP*) is the proxy for market development in the country, which is obtained by dividing the market capitalization of the stock market in country *i* and year *t* by the respective GDP. Secondly, MSCI stands for the stock market performance, where the index captures around 85% of the middle and large companies on the equity markets (MSCI, 2025). The third variable is the logged value of pension fund assets in USD, which reflects the size and strength of the certain financial system. The logged value is calculated to interpret the coefficients as semi-elasticities and reduce skewness: volumes of pension assets vary among the countries to a large extent (OECD, 2024). The last two ratios are related to the long-term economic growth and financial health potential, with the first one reflecting the domestic capital formation trends and the latter one the sovereign debt burden relative to the size of the economy. All the above-mentioned variables included in the model are widely used in academic literature addressing a similar research question.

Secondly, for the robustness check, the countries were divided into two categories depending on their level of capital markets development measured by *MarketCaptoGDP* variable - below or above the mean, calculated for the sample of OECD countries. The maturity of the financial system in a country was found to play a role in estimating the effect of pension fund assets (Meng & Pfau, 2010). As stated in the previous academic literature, more developed markets enhance the integration of pension systems and augment long-term investment dynamics, whereas less developed capital markets are prone to constraints and restraints on pension system development (Alda García & Marco Sanjuán, 2016; Meng & Pfau, 2010). Hence, the idea of this check is to explore whether the impact of pension funds is amplified depending on the level of market development.

Lastly, three demographic variables were interacted with the logged pension fund assets variable to study the effects of pension funds on market development under demographic trends. The variables included the age dependency ratio, which is the proportion of people aged below 15 and above 64 to the working-age population, the share of the elderly population, and the share of the working-age population to the total population. The relationship can be twofold. On the one hand, a larger proportion of the elderly population might reinforce the demand for pension instruments and enhance the prominence of pension funds for market development. On the other hand, the larger share of the working-age population facilitates contributions that expand the volumes of assets, hence adding to the development of a strong market. Therefore, it is of interest to explore how the demographic trends can moderate the role that pension fund assets play in developing the capital markets. To summarize, the hypothesis can be written as:

H1: Pension funds investment has an impact on market development in OECD countries considering the aging population.

$$MarketCaptoGDP_{it} = \beta_0 + \beta_1 MSCI_{it} + \beta_2 PFUSD_{it} * AgeDependencyRatio_{it} + \beta_3 GDI\_GDP_{it} + \beta_4 DebttoGDP_{it} + u_{it}, \tag{9}$$

$$MarketCaptoGDP_{it} = \beta_0 + \beta_1 MSCI_{it} + \beta_2 PFUSD_{it} * Pop15to64_{it} + \beta_3 GDI\_GDP_{it} + \beta_4 DebttoGDP_{it} + u_{it}, \tag{10}$$

$$MarketCaptoGDP_{it} = \beta_0 + \beta_1 MSCI_{it} + \beta_2 PFUSD_{it} * Pop65plus_{it} + \beta_3 GDI\_GDP_{it} + \beta_4 DebttoGDP_{it} + u_{it}, \tag{11}$$

Hence, to examine the relationship for 17 OECD countries observed over the period of 21 years, a panel framework was considered, with the heterogeneity among countries assumed to be present. One-way, two-way error component fixed effects and random effects models were applied to a cleaned dataset, as well as the simple pooled OLS as the starting point.

5.2 Asset reallocation after interest rate shock

The second part of the analysis addresses another research question, mainly if the increase in the interest rates affects the shares of pension fund assets allocated in the bills and bonds. For such a purpose, a panel vector autoregressive model, capturing the dynamic interdependencies while allowing for the feedback effects, was applied to a balanced panel. It was estimated with the two-step GMM estimator with the lagged levels as instruments. The forward orthogonal deviations were applied to efficiently get rid of the individual unit effects and preserve orthogonality (Sigmund & Ferstl, 2021). The optimal lag length was selected based on the procedure of Andrews and Lu, using 3 different information – criteria: Akaike, Bayesian, and Hannan-Quinn (Sigmund & Ferstl, 2021). The model and the hypothesis are presented below:

$$\begin{pmatrix} InterestRate_{i,t} \\ ShareBB_{i,t} \end{pmatrix} = \begin{pmatrix} \alpha_{1,i} \\ \alpha_{2,i} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix} \begin{pmatrix} InterestRate_{i,t-1} \\ ShareBB_{i,t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1,i,t} \\ \varepsilon_{2,i,t} \end{pmatrix} \quad (12)$$

H2: Higher interest rate policies lead to an increase in pension fund asset allocation in fixed-income securities.

Moreover, a dynamic effect of a shock in the variable, here interest rates, can be modeled and traced on the system over time. The IRFs analysis is essential to comprehending how the shock propagates to the allocated share. Hence, the GMM yields consistent estimates of the coefficients with the dynamic relationship and the IRF uses them to obtain responses to a shock in a variable, both instantaneous and prolonged in time. The analysis will focus on the time horizon of h=3 to observe how a one standard deviation (SD) shock to an interest rate affects the allocation of assets of pension fund investors in bills and bonds.

6. Results

6.1 Static random effects model with robustness check

After the diagnostic, the one-way random effects model was selected. Firstly, the F-test and the Breusch-Pagan LM test suggested the presence of individual effects (country-specific), so that simple pooled OLS model was not appropriate for the analysis. Moreover, the Hausman test failed to reject the null hypothesis (with $p=0.118$), so that the random effects model had to be considered. On the other hand, while time effects were also tested, they were not statistically significant, supporting the application of the one-way model.

Additionally, tests for heteroskedasticity and cross-sectional dependence were implemented. The statistics of both Breusch-Pagan and Pesaran CD tests were significant ($p<0.001$), leading to a conclusion that both heteroskedasticity and cross-sectional dependence are present. Given that, Driscoll–Kraay covariance estimators were used to adjust standard errors, so that estimators are robust to heteroskedasticity, cross-sectional dependence, and autocorrelation.

Moreover, the main dependent variable, market capitalization to GDP, was persistent for OECD countries studied, so second-generation unit root tests were applied to avoid getting misleading results (Baltagi, 2005). Such tests are applied where the evidence of cross-sectional dependence exists (Baltagi, 2005). Therefore, Pesaran's CIPS test with Hartung's correction was utilized, with the null of unit root rejected at the 1% level (Kleiber & Lupi, 2011). This correction is used to avoid the understatement of the variability of the ADF statistics when individuals in a panel move together (Kleiber & Lupi, 2011). However, when looking at each individual country isolated after cleaning the data ($N=10$, $T=17$), for some of them the rejection of the null hypothesis is not possible – with a restricted number of observations the test can have limited power. Such results also suggest that the panel analyzed is heterogeneous in the individual dimensions. While the analysis will proceed further by using levels, the sample will be divided into two groups to estimate a one-way random effects model separately on the subgroup and identify if the effect of pension fund assets on the development of the markets is robust. Additionally, simultaneity bias was addressed in the robustness analysis with the Hausman-Taylor (HT) estimator (Baltagi, 2005).

The results of the first one-way random effects regression model (1) for all the countries together with corrected standard errors are presented in Table 5. For this model, 287 observations were considered in total. The R^2 and the adjusted R^2 reported are around 20-21%. As can be noticed from Table 5, after the previously mentioned correction of the standard errors, only the coefficient for MSCI remained significant. The positive coefficient suggests that an increase in the return of the stock market index is associated with an increase in the size of listed equities volumes to national output, all else equal.

Secondly, the robustness check was completed, where the countries were divided into two groups based on their level of market development: above (2) or below (3) the mean. While the MSCI coefficient remains positive in both groups, it is twice as large for the group with the above mean market development level. Moreover, the pension fund size coefficient is positive and significant only for the group with a high level of market development. The level of the public debt to GDP matters for the countries with smaller markets, having a negative effect on the dependent variable. Lastly, the coefficient for GDI to GDP is not significant in models 1-3. Hence, pension fund assets have a positive and significant effect on the capital market development in larger markets only with eased market frictions and limitations, promoting growth of the system.

Table 5

Summary of 4 random effects (RE) models (for all OECD countries, for high and low market development groups, with endogeneity correction)

	Dependent variable:			
	MarketCaptoGDP			
	General One-way RE model	High MC/GDP	Low MC/GDP	RE-IV (HT)
	(1)	(2)	(3)	(4)
MSCI	0.336***	0.496***	0.189***	0.337***
	(0.070)	(0.111)	(0.038)	(0.042)
log(PFUSD)	6.817	11.442*	−0.468	5.633***
	(4.338)	(6.419)	(2.323)	(1.986)
DebttoGDP	−0.033	0.048	−0.094*	−0.016
	(0.063)	(0.074)	(0.050)	(0.054)
GDI_GDP	−0.545	−0.841	−0.093	−0.581
	(0.736)	(0.883)	(0.747)	(0.590)
Constant	53.706	31.925	54.767	73.808
	(49.950)	(63.370)	(78.102)	(62.204)
Observations	287	191	96	287
R^2	0.212	0.285	0.288	0.209
Adjusted R^2	0.201	0.270	0.257	0.198
F Statistic	77.350***	75.428***	34.031***	74.644***
Note:				*p<0.1; **p<0.05; ***p<0.01

According to the results, a 1% increase in the pension fund volumes leads to an increase in a proxy ratio for market development of 11.4 p.p. In model (1), the effect is diluted due to the heterogeneity. Lastly, an issue of endogeneity was accounted for because of potential feedback between *log(PFUSD)* and *MarketCaptoGDP*. The Hausman-Taylor estimator with instrumental variables (IV) was applied in model 4, which preserves the random effects structure and uses internal instruments (Baltagi, 2005). The significant coefficient for *log(PFUSD)* suggests that the relationship is robust even after a correction for endogeneity and is not guided by reverse causality. In this case, the effect is significant for the whole sample but less strong than for the developed countries.

Lastly, the demographic interaction terms were considered, to reflect the findings of Alda (2017) concerned with the effects of pension fund assets in light of the aging population trends. The results are summarized in Table 6, where models 5-7 are depicted: with the age dependency ratio, proportion of the working-age population, and elderly population to the total one. The Driscoll–Kraay SEs are written in parentheses. While MSCI return continues to have a positive impact on market development, the crowding out effect of public debt on market development is reflected in the statistically significant and negative coefficients of public debt to GDP in all three regression models.

Table 6

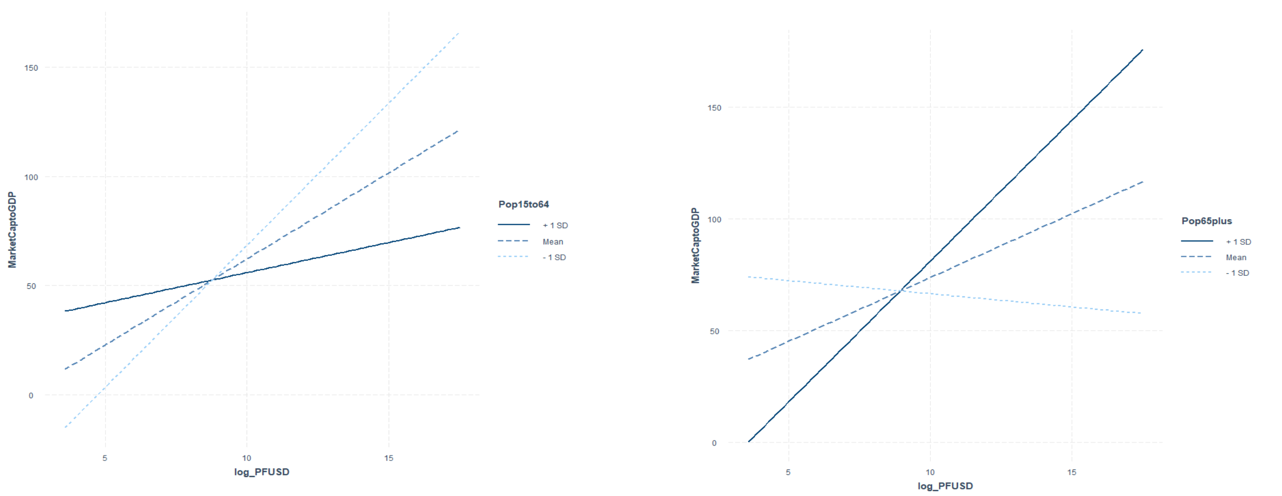
Random effects models with demographic interaction terms

	Dependent variable:		
	MarketCaptoGDP		
	AgeDependency	Pop15to64	Pop65plus
	(5)	(6)	(7)
MSCI	0.301***	0.294***	0.303***
	(0.071)	(0.068)	(0.072)
DebttoGDP	−0.389***	−0.362***	−0.367***
	(0.081)	(0.066)	(0.083)
GDI_GDP	0.665	0.965	0.377
	(0.856)	(1.019)	(0.865)
log_PFUSD:AgeDependencyRatio	0.832***		
	(0.225)		
log_PFUSD:Pop15to64		−2.100***	
		(0.432)	
log_PFUSD:Pop65plus			1.619***
			(0.468)
Observations	240	240	240
R^2	0.413	0.407	0.404
Adjusted R^2	0.398	0.392	0.389
F Statistic	164.305***	160.071***	158.399***
Note:			*p<0.1; **p<0.05; ***p<0.01

Regarding the interaction terms, in countries with higher ratios of elderly to the working-age population and elderly to the total population, the effect of pension fund volume growth on the market development is amplified (additional +0.8/1.6 percentage-point increase to the baseline effect). The economic intuition lies in the concept that larger ongoing payments in aging societies can boost transactions, expansion of capital markets and drive stronger equity market capitalization. Alternatively, the larger the share of the working-age population, the more the positive effect of pension assets deteriorates, as accumulation into the pension process is dominant, dampening an immediate effect on the stock market. Figure 6 visualizes how a relationship between pension fund investments and capital market development is moderated at 3 different standard deviation levels of demographic proportions. At a high working-age population share on the left chart (dark blue line), the slope is the flattest, hence, given a higher proportion value, the growth of pension funds has a smaller effect on the dependent variable than at a low working-age population level (the steepest dashed light blue line). On the other hand, for the share of the elderly to the total population on the right chart, the interpretation is the opposite, as the dark blue line is the steepest (+ 1 SD from the mean). This depicts the negative *log(PFUSD)×Pop15–64* and the positive *log(PFUSD)×Pop65plus* interactions.

Figure 6

Interaction terms relationship analysis



6.2 Dynamic panel VAR model and IRFs analysis

The second analysis of the dynamic relationship with the PVAR model yielded results depicted in Table 7. The balanced panel included 414 observations for each of the variables (*N=18, T=22*). All the coefficients are significant, except the lagged share of assets invested in fixed-income securities in the first *InterestRate* equation. As can be observed, there is a strong persistence of interest rate shock, so that it is carried over in the next period. On the other hand, previous values of pension fund volumes allocated to bills and bonds do not have a statistically significant impact on current rates set by the Central Banks. Secondly, in the *ShareBB* equation, its own lag is positive and statistically significant. The main interest of this analysis is the impact of interest rates on the share. The coefficient is positive and significant at the 5% level. Such a result implies that a shock to rates is associated with a 0.9 percentage-point increase in the share of assets allocated to bills and bonds. Such behavior can be explained by a search for higher yields by pension asset managers.

Table 7

PVAR (1) model

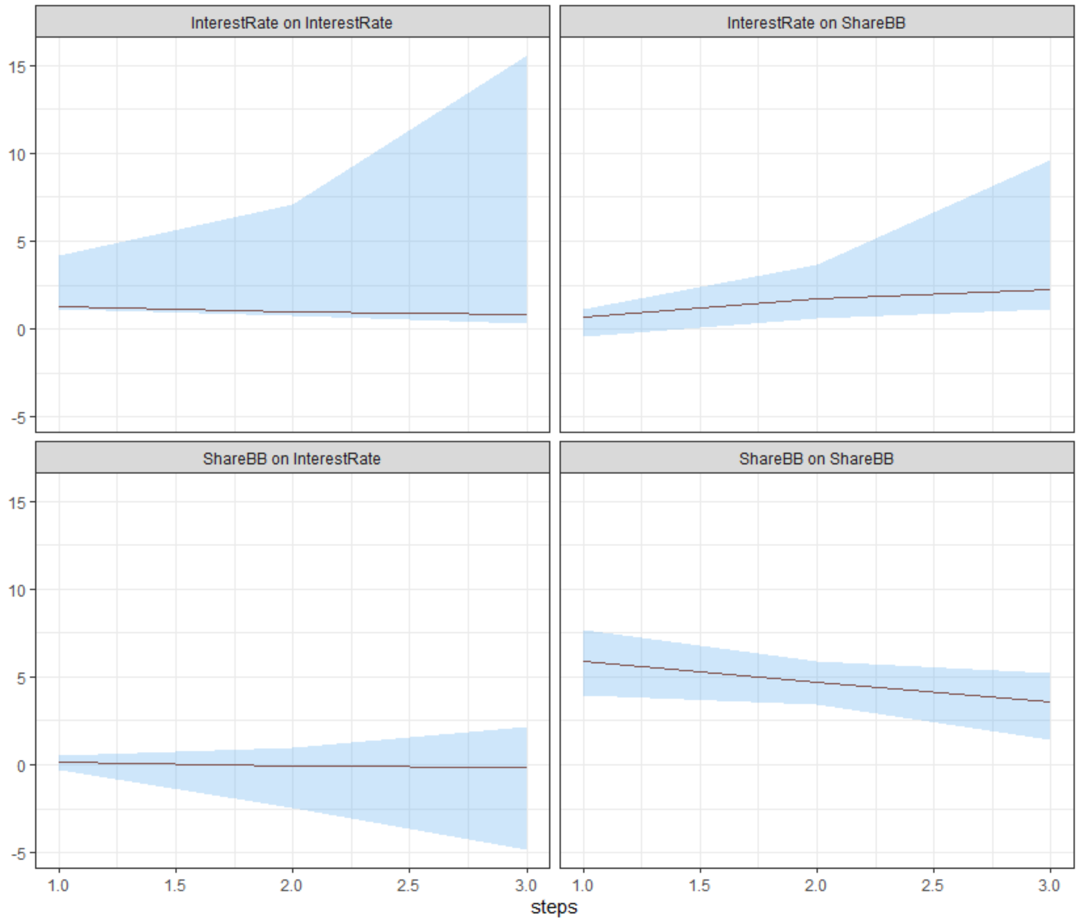
	InterestRate	ShareBB
lag_1(InterestRate)	0.828^{**}	0.920^{*}
	(0.297)	(0.387)
lag_1(ShareBB)	-0.027	0.772^{***}
	(0.038)	(0.103)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

The last part of the analysis included GIRFs with 95% confidence intervals with bootstrapping. The graph in Figure 7 illustrates how the shocks propagate through the period of 3 years on the variables of interest. Pension fund allocation to bills and bonds is persistent and sensitive to the rates. The 1 SD shock leads to an increase in share up to 2.5 percentage points in three years, with the results being significant only closer to the 2nd year. Hence, a meaningful response is shown with some delay as CI includes 0 in the first years. Lastly, as predicted, the share is persistent and the higher share at the current period translates into further increase with subsequent slowdown and deterioration - falling slowly from +6 to +3 percentage-points increase in three years. Hence, as investors rebalance their portfolios, they tend to hold to such a reallocation for a certain time. Assuming that the countries studied are heterogeneous, the IRFs are showing the smoothed averaged behavior, which might not reflect different responses that countries demonstrate.

Figure 7

Generalized impulse response function
GIRF and 95% confidence bands



7. Discussion

The empirical findings of this thesis reinforced the assumption that pension fund investments play an important role in the development of capital markets, particularly in the large and mature OECD markets. By assessing the one-way random effects model estimates with the adjusted standard errors, together with a subsequent robustness check, the statistically significant positive relationship between the variables of interest was found. These findings are in line with the conclusions of previous researchers (Alda, 2017; Catalan et al., 2000; Sun & Hu, 2014). Specifically, the relationship was strong in the OECD countries with the market development classified as high, which was determined based on the average in the group of countries studied. Such a result goes hand in hand with the findings of Meng and Pfau (2010), who specified a caveat in the relationship between pension investments and market growth – it depends on the level of the country´s financial development. Meng and Pfau argued that countries with low levels of financial development do not harvest the benefits of pension fund growth, and a statistically significant relationship was found only for the countries with a high level of financial development (2010). Hence, while pension funds are prone to contribute to the enhancement of financial innovation and availability of funds on the long-term horizon, there is a prerequisite of them reaching a certain size so that the effect would be significant (Meng & Pfau, 2010). The explanation can lie in the fact that the role of pension funds for the economy is amplified when regulatory environment is stable and investment decisions are unconstrained, so that no focus on domestic instruments with low risk level only would be made. As a result, different investment instruments in the portfolios together with the deep financial systems foster impact on market growth.

In addition, when incorporating demographic trends into an analysis, the results align with the findings of Alda (2017), as with the aging population, pension funds have a greater impact on market development, with a smaller positive effect when the proportion of the elderly population to the working-age population grows, substantially increasing the burden. Conversely, a negative impact of an increase in the proportion of the working-age population was found in this analysis, which suggests that immediate positive impacts might be delayed by a longer accumulation process with a less immediate effect on the market (Alda, 2017). Hence, a larger proportion of the elderly population can magnify the impact on the market development as enhanced transactions, rebalancing, and more active management of the pension assets are required to meet the ongoing obligations (Alda, 2017). As a result, increased financial market activity, depth, and turnover due to a decumulation of assets are stimulated in the countries with a higher ratio of the elderly population (Alda, 2017). However, such dynamics might also translate into a larger burden on the younger cohort of the population, facilitating negative societal implications in the long term, unless regulated properly (Bodnár & Nerlich, 2022).

Moreover, the dynamic analysis with the PVAR model sheds light on the asset allocation dilemma of the pension investors. The hypothesis developed in the work of Boubaker et al. (2018) was supported, implying that an increase in interest rates translates into an emphasis on fixed-income securities in the portfolios as they search for a high yield. Additionally, the IRFs analysis substantiated the findings, showing a lagged but significant alteration in the asset allocation in favor of bills and bonds, peaking in two years after an initial shock. Portfolio adjustments can be delayed because of institutional stickiness, as regulation and liquidity concerns slow down the process of portfolio alterations. At the same time, once the process is initiated, the effect is sustained over some periods as pension investors behave pro-cyclically in the fixed-income markets. Consequently, when yields decline, pension investors can contribute to the destabilization and volatility in the market due to their large trading volumes and the pressure to sell in the downfall (Thomas et al., 2014). Therefore, it is important to note that pension investors' behavior has a substantial influence on the markets, which should be considered by policymakers.

8. Conclusion

This work has quantitatively confirmed the main findings presented in the related academic literature and provided new insights considering demographic trends and contractionary monetary policy in OECD countries. The results imply that the influence of assets backed for retirement on capital market development is positive and significant, albeit conditional on the level of the maturity and development of the latter and augmented in the aging societies. A higher share of retirees among the population promotes an active stage for pension investors with a need to rebalance, meet obligations and adjust strategies, which translates into a larger impact on capital market development. Additionally, the responsiveness of pension fund managers to alterations in the interest rate environment was evident: a delayed but positive increase in the share of funds allocated to fixed-income securities following a shock in the rate was observed. Hence, under a change in the monetary policy, a yield-seeking behavior of the decision-makers was evidenced. The immediate effect is limited due to the possible portfolio constraints resulting from regulations and liquidity management concerns.

The study contributes to the existing academic literature by extending the data for a panel analysis to capture a high-interest rate environment not observed in the past decade and accounting for moderating demographic effects. The implications of the findings for policies are that an increase in the market growth can be fostered by promoting pension fund participation and developing pension system. Pension fund investments are influential for the growth of the capital markets so that transparency in the system and long-term investments are incentivized. However, for the effect to be substantial, the factors limiting the growth of the capital markets, such as underdeveloped markets with constraining regulations and investor protection issues, should be controlled. Moreover, as pension funds are backed by large institutional investors with substantial trading volumes, any change in the investment behavior and asset allocation to monetary policy decisions can have implications for markets. Hence, control of the risk-taking behavior of pension investors given monetary policy changes is to be considered. In addition, rising demographic pressure given a larger proportion of elderly population should be addressed by pension policies to ensure the maintenance of long-term fiscal sustainability.

To conclude, despite the robust methodology, certain limitations of the study are present. As there was heterogeneity among the countries in the OECD panel due to the quality of institutions, level of development, and legal environment, the results provide evidence of the average effect and might not be extrapolated on the specific group of countries. Additionally, the pension reforms, including changes in the limits for investment decisions, were not explicitly modeled in this analysis. Moreover, the VAR analysis can be extended in terms of both endogenous and exogenous variables for a more sophisticated study. The analysis was also limited by the unavailability of a long data history, which lowers the number of observations for the regression analysis. For the future analysis, subdivision of countries for a more granular analysis, considering heterogeneity, is advised. Moreover, the spillover effects from cross-border investments in OECD can be modelled. Lastly, an examination of the role of regulatory reforms in pension systems in shaping the impact of pension fund investments on capital markets is suggested.

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[1] Applied only for grammar corrections